Sustainable Water Management Initiative Pilot Project Phase 1

Completed for

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August 7, 2012

Table of Contents

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

List of Appendices

Table of Contents (cont.)

List of Tables

Table of Contents (cont.)

List of Tables

Table of Contents (cont.)

List of Figures

Table of Contents (cont.)

List of Figures

Section 1 Executive Summary

The Massachusetts Executive Office of Environmental Affairs (EEA) has developed the Draft Sustainable Water Management Initiative (SWMI) permitting Framework to enable a comprehensive approach to balancing water supply needs with the environmental sustainability of the Commonwealth's freshwater rivers and streams. This Draft Framework envisions a holistic approach to the permitting of water withdrawals under the Water Management Act (WMA) by the Massachusetts Department of Environmental Protection (MassDEP). The Draft Framework is based on an evaluation of the safe yield of affected major basins (watersheds) for both surface and groundwater supply, and couples measures to reduce demand, return water to aquifers (e.g., recharge stormwater runoff), and manage water supply and wastewater in communities and between basins in a manner designed to minimize impacts to stream resources.

The Draft Framework characterizes basins throughout the Commonwealth based on biological and flow criteria, and establishes requirements for Public Water Suppliers (PWSs) under the WMA permitting process. Specifically, a PWS requesting an increase in permitted water withdrawals or renewing its WMA permit may be required to evaluate options to minimize existing water withdrawal impacts and to mitigate new withdrawal volumes, depending on their basin characteristics and categorization. MassDEP has undertaken this Pilot Project to test the implementation of the Draft SWMI Framework. MassDEP and its consulting team have undertaken Phase 1 of the Pilot Project and this report describes the results of this effort.

The Pilot Project applies the Draft SWMI permitting Framework to four Massachusetts PWSs that have WMA permits. The four PWSs are:

- Amherst DPW Water Division
- Danvers-Middleton Water Divisions
- Dedham-Westwood Water District
- Shrewsbury Water Department

The report covers Phase 1 of the Pilot Project, which focuses on the evaluation of options to minimize and/or mitigate the impacts of PWS groundwater withdrawals on streamflows in accordance with the SWMI permitting Framework. Phase 2 may evaluate additional tools to help PWSs through the SWMI permitting process and evaluate how surface water withdrawals fit into the process.

The project was funded by the EEA and the results of the Pilot Project will inform EEA and its agencies and guide the development of regulations.

Section 2 of this report provides an overview of SWMI and the Pilot Project, and also introduces the water suppliers that participated in the Phase 1. The scope of the Phase 1 Pilot Project included:

1. Gathering background data and studies through MassDEP and online resources and direct contact with the PWSs and local communities.

2. Evaluating how to take wastewater discharges into account and developing a methodology for crediting wastewater discharges to offset groundwater withdrawals.
3. Evaluating measures to minimize impacts of existing withdrawals in subbasins where withdrawals exceed 25% of natural August median flows (e.g., Flow Level 4 and 5 subbasins).
4. Evaluating options for mitigating/offsetting increases in withdrawals, including options that result in flow volume offset benefits that can be directly estimated, as well as more qualitative measures that benefit the environment and merit credit in the withdrawal permitting process.
5. Meeting and coordinating with affected stakeholders, including meetings of the MassDEP and the project team with PWS representatives, local watershed groups, and a Pilot Stakeholder Committee.
6. Preparing and issuing this Draft Report to summarize the results of Phase 1 of the Pilot Project.

Section 3 of the report discusses factors influencing stream flows that may provide opportunities for developing potential offset and mitigation strategies under the Draft SWMI Framework. Factors considered include groundwater withdrawals, wastewater management, stormwater management, and stream corridor habitat considerations. The Draft SWMI Framework recognizes that these various streamflow and habitat influences all merit consideration in the development of potential minimization and mitigation actions to help address the impacts of water withdrawals on Commonwealth streams.

Section 4 of this document discusses minimization, mitigation, and offset actions for consideration under the Draft SWMI Framework. The goal of the Framework is to minimize and mitigate the impacts of groundwater withdrawals on streamflows. Recognizing that there are several factors that influence streamflow, beyond just water withdrawals, the Draft SWMI Framework offers a wide variety of options from which water suppliers, in consultation with state agencies, may choose to help minimize and offset the impacts of their withdrawals. These include optimizing existing sources, using alternative sources, surface water releases from dams, wastewater and stormwater improvements, habitat improvements, and demand management.

The report introduces these options and discusses their value towards offsetting withdrawal impacts. Section 4 presents a volumetric credit system that PWSs can use to evaluate, select, and determine the appropriate level of alternative actions to minimize and mitigate their withdrawal impacts. Mitigation and offset options include surface and groundwater discharges of treated wastewater, other wastewater improvement programs, stormwater management programs, habitat improvement measures, and demand management measures.

The methodology for estimating flow offsets for withdrawals is presented and discussed in detail, including two categories of methods:

1. Direct Offset Volume – The credit is based on a calculated water savings volume, which may be associated with a reduction in demand, increased groundwater recharge or direct discharge to surface water. It is calculated using standardized reference materials.

2. Indirect Offset Volume – The credit is based on a qualitative assessment of the water offset. The relative value of the offset is rated by a scoring system, which is then used to compute a corresponding flow-offset credit. The qualitative scoring system is described in detail in Appendix E.

In **Sections 5 through 8**, the report describes the application of the Draft SWMI permitting Framework to each of the participating PWSs. The Pilot application is based on review of data collected from MassDEP, the participating Towns and water suppliers, the Massachusetts Division of Ecological Restoration (DER) and other relevant sources as outlined in the annotated bibliography included in Appendix C.

Each of Sections 5 through 8 describes relevant characteristics of the water system and its community(ies), discusses permitting considerations and requirements under the Draft SWMI Framework, identifies measures for minimizing impacts of withdrawals in the affected subbasins, and identifies potential mitigation and offset credit actions.

Section 9 presents the Pilot Project Team's recommendations, based on the initial Phase 1 application of the Draft SWMI permitting Framework to the participating PWSs. Recommendations include:

- The Phase 1 Pilot Project revealed that wastewater and stormwater both have the potential for significant credits.
- Demand management in the form of individual property water fixture retrofits offers less significant results for flow offsets. However, a lot of water is used for lawn irrigation, as expected, and its management has greater offset credit potential.
- A more refined tracking system is needed so that reporting implementation of actions for offset credits to MassDEP can be reliable and systematic.
- A major product of the Phase 1 Pilot Project is the identification of methods to quantify and apply direct and indirect flow-offset credits; however, further vetting and testing is recommended.

More testing on real or theoretical communities could be done in Phase 2. Phase 1 went as far as quantifying the potential credits, but the consulting team could not make the local decisions on how to fund projects or what types of credits would be more suitable in each town. To help guide implementation, the next phase could include some scenarios of what communities might decide. These "feasibility examples" would help guide the draft regulations and guidelines and provide examples for the regulated community and watershed groups.

Section 2 Introduction and Overview

The purpose of this Pilot Project is to test implementation of the Massachusetts Executive Office of Environmental Affairs' (EEA's) Draft Sustainable Water Management Initiative (SWMI) permitting Framework on four Massachusetts Public Water Suppliers (PWSs) that have Water Management Act (WMA) permits (see Appendix A for Glossary of terms and acronyms). The four PWSs are:

- Town of Amherst Department of Public Works (DPW) Water Division
- Danvers-Middleton Water Divisions
- Dedham-Westwood Water District
- Town of Shrewsbury Water Department

There are two phases of the Pilot Project, including a Phase 1 that is the subject of this Draft Report. Phase 1 focuses on the evaluation of minimization and mitigation options to reduce the impacts of groundwater withdrawals on streamflows in accordance with the Draft SWMI Framework. Phase 2 may evaluate additional tools to help PWSs through the Draft SWMI permitting process and evaluate how surface water withdrawals fit into the process. MassDEP selected the Team of Comprehensive Environmental Inc. in association with Tighe & Bond to complete both Phases of the Pilot Project.

The project was funded by EEA and the results will inform EEA and its agencies and guide the development of regulations.

2.1 Summary of SWMI

The EEA and its agencies developed the Draft SWMI Framework to help balance ecological and human water needs through the regulation of water withdrawals. The Draft Framework characterizes river basins throughout the Commonwealth and establishes requirements for permitting under the WMA. Specifically, all permit holders will be required to evaluate options to minimize existing water withdrawal impacts and those permit holders requesting an increase to permitted water withdrawals above an established baseline volume will be required to offset those new withdrawal volumes, depending on the characteristics and categorization of the river basin(s) where their wells are located. The Draft Framework also includes a transition rule for surface waters with similar minimization and mitigation requirements.

2.1.1 Basin Characterization and Categorization

The Draft SWMI Framework categorizes major basins and subbasins to help establish the level of mitigation and improvement that will be required of PWSs under the WMA permitting process, as triggered by a request for increased withdrawal or through the periodic WMA permit renewal process. There are 1,395 nested subbasins delineated within the state of Massachusetts. Subbasins are defined as the total upstream land area that drains to a selected point on a stream ("subbasin outlet"). Subbasin areas increase in the downstream direction, and were designed with a nesting effect that accumulate successive areas draining to a particular stream reach. Nested subbasins range in size from 1.6 to 723 square miles, while individual subbasins range in size from approximately 2 to 15 square miles. (MWI Report)

Basin characterization and categorization includes the following elements:

Safe Yield – Safe yield has been calculated for each major basin to determine the maximum amount of water that may be withdrawn while maintaining sufficient water in streams and rivers for environmental protection.

Biological Categories – Subbasins are grouped into five Biological Categories (BCs) that represent an estimate of existing aquatic habitat integrity of the receiving streams and rivers. Fish communities were used as a surrogate for aquatic habitat integrity and a model developed by USGS established the relationship between fluvial fish abundance and variations in flow, percent of impervious cover and natural basin characteristics. Categories range from Category 1, which represents high quality aquatic habitats, relatively un-impacted by human alteration, to Category 5, which represents a significant decline in fluvial fish populations and aquatic habitat.

Flow Levels – Subbasins are also categorized into five Flow Levels (FLs) that represent the percent alteration of natural August median flows due to groundwater withdrawals within the basin and upstream of the basin. The percent alteration assumes each gallon of water withdrawn from the basin by public and private groundwater supplies, and not surface water withdrawals, results in a direct and equal decrease in streamflow. FL 1 represents the least impact to, or alteration of, streamflow, with less than 3% of the August unimpacted streamflow withdrawn, and FL 5 represents the greatest impact to, or alteration of, streamflow, with 55% or more of the August streamflow withdrawn. The percent alterations due to groundwater withdrawal used to define each flow level are based on the level of withdrawal/alteration that caused the BC to backslide one category (e.g., go from BC 1 to BC 2) with impervious cover set to one percent.

Although August flow alteration is used to define the subbasin FL, the Draft SWMI Framework also includes guidelines for allowable alteration of unimpacted median flow in October, January and April for FL 1, 2 and 3 subbasins. For most subbasins the flow alteration in the non-August months equates to a FL equal to or lower than the FL determined by the August flow alteration.

2.1.2 Application of SWMI

The Draft SWMI Framework will apply when a permit holder requests an increase in its permitted withdrawal volume above an established baseline or when its WMA permit is up for renewal. The process is as follows for PWS permit holders:

Step 1 - DCR will develop a 20-year Water Needs Forecast (WNF) for the communities served by the PWS.

Step 2 - MassDEP will check the volume requested against the DCR projections and the basin safe yield to determine whether the total approved and requested withdrawals in the basin will exceed the safe yield.

Step 3 - MassDEP will calculate the PWS's baseline[1] withdrawal and compare it to the water withdrawal requested to determine the PWS's permit review tier as follows:

- Tier 1 – No additional withdrawal request above baseline.
- Tier 2 – Additional withdrawal request above baseline is small[2] and no change in FL or BC.
- Tier 3 – Additional withdrawal request above baseline is large[2] and no change in FL or BC.
- Tier 4 – Additional withdrawal request above baseline will change FL and/or BC.

The permit review tier will then establish the requirements of the WMA permit based on the basin's BC and FL. Refer to Figure 2-1a for a summary of the Draft SWMI Framework and Figure 2-1b for the Draft SWMI Framework Tier permitting requirements.

WMA Standard Conditions 1-8 (refer to Appendix B) will apply to all WMA permits. Standard Conditions 6, 7, and 8 will be developed for PWSs to minimize existing withdrawal impacts on streamflow to the greatest extent feasible and to offset withdrawal impacts when the withdrawal requested is greater than the established baseline. Standard Condition 8 will only apply to PWSs in FL 4 and 5 subbasins.

Table 2-1 outlines potential minimization and mitigation options that a PWS may consider. Additional requirements (separate from FL 4 or 5 considerations) also apply for PWSs if there are quality natural resources (e.g., BC 1, 2, and 3 and/or coldwater fishery resource present) within the basin.

[1] Baseline is currently defined as the volume withdrawn in compliance with the Act during the calendar year 2005, the average volume withdrawn in compliance with the Act from 2003 to 2005, or the registered volume, whichever is the highest. The new baseline proposal under the SWMI framework would add 5% to the higher of 2003-2005 average use, or 2005 use. Proponents may be able to add up to 8% provided they can demonstrate that the additional increase would not result in a drop in Flow Level. If baseline is the registered volume, no additional percentage can be added.

[2] 5% alteration of unimpacted August median flow was selected to distinguish large withdrawal requests from smaller withdrawal requests.

Figure 2-1a. Draft SWMI Framework - Summary

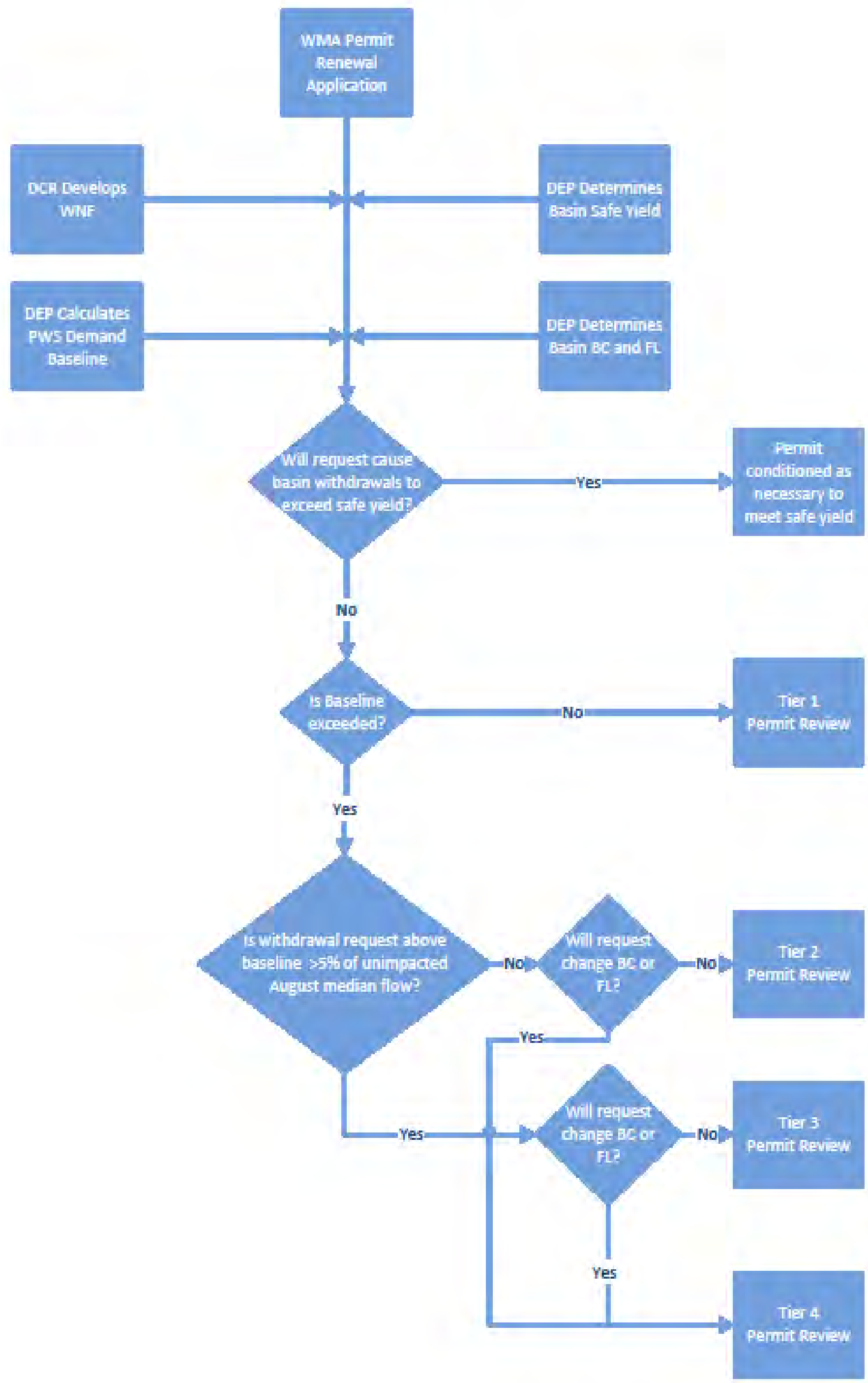


Figure 2-1b. Draft SWMI Framework - Tier Requirements

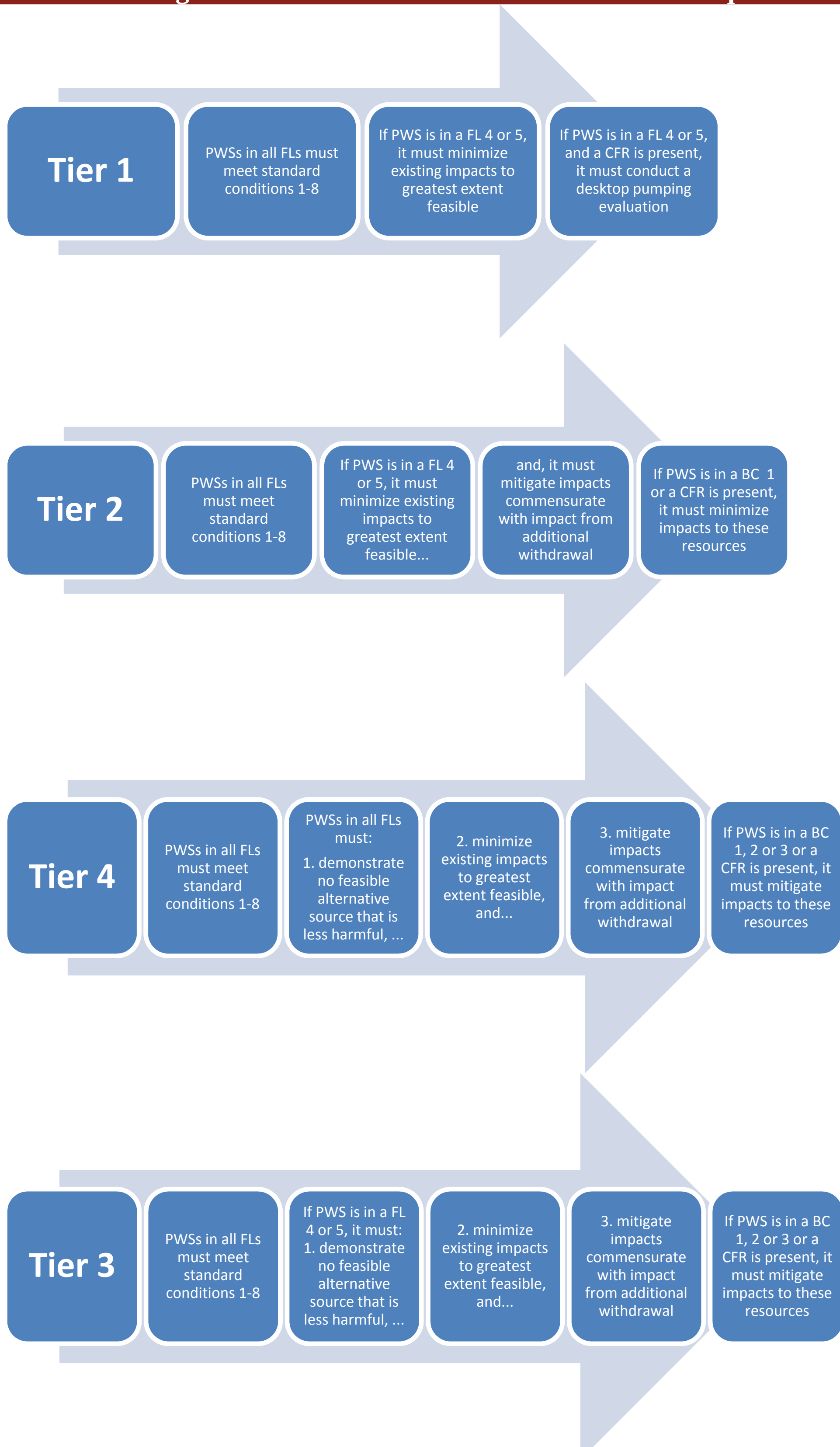


Table 2-1. Minimization and Mitigation Options	
Minimization	**Mitigation**
1. Optimization of existing resources; 2. Use of alternative sources; 3. Interconnections with other communities or suppliers; 4. Releases from surface water impoundments; 5. Outdoor water restrictions tied to streamflow triggers (e.g., greater restrictions on outdoor watering than is currently applied); 6. Implementation of reasonable conservation measures; 7. New England Water Works Association Best Management Practice (BMP) toolbox; 8. Other measures that return water to the subbasin.	1. Instream flow improvements through release of surface waters; 2. Wastewater improvements including additional septic or treated groundwater discharge and I/I removal; 3. Stormwater/impervious cover improvements including recharge, adoption of a stormwater utility, adoption/implementation of MS4 requirements, reduction of impervious cover; 4. Water supply management including adoption of an enterprise account; 5. Habitat improvement including improving habitat connectivity, restoration of stream buffers; 6. Demand management to reduce water withdrawals.

Source: Table 5 and Table 6 of the Draft SWMI Framework dated February 3, 2012.

2.2 SWMI Pilot Project Overview

The scope of the Phase 1 Pilot Project included:

1. Gather background data and studies – Available information useful to the pilot was first collected through MassDEP and online resources, followed by direct contact with the PWSs, local communities, and watershed groups. An Annotated Bibliography of all documents used during the Pilot Project evaluations is in Appendix C.

2. Evaluate how to take wastewater discharges into account – The team developed a methodology for crediting wastewater discharges to offset groundwater withdrawals. Refer to Section 7.1 for the methodology.

3. Evaluate minimization of impacts in Flow Level 4 and 5 subbasins – All four pilot PWSs have groundwater withdrawals in Flow Level 4 or 5 subbasins. Options for minimizing the impacts of these existing withdrawals were evaluated by considering their feasibility and ability to implement.

4. Evaluate options for mitigating/offsetting increases in withdrawals – Options for mitigating proposed increases in withdrawal above the baseline were evaluated for each pilot PWS. A series of worksheets were developed to help quantify the mitigation volume and associated costs for implementing each measure. The mitigation measures applicable to each PWS/community were identified and applied.

5. Coordination and meetings – MassDEP and the project team held a series of meetings with various stakeholders as follows:

   a. PWS Meetings – Two meetings were held with each pilot PWS. The first was to introduce the SWMI process, collect data and learn about the PWS systems and their concerns. The second was to present preliminary findings of the Pilot Project.

   b. Watershed Meetings – One meeting was held for each PWS with local watershed groups with interests in the basins from which the PWSs withdraw. The purpose of the meetings was to obtain feedback from the watershed groups on the SWMI process, their concerns and priority habitat projects in the area, as well as to present preliminary findings.

   c. SWMI Pilot Stakeholder Committee Meetings – One meeting was held with the SWMI Pilot Stakeholder Committee to obtain technical and policy guidance, and to identify areas of agreement and areas for further exploration.

   The meeting process and feedback obtained was also used to help develop a framework for the agency consultation process to be used with applicants under the Draft SWMI permitting Framework to ensure effective communication between state agencies and the PWSs. Refer to Section 7.3 for recommendations on the agency consultation process.

6. Draft Report – This Draft Report was developed to summarize the results of Phase 1 of the Pilot Project.

2.3 Pilot Communities

Four PWSs were selected to participate in the SWMI Pilot Project. These were:

- Amherst DPW Water Division
- Danvers-Middleton Water Divisions
- Dedham-Westwood Water District
- Shrewsbury Water Department

Refer to Figure 2-2 at the end of this section for a locus map showing the locations of communities served by the pilot PWSs.

2.3.1 Amherst DPW Water Division

The Town of Amherst, Massachusetts is located in Hampshire County in western Massachusetts, approximately 25 miles north of Springfield, Massachusetts. The town is approximately 28 square miles in area. The MassDEP requested the Amherst DPW Water Division (AWD) participate in the Pilot Project for two major reasons. First, inclusion of AWD broadens the geographic area encompassed in the project. Second, the AWD uses a combination of groundwater and surface water sources, which would allow for evaluation of additional optimization scenarios and future evaluation of the Surface Water Transition Rule in the Draft SWMI Framework.

Amherst's sources are located within two subbasins of the Connecticut River Basin. Amherst's maximum authorized withdrawal volume is 4.55 million gallons per day (mgd), including permitted withdrawals of 1.21 mgd from six groundwater wells (South Amherst Wells #1, #4, and #6, Brown Well #3, Bay Road Well #5, and Replacement Well #2) and two surface water supplies (the Hills/Hawley/Intake Reservoirs and Atkins Reservoir), and registered withdrawals of 3.34 mgd from five groundwater wells (South Amherst Wells #1 and #4, Brown Well #3, Bay Road Well #5, and Replacement Well #2) and two surface water supplies (the Hills/Hawley/Intake Reservoirs and Atkins Reservoir).

In 2010, Amherst had a population of 37,819, of which the AWD served 21,095 inclusive of colleges/universities. The total number of households in 2010 was 9,259 and the average household size was 2.44, not including colleges/universities. The Massachusetts Department of Conservation and Recreation (DCR) has not completed a Water Needs Forecast for the AWD. There are three colleges/universities located in Amherst, making water needs forecasting problematic. The University of Massachusetts Amherst (UMass) alone has over 12,000 students living in 45 dormitories and staff, families, and graduate students living in two apartment complexes (U.S. Census Website and UMass Student Life Website) (See Appendix D for References).

Approximately 93% of the Town of Amherst is served by a sanitary sewer system, which transports wastewater to the Amherst Wastewater Treatment Plant, with discharges of treated effluent directly to the Connecticut River. Approximately 100,000 to 120,000 gpd of this treated effluent goes to UMass for additional treatment and reuse at the Central Heating Plant.

2.3.2 Danvers-Middleton Water Divisions

The Town of Danvers, Massachusetts is located in Essex County in the northeast part of the state, approximately 17 miles north of Boston and is approximately 13.6 square miles in area. The MassDEP requested the Danvers-Middleton Water System participate in the Pilot Project because it is located in the Ipswich River Basin, one of only two major basins that have authorized withdrawals greater than the MassDEP calculated safe yield. Danvers-Middleton also uses both groundwater and surface water supplies.

In 2010, Danvers had a population of 26,493. The Danvers-Middleton Water System serves 100% of the population of Danvers and approximately 56% of the population of Middleton for a total of 31,545 residents served. The total number of households in Danvers in 2010 was 10,615 and the average household size was 2.42. (The total number of households in Middleton in 2010 was 2,898 and the average household size was 2.68).

The Town of Middleton has its own Public Water System identification number; however, it does not have its own sources and purchases all of its water from Danvers. Middleton essentially only operates its own distribution system. Danvers Water Division directly bills all of the Middleton water customers. Danvers bills Middleton for water based on Middleton water customers' meters. As a result, all unaccounted for water (UAW) in both systems is attributed to Danvers.

Danvers-Middleton's maximum authorized average daily withdrawal volume is 3.72 mgd. It is permitted for 0.58 mgd and registered for 3.14 mgd from four groundwater wells (Well #1, Well #1 North Replacement Well, Well #1 South Replacement, and Well #2), and three surface water supplies (Middleton Pond, Swan Pond, and Emerson Brook Reservoir).

Approximately 99% of the Town of Danvers is served by a sanitary sewer system which transports wastewater to the South Essex Sewerage District and its regional wastewater treatment facility in Salem, Massachusetts. This plant discharges treated effluent to Salem Sound. Middleton's wastewater needs are primarily served by on-site systems. Localized areas, including the Ferncroft area, the Bostik industrial facility and the Essex County Industrial Camp (jail) are served by sewer systems that tie into the South Essex Sewerage District system.

2.3.3 Dedham-Westwood Water District

Dedham and Westwood, Massachusetts are located in Norfolk County in the eastern part of the state, approximately 10 miles southwest of Boston. Dedham is approximately 10.3 square miles in area and Westwood is approximately 11.1 square miles in area. In 2010, Dedham had a population of 24,729 and Westwood had a population of 14,618. The Dedham-Westwood Water District (DWWD) serves 100% of the population of both Dedham and Westwood for a total of 39,347 residents served. The total number of households in Dedham in 2010 was 9,651 and the average household size was 2.45. The total number of households in Westwood in 2010 was 5,249 and the average household size was 2.78.

MassDEP requested DWWD participate in the Pilot Project mainly because it is a water district rather than a municipally-owned and operated water department. This structure can provide additional challenges for implementing minimization and mitigation measures that are municipally controlled (e.g., wastewater or stormwater improvements).

DWWD's sources are located within two subbasins of the Charles River Basin and two subbasins of the Neponset River portion of the Boston Harbor Basin.

DWWD's maximum authorized average daily withdrawal volume for the Neponset is 3.11 mgd (permitted for 0.49 mgd and registered for 2.62 mgd). DWWD's permitted sources located in the Neponset include five groundwater wells (White Lodge Wells #1, #2, #3, and #4, and Fowl Meadow Well). Registered sources located in the Neponset include five groundwater wells (White Lodge Wells #1, #2, #3, #4, and #3A).

DWWD is registered for 1.91 mgd in the Charles River Basin. Its registered sources located in the Charles include ten groundwater wells (Bridge St. Wells A2, B1, D1, E, F, B2, D2, E1, and E2, and Rock Meadow Well #11). DWWD does not have a permitted withdrawal volume within the Charles River Basin.

In addition, DWWD is a member community of the Massachusetts Water Resources Authority (MWRA) and can purchase up to an annual average of 100,000 gallons per day to supplement its local supply sources.

The Towns of Dedham and Westwood are both served by the MWRA sewer system; therefore, the majority of the water withdrawn from the Charles and Neponset River Basins are discharged to Boston Harbor. Dedham is 100% sewered; approximately 95% of Westwood is sewered with the remaining 5% served by on-site septic systems.

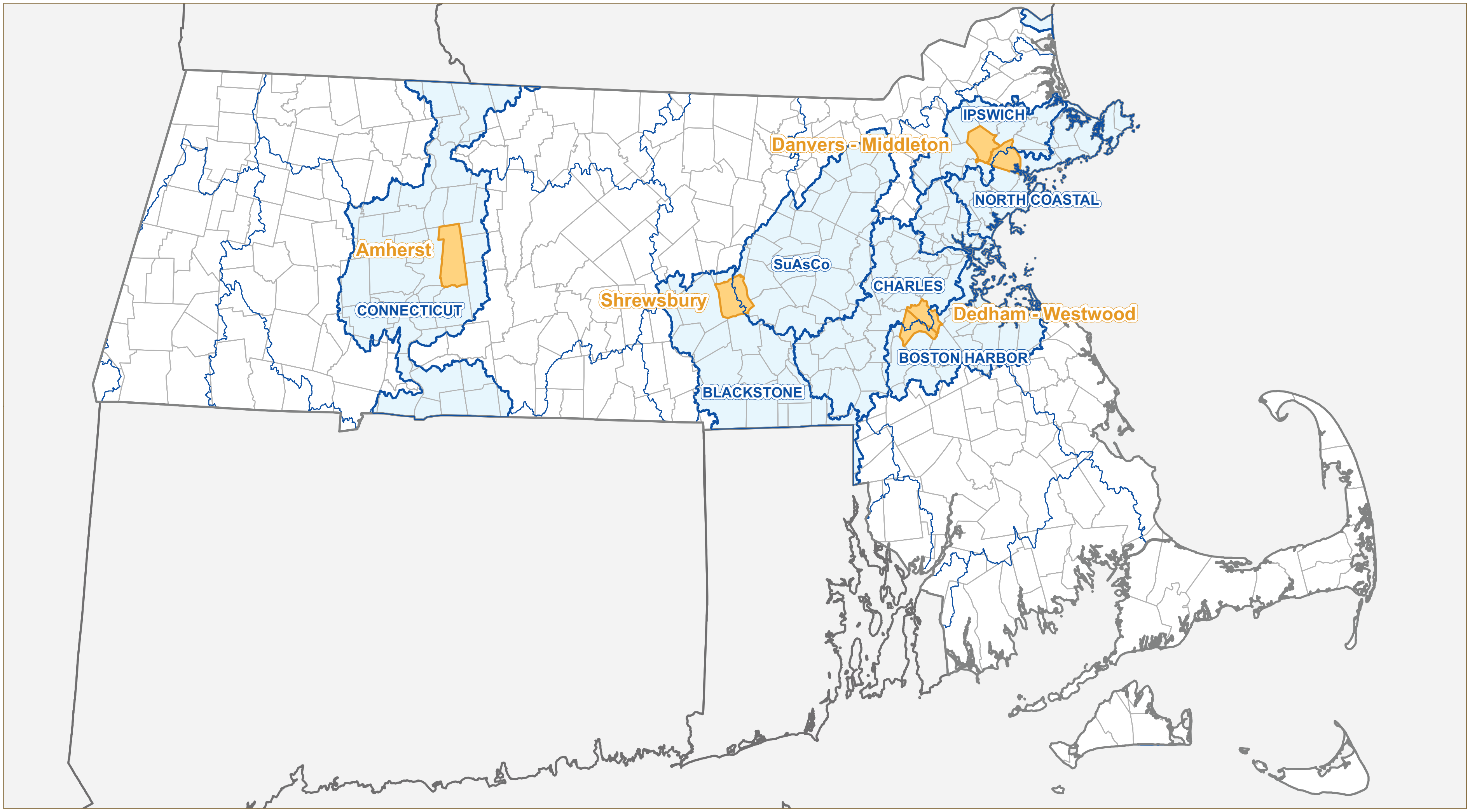
2.3.4 Shrewsbury Water Department

The Town of Shrewsbury, Massachusetts is located in Worcester County in the central part of the state, approximately 35 miles west of Boston. The town is approximately 21.6 square miles in area. The Shrewsbury Water Department serves 100% of the population of Shrewsbury, which in 2010 numbered 35,608. The total number of households in 2010 was 13,424 and the average household size was 2.62.

MassDEP requested Shrewsbury participate in the Pilot Project because it is a quickly growing Town that has been investing significantly in its water and wastewater infrastructure, and may be seeking increased water withdrawals and wastewater capacity in the future. Shrewsbury's population has increased by 11,462 people since 1990, while the populations in the other Pilot Communities have had smaller increases in the range of 947 to 4,066 over the same time period. Currently, about 12% of water use is commercial and 88% is residential. Shrewsbury has expressed a desire to reserve future water capacity for commercial/industrial development.

Shrewsbury's sources are located within two subbasins of the Blackstone River Basin. Shrewsbury's maximum authorized withdrawal volume is 3.91 mgd. It is permitted for 1.27 mgd and registered for 2.64 mgd from six groundwater wells (Sewell Street Well #4, Lamberts Sand Pit Wells 3.1 and 3.2, and Home Farm Wells 6.1, 6.2, and 6.3). Note that Well 6.4 is the new replacement well for 6.2 but this is not reflected in the current WMA permit currently available to the Pilot Project Team.

Approximately 85% of the Town of Shrewsbury is sewered, with an annual average of 3.79 mgd of wastewater treated at the Westborough Wastewater Treatment Plant in Westborough, Massachusetts, with discharge of treated effluent to the Assabet River, part of the Concord River basin. Water pumped from the Blackstone River Basin discharges as wastewater to the Concord River Basin in Westborough. There are about 1,700 septic systems in Shrewsbury, with the associated treated effluent discharged within the Blackstone and Concord River Basins. The capacity of the wastewater treatment plant is a limiting factor affecting future development in the Town. The Westborough Wastewater Treatment Plant capacity is 7.68 mgd, of which Shrewsbury's allocation is 4.39 mgd, or approximately 60% of the plant's capacity. Shrewsbury could potentially increase its discharge by up to 0.60 mgd.



LEGEND

- Pilot Communities
- Pilot Basins
- Major Basin Boundary
- Town Boundary

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W E
S

0 10 20 30 40 50 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 2-2

Locus Map
Pilot Community and Major Basins

Comprehensive Environmental Incorporated

Tighe&Bond

Section 3 Factors Impacting Streamflows and Habitat

The Sustainable Water Management Initiative (SWMI) is directed towards water withdrawals and their impact on streamflow. This section provides important background information on these withdrawals, as well as on some additional factors that often influence streamflows since these may, in some cases, provide opportunities for developing potential offset and mitigation strategies under the Draft SWMI Framework. Factors discussed in this section include: groundwater withdrawals, wastewater management, stormwater management, and stream corridor habitat considerations.

Sufficient water to sustain both water supplies and streamflows for aquatic wildlife is becoming scarcer in the Northeast, largely due to the alteration of the hydrologic cycle caused by development. The hydrologic cycle is altered in several ways, including increased impervious surfaces that limit the amount of groundwater recharge and baseflow discharge to streams. Higher populations require withdrawal of more water for residential, commercial and industrial use. Homes and businesses create wastewater that is discharged through subsurface septic systems or collected and treated through municipal sewage systems. The availability of sewers to collect wastewater discharges often allow for greater development densities, higher water demands and more stormwater runoff. Each facet of development affects the other, and all affect water resources.

The U.S. Environmental Protection Agency (EPA) and the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) are continuously working on regulations, policies and guidance to better control the impacts of development to our natural resources. Areas of focus include: water supply withdrawals, wastewater discharges, stormwater runoff and habitat protection, each of which is regulated by a various divisions of EPA and EEA agencies.

The subject of this Pilot Project is Public Water Supply (PWS) withdrawals regulated under the Water Management Act (WMA), with a focus on how the Draft SWMI Framework would impact four pilot PWSs. However, the Draft SWMI Framework also recognizes other streamflow and habitat influences, including wastewater discharges, stormwater recharge and habitat connectivity. The Draft Framework recognizes these other streamflow and habitat influences in the development of potential minimization and mitigation actions.

3.1 Groundwater Withdrawals

The premise behind the Draft SWMI Framework is a USGS study of riverine fish assemblages in Massachusetts (USGS, SIR 2011-5193), which found a significant correlation between percent impervious cover and percent flow alteration from groundwater withdrawals and fluvial (riverine) fish assemblages. The study essentially concluded that greater percent alterations of natural streamflows, using August median flow as a surrogate, and greater percent impervious cover, are significantly associated with decreases in the relative abundance of fluvial fish.

The magnitude of groundwater withdrawals needed by a PWS and their impact on natural streamflows is primarily driven by system demands (residential, commercial, industrial, and institutional) and the natural hydrologic system of streams and aquifers.

3.1.1 User Demands

The volume of groundwater withdrawal required by a PWS is primarily driven by residential, commercial, industrial, and institutional user demands. Residential demand includes essential water uses such as drinking and showering and non-essential water uses such as lawn and landscape watering.

The efficiency of water devices can play a large role in water demands. Older buildings often use more water indoors than newer buildings due to less efficient toilets, faucets and shower heads installed before the Massachusetts plumbing code changes of 1989 and the Federal Energy Policy Act of 1992, effective 1994. Older washing machines and dishwashers also may use more water than newer or more efficient models.

Inefficient landscape irrigation can waste large volumes of water by watering more than necessary and at the wrong time of the day when much of the water evaporates. EPA's WaterSense Program estimates that landscape irrigation can waste up to 1.5 billion gallons every day across the country (EPA WaterSense Website). These inefficiencies may occur on both residential and commercial properties.

3.1.2 System Operation/Integrity

Inefficiencies can also occur in the water supply distribution system and operations. For example, leaks in the system piping cause unnecessary withdrawals. Leakage in water systems may be from corrosion, improperly installed materials, defective materials, excessive pressure, frost loading, damage during other work, soil materials and electrical conductance. The amount of leakage depends on the system pressures, soil types, frequency of leak detection and infrastructure integrity. Large leaks in water mains are typically discovered quickly since the water tends to migrate to the ground surface quickly and the PWS may notice pressure drops in an area or an abnormal increase in demands.

Leaks in services between the main and the customer meter have the potential to contribute significantly to the PWS water demands. It is generally accepted that service leaks result in much more lost water than water main leaks. Service leaks are not typically discovered immediately and could be leaking for days, months or years before being discovered, if ever.

Relative to system operations, water suppliers may have an opportunity to actively select/operate their various supply sources to optimize withdrawals in order to reduce streamflow impacts, as withdrawals from some wells may have a greater streamflow impact than others.

3.2 Wastewater

Streamflow and aquatic habitat are influenced by a number of variables. How a community addresses wastewater disposal can influence streamflow. Options for discharging wastewater to the ground are generally driven by the ability of the soil to absorb the wastewater effluent. Factors that influence whether or not on-site wastewater systems will function adequately include: route of discharge, soil permeability, development density, proximity to water resources, and depth to groundwater. Addressing wastewater concerns is often a balancing act between addressing water quality and recharging water locally. In considering wastewater in the context of streamflow and aquatic habitat, the Pilot Project focuses on water quantity.

Wastewater management options are generally limited to three broad categories: on-site septic systems, regulated groundwater discharges, and surface water discharges. These options are summarized in Table 3-1 and discussed in more detail below.

Table 3-1. Summary of Wastewater Management Alternatives

Category	Definition	Applicability to SWMI
Septic Systems	Up to 10,000 gallons per day (gpd), regulated by the local Board of Health/Title 5 (310 CMR 15)	• Provides localized direct groundwater recharge
Regulated Groundwater Discharges	10,000 gpd or more, regulated by MassDEP (314 CMR 5)	• Requires treatment • Provides direct groundwater recharge • Groundwater recharge may be localized if treating wastewater at a site or may be out of Town or out of basin if a regional facility
Regulated Surface Water Discharges	Collection, treatment and surface water discharge at one location, regulated through EPA NPDES program	• Requires treatment • Does not provide direct groundwater recharge • May be located out of Town or out of basin • Augments surface water flows, depending on geology; this may also augment groundwater recharge

With the focus on keeping water local, groundwater disposal, and to some extent, reuse of treated effluent, are preferred alternatives where feasible. Groundwater disposal is regulated by two programs, depending on the quantity of effluent to be discharged. Flows less than 10,000 gallons per day (gpd) fall under the jurisdiction of the local Board of Health under Title 5 (310 CMR 15). Flows greater than 10,000 gpd are regulated under the Massachusetts Department of Environmental Protection’s (MassDEP’s) groundwater disposal program (314 CMR 5). Reuse of treated wastewater effluent is further regulated by MassDEP under 314 CMR 20.

Due to environmental and development conditions, many communities have developed centralized collection, treatment and disposal facilities. The majority of the centralized wastewater treatment and disposal facilities in Massachusetts discharge treated effluent to surface waters. Surface water discharges are regulated by EPA and MassDEP under the National Pollutant Discharge Elimination System (NPDES), in compliance with the Federal Clean Water Act (33 USC Section 1251 et seq.) and the Massachusetts Clean Waters Act (MGL Chapter 21, Section 26-53). Surface water discharges provide minimal opportunity for direct groundwater recharge; however, surface water discharges directly augment streamflows although quality may be an issue. Depending on geologic setting, these augmented streamflows may in turn augment groundwater recharge.

Sanitary sewer collection systems can also be a conduit for transport of groundwater and stormwater out of a watershed basin. Viewed from the standpoint of community infrastructure, groundwater and stormwater influence on the sanitary sewer collection system is generally referred to as Infiltration and Inflow or I/I. Infiltration is groundwater that enters the sewer system through sources such as defective pipes, pipe joints and manhole walls. Inflow is stormwater that enters the sewer system through direct sources such as catch basins, manhole covers, cross connections with storm drains, and illegal connections from sump pumps, foundation drains and downspouts. Both infiltration and inflow increase the volume of wastewater for treatment. Minimizing infiltration into the sanitary sewer system is desirable and has a direct and usually positive result on local groundwater. Minimizing inflow into the system is also desirable from a cost standpoint and can help maintain local stormwater recharge to groundwater.

As noted above, the Pilot Project focuses on the influence of wastewater relative to water quantity. The wastewater disposal options were identified, and for municipal collection systems, the potential influence of I/I was considered. The methodology is discussed in Section 4 and the results for each pilot PWS are detailed in their respective sections. While recharge from wastewater disposal was considered in the background science for the Draft SWMI Framework, the FL designations do not incorporate the influence of wastewater recharge on streamflows.

3.3 Stormwater

The amount of impervious cover also has a significant influence on streamflows and water quality, primarily through the reduction of recharge essential to maintaining summer groundwater baseflows (i.e., groundwater discharge to the stream) and through the introduction of high velocity stormwater runoff that can damage aquatic habitat and stream channels. Runoff from impervious cover also has warmer temperatures and greater pollutant loads and concentrations than natural conditions. The USGS Factors Influencing Riverine Fish Communities study cited above correlated a decrease in fluvial fish assemblages with an increase in impervious cover. The impacts of development and increased imperviousness are many and significant, as outlined below:

Interference with the Natural Hydrologic Cycle - In a natural hydrologic cycle, a portion of the precipitation returns to the atmosphere through evaporation and transpiration (evapotranspiration); a portion infiltrates into the ground, where it is able to recharge groundwater flows and provide baseflows for streams, and lastly a portion runs off over the surface of the land and is discharged into nearby surface waters. Figure 3-1 shows a simplified diagram of the hydrologic cycle under natural conditions before development occurs.

Traditional development interferes with the natural hydrologic cycle. In urbanized areas, the three components (evapotranspiration, infiltration and runoff) still occur but in different proportions and with other factors coming into play. Increased imperviousness significantly increases runoff at the expense of infiltration. Water that once infiltrated through soils to recharge groundwater and replenish stream baseflows is converted into stormwater runoff. This runoff reaches streams in a matter of hours, as opposed to the months or years it would take to reach the streams as recharge. Impervious cover alters the hydrologic flow pattern by making the low flows lower due to decreased groundwater recharge, and by making the high flows higher as precipitation flows to streams immediately following a storm.

Runoff is further increased as evapotranspiration is reduced when the original forested cover is removed. For each acre of land, the natural rainfall in Massachusetts is roughly 1 million gallons (mg) per year. Of this 1 mg, about half is evapotranspiration and about half (in a well-drained soil) is recharge. The same acre when developed still receives 1 mg of rainfall, but it may ALL become stormwater runoff, even where none existed before. This new runoff contains pollutants and increases temperatures, causes flooding problems, and results in damage to infrastructure, private property, and natural habitats.

Groundwater and surface water withdrawals also impact the hydrologic cycle. In some cases, much of this water consumption is returned to the ground using septic systems for wastewater disposal, but in other cases the used water is transferred from the area and discharged in other locations. The combined effect of development impacts (increased runoff, decreased infiltration, withdrawal of groundwater for water supply, and transfer of wastewater to other basins for disposal) is the lowering of local groundwater tables. In turn, the reduction in groundwater levels may reduce groundwater discharge to streams (as baseflow), and these streams may eventually be impacted, especially during dry periods. Figure 3-2 shows a simplified diagram of the hydrologic cycle under developed conditions.

Reduced Recharge - Reduced recharge to groundwater is one of the greatest impacts of development. Recharge is essential to replenish groundwater aquifers, rivers and streams. Without adequate recharge, water supply wells can be impacted as their yield can be significantly reduced. Rivers and streams can also be impacted as groundwater tables are lowered, reducing groundwater baseflows. This is particularly true in the summer when evapotranspiration rates are high and runoff is low. Groundwater baseflows reduced by pumping wells could also result in higher stream temperatures and greater pollutant concentrations, as more of the streamflow comes from surface runoff that has heated and picked up pollutants as it traveled over dark, impervious surfaces such as pavement and rooftops.

Flooding - Increased runoff from impervious surfaces can increase the frequency of bankfull stream flow events, and the frequency and magnitude of flooding. These conditions can lead to erosion of natural streambanks and incision and widening of the stream channel. In turn, this erosion increases sediment loads to the streams and exposes tree and other plant roots along the banks. Although flood controls such as detention basins have been used for many years to reduce peak flows, they only address the larger infrequent storms, typically those above the 2-year, 24-hour storm. Meanwhile, stream channels are exposed to more frequent erosive flows associated with the smaller storms, resulting in loss of bottom dwelling and other aquatic organisms that rely on relatively stable, sediment-free habitat. Infrastructure such as roads, bridges and pipelines may also be damaged as the bank erodes, setting the scene for potentially devastating damage during major floods.

Increased Water Temperature - Impervious surfaces also increase stream temperatures. Stormwater runoff is warmed as it travels over hot surfaces like black pavement and rooftops. This heated surface runoff replaces much of the cool baseflow that reaches the stream under natural, undeveloped conditions.

This effect is then exacerbated by clearing of trees along streams, eliminating shade needed to keep streams cool. The increased temperatures can reduce dissolved oxygen levels necessary for fish and other aquatic life to survive. This may lead to the replacement of sensitive fish species and other life forms with organisms that are better adapted to warm, low-oxygen conditions.

Higher Pollutant Loads - Pollutant concentrations and loads also increase with increased runoff from impervious surfaces. As human land use intensifies, pollutants build up (i.e., pesticides, fertilizers, animal wastes, oil, grease, heavy metals, sediment, phosphorus, pathogenic bacteria and road salt). These materials are then washed off by rain and runoff, increasing the pollutant load to receiving waters. Not only does this impact rivers and streams by reducing sensitive species and increasing more tolerant species, but it also impacts receiving lakes and ponds. Increased phosphorus and nitrogen loads to lakes and ponds can cause eutrophication, which can lead to filling in of the water body due to increases in aquatic vegetation. Increased populations of pathogenic bacteria associated with these conditions can lead to beach closures, more costly treatment requirements for surface water supplies, and closure of shellfish beds.

Each of these impacts, water withdrawals, wastewater disposal and impervious surfaces must be managed to sustain a healthy water balance and environment, and are considered in the minimization and mitigation options discussed in Sections 4.2 and 4.3.

3.4 Habitat Barriers

Water withdrawals, wastewater discharges and stormwater runoff are not the only negative influences on aquatic habitat. Stream connectivity is also important and is often interrupted by man-made structures such as road crossings and dams. In addition, riparian vegetative cover is an important element of aquatic habitat and is often impacted by land use development practices.

Roads frequently intersect streams at multiple locations causing fragmentation of streams and disruption of the mobility of aquatic organisms. Historically, stream crossing structures have been designed to address traffic considerations, structural integrity, and hydraulic capacity with minimal consideration to ecosystem processes like the natural hydrology, sediment transport, fish and wildlife passage, or the movement of woody debris. Replacement of the natural streambed with artificial structures can inhibit or prevent passage of both aquatic and terrestrial species along the stream corridor. Crossings that constrict streams or rivers result in increased velocities downstream of the crossing that can scour streambeds and banks and result in drops at culvert outlets that act as barriers to wildlife passage. These impacts will usually result in direct loss of some habitat value. Based on GIS analysis conducted by the MA Riverways Program, it is estimated that there are over 28,500 road and railroad crossings affecting Massachusetts streams. (UMass River and Stream Continuity Website)

Dams are another type of barrier that interrupt the natural hydrology of streams and prevents passage of wildlife. Dam structures prevent fish and other wildlife migration. Dams also trap sediments, which are critical for maintaining physical processes and habitats downstream of the dam. The river may obtain the necessary sediments by eroding the downstream river bed and banks. The impoundment of water upstream of the dam can create an artificial slack-water reservoir habitat, changing the species and diversity that would otherwise exist in a free-flowing river ecosystem. Changes in temperature, chemical composition, dissolved oxygen levels and other physical properties of the impounded water also impact the species that can survive and reproduce in those conditions. Flow alteration can also be significant, with changes to the quantity and timing of water flows, which can disrupt the ecological web of a river system. (International Rivers Website – see Appendix D - References)

Loss of riparian stream buffers can also degrade habitat quality. Buffers offer many benefits to rivers and streams, such as: filtering pollutants in stormwater runoff before it enters the stream, providing flood storage for high stream flows, minimizing erosion of streambanks, shading streams to reduce temperature variation, providing food and refuge cover to aquatic and terrestrial organisms inhabiting the stream corridor, contributing natural plant detritus which provide hiding and breeding places and food for aquatic insects, providing small and large woody debris that contribute to habitat structure within the stream channel and bed, and providing travel paths to animal habitat and for migration.

Habitat continuity and riparian cover become of increasing concern as stream hydrology is altered by other development impacts. Aquatic organisms may move when stream flows are reduced by such impacts, to seek conditions more supportive for survival. If barriers inhibit such movement, then local populations of these organisms may be at risk. Therefore, measures to improve habitat continuity and riparian cover may be important mitigation tools where development impacts (including water supply withdrawals) are anticipated to affect streamflows, particularly where impacts may result in decreased stream flows during critical periods in aquatic species' life cycles.

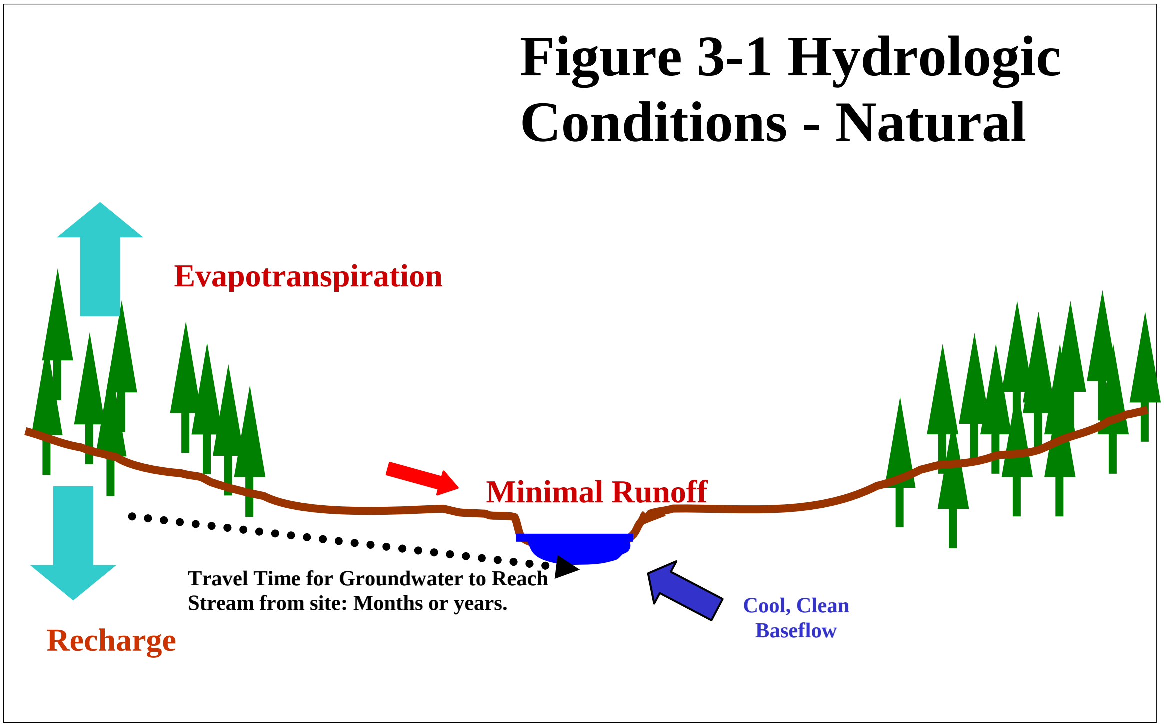
Figure 3-1 Hydrologic Conditions - Natural
Evapotranspiration
Minimal Runoff
Travel Time for Groundwater to Reach Stream from site: Months or years.
Cool, Clean Baseflow
Recharge

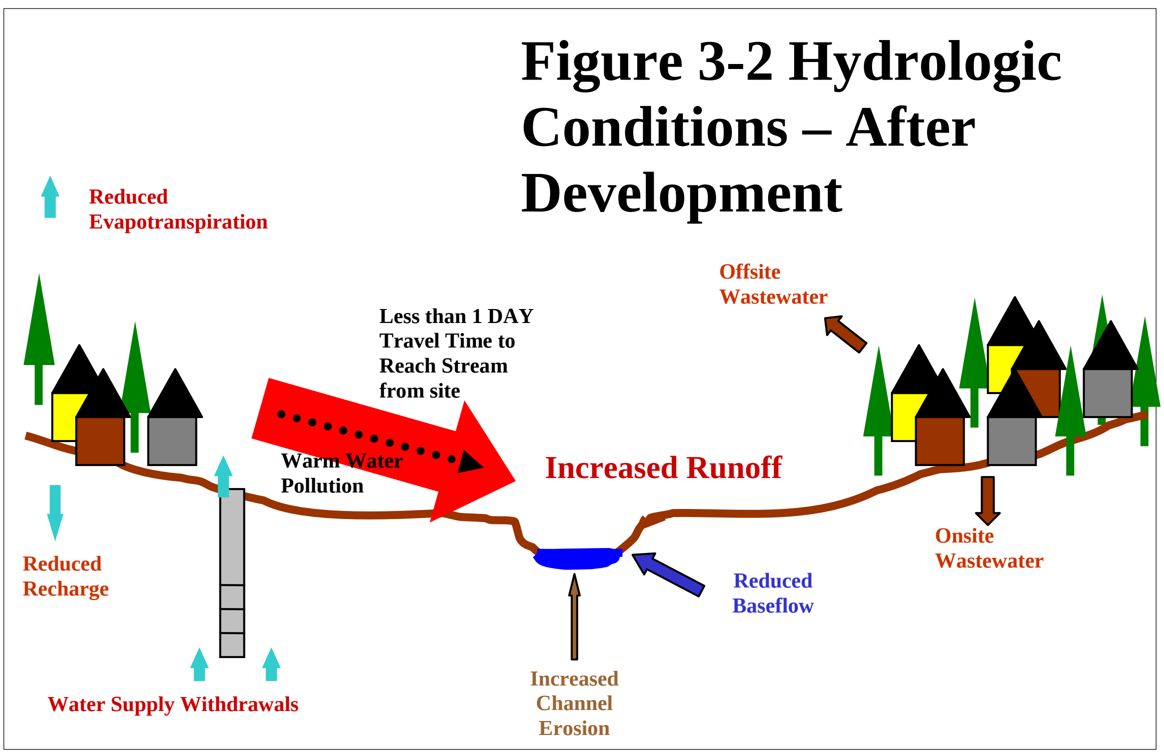
Figure 3-2 Hydrologic Conditions – After Development
Reduced Evapotranspiration
Offsite Wastewater
Less than 1 DAY Travel Time to Reach Stream from site
Warm Water Pollution
Increased Runoff
Onsite Wastewater
Reduced Recharge
Reduced Baseflow
Water Supply Withdrawals
Increased Channel Erosion

Section 4 Minimization and Mitigation Options

The goal of the Massachusetts Executive Office of Environmental Affairs' (EEA's) Sustainable Water Management Initiative (SWMI) permitting Framework is to minimize the impacts of groundwater withdrawals on streamflows. Recognizing that there are several factors that influence streamflow beyond just water withdrawals, the Draft SWMI Framework offers a wide variety of options from which water suppliers, in consultation with EEA and its agencies may choose in order to minimize and offset the impacts of their withdrawals. These include (in no particular order) optimizing operation of existing sources to minimize the percent streamflow alteration, using alternative sources, surface water releases from dams, wastewater and stormwater recharge, habitat improvements and demand management.

This section introduces these options and discusses their cost-benefit towards offsetting withdrawal impacts. This section presents a volumetric credit system that PWSs can use to evaluate which actions can provide the greatest impact for the least cost to minimize and mitigate their withdrawal impacts.

4.1 Minimization of Impacts

The Draft SWMI Framework requires that certain permits include an evaluation and implementation of options to minimize the impact of existing withdrawals on stream flow and aquatic habitat to the greatest extent feasible. In determining whether an alternative is feasible, a PWS should consider cost, level of improvement expected and the practicality of implementation (e.g., what actions are in the control of the water supplier). The Draft Framework lists the following potential actions to be included in the evaluation of minimization alternatives:

1. Optimization of existing resources
2. Use of alternative sources, including sources available to meet seasonal needs
3. Interconnections with other communities or suppliers
4. Releases from surface water impoundments
5. Outdoor water use restrictions tied to streamflow triggers
6. Implementation of reasonable conservation measures
7. New England Water Works Association (NEWWA) Best Management Practice (BMP) toolbox
8. Other measures that return water to the subbasin or basin intended to improve flow

This sub-section discusses the approach used during the SWMI Pilot Project for evaluating minimization alternatives 1 through 3. The discussion and evaluation of opportunities to interconnect with neighboring water systems (Item 3 above) is consolidated with the evaluation of other alternative sources within the community (Item 2 above). The remaining actions can be applied to both minimize impacts from existing withdrawals and/or mitigate impacts from additional withdrawals and are included in the discussion of mitigation alternatives in Section 4.2 of this report. Tier 1 permits (Flow

Level 4 and Flow Level 5), which only need consider minimization options, would also need to evaluate the feasibility of these actions.

4.1.1 Optimization of Existing Sources

The Pilot Project Team reviewed data available for the four pilot communities. For each community, the methodology began with a consideration of the relative impact of each source on subbasin flow to identify opportunities to optimize the operation of existing sources on streamflow.

Preference was given to sources that either:

- Utilize surface water storage.
- Withdraw from basins with larger natural median August flow such that the percent alteration resulting from the withdrawal is minimized (unless the change in withdrawal would result in an increase in the established Flow Level).
- Withdraw from wells with less direct impact on streamflow during low flow periods. For purposes of the Pilot Project, the relative withdrawal impact was primarily based on distance from the stream and, where available, the results of pump tests that considered induced infiltration impacts. A more thorough evaluation of the specific well hydrogeology would be expected in a full permit review.

Opportunities to prioritize use of these lower impact sources, particularly during low streamflow periods, were considered in each pilot community. The Draft SWMI Framework designates Flow Level based on August flow alteration, but does not provide further definition of the low flow period to be optimized. Further study of the critical period would provide a more comprehensive low flow characterization when developing source optimization operation plans.

4.1.2 Alternative Sources of Water Supply

For purposes of the Pilot Project, the Team identified potential alternative supplies based on a review of existing reports and discussions with each pilot community and the Massachusetts Department of Environmental Protection (MassDEP). Similar to the approach for evaluating the operation of existing sources, alternative supplies and interconnections were evaluated based on their relative streamflow impact with a focus on the ability to reduce the percent alteration of August basin flow.

Where readily available, the cost for developing alternative sources of supply was quantified. In some cases, order of magnitude estimates were developed. In considering the cost of SWMI compliance it is important to consider only the incremental cost of developing an alternative source as the result of Draft SWMI Framework. The costs of developing new supplies to meet growing demand are not SWMI compliance costs.

4.2 Mitigation and Offsets to Withdrawals

The Draft SWMI Framework requires mitigation actions that are commensurate with the impact from additional withdrawals and proposes a system of offset/mitigation actions from which PWSs may select. This section of the report identifies the mitigation options that were identified for credit under the Draft SWMI Framework. A potential method for computing the credit is offered for each mitigation action.

4.2.1 Credit Approach

This section presents the proposed methodology for calculating offset credits for each mitigation action. Two approaches to calculating credits are used in the proposed methodology as follows:

1. Direct Offset Volume – The credit is based on a calculated water savings volume, which may be associated with a reduction in demand, and augmentation of groundwater recharge or streamflow through wastewater discharges. It is calculated using standardized reference materials.
2. Indirect Offset Volume – The credit is based on a qualitative assessment of the water offset, as described in Appendix E of this report. The relative value of the offset is rated by a scoring system, which is then used to compute a corresponding flow-offset.

Each of these approaches is discussed below in greater detail.

4.2.1.1 Direct Offset Volume Calculation Methodology

Each action that uses the "Direct Offset Volume" approach will follow the methodology outlined below:

1. Volume Calculation – The total volume of water savings is computed using the estimation methods presented for each action.
2. Location Adjustment Factor – In cases where the offset volume represents recharge to groundwater, either as wastewater or stormwater recharge, this recharge volume is further adjusted to account for the location of the discharge relative to the withdrawal. The potential amount of recharge that directly offsets water withdrawn by the water suppliers is a function of the relative location of the discharge to the water withdrawal point(s). Water recharged upstream of or in the Zone II of the water supply well has a higher potential to offset withdrawals for the PWS than water recharged at a location in a different watershed subbasin or major basin. This Pilot Project identifies four subgroups to take into account the location differences, as follows:
    1) Upstream of the water supply well or within the Zone II;
    2) Within the watershed subbasin, but downstream of the water supply and outside of the Zone II;
    3) Within the major watershed basin, but not within or upstream of the subbasin; and
    4) Outside of the major watershed basin.

Each of these subgroups is assigned a factor for adjusting the value of the computed flow volume to determine the corresponding volume-offset credit. The location adjustment method is the same for all categories of recharge, wastewater and stormwater offsets that qualify for the "direct offset volume" approach.

These standardized adjustments are shown in Table 4-1. Watershed boundaries correspond to the 27 MassGIS-defined major basins and the 1,395 USGS-defined subbasins that were developed for the Massachusetts Water Indicators report.

Table 4-1. Location Adjustment Factors for Mitigation Credits – Relative to Water Withdrawal

Location of Mitigation Action Relative to Withdrawal	Adjustment Factor for Mitigation Credits
Upstream or in Zone II	100%
Subwatershed Basin Downstream	75%
Watershed Basin	25%
Out of Watershed Basin	10%
General Measure With No Relation to Location[1]	25%

[1]A number of the Indirect Offset measures are general programs, are not location specific, or typically do not involve "on the ground" mitigation activities. These activities are assigned a location factor equivalent to the category "within the watershed basin, but outside of the subbasin" with an adjustment factor of 0.25 or 25%. Refer to Section 4.2.1.1 and Appendix D for full methodology explanation.

4.2.1.2 Indirect Offset Volume Calculation Methodology - Qualitative Assessment Approach

The indirect offset volume calculation methodology uses a qualitative assessment scoring system to assess the benefits of a particular offset action relative to augmenting stream flow (e.g., by promoting groundwater recharge or surface water discharge, or reducing impoundment), improving water quality, improving habitat, improving watershed protection, or other benefit that would offset a withdrawal. Measures rated under this approach are generally not amenable to quantitative measurement. The system is thus based on a qualitative assessment that is converted to a flow-offset rating. The offset action scoring system and corresponding flow offset score for each action using this methodology is included in Appendix E. In some cases, such as habitat improvements to specific stream reaches, the location adjustment factor defined under the Direct Offset Volume Calculation Methodology may be applied.

Each mitigation action described below includes a definition describing the action, the applicable credit approach, how to calculate the credit using assumptions from referenced literature, and whether to apply the location adjustment factor. It is anticipated that the 5-year WMA Permit renewal would include a progress report on the offset categories that a PWS has committed to undertake.

4.2.2 Mitigation Options

The Draft SWMI Framework provides the options for mitigation of new withdrawals by crediting surface water releases and wastewater-related contributions. These two mitigation options and the methodology for crediting these options are described below.

4.2.2.1 Instream Flow/Surface Water Releases

Releases from surface water impoundments can be used to minimize or mitigate the impact of public water supply withdrawals in several ways:

1. Releases from public water supply reservoirs to the stream below a dam can reduce the impact of withdrawals from the reservoir. These releases are most applicable to the Transition Rule for Surface Waters.
2. Releases from impoundments upstream (or a short distance downstream) of a groundwater withdrawal can be used to supplement streamflow to offset induced infiltration from the withdrawal. These releases should be relatively consistent each month and could provide a direct offset to withdrawals made in the same month.
3. Releases from non-public water supply impoundments can be used to maintain near natural downstream flows.

The Pilot Project screened potential opportunities for surface water release minimization/mitigation measures utilizing MassDEP's statewide dam inventory, but did not include a detailed evaluation of the impact of potential releases on available public water supply, nor an analysis of the inflows or storage available to make releases from non-public water supply impoundments. Any proposed reservoir release rule should include modeling of the impact on public water supply operations including firm yield, potential need to increase groundwater withdrawals to offset firm yield reductions, drought frequency and duration, and water quality.

4.2.2.2 Wastewater

The following are methodologies for crediting wastewater improvements that offset the impact of groundwater withdrawals. These credit methodologies focus on the potential for wastewater-related returns within the boundaries of the municipalities served by the PWS.

Wastewater Credit 1. Septic Systems

- *Definition*: Septic systems are defined as systems that treat less than 10,000 gpd and are generally regulated through the local Board of Health under 310 CMR 15, known as "Title 5". The term "Title 5" system is most often used to refer to conventional septic tank/soil adsorption system for a single parcel. However, other configurations of systems also fit into this category, including innovative/alternative (I/A) systems, and cluster systems.

- *Wastewater Offset Credit Approach*: Direct offset volume, with applied location adjustment factor.

- *Offset Volume Calculation:* The offset volume shall be based on the following calculation adjusted by a presumptive location factor to account for the location of the septic systems relative to the water supplies (Table 4-1). Septic systems that are served by private water supplies are not included in this calculation, as properties served by private wells and private septic systems are considered flow neutral.

  For residential flows: Total Flow (gpd) = average number of household occupants x 85% of per capita water use reported by the water supplier x number of households within the area x location adjustment factor (MWI Report, p.10)

  For non-residential flows: Total Flow (gpd) = 90% of water use reported by the water supplier (USGS Concord River Basin Report, p.53.)

  If water use information is unavailable:

  - Residential gallons per capita day water use = 65 gpd x 85%
  - Non-residential flows = published guidelines for average flows and/or 50% of Title 5 flows

- *Potential Data sources*:
  - Average number of households and number of household occupants: Most recent Federal 10-year census data
  - Per capita water use: water supplier
  - Parcels: Municipality GIS mapping/parcel mapping or MassGIS land use data
  - Watershed boundaries: MassGIS and USGS

Wastewater Credit 2. Regulated Groundwater Discharges

- *Definition*: Regulated groundwater discharges are defined as systems that treat more than 10,000 gpd and are regulated by MassDEP through the Groundwater Discharge Permit program under 314 CMR 5. Discharge methods can include but are not limited to surface infiltration, subsurface infiltration and groundwater injection.

- *Wastewater Offset Credit Approach*: Direct offset volume with applied location adjustment factor. For surface infiltration, a percentage of the water is typically lost to evaporation and plant uptake. Therefore, 80% of the total calculated volume for surface infiltration is available for the calculated flow offset.

- *Offset Volume Calculation:* The offset volume shall be based on the following calculation adjusted by a presumptive location factor to account for the location of the systems relative to the water supplies (Table 4-1).

  Total flow from groundwater discharges shall be based on the following (adjusted as noted above for surface infiltration systems):

Existing Systems: Total Flow (gpd) = current 12-month average of daily flows reported to MassDEP via the Groundwater Discharge Permit Program. In addition, future flows from planned growth in the sewershed may be calculated using the same methodology.

New System: Total Flow (gpd) = design annual average flows

- *Potential Data Sources*:
  - MassDEP: Reported actual flow data for Groundwater Discharge Permits
  - Local Planning Documents, including Comprehensive Wastewater Management Plans (CWMPs): schedule and volume for new discharges
  - Watershed boundaries: MassGIS and USGS

Wastewater Credit 3. Infiltration Improvements

- *Definition*: Infiltration is extraneous groundwater that unintentionally enters the sewer system through openings such as defective pipes, pipe joints and manhole walls. Typical I/I Studies quantify seasonally high groundwater infiltration rates for areas within a wastewater collection system.

- *Wastewater Offset Credit Approach*: Direct offset volume with applied location adjustment.

- *Offset Volume Calculation:* The offset volume shall be based on a calculated total removable infiltration volume determined in accordance with MassDEP's Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation, revised January 1993, and as described below. Generally, a maximum of 50% infiltration removal is achieved through infiltration mitigation. This percentage may be adjusted depending on the specifics of the infiltration removal process. To gain credit for infiltration removal, an assessment must be provided that identifies the basis for the infiltration volumes, the infiltration removal project(s) proposed or completed, and the timeframe for undertaking the project(s).

  Typical I/I Studies quantify seasonally high groundwater infiltration from specific infiltration sources within a wastewater collection system. These infiltration amounts are typically measured in the springtime and are higher than the annual average contribution of infiltration to the system due to high groundwater levels. Because annual average infiltration may not have been measured for the specific infiltration source proposed to be eliminated, the annual average infiltration volume may be approximated using wastewater treatment facility (WWTF) flow data. The offset volume shall be based on the following calculation adjusted by a presumptive factor to account for the location of the systems relative to the water supplies (Table 4-1).

  Annual Average Infiltration Flow (gpd) = Measured seasonal, high groundwater infiltration rate from source (gpd) x ratio of the average annual WWTF flow rate to the seasonal high groundwater average WWTF flow rate. If high and low groundwater infiltration has been measured, this data may be used to estimate average annual infiltration. (MassDEP I/I Guidelines)

Volume for credit = 50% x annual average infiltration flow.

- *Potential Data sources*:
  - I/I and Sanitary Sewer Evaluation Survey (SSES) studies
  - Local Planning Documents, including CWMPs: schedule and size for new discharges
  - MassDEP and U.S. Environmental Protection Agency (EPA): Wastewater treatment plant flows

Wastewater Credit 4. Inflow Improvements

- *Definition*: Inflow is extraneous water that enters the sanitary sewer system through direct sources such as: catch basins, manhole covers, cross connections with storm drains, sump pumps, foundation drains and downspouts. Typical I/I Studies quantify inflow rates measured during various storms for areas within a wastewater collection system and quantify inflow from specific sources based on the MassDEP I/I Guidelines. An Inflow reduction project typically results in the removal of 100% of the inflow to the sanitary sewer system from the identified source(s). Inflow may be redirected to the ground, to a dry well, or to a storm sewer system. However, a portion of the inflow removed may not recharge the groundwater (a portion of the inflow removed from the sewer system may be piped to a nearby waterway). Only that portion of inflow that is directed to groundwater recharge may be used for a volume-based offset credit.

- *Wastewater Offset Credit Approach*: Direct offset volume with applied location adjustment factor.

- *Offset Volume Calculation:* The offset volume shall be based on a calculated annual average removable inflow volume, determined in accordance with MassDEP's Guidelines for Performing Infiltration/ Inflow Analyses and Sewer System Evaluation, revised January 1993 and as described below. To gain credit for inflow removal, an assessment must be provided that identifies the basis for the inflow volumes, the inflow removal project(s) proposed or completed, and the timeframe for undertaking the project(s). Systems will only receive credit for inflow that is removed and directed to the ground or infiltrated. No credit will be given for inflow that is removed and discharged to the municipal separate storm sewer system (MS4).

  Average annual inflow volumes can be estimated using the design storm inflow volumes estimated for a particular inflow source so that the removable inflow volume can be related to the water recharge volume in the Water Management Act permit. The offset volume shall be based on the following calculation adjusted by a presumptive factor to account for the location of the systems relative to the water supplies (Table 4-1).

Average Annual Rainfall for County/total rainfall amount for the MassDEP defined design storm (one-year, six-hour duration storm, producing approximately 1.72 inches of rainfall) = # of days per year of equivalent design storm activity (MassDEP I/I Guidelines)

# of days of equivalent design storm activity x estimated design storm inflow volume for source = estimated average annual inflow volume for the inflow source

Estimated average annual inflow volume for the inflow source / 365 = average annual inflow rate in gpd

Volume for credit = only that portion of inflow directed to groundwater recharge

- *Potential Data Sources*:
  - I/I and Sanitary Sewer Evaluation Survey (SSES) studies
  - Local Planning Documents, including CWMPs: schedule and size for new discharges
  - MassDEP and EPA: National Pollutant Discharge Elimination System (NPDES) wastewater treatment plant annual reported flow data for annual average and peak flows
  - Watershed boundaries: MassGIS and USGS

Wastewater Credit 5. Reclaimed Water Reuse - Irrigation

- *Definition*: Reclaimed water reuse from treated wastewater can be used as a demand management tool. Reclaimed water reuse for irrigation is permitted by MassDEP under 314 CMR 20, Reclaimed Water Permit Program and Standards.

- *Wastewater Offset Credit Approach*: Direct offset volume.

- *Offset Volume Calculation:* The calculated offset volume for reclaimed water used for irrigation shall be based on either design average annual flows or existing flows.

- *Potential Data Sources*:
  - MassDEP: water reuse permits
  - Local Planning Documents, including CWMPs: schedule and size for new discharges
  - Metered flow data
  - Engineering report(s) and documentation for the system design, identifying the projected water balance of the system.

Wastewater Credit 6. Private Inflow Removal Program

- *Definition*: Private inflow removal programs are designed to encourage homeowners to eliminate inflow sources to sanitary sewers that originate on private property, such as basement sump pumps and roof leaders. While sewer regulations may require that stormwater is not connected to the sanitary sewer system, public departments typically do not have the authority to perform work on private property. The private inflow removal program provides an incentive for private properties to disconnect stormwater from the sanitary sewer system.

- *Wastewater Offset Credit Approach*: Indirect offset volume with presumptive factor for general measure with no relation to location.

- *Offset Volume Calculation:* Because the volume of inflow correction accomplished by such a program is variable and dependent on voluntary participation by private property owners, and can also vary considerably from site to site and with weather, property, and groundwater conditions, it is not easily quantified for determining an offset volume. This approach is therefore subject to the qualitative assessment procedure presented in Appendix E.

  The flow offset is computed using the spreadsheet presented in Appendix E.

- *Potential Data Sources*:
  - Private Property Inflow Removal Program

Wastewater Credit 7. Sewer Bank (I/I Offset Program)

- *Definition*: A sewer bank (I/I offset program) is a program that is designed to provide a dedicated funding source for I/I removal projects. Typically, programs require new development/sewer connections to offset their flows with I/I removal. Typical ratios of new inflow to I/I removal are 1:1, 2:1, 4:1 and 10:1.

- *Wastewater Offset Credit Approach*: Indirect offset volume.

- *Offset Volume Calculation:* Because this is a program for funding future I/I improvements, the volume of actual inflow reduction and its location cannot be easily estimated for computing a direct flow offset volume. This approach is therefore subject to the qualitative assessment procedure presented in Appendix E. The assessment and computation procedure includes an adjustment factor to account for whether the program is based on a ratio of 1:1, 2:1, 4:1 or 10:1.

  This approach is subject to the qualitative assessment procedure presented in Appendix E.

- *Potential Data Sources*:
  - Local Sewer Bank (I/I Offset Program)

Wastewater Credit 8. Wastewater Enterprise Fund

- *Definition*: A wastewater enterprise fund is an account that is dedicated to the operation, maintenance, repair, and management of the municipality's wastewater infrastructure. Revenues to the Wastewater Enterprise Fund are kept separate from other municipal funds and uses, and cannot be co-mingled with funds for any other activities. This also includes a "functionally equivalent" wastewater enterprise fund, where all of the revenues collected through billings are dedicated to sewer department expenditures and cannot be used in the general fund.

- *Wastewater Offset Credit Approach*: Indirect offset volume.

- *Offset Volume Calculation:* The presence of a wastewater enterprise fund ensures a higher probability that necessary capital will be available for the operation, maintenance and improvements to the system. This approach is subject to the qualitative assessment procedure presented in Appendix E.

  The flow offset is computed using the spreadsheet presented in Appendix E.

- *Potential Data Sources*:
  - Local Wastewater Enterprise Fund

Wastewater Credit 9. Surface Water Discharge Credit

The following methodology for crediting wastewater discharges considers a credit option accounting for surface water discharges that surcharge a stream upstream of a water withdrawal.

Recognizing that surface water discharges from NPDES wastewater discharges directly augment stream flows, resulting in surcharged stream conditions, and that these discharges were not taken into consideration in developing the Flow Level or Biological Category, options for accounting for wastewater contributions from surface water discharges that surcharge streams upstream of water withdrawals were considered as part of this Pilot Project.

Certain wells located in proximity to a surcharged stream and downstream of a surface water discharge are considered eligible for potential surface water discharge credit. Wells that are influenced by the adjacent surcharged stream may obtain credit. Factors involved in determining whether a well is influenced by the adjacent stream include distance from the stream, type of well (unconfined overburden, confined overburden, or bedrock), aquifer characteristics (hydraulic conductivity and transmissivity), streambed hydraulic conductivity and well pumping rate. If the well's Zone II incorporates a portion of the surcharged stream below the surface wastewater discharge point, it is presumed that the well is eligible for the surface water discharge credit. If the Zone II does not incorporate a surcharged stream, but a well is located within the watershed of the surcharged stream, the PWS may provide analysis of the specific well hydrology or results of pump tests to determine if the wells are under the influence of the adjacent surcharged stream and are therefore eligible for the surface water discharge credit.

- *Definition*: Surface water discharges include treated discharges regulated by the EPA and MassDEP under the NPDES permit program.

- *Wastewater Offset Credit Approach*: Direct offset volume.

- *Offset Calculation:* The calculation depends on the ratio of the discharge to the unaffected August median flow for the receiving stream.

  Surface Water Discharge: Identify the percentage of the NPDES surface water discharge to the unaffected August median flow by dividing the August Average Flow for the NPDES surface water discharges (taking the reported August monthly flow and dividing by 31 days) by the MWI unaffected August median flow.

  The apportionment of the volume credit to the PWS is a percentage of the unaffected August median flow based on the percentage of surface water discharge of the unaffected August median flow as summarized below in Table 4-2.

Table 4-2.

Ratio of Surface Water Discharge to Unaffected August Median Flow	Credit (% of unaffected August Median Flow
< 0.1	0%
0.1 to 0.25	25%
0.26 to 0.50	50%
0.51 to 0.75	75%
> 0.76	100%

  The credit percentages will be decreased accordingly if withdrawals from the subbasin are less than 100% of natural August median flow

  The methodology for apportionment to multiple PWSs in a subbasin needs to be determined.

- *Potential Data Sources*:
  - Discharge Monitoring Reports available from EPA and MassDEP for August Average Flow from NPDES Discharges.
  - USGS SYE Report and MWI Report data available from MassDEP for cumulative NPDES surface water discharge data within the subbasins and nested subbasins.
  - MassGIS for Zone II delineations.

Wastewater Credit 10. Alternative Wastewater Credit

The following alternative methodology for crediting wastewater discharges considers a credit option accounting for both groundwater and surface water discharges upstream of a water withdrawal.

Recognizing that surface water discharges from NPDES wastewater discharges directly augment stream flows, that regulated groundwater discharges indirectly augment stream flows, and that these discharges were not taken into consideration in developing the Flow Level or Biological Category, options for accounting for wastewater contributions upstream of water withdrawals were considered as part of this Pilot Project. Wells located downstream of groundwater or surface water discharge are considered eligible for potential credit.

- *Definition*: Groundwater discharges include on-site septic systems that treat less than 10,000 gpd and are regulated through Title 5 (310 CMR 15) and regulated groundwater discharges that treat more than 10,000 gpd and are regulated by MassDEP through the Groundwater Discharge Permit program (314 CMR 5). Surface water discharges include treated discharges regulated by the EPA and MassDEP under the NPDES permit program.

- *Wastewater Offset Credit Approach*: Direct offset volume.

- *Offset Calculation:* The calculation depends on the ratio of the discharge to the unaffected August median flow for the receiving stream.

  Surface Water Discharge: Identify the percentage of the NPDES surface water discharge to the August low flow by dividing the August Average Flow for the NPDES surface water discharges (taking the reported August monthly flow and dividing by 31 days) by the MWI unaffected August median flow.

  Regulated Groundwater Discharge: Identify the percentage of the cumulative groundwater discharge to the unaffected August median flow by dividing the Annual Average Flow for the groundwater discharges (taking the reported average annual flow and dividing by 365 days) and the average daily septic systems flows by the MWI unaffected August median flow.

  For Average Daily Septic Flows:

  For Residential Flows: Total Flow (gpd) = Average number of household occupants x 85% of per capita water use reported by the water supplier x number of parcels within the subbasin (MWI Report, p.10)

  For Non-Residential Flows: Total Flow (gpd) = 90% of water use reported by the water supplier (USGS Concord River Basin Report, p.53.)

If Water Use Information is Unavailable:

- Residential gallons per capita day water use = 65 gpd x 85%
- Non-residential flows = published guidelines for average flows and/or 50% of Title 5 flows

The apportionment of the volume credit to the PWS is a percentage of the unaffected August median flow based on the percentage of combined surface water and groundwater discharges to the August median flow as summarized in Table 4-3.

Table 4-3.

Ratio of Combined Surface Water and Groundwater Discharge to Unaffected August Median Flow	Credit (% of unaffected August Median Flow
< 0.1	0%
0.1 to 0.25	25%
0.26 to 0.50	50%
0.51 to 0.75	75%
> 0.76	100%

The credit percentages will be decreased accordingly if withdrawals from the subbasin are less than 100% of natural August median flow

The methodology for apportionment to multiple PWSs in a subbasin needs to be determined.

- *Potential Data Sources*:
  - Discharge Monitoring Reports available from EPA and MassDEP for August Average Flow from NPDES Discharges
  - Massachusetts Groundwater Discharge Permit Monthly Report submitted to MassDEP for Annual Average Flow for Groundwater Dischargers
  - USGS SYE Report and MWI Report data available from MassDEP for cumulative groundwater discharge data and NPDES surface water discharge data within the subbasins and nested subbasins

4.2.2.3 Stormwater/Impervious Cover

As discussed in Section 3.0, impervious cover can have a significant impact on streamflows and habitat quality by significantly reducing natural recharge to baseflow. The result is lower low flow period streamflows than would naturally occur without development. Recharging stormwater runoff into the groundwater of a river's watershed helps replenish groundwater baseflows that were lost from past development and provide more water for future withdrawal increases.

A number of stormwater mitigation options were evaluated under the Draft SWMI Framework. These include:

- Recharge runoff from impervious surfaces
- Reduce impervious surfaces
- Roof leader disconnection
- Rain barrels
- Stormwater bylaws with recharge requirements
- Stormwater collection and reuse
- Stormwater utility
- Implement MS4 requirements

Offset volume credits were developed for each of the stormwater mitigation options. These are summarized in Table 4-4 based on specific assumptions on BMP size (e.g., length, width and depth), along with cost estimates for each. This is followed by specific discussion of each.

Stormwater Credit 1. Recharge Impervious Surfaces

Definition: Recharging stormwater runoff from existing impervious surfaces (e.g., redevelopment or retrofit projects) puts runoff water back into the ground that was previously lost when the property was first developed. Recharge can be accomplished through the use of several best management practices (BMPs):

- Leaching catch basins (LCBs) – A LCB is a concrete structure with perforated sides and no bottom, allowing the water it collects to discharge into the surrounding soils and groundwater. LCBs can be used offline or in place of standard catch basins to infiltrate stormwater runoff from roadways and parking lots.
- Tree box – A tree box filter is a mini bioretention area installed beneath trees. Stormwater runoff is directed to the tree box, where it is infiltrated.
- Infiltration trench – An infiltration trench is a stone filled trench that provides storage volume for stormwater runoff before infiltrating it into the ground.
- Infiltration divider – An infiltration divider is similar to an infiltration trench and can be installed in place of raised islands in parking lots to collect, store and infiltrate runoff.
- Subsurface infiltration – Subsurface infiltration is located beneath an impervious surface where there is limited space for other recharge BMPs.
- Bioretention cells – Bioretention cells are landscaped areas designed to collect, store and infiltrate stormwater runoff. They use a specific soil mix to promote pollutant removal. Raingardens are an example of a bioretention cell.
- Infiltration basin – Infiltration basins are larger depressed areas where stormwater runoff collects and ponds before infiltrating into the ground. They are often vegetated with grass.

Table 4-4. Cost Estimating Guidance Tool Part 1 Stormwater						
Offset/Mitigation	**Units**	**$/unit**	**gal/unit/year**	**$/gal**	**Impervious Area Treated per Unit (sf)**	**Assumptions**
recharge impervious surfaces						
leaching catch basin	leaching catch basin	$ 6,500	22,001	$ 0.30	2,598	4'diam x 4'deep with 2' stone surround
tree box	tree box	$ 7,000	5,105	$ 1.37	603	8'diam x 4'deep
infiltration trench	linear foot	$ 22	370	$ 0.06	44	1'l x 1'w x 4'deep
infiltration divider	linear foot	$ 56	908	$ 0.06	107	1'l x 3'w x 3'deep
subsurface infiltration	linear foot	$ 45	1,318	$ 0.03	156	1'l x 3'w x 5'deep
bioretention cell	linear foot	$ 30	370	$ 0.08	44	1'l x 1'w x 4'deep
infiltration basin	square foot	$ 27	1,016	$ 0.03	120	1'l x 1'w x 5'deep
reduce impervious surfaces						
removal & vegetation	square foot	$ 1	7.9	$ 0.13	1	recharge will vary based on soil type, assumes average of A&B soils using MassDEP Policy
removal & porous asphalt	square foot	$ 7	14.1	$ 0.50	1	assumes 1" infiltration based on 4" reservoir course
removal & porous pavers	square foot	$ 25	14.1	$ 1.78	1	assumes 1" infiltration based on 4" reservoir course
roof leader disconnection	drywell kit	$ 5,000	7,177	$ 0.70	500	2'dia x 2'deep with 2' stone surround, collects 1.8" precipitation off 1,000 sf roof with two drywells. Installation by contractor.
rain barrel	rain barrel	$ 120	177	$ 0.68	500	55 gal capacity, collects 0.18" off 1,000 sf roof with two rainbarrels, assumes storage is available for 25% of annual rainfall (e.g., not emptied each time).

Table 4-4. Cost Estimating Guidance Tool Part 1 Stormwater (continued)						
Offset/Mitigation	**Units**	**$/unit**	**gal/unit/year**	**$/gal**	**Impervious Area Treated per Unit (sf)**	**Assumptions**
stormwater bylaw with recharge requirements (Stormwater Policy Townwide)						
A soils (0.60 inches)	square foot		9.9		1	
B soils (0.35 inches)	square foot		6.0		1	
C soils (0.25 inches)	square foot		4.1		1	
D soils (0.10 inches)	square foot		0.9		1	
stormwater bylaw with recharge requirements (More Aggressive Policy)						
A soils (1.25 inches)	square foot		15.3		1	
B soils (1.00 inches)	square foot		14.1		1	
C soils (0.50 inches)	square foot		8.5		1	
D soils (0.10 inches)	square foot		0.9		1	
stormwater collection & reuse - cistern	cistern	$ 37,000	123,162	$ 0.30	16,041	assumes 10,000 gallon tank collecting 1" design storm
stormwater utility meeting environmental requirements						
implement MS4 requirements						

Notes:
1. Cost estimates are based on CEI's professional experience in designing and implementing stormwater best management practices (BMPs).
2. $/gal are based on one year of water savings. The life of the improvement is much greater, resulting in actual lower costs per gallon.
3. Costs are not included for bylaw development, stormwater utility development, and implementation of MS4 requirements as some of these items are completed by Town staff and others will vary from one community to the next depending on the components included in their program. These options are included in this table to identify the full array of options considered within this report.
4. Revenue losses associated with the water savings (e.g., reduced demand from rain barrels, cisterns) are not accounted for in these cost estimates.

Offset Credit: Direct offset volume with applied location adjustment factor.

Offset Volume Calculation: The offset volume shall be calculated based on the sizing criteria used for the infiltration BMP, specifically, the inches of rainfall per storm (design storm depth) that the BMP is sized to hold and the impervious surface area that it is collecting runoff from.

To convert this design storm depth to an equivalent total annual depth, a graph of capture volume vs. design storm depth was developed (Figure 4-1) based on an analysis of multiple years of rainfall record at several Massachusetts data collection stations representative of impervious surfaces. The graph shows how to convert an event runoff depth (values on the x-axis) to an equivalent total annual depth (values on the y-axis), which can also be performed through the equation:

$$y = -13.513x^2 + 38.265x - 2.1723$$

Where:

x = design storm depth (inches)
y = average annual runoff capture (inches)

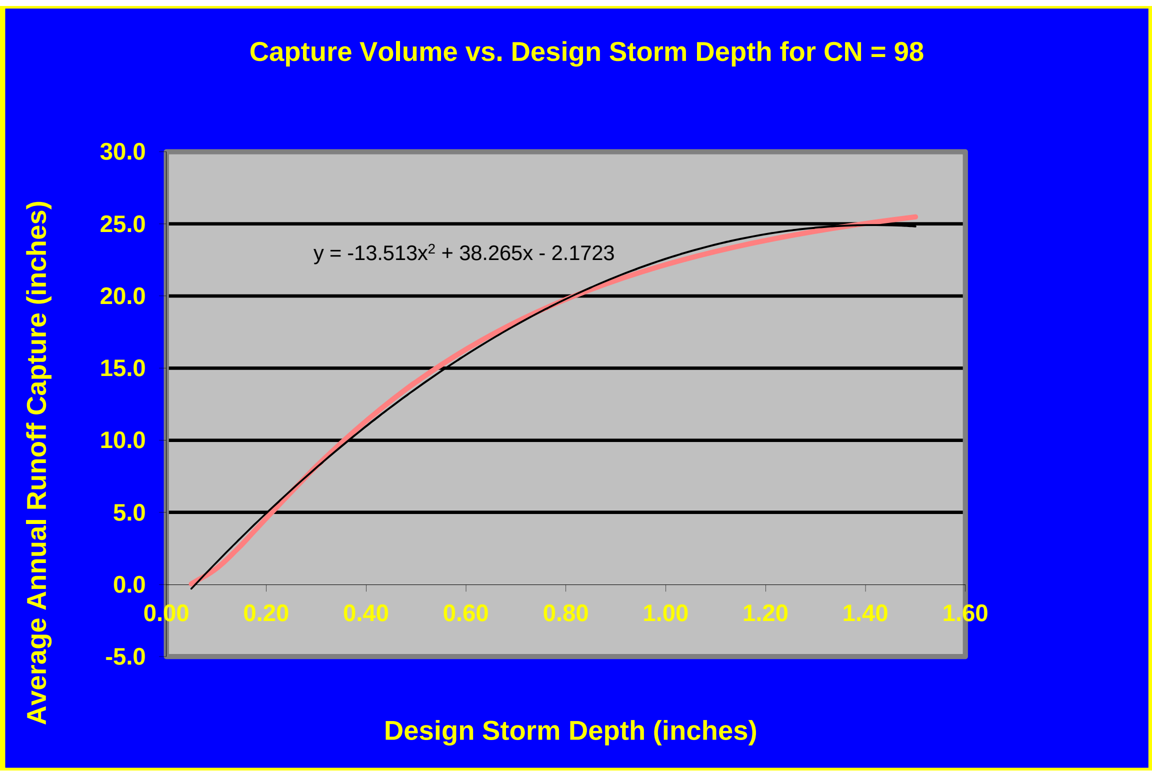

Figure 4-1. Capture Volume vs. Design Storm Depth (Nyman, D.C., 2002)
Note: CN is an acronym for 'runoff curve number'. The CN is a hydrologic parameter used to describe the stormwater runoff potential for drainage area. The curve number is a function of land use, soil type, and soil moisture. Higher CN values produce more stormwater runoff than lower CN values.

Note that at most about 25 inches of runoff can be captured annually from an impervious surface (in comparison to an average rainfall that exceeds 40 inches). This is because even on pavement, very small storms do not generate measureable runoff, and in all storms, there is some initial absorption.

The offset volume shall be based on the following calculation adjusted by the presumptive location factor to account for the location of the stormwater recharge systems relative to the water supplies (Table 4-1).

Step 1. Calculate average annual runoff capture (inches) using design storm and Figure 4-1 or equation.

Step 2. Calculate offset volume as follows:

Annual Average Infiltration Volume (gal) = Impervious surface area directed to recharge (s.f.) x average annual recharge capture (inches) / 12 in/ft x 7.481 gal/c.f.

Refer to Table 4-4 for offset volumes per unit (e.g., per linear foot of infiltration trench or per square foot of infiltration basin area) and the assumptions used for these.

Stormwater Credit 2. Reduce Impervious Surfaces

Definition: This includes the removal of impervious surfaces and replacement with vegetation, porous asphalt or porous pavers, allowing runoff to infiltrate into the ground under these surfaces.

Offset Credit: Direct offset volume with applied location adjustment factor.

Offset Volume Calculation: The offset volume shall be calculated based on soil types, the amount of impervious area removed and in the cases of replacement with porous asphalt or porous pavers, the storage volume of the subbase (reservoir course).

Removal of impervious surfaces and replacement with vegetation assumes recharge will be the same as natural recharge for an undeveloped site. Natural recharge was assumed to match the recharge requirements of the Massachusetts Stormwater Handbook for each of the four soil types as summarized in Table 4-5.

Table 4-5. Recharge Performance Criteria of the Massachusetts Stormwater Handbook

Hydrologic Soil Group	Stormwater Handbook (inch over impervious surface)
A	0.60
B	0.35
C	0.25
D	0.10

Removal of impervious surfaces and replacement with porous asphalt or pavers was based on design of the reservoir course[1] in the subbase to hold a minimum of 1" of rainfall over the impervious surface.

The offset volume shall be based on the following calculation adjusted by the presumptive location factor to account for the location of the systems relative to the water supplies (Table 4-1).

Step 1. Calculate average annual runoff capture (inches) using design storm (Table 4-4 for replacement with vegetation and 1" for replacement with porous asphalt and porous pavers with a reservoir course) and Figure 4-1 or equation.

Step 2. Calculate offset volume as follows:

Annual Average Infiltration Volume (gal) = Impervious surface area replaced with pervious materials (s.f.) x average annual recharge capture (inches) / 12 in/ft x 7.481 gal/c.f.

Refer to Table 4-4 for offset volumes per unit (e.g., per linear foot of infiltration trench or per square foot of infiltration basin area) and the assumptions used for these.

Stormwater Credit 3. Roof Leader Disconnection

Definition: Frequently, in more developed, high density areas, roof leaders discharge onto a driveway and the stormwater runoff from the roof runs into the street and municipal stormwater drainage system. In some cases, roof leaders may be connected directly to the municipal stormwater drainage system or the sanitary sewer system. Directing roof leaders to a drywell allows the roof runoff to recharge and can result in a significant water savings/recharge credit if instituted on a town-wide basis. Dry well kits are relatively inexpensive and can be installed by the homeowner with minimal expense. Credit could also be given for directing roof leader runoff to a lawn or garden area; however, this would require additional design standards to ensure the runoff has adequate area to infiltrate into the soils.

Offset Credit: Direct offset volume with applied location adjustment factor.

Offset Volume Calculation: The offset volume shall be calculated based on the size of the roof and drywell. The offset volume shall be based on the following calculation adjusted by a factor to account for the location of the systems relative to the water supplies (Table 4-1).

Step 1. Determine storage volume of each dry well and stone surround.

Step 2. Calculate the design storm treated by all drywells as follows:

[1] The reservoir course is a base of stone used to store stormwater runoff until it can infiltrate into the soil.

Design Storm (inches) = Total dry well volume (c.f.) / roof area (s.f.) x 12 in/ft

Step 3. Calculate average annual runoff capture (inches) using design storm and Figure 4-1 or equation.

Step 4. Calculate offset volume as follows:

Annual Average Infiltration Volume (gal) = Roof area sent to drywell (s.f.) x average annual recharge capture (inches) / 12 in/ft x 7.481 gal/c.f.

Refer to Table 4-4 for offset volumes per unit (e.g., per linear foot of infiltration trench or per square foot of infiltration basin area) and the assumptions used for these.

While the credit is intended to be applied as roof leaders are disconnected from the storm drain network, it can also be applied to determine potential recharge/ mitigation a town can receive if a town-wide program were implemented to disconnect roof leaders from all directly connected households. This can be applied based on residential density and level of connection based on the "Small MS4 Permit Technical Support Document, April 2011, Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for Massachusetts Small MS4 Permit." This document describes the methodology used for calculating IA and DCIA in Massachusetts communities. The document defines the 'connection' for various residential land uses as follows:

- Low density residential – somewhat connected – 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration
- Medium density residential – average – mostly storm sewered with curb & gutter, no dry wells or infiltration, residential rooftops not directly connected
- High Density – highly connected – same as average, but residential rooftops are connected

Based on these descriptions, the following assumptions were made for calculating the directly connected households for each of the three residential land use categories:

- Low density residential – includes households on lots greater than 1 acre in size and assumes none are connected to the drainage system
- Medium density residential – includes households on lots ½ to 1 acre in size and assumes 5% are connected (technical document says 'residential rooftops not directly connected', but 5% was assumed for these purposes to incorporate a margin of error)

High Density – includes households on lots less than ½ acre and assumes 95% are connected (technical document says 'residential rooftops are connected' but 95% was assumed for these purposes to incorporate a margin of error)

These assumptions allow estimates of connected roof leaders (households) to determine the potential mitigation available if all were disconnected. However, actual credits will be based on the actual number of households disconnected and the location adjustment factors would still apply.

Stormwater Credit 4. Rain Barrels and Cisterns

Definition: Rain barrels can be used to collect roof runoff and the collected water can be used for irrigation of gardens or landscape, decreasing the amount of water needed from the PWS for these uses. The annual storage achieved with the use of rain barrels will vary based on how often it is emptied to allow storage for the next storm. The water savings assume the barrel only collects water between May through October and the storage is only available 25% of the time.

Offset Credit: Direct offset volume.

Offset Volume Calculation: The offset volume shall be calculated based on the size of the roof and rainbarrel. The offset volume shall be based on the following calculation.

Step 1. Determine storage volume of cistern or rainbarrel.

Step 2. Calculate the design storm collected by all rain barrels as follows:

Design Storm (inches) = Total rain barrel volume (c.f.) / roof area (s.f.) x 12 in/ft

Step 3. Calculate average annual runoff capture (inches) using design storm and Figure 4-1 or equation

Step 4. Calculate offset volume as follows:

Annual Average Volume (gal) = Roof area sent to rain barrel (s.f.) x average annual recharge capture (inches) / 12 in/ft x 55% (% precip between May & Oct) x 7.481 gal/c.f. x 25% (% time rain barrel storage is available)

A similar calculation can be applied to cisterns. Refer to Table 4-4 for offset volumes per unit (e.g., per linear foot of infiltration trench or per square foot of infiltration basin area) and the assumptions used for these.

Stormwater Credit 5. Stormwater Bylaws with Recharge Requirements

Definition: MassDEP has an existing Stormwater Handbook that outlines performance criteria and controls to increase recharge and address pollutants. However, this policy only applies to discharges within jurisdiction of the Wetlands Protection Act, leaving most uplands unprotected unless a town chooses to adopt this as a town-wide requirement. Additionally, although the policy does require some recharge, runoff is allowed to increase significantly in quantity and the controls on quality are limited. Measures to correct past degradation of natural recharge (which could improve existing streamflow conditions) are not considered. In addition, the current state stormwater management standards do not address the damage associated with small, frequent storms, which have recently been identified as a major concern for stream channels.

Under the NPDES Phase II program, regulated municipal separate storm sewer systems (MS4s) are required to regulate post-construction stormwater runoff, however, the level of control required is not specified, leaving it up to the individual MS4 to regulate to the level they see fit. In many cases, the focus is on control of peak flows to prevent flooding, with no recharge requirements. Some towns, like Danvers, have elected to apply the Stormwater Management Handbook town-wide. Others, such as Boston, have required even more stringent stormwater management requirements in limited areas where declining groundwater levels are a problem.

Requiring increased stormwater recharge through a stormwater bylaw can provide a significant amount of water to the groundwater aquifer and streams, particularly in less developed areas such as Middleton where there is the potential for a lot of development growth. Two recharge bylaw scenarios were considered under the Pilot Project. The first involves applying the recharge standards of the Stormwater Management Handbook town-wide. The Standards stipulate the amount of rainfall required to be recharged based on hydrologic soil group (HSG), with more recharge required in the more permeable HSG A soils and less recharge in tighter soils (HSG D). The second scenario applies more aggressive recharge standards for each soil group. The more aggressive recharge standards allow more water to infiltrate to the groundwater and therefore replenish baseflows while accommodating the potential increased runoff generated when the forest cover is lost and evapotranspiration is converted to runoff. Table 4-6 outlines the recharge requirements under both scenarios.

Table 4-6. Recharge Performance Criteria for Stormwater Bylaw

Hydrologic Soil Group	Stormwater Handbook (inch over impervious surface)	More Aggressive Recharge (inch over impervious surface)
A	0.60	1.25
B	0.35	1.0
C	0.25	0.50
D	0.10	0.10

Offset Credit: Direct offset volume with applied location adjustment factor.

Offset Volume Calculation: The offset volume shall be calculated based on the actual development impervious area meeting the adopted regulations. The offset volume shall be based on the following calculation adjusted by a factor to account for the location of the systems relative to the water supplies (Table 4-1).

Step 1. Obtain impervious area from plans.

Step 2. Calculate average annual runoff capture (inches) using design storm (Table 4-4 and soil type) and Figure 4-1 or equation.

Step 3. Calculate offset volume as follows:

Annual Average Infiltration Volume (gal) = Impervious surface area (s.f.) x average annual recharge capture (inches) / 12 in/ft x 7.481 gal/c.f.

The same equations can also be used to predict the overall recharge credit potential of a community at buildout from existing conditions. In this case, the estimated impervious area at buildout for each soil type as obtained through a series of GIS overlays is used in place of the actual impervious surface area.

Alternative methods for taking credit of the bylaw may be evaluated under Phase 2.

Refer to Table 4-4 for offset volumes per unit (e.g., per linear foot of infiltration trench or per square foot of infiltration basin area) and the assumptions used for these.

Stormwater Credit 6. Stormwater Collection and Reuse

Definition: Stormwater can be collected and reused for irrigation or as grey water. In this respect, it serves as a demand management tool by reducing the amount of potable water that would otherwise be consumed for the same purpose.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: The offset volume shall be calculated based on the size of the cistern used to store the water and the size of the impervious area draining to the cistern. The offset volume shall be based on the following calculation.

Step 1. Determine storage volume of each cistern.

Step 2. Calculate the design storm collected by cistern as follows:

Design Storm (inches) = Total cistern volume (c.f.) / impervious area (s.f.) x 12 in/ft

Step 3. Calculate average annual runoff capture (inches) using design storm and Figure 4-1 or equation

Step 4. Calculate offset volume as follows:

If the water is collected and used year round, calculate offset as follows:

Annual Average Volume (gal) = Impervious area draining to cistern (s.f.) x average annual recharge capture (inches) / 12 in/ft x 7.481 gal/c.f.

If the water is collected and used seasonally, spring through fall, calculate offset as follows:

Annual Average Volume (gal) = Impervious area draining to cistern (s.f.) x average annual recharge capture (inches) / 12 in/ft x 55% (% precip between May & Oct) x 7.481 gal/c.f.

Refer to Table 4-4 for offset volumes per unit (e.g., per linear foot of infiltration trench or per square foot of infiltration basin area) and the assumptions used for these.

Stormwater Credit 7. Stormwater Utility

Definition: A stormwater utility fund is an account that is dedicated to the operation, maintenance, repair, and management of the municipality's stormwater infrastructure. Revenues to the Stormwater Utility are kept separate from other municipal funds and uses, and cannot be co-mingled with funds for any other activities. This also includes a "functionally equivalent" stormwater fund where all of the revenues collected through stormwater utility rates or fees are dedicated to stormwater expenditures and cannot be used in the general fund.

Stormwater Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: The presence of a stormwater utility fund ensures a higher probability that necessary capital will be available for the operation, maintenance and improvements to the system. This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in that Appendix.

Potential Data sources:

Local Stormwater Utility Fund

This approach is subject to the qualitative assessment procedure presented in Appendix E. The flow offset is computed using the spreadsheet presented in that Appendix.

Stormwater Credit 8. Implement MS4 Requirements

Definition: Regulated MS4s are required to have stormwater management programs that address the six minimum measures of the NPDES Phase II Stormwater program. These six minimum measures include:

1. Public education and outreach
2. Public participation/involvement
3. Illicit discharge detection and elimination
4. Construction site runoff control
5. Post construction runoff control
6. Pollution prevention/good housekeeping

The overall goal of the program is to improve water quality, however, flexibility is offered to regulated MS4s to design a program that works for them. This results in large variability in stormwater management plans and implementation actions from town to town, each designed to fit within an available budget.

While the existing Phase II permit does not require recharge or other actions that would result in a water savings, it is geared towards water quality improvement, which will also improve habitat quality; therefore, an offset credit is provided to PWSs located in MS4 communities and to those communities that voluntarily implement the MS4 permit requirements.

Offset Credit: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in that Appendix.

4.2.2.4 Habitat Improvements

As discussed in Section 3.0, habitat continuity and riparian cover are also important factors in the health of aquatic habitat. While such measures may not improve baseflow volumes reaching streams, they do offer greater opportunity for aquatic organisms to migrate and survive when other stream conditions, such as flow, are not optimal.

A number of habitat mitigation options were evaluated under the Draft SWMI Framework. These include:

- Fish ladders
- Dam removal
- Acquire property in Zone II
- Restore stream buffer
- Acquire property for other natural resource protection
- Establish culvert rating stream teams
- Culvert replacement to meet stream crossing standards
- Natural streambank restoration
- Other restoration project
- Contribute to aquatic habitat restoration fund
- Increase watershed tree canopy

Since these improvements are not directly related to an increase in stream flow, offset volume credits were developed using the indirect offset volume calculation methodology as included in Appendix E. Each is discussed below.

Habitat Credit 1. Fish Ladders

Definition: Fish ladders can be incorporated into dams to allow the passage of migrating fish around the dam. While the best fish passage is the complete removal of the dam, it is not always possible. A fish ladder provides an opportunity for some, but not all, species of fish to get beyond the dam.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This measure contributes to aquatic habitat improvement by increasing the miles of stream habitat accessible to selected fish species. This approach is subject to the qualitative assessment procedure presented in Appendix E. The procedure includes an adjustment for the number of stream miles made accessible by the improvement, relative to the total miles of the stream reach upon which the improvement is made.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 2. Dam Removal

Definition: Dam removal allows unobstructed passage of fish and other wildlife, restores the natural hydrology of the stream system, restores natural sediment and debris conveyance and deposition, and may help moderate stream temperatures where the action reduces the total area of open water. Unlike fish ladders, passage is not limited to certain species of migrating fish.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E. The approach includes adjustments to account for the increase in undammed stream miles on the stream reach affected by the dam removal.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 3. Acquire Property in Zone II or Reservoir Watershed

Definition: Acquiring and protecting land within the Zone II of a water supply well helps protect the quality and capacity of the well by limiting impervious surfaces and thereby promoting greater recharge and filtering of precipitation into the aquifer, which helps to maintain groundwater baseflows to streams. To receive credit, the land acquired must be maintained or restored to a natural state.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E. The procedure includes an adjustment to account for the portion of unprotected Zone II covered by the acquisition.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 4. Restore Stream Buffer

Definition: Stream buffers, or riparian buffers, provide a vegetated, protective area between a body of water and human activity. This helps improve stream health and water quality by filtering and slowing pollution runoff, preventing soil erosion, maintaining cooler stream temperatures by providing shadings, providing upland habitat and providing woody debris for in-stream habitat. Restoring stream buffers to their natural state helps to improve stream habitat. To receive credit, the buffer must be at least 200 feet wide from the top of bank and be maintained or restored to a natural state.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E. The procedure includes a factor to account for the portion of unprotected stream buffer addressed by the restoration activity for the stream reach under study.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 5. Acquire Property for Other Natural Resource Protection

Definition: Acquiring and protecting other (non-Zone II) property within a watershed can also benefit habitat quality by improving stream corridor habitat and reducing impervious cover. To receive credit, the property must be maintained or restored to a natural state.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E. The procedure includes an adjustment to reflect the specific property and resource proposed for protection, based on a case-specific review and negotiation with the reviewing agencies.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 6. Establish Culvert Rating Stream Teams

Definition: As discussed in Section 3.0, culverts can create a barrier to habitat continuity. Replacing deficient culverts with culverts that allow for full wildlife passage improves habitat quality. The first step in a culvert replacement program is to assess and prioritize culverts for replacement. One way to achieve this is to establish a culvert rating stream team, trained and assigned to evaluating culverts in a designated area using criteria developed by the Massachusetts River and Stream Continuity Partnership. The data collected is used by that program to rate the degree to which the culverts are barriers. This then provides the PWS/community with the data necessary to pursue culvert upgrades and available funding.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 7. Culvert Replacement to Meet Stream Crossing Standards

Definition: Replacement of culverts that constrict stream channels, cause scour, and inhibit wildlife movement can result in an array of habitat benefits. Such replacement improves habitat continuity, reduces hydraulic stresses on the natural channel, restores natural stream hydraulic processes, restores natural sediment and debris transport and deposition, and provides suitable streambed to support aquatic organisms. Offset credits are offered for replacement of culverts rated as moderate to severe barriers using procedures developed by the Massachusetts River and Stream Continuity Partnership.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E. The assessment procedure includes a factor to account for the area of watershed made accessible to wildlife by the replacement, as a percentage of the total area of the stream reach on which the replacement is implemented.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 8. Natural Streambank Restoration

Definition: Unstable and damaged streambanks can erode faster than would naturally occur, carrying and depositing loose soils downstream in areas normally free of sediment. This excess sediment can suffocate fish, smother spawning beds, kill aquatic insects, impair filtration and degrade water quality, disrupting the ecological web of the stream and threatening the surrounding habitat. Streambank erosion can be the result of many factors, include damage to the bank vegetation through human encroachment and the alteration of frequency and magnitude of higher stream flows and overbank flooding associated with greater impervious area in the surrounding watershed. Stabilizing these banks is important to help maintain a healthy habitat.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 9. Other Restoration Project

Definition: There may be other restoration projects (e.g., wetlands restoration) that do not fit into one of the other habitat mitigation option criteria discussed above. This option is provided to cover these “other” options and provide an offset credit in consultation with state agencies.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 10. Establish or Contribute to Aquatic Habitat Restoration Fund

Definition: Some states offer a compensatory mitigation program to replace or protect wetland functions and values that are impacted by development projects, where it is infeasible to offset the impacts by means of wetland restoration or creation. Such a fund allows the collected money to be used towards other restoration and/or preservation projects in the watershed where the impacts occurred. For example, the New Hampshire Department of Environmental Services (NHDES) has a Compensatory Mitigation Program and payment into this fund is provided to the Aquatic Resource Mitigation Fund, which provides grants for other restoration and/or preservation projects. While Massachusetts does not have a comparable program at the state level, this option is included to provide the opportunity for PWSs and communities to explore future local, regional, or state programs that would establish and administer a similar program. Credit will be provided to PWS/communities who establish or contribute to such a fund.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E, and anticipates the credit would be developed on a case-by-case consultation and negotiation with state agencies involved in the permitting process.

The flow offset is computed using the spreadsheet presented in Appendix E.

Habitat Credit 11. Increase Watershed Tree Canopy

Definition: Tree canopy in the urban landscape can provide multiple benefits including interception of stormwater runoff, shading which provides cooler temperatures, increased property value, air quality improvements by mitigating harmful air pollutants and atmospheric carbon dioxide reduction. These benefits are not limited to reforestation of watersheds, but also apply to tree plantings along streets and in urban landscapes. The USGS Factors Influencing Riverine Fish Assemblages study found a positive correlation between tree cover and relative abundance of fluvial fish and a negative correlation between impervious area and relative abundance of fluvial fish. The regression relationship developed by that study provides the basis for developing a canopy cover offset for water withdrawals; that relationship is noted in the discussion of offset volume computation in Appendix E.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

4.2.2.5 Demand Management

As discussed in Section 3.0, the volume of groundwater withdrawal is primarily driven by user demands, some of which can be controlled with the use of more efficient water devices and restrictions on non-essential water use.

A number of demand management mitigation options were evaluated under the Draft SWMI Framework. These include:

- Outdoor watering restrictions
- Irrigation audits
- Irrigation sensors
- Irrigation bylaw
- Low flow faucets or faucet aerators
- Low flow showerheads
- Low flow toilets
- Watersmart washing machines
- Watersmart dishwashers
- Commercial water audits
- Municipal building retrofits
- Pistol grip hose nozzles
- Water bank
- Water supply enterprise account
- Water conservation rates
- Monthly billing/remote meters
- Conservation education/outreach
- Unaccounted-for-Water
- Leak Detection

Offset volume credits were developed for each of the demand management mitigation options. Unlike the other mitigation options, an adjustment for the location in the watershed is not applied to quantifiable demand management, since the application of these mitigation measures reduces the amount of water withdrawn, regardless of where they are implemented. The offset volume credits are summarized in Table 4-7 based on specific assumptions, along with cost estimates for each. This is followed by specific discussion of each.

Additional items such as mitigation credits for meeting unaccounted for water thresholds may also be considered under Phase 2 of the Pilot Project.

Table 4-7. Cost Estimating Guidance Tool Part 2 Demand Management				
Offset/Mitigation	**Units**	**$/unit**	**gal/household/ year**	**$/gal**
outdoor watering restrictions - public or private				
3 days/week	household		7,650	
2 days/week	household		11,475	
1 day/week	household		15,300	
0 days/week	household		19,125	
irrigation audits	household	$210	2,578	$0.08
irrigation sensors	household	$50	2,578	$0.019
irrigation bylaw	household		2,578	
faucet aerators	household	$15	2,897	$0.005
low flow faucets	household	$150	2,897	$0.05
low flow showerheads	household	$20	25,346	$0.001
low flow toilets (1.6 gpf)	household	$50	8,685	$0.01
low flow toilets (1.28 gpf)	household	$75	10,148	$0.01
watersmart washing machines	household	$100	3900	$0.03
watersmart dishwashers	household	$100	430	$0.23
commercial water audits				
municipal building retrofits				
pistol grip hose nozzles				
water bank				
water supply enterprise account				
water conservation rates				
monthly billing/remote meters				

Notes:

1. $/gal are based on one year of water savings. The life of the improvement is much longer, resulting in actual lower costs per gallon.
2. The gal/household/year for outdoor watering restrictions represents the water savings from achieved by restricting the number of days of allowed outdoor watering from 5 days/week over a 17 week watering season (June through August) to those shown in the table. Refer to Demand Management Credit 1. Outdoor Watering Restrictions in this section for the calculation methodology.
3. Costs ($/unit) for irrigation sensors, faucet aerators, low flow faucets and low flow showerheads are based on purchase costs, assuming three faucet aerators or low flow faucets per household. Costs for low flow toilets, watersmart washing machines, watersmart dishwashers are based on a possible rebate. Actual rebates may vary from town to town.
4. Water savings are not included for commercial water audits, municipal building retrofits, pistol grip hose nozzles, water banking, use of water supply enterprise account, development of water conservation rates or use of monthly billing/remote meters as the water savings cannot be readily quantified for these items and refer to the indirect offset mitigation credit method in Appendix E to quantify. Results of this method will vary for each community. Similarly, costs are not provided as many of these items are implemented by Town staff and can also vary based on the level of each program.
5. Revenue losses associated with the water savings are not accounted for in these cost estimates. Revenue losses will vary between PWSs based on their water rates. Revenue losses associated with potential mitigation options for each PWS are included in Sections 5 through 8.

Demand Management Credit 1. Outdoor Watering Restrictions

Definition: Large volumes of water are used for outdoor watering of lawns and landscape areas during the growing season. This increases the stress on summer streamflows, by taking more from the streams when streamflow is at its lowest. The use of outdoor watering restrictions can help alleviate some of this stress by reducing peak summer demands and overall summer withdrawals. Restrictions can include voluntary or mandatory watering restrictions ranging from hourly watering to no outdoor watering. The water savings assume the restrictions are implemented over a 22 week season from May 1st through September 30th.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: The offset volume shall be calculated based on the level of restriction (e.g., watering 3 days/week), number of weeks the restriction is applied and number of households that the restriction applies to. Thus, if a PWS has a bylaw that restricts outdoor watering of private irrigation wells, they can receive a credit for those households. If the bylaw only restricts outdoor watering for those on the water supply, then they will only obtain a credit for those households. The offset volume in the following calculation assumes a watering baseline of 5 days per week for unrestricted watering. The offset volume or water savings is the difference between watering 5 days per week and the restricted outdoor watering (e.g., 3 days a week, 2 days a week). The offset volume shall be based on the following calculation:

> Annual Average Volume (gal) = (Unrestricted weekly water use (gal/week) – weekly water use with restriction (gal/week)) x 17 weeks per year (mid-May through mid-September) x number of households restricted
>
> Where[2]:
>
> > Unrestricted weekly water use (gal/week) = Average watering flowrate (5 gpm) x average watering run time (45 min/day) x number of days/week (5 days/week)
> >
> > Weekly water use with restriction (gal/week) = Average watering flowrate (5 gpm) x average watering run time (45 min/day) x number of days/week watering is allowed (specific to restriction)

Refer to Table 4-7 for default offset volumes (gal/household/year) assuming various restrictions are applied for the 17 week watering season.

[2] Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

Demand Management Credit 2. Irrigation Audits

Definition: Another mitigation option to help reduce the demand associated with outdoor watering is to offer irrigation audits to water customers. Irrigation audits help identify inefficiencies in an irrigation system and its operation and should focus on:

- Site Inspection – Systems are inspected for issues such as:
    - sunken sprinkler heads that do not "pop-up" properly;
    - misaligned spray patterns that throw water onto impervious surfaces where it is wasted;
    - broken or missing sprinkler heads that lead to water leaks;
    - inefficient spacing of heads, which can lead users to set the system to operate longer; and
    - operating pressures as excessive pressures can cause excessive misting of water that is easily evaporated or carried by the wind.
    - leaks

- Performance Testing – The amount of water that hits the ground at various points within the landscape is measured and used to determine the actual performance rather than relying on manufacturer's rated performance, which is based on a specific set of operating parameters that may or may not exist at the specific location. This allows adjustments to the irrigation scheduling based on actual performance.

- Irrigation Scheduling – Irrigation schedules can be adjusted based on the actual performance of the system, site-specific soil conditions and plant water requirements to maximize watering efficiency. The use of rain and soil sensors can also be incorporated to eliminate watering during and around precipitation events.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: An offset volume of 2,578 gal/household/year was calculated as follows:

> Offset Volume (gal/household/year) = 65 gpcpd x 2.48[3] people per household x 365 days/year x percent reduction from implementation of water audit (13.4%[4]) x ratio of New England watering season to Florida watering season (0.32[5])

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[3] Average household population in Massachusetts from http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

[4] Percent reduction in water use from implementation of irrigation recommendations based on Florida Water Resources Journal. "Quantifying Potable Water Savings Derived from a Residential Irrigation Audit Program in Seminole County" by Terrence McCue, James Murin, and Debbie Meinert. August 2007.

Demand Management Credit 3. Irrigation Sensors

Definition: Irrigation sensors include rain and soil sensors. Rain sensors and soils moisture sensors are used to bypass scheduled irrigation cycles on the irrigation timer. Rain sensors can detect precipitation, while soil sensors measure the water content in the soils. Both prevent unnecessary watering when there is enough water from precipitation events.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: The same offset volume of 2,578 gal/household/year used for *Irrigation Audits* was applied to *Irrigation Sensors*, as much of the water savings associated with water audits includes better irrigation timing associated with the use of these sensors.

Demand Management Credit 4. Irrigation Bylaw

Definition: An irrigation bylaw is used to lay out specifications for the proper design and installation of an irrigation system. Thus, systems will be installed to operate at their highest efficiency and using the least amount of water.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: The same offset volume of 2,578 gal/household/year used for irrigation audits was applied to irrigation bylaw, assuming that the irrigation system is installed to operate at the highest efficiency.

Demand Management Credit 5. Low Flow Faucets or Faucet Aerators

Definition: Low flow faucets or the use of faucet aerators, limit the flow of water from a faucet. The Federal Energy Policy Act of 1992, required all faucet fixtures to have a peak flow rate of no more than 2.2 gpm, however, many faucets use much less than this. Compared to a conventional faucet flowrate of 3 gpm, the average savings associated with a low flow faucet or faucet aerator is 0.8 gpm.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: An offset volume of 2,897 gal/household/year was calculated as follows:

> Offset Volume (gal/household/year) = faucet savings (0.8 gpm) x average faucet use (4 min/person/day[6]) x average household size (2.48 persons/household) x 365 days/year

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[5] Ratio of New England watering season to Florida watering season assumes 17 week watering season in New England and 52 week watering season in Florida.

[6] Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

This assumes all faucets (e.g., kitchen and bathroom) in the household are low flow. Refer to Table 4-7 for default offset volumes (gal/household/year) and associated costs. Costs are provided for both faucet and aerator options.

Demand Management Credit 6. Low Flow Showerheads

Definition: Low flow showerheads limit the flow of water from a shower. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate for all new construction, remodeling and replacement projects. Compared to a conventional showerhead of 6 gpm, the savings associated with a low flow showerhead average 3.5 gpm.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: An offset volume of 25,346 gal/household/year was calculated as follows:

> Offset Volume (gal/household/year) = showerhead savings (3.5 gpm) x average shower length (8 min/person/day) x average household size (2.48 persons/household) x 365 days/year

This assumes all showerheads in the household are low flow. Refer to Table 4-7 for default offset volumes (gal/household/year) and associated costs.

Demand Management Credit 7. Low Flow Toilets

Definition: Low flow toilets use less water per flush than conventional toilets. The 1989 Massachusetts Plumbing Code required installation of low flow toilets meeting 1.6 gallons per flush (gpf) for all new construction, remodeling and replacement, however, more efficient toilets (high efficiency (HE) toilets) meeting 1.28 gpf are now available. Compared to a conventional toilet of 3.5 gpf, the savings associated with a low flow toilet are 1.9 gpf, and 2.22 gpf for HE toilets.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: An offset volume of 8,685 gal/household/year for low flow toilets and 10,148 gal/household/year for HE toilets was calculated as follows:

> Offset Volume (gal/household/year) = toilet savings (1.9 or 2.22 gpf) x daily flushes per person (5.05 flushes/person) x average household size (2.48 persons/household) x 365 days/year

This assumes all toilets in the household are low flow. Refer to Table 4-7 for default offset volumes (gal/household/year) and associated costs.

Demand Management Credit 8. Watersmart Washing Machines

Definition: Watersmart or HE washing machines use less water than conventional washing machines at 14 gallons per load compared to 27 gallons per load for a conventional machine. This equates to a water savings of 13 gallons of water per wash load.[7]

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: An offset volume of 3,900 gal/household/year for HE washing machines was calculated as follow[7]:

> Offset Volume (gal/household/year) = washing machine savings (13 gal/load) x average number of loads (300 loads/household/year)

Refer to Table 4-7 for default offset volumes (gal/household/year) and associated costs.

Demand Management Credit 9. Watersmart Dishwashers

Definition: Watersmart or HE dishwashers use less water than conventional dishwashers at 4 gallons per cycle compared to 6 gallons per cycle for a conventional dishwasher. This equates to a savings of 2 gallons of water per cycle.[8]

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: An offset volume of 430 gal/household/year for HE washing machines was calculated as follows:

> Offset Volume (gal/household/year) = dishwasher savings (2 gal/cycle) x average number of cycles (215 cycles/household/year)

Refer to Table 4-7 for default offset volumes (gal/household/year) and associated costs.

Demand Management Credit 10. Commercial Water Audits

Definition: Commercial water audits can be provided to the largest commercial/industrial water users to identify potential water savings at their facility.

Offset Credit Approach: Direct offset volume.

Offset Volume Calculation: The offset volume associated with commercial water audits will be based on the results of the audit and actual implementation of the recommendations.

Demand Management Credit 11. Municipal Building Retrofits

Definition: Replacing water fixtures such as toilets, faucets and showerheads in municipal buildings can result in water savings associated with using the more efficient devices.

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[7] Water use and assumptions obtained from Energy StarWebsite.

[8] Based on assumptions from Energy Star Dishwasher Calculator on Energy Star Website.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Demand Management Credit 12. Pistol Grip Hose Nozzles

Definition: Pistol grips are garden hose spray nozzles used to control the release of water from a hose, without turning the water off and on at the house. The nozzles prevent excess water use by providing water only when activated by the user.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Demand Management Credit 13. Water Bank

Definition: A water bank is a program that is designed to provide a dedicated funding source for water conservation projects. Such a program may require new development/water connections to offset their demand with water conservation fees.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Demand Management Credit 14. Water Supply Enterprise Account

Definition: A water enterprise account is an account that is dedicated to the operation, maintenance, repair, and management of the municipality's water infrastructure. Revenues to the Water Enterprise Account are kept separate from other municipal funds and uses, and cannot be co-mingled with funds for any other activities. Other equivalent funds or accounts can also receive this credit.

Offset Credit Approach: Calculated direct offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Demand Management Credit 15. Water Conservation Rates

Definition: Water conservation rate structures are used to help reduce per capita water use, while maintaining revenues. Typical water conserving rate structures use increasing block rates, where the water price increases with increasing block of water use.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Demand Management Credit 16. Monthly Billing/Remote Meters

Definition: Remote meters allow PWSs to read water meters more efficiently and at a greater frequency, which in turn allows for more frequent billing (e.g., monthly versus quarterly). More frequent billing can result in a reduction of water use, as consumers see the immediate financial impact of high water use on their bill, and are more likely to adjust for it during the next month. It can also help identify leaks in the system more quickly as water consumption is compared to pumping rates more often.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Demand Management Credit 17. Conservation Education/Outreach

Definition: Water conservation education can help reduce water demands by supplying the public with information on how they can save water at home. Public education materials should include tips for conserving both indoor and outdoor water use.

Offset Credit Approach: Indirect offset volume.

Offset Volume Calculation: This approach is subject to the qualitative assessment procedure presented in Appendix E.

The flow offset is computed using the spreadsheet presented in Appendix E.

Section 5 Amherst

This Pilot Project applied the Draft Sustainable Water Management Initiative (SWMI) Framework to each of the PWSs included in the study. This section describes its application to the Amherst DPW Water Division. The application of the Draft Framework is based on review of data collected from the Massachusetts Department of Environmental Protection (MassDEP), the Town of Amherst, the Massachusetts Division of Ecological Restoration (DER) and the University of Massachusetts, Amherst (UMass Amherst) as outlined in the annotated bibliography included in Appendix C.

The following summary describes relevant characteristics of the water system and its service area. Potential permitting considerations and requirements under the Draft SWMI Framework are then described along with measures for minimizing impacts of withdrawals and potential mitigation and offset actions for credits against requested withdrawals.

5.1 Town Characteristics

Understanding existing town characteristics is an essential step in identifying and applying the Draft SWMI Framework minimization and mitigation options discussed in Section 4.0. Existing conditions pertaining to water supply sources, local water resources and habitat, wastewater and stormwater are provided below, followed by specific discussions on the application of the Draft SWMI Framework.

5.1.1 Water Supply Sources

The Town of Amherst has seven sources of water supply, as shown on Figure 5-1: The Atkins Reservoir, the Pelham Reservoir System (which includes the Hill, Hawley, and Intake Reservoirs), the South Amherst Wells (#1 & #2), the Brown Well (#3), the Lawrence Swamp Well (#4) and the Bay Road Well (#5). Both surface water supplies and Wells 1, 2 & 3 are used as baseline supplies to satisfy water supply demands. These five sources supply approximately 90% of the total water produced. Wells No. 4 and No. 5 operate during high demand periods and in late summer if the surface water supplies need to be removed from service due to water quality or low reservoir storage. Well No. 6 is a permitted well but is inactive and not currently connected to the system or used as a source of supply.

The five active groundwater sources are all gravel packed wells and draw water from an area known as the Lawrence Swamp in subbasin 14061 of the Connecticut River Basin. This area lies in the southeast section of Amherst and the northwest section of Belchertown. The inactive well, Well No. 6, is also in the Lawrence Swamp aquifer. Well No. 5 is furthest from the stream (Hop Brook) and located in a shallow unconfined aquifer, not within the main body of the confined aquifer which is utilized by the other wells. (8-1H Pump Test Report) Due to poor water quality, however, Well No. 5 is the last well utilized.

The Pelham Reservoir System, located in Pelham, is illustrated on Figure 5-2. Water from Dunlop Brook is impounded in the Hill Reservoir which spills into Intake Reservoir, from which water is withdrawn for the Centennial Water Treatment Plant (WTP). Hawley Reservoir impounds Harris Brook and also spills into Intake Reservoir. Intake Reservoir in turn spills to Amethyst Brook. Hill, Hawley and Intake impoundments typically spill (discharge) to the downstream watercourses. When Intake Reservoir stops spilling, Amherst releases water from storage in the Hill or Hawley Reservoirs. When the water level in Intake Reservoir can no longer be maintained, or water quality deteriorates, the Centennial WTP is shut down and withdrawals from the wells are increased (typically by activating Well No. 4) to offset the lost supply. The combined usable storage in the three reservoir system is approximately 30 MG. Amherst's Annual Statistical Report (ASR) notes that the safe yield of the Pelham Reservoir System is 1.3 mgd and USGS estimated the firm yield of the system to be 0.87 mgd. The capacity of the Centennial WTP is 1.5 mgd.

The Atkins Reservoir, located in Shutesbury, is illustrated on Figure 5-2. The Atkins Reservoir has its own watershed of approximately 1.72 square miles but is primarily operated as off-line storage. A portion of the flow from Dean and Nurse Brooks can be diverted to Atkins Reservoir for storage through a control structure approximately one-quarter mile upstream of the reservoir. Amherst operates the system to keep Atkins Reservoir as full as possible. Total storage in the reservoir is approximately 262 MG, almost all of which is usable above the bottom intake. Amherst's ASR lists the safe yield of Atkins Reservoir System as 1.25 mgd while USGS estimated the firm yield of the system to be 1.16 mgd. The capacity of the Atkins WTP is 1.5 mgd. Amherst also maintains two emergency interconnections with the Town of Hadley: one on Greenleaves Drive and the other on Meadow Street. Both emergency interconnections are through 8" diameter pipe - neither is operated regularly. (Amherst Interconnections). Amherst estimated that the last time these interconnections were activated was in the 1980s.

Table 5-1 summarizes pertinent information regarding the authorized withdrawal volumes of Amherst's sources of supply. As indicated, the system has a registered volume of 3.34 mgd and a permitted volume of 1.21 mgd for a total authorized withdrawal volume of 4.55 mgd (Amherst WMA Permit, Amherst WMA Registration).

Table 5-1. Amherst - Sources of Supply					
Source	MassDEP ID	Subbasin	WMA Permit Limits (mgd)		WMA Permit + Registration Annual Average (mgd)
			Annual Average	Maximum Day	
Well #1	1008000-01G	14061	1.21	0.65	4.55
Well #2	1008000-08G	14061		0.56	
Well #3	1008000-02G	14061		1.48	
Well #4	1008000-05G	14061		1.74	
Well #5	1008000-06G	14061		0.50	
Well #6 (inactive)	1008000-07G	14061		1.18	
Atkins Reservoir	1008000-01S	14042 14047	1.25	1.5[(1)]	
Pelham Reservoirs	1008000-02S	14050	NA	1.5[(1)]	
		Total	2.46	9.11	

1. WTP Capacity

The average annual withdrawal from each supply over the past three years is summarized in Table 5-2. (Amherst ASRs).

Table 5-2. Amherst – Annual Production			
Source	Average Annual Production (mgd)		
	2009	2010	2011
Well #1	0.298	0.242	0.146
Replacement Well #2	0.255	0.285	0.188
Well #3/the Brown Well	0.706	0.704	0.632
Well #4	0.094	0.391	0.214
Well #5	0.001	0.028	0.005
Well #6	0.000	0.000	0.000
Atkins Reservoir	0.936	0.645	1.011
Hills/Hawley Reservoir	0.836	0.660	0.626
Total	3.126	2.956	2.821

As indicated in the Table, Amherst's withdrawals have been consistently below their authorized volume and demands declined from 2009 to 2011. The 2009 to 2011 volumes are also lower than the 2000 to 2004 five-year average of 3.69 mgd.

5.1.2 Local Water Resources and Stream Habitat

Amherst's natural resources, habitat and infrastructure influencing habitat (e.g., dams and culverts) are shown on Figure 5-3.

Amherst's water supply sources are located within the Connecticut River Basin. Its groundwater sources are located in Lawrence Swamp in Subbasin 14061. Amherst Well

#1 and Replacement Well #2 are located on the eastern edge of Lawrence Swamp in southeast Amherst. Well #3 (Brown Well) is located in the Town of Belchertown, Massachusetts, and Wells #4 (Baby Carriage Brook Well), #5 (Bay Road Well), and #6 are located in the center of Lawrence Swamp in southern Amherst. Lawrence Swamp is the largest remaining wetlands complex in Amherst and is also one of the largest continuous forest blocks in the town. It contains scattered agricultural fields, marsh and open water. Subbasin 14061 is designated as Biological Category 5.

Hawley Reservoir, Hill Reservoir, and Intake Reservoir are located in Pelham, Massachusetts. These reservoirs are known collectively as the Pelham Reservoirs. Hawley Reservoir is 6.3 acres and holds 14 million gallons (MG); Hill Reservoir is 7 acres and holds 30 MG; and Intake Reservoir is a 1-acre impoundment that holds approximately 2 MG. The Pelham Reservoirs' watershed area is about 6.2 square miles and is mostly forested with some rural residences.

Atkins Reservoir is located in Shutesbury, Massachusetts. It is 51 acres with a storage capacity of 200 MG. The watershed is 5.7 square miles and is primarily forested and rural residential.

There are several coldwater fishery resources (CFRs) located throughout Amherst as well as in the watershed areas for the reservoirs in Pelham and Shutesbury. The Mill River/Cushman Brook Corridor is a CFR located in northern Amherst that flows southwest from Leverett through Amherst and Hadley to the Connecticut River. The Atkins Reservoir is a tributary to Cushman Brook and the stream below the Atkins Reservoir Dam is also designated a CFR.

The Fort River is another CFR and is the primary river that runs through central and south Amherst with sections included on the Massachusetts Natural Heritage Program's "Estimated Habitat Map of Endangered and Rare Wetland Species." (Amherst 2009 OSRP) Amethyst Brook and Plum Brook are tributaries to the Fort River and are also designated as CFRs. The Pelham Reservoirs are both tributaries to Amethyst Brook.

A portion of Jabish Brook in subbasin 14061 is also a CFR, however, it is located within the Town of Belchertown, upgradient of Amherst's groundwater supplies.

There are four privately-owned and four publicly-owned dams in Amherst. Amherst also owns two dams in Shutesbury on the Atkins Reservoir, and four dams in Pelham associated with the Pelham Reservoirs. These are summarized in Table 5-3, along with ownership and location.

Table 5-3. Dams in or Owned by Amherst			
Dam Name	**Location**	**Owner**	**Subbasin**
Atkins Reservoir Dam	Shutesbury	Town of Amherst DPW	14050
Atkins Reservoir Dike	Shutesbury	Town of Amherst DPW	14050
Bartlett Fishrod Co. Dam	Pelham	Private	14050
Echo Hill Association Pond Dam	Amherst	Private	14055
Epstein Pond Dam	Amherst	Private	14064
Hawley Reservoir Dam	Pelham	Town of Amherst DPW	14050
Hill Reservoir Dam	Pelham	Town of Amherst DPW	14050
Ice Pond Dam	Amherst	Private	14056
Intake Reservoir Dam	Pelham	Town of Amherst DPW	14050
Market Pond Dam	Amherst	Town of Amherst DPW	14064
Owens Farm Pond Dam	Amherst	Town of Amherst Conservation Commission	14055
Puffer's Pond Dam	Amherst	Town of Amherst Conservation Commission	14042
Puffer's Pond Dike	Amherst	Town of Amherst Conservation Commission	14042
University Pond Dam	Amherst	Department of Higher Education	14048

Using GIS mapping, about 149 stream culverts were identified in Amherst based on observed intersections of roadways and streams.

5.1.3 Wastewater

Approximately 93% of Amherst's population is served by the Town of Amherst Wastewater Treatment Plant (WWTP). The sewer collection system extends throughout Amherst and to a few properties in Hadley. In addition to the residential, commercial and industrial connections, the WWTP serves the three colleges in Amherst: UMass Amherst, Amherst College and Hampshire College. Due to the large student population, wastewater discharge fluctuates with the academic calendar, with lowest flows occurring during the summer. Approximately 800 on-site septic systems are still used in the less dense areas of town; however, the town has plans to extend sewers to approximately 240 lots. The sewershed area lies entirely within the Connecticut River Basin. See Amherst Wastewater Infrastructure Figure 5-4.

The Amherst sewer system consists of approximately 78 miles of sewer lines and 19 pump stations. The current WWTP was built in 1979 with a 7.1 mgd design flow. Secondary treatment is provided and effluent is discharged via a 1.8 mile effluent force main through Hadley to a discharge diffuser along the Connecticut River. The WWTP average annual discharge is 4.4 mgd. Average monthly flows range from 2.76 to 5.6 mgd and peak flow discharge was recorded in 2011 at 18.1 mgd.

The 2005 Sewer Extension Master Plan identified extra capacity in the existing collection system to accommodate future growth, and assessed extending sewers to areas with on-site disposal problems. An update in 2011 identified a priority list of nine study areas, of which three study areas are anticipated to be sewered. One of the priority sewer areas includes the Centennial Water Treatment Plant area in Pelham. The 2011 Sewer Extension Update looked at alternatives to conventional sewers that would provide localized discharge, including innovative on-site systems and community systems, but these were not recommended due to cost.

The report recognized that sewering in the vicinity of public supply wells would reduce groundwater recharge. The report recommended that the town take steps to identify infiltration and inflow from several of the subbasins to provide additional carrying capacity for the anticipated growth. The reduction of infiltration and inflow from the Town's sewer system was also included as a goal in Amherst's 2010 Master Plan.

5.1.4 Stormwater

5.1.4.1 Summary of Phase II Program

The Town of Amherst is not currently subject to the National Pollutant Discharge Elimination System (NPDES) Phase II stormwater program, as the Town does not contain an Urbanized Area (UA) as defined by the 2000 United States Census. It is possible that UA boundaries as defined by the 2010 U.S. Census will include Amherst, thus subjecting the Town to regulation under the upcoming new Phase II permit.

5.1.4.2 Infrastructure

The March 2011 Amherst Drainage System map shows about 5,000 catch basins and 300 outfalls. Additional unmapped structures and outfalls may exist. Many of the structures appear to be located on properties owned by Amherst College and the UMass Amherst, and may not be owned by the Town.

5.1.4.3 Impervious Cover

Refer to Figure 5.5 for Impervious Cover in Amherst. As Amherst is not subject to the NPDES Phase II program, no information is currently available regarding directly connected impervious area.

5.1.4.4 Stormwater Regulations

The Pilot Project Team reviewed Amherst's regulations for stormwater control requirements that could be considered as mitigation measures for groundwater withdrawals, particularly recharge requirements. Amherst's regulations include the following requirements:

- Zoning bylaws and regulations established a Watershed Protection District in the northeast corner of the Town. Stormwater runoff in this area must not be diverted into another basin, so as to preserve existing infiltration capacity.
- Amherst designated an Aquifer Recharge Protection (ARP) District in the southeast corner of the Town around the Lawrence Swamp aquifer. The following requirements apply:
  - Groundwater recharge must be maintained and residential subdivisions must be cluster developments to help maintain groundwater recharge.
  - Stormwater runoff from impervious surfaces must be recharged onsite by diverting runoff to pervious areas.

- No more than 15% of the post-development increased runoff may be diverted out of the ARP District.
- All stormwater BMPs must be maintained as needed.
- New development must limit impervious area to 15% of the total lot area, or 2,500 square feet, whichever is greater unless a Special Permit is obtained. For areas with larger impervious area, a system for artificial recharge of precipitation to groundwater must be implemented that protects against the degradation of groundwater quality.
- For non-residential uses, recharge must be by storm water infiltration basins or similar system covered with natural vegetation. Drywells are only allowed when other methods are infeasible. All basins and wells must be preceded by oil, grease and sediment traps.

5.1.4.5 Impaired Waters and TMDL Status

The final Massachusetts Year 2010 Integrated List of Waters defines the following waterbodies as impaired:

Table 5-4. Amherst Impaired Waters and TMDL Status					
Category	**Waterbody**	**Waterbody ID**	**Length**	**Impairment**	**EPA TMDL No.**
Category 5	Mill River	MA34-25	5.2 miles	Escherichia coli	-
Category 5	Fort River	MA34-27	12.8 miles	Escherichia coli	-

Note: Category 5 – Waters requiring a TMDL

To date, no TMDLs have been prepared for Amherst waterbodies.

5.2 Permit Tier Designation

As described in Section 2.1 of this report, the Draft SWMI Framework proposes Water Management Act (WMA) Permit requirements based upon the Flow Level and Biological Category of the subbasins from which withdrawals are to be permitted and the amount of the community’s withdrawal request.

5.2.1 Biological Category

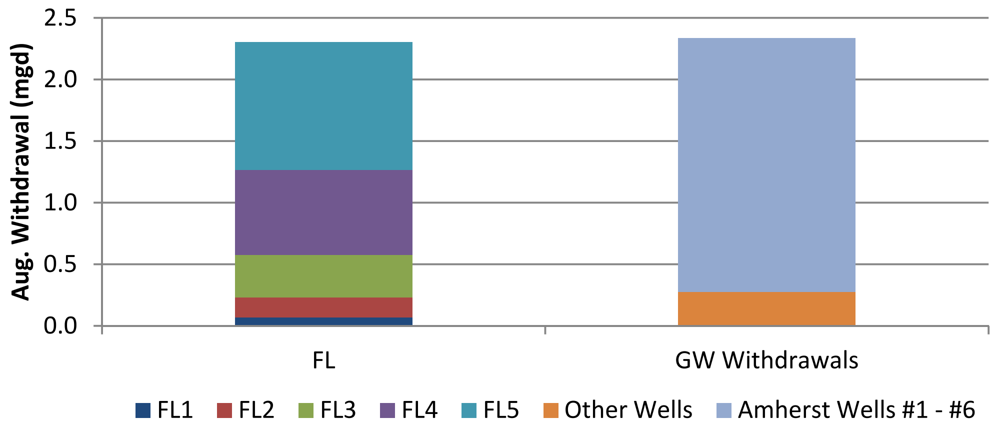
All of Amherst’s groundwater sources are located in a Biological Category (BC) 5 subbasin; therefore, no increase in withdrawal volume requested could cause a change in the BC and the subbasin is not considered a Quality Natural Resource as a result of its BC. No additional evaluation related to BCs was conducted for Amherst.

5.2.2 Flow Level

The Flow Level (FL) of each subbasin in the State was determined by MassDEP based upon the estimated percent alteration of the subbasins unaffected August median flow. The unaffected flow was determined utilizing the Sustainable Yield Estimator (SYE) at the pour point (exit) of the subbasin and includes the flow from any upstream subbasins. Withdrawals were based on 2000 – 2004 annual average withdrawals for all WMA registered and permitted wells and estimated private well withdrawals in the subbasin and upstream subbasins. Annual average withdrawals were adjusted by a peaking factor of 115.5% to determine August monthly withdrawals. The percent alteration of August flow was determined by dividing the August withdrawals by the August unaffected flow, which presumes a 1:1 relationship between withdrawals and streamflow reduction.

Figure 5-6 depicts the FL designations for each subbasin located within and proximate to Amherst. Figure 5-7 presents the FL designations for subbasin 14061, where all of Amherst's groundwater withdrawals are located. This subbasin is estimated to have greater than 55% alteration of unaffected August median flow and is therefore a FL5 subbasin. There is also a Cold Water Fishery in the subbasin upstream of Amherst's withdrawal points. Figure 5-7 and Table 5-5 present the data used in determining the FL for subbasin 14061.

Figure 5-7
Subbasin 14061 FL Determination



The FL bar in the Figure shows that the unaffected August flow at this subbasin pour point is approximately 2.31 mgd. Withdrawals greater than 55%, or approximately 1.27 mgd, result in a FL5 designation for this subbasin. The GW Withdrawal bar in the Figure illustrates the estimated 2000 – 2004 August withdrawals used in the FL determination, and the portion of those estimated withdrawals attributed to Amherst's wells. Amherst's withdrawals account for the majority of estimated withdrawals in this subbasin. Other withdrawals may include the Belchertown Daigle Well and private wells.

Table 5-5. Amherst – FL Determination

Criterion	Wells 1 - 6
2000–2004 Estimated Amherst August Withdrawal (mgd)	2.06
2009-2011 Actual August Withdrawal (mgd)	1.40
Subbasin	14061
Unaffected August Flow (mgd)	2.31
Estimated Total (Amherst and others) August Withdrawals (mgd)	2.34
August Flow Alteration (%)	101
Flow Level	5

Because Amherst's largest customer is UMass Amherst, and because they utilize the surface water sources to provide base demand through most of the summer, the actual August peaking factor for groundwater withdrawals is significantly different than the state-wide 115% utilized in the FL determination study. In 2009-2011, for example, Amherst's August peaking factor for groundwater sources was 97%. Although not in the scope of this Pilot Project, the Draft SWMI Framework states that the regulations that ultimately result from the Framework may give the applicant an opportunity to demonstrate through a Site-Specific Study that the model has placed a particular location in an incorrect category. MassDEP will develop guidance on how such site specific work would be done. Amherst has requested that this correction process be implemented prior to finalizing the subbasin FL designations so that the public can be informed with the most accurate information available.

5.2.3 Tier Designation

As described in Section 2.1, the permit review tier is based upon the volume of water that a community is requesting authorization to withdraw above the baseline volume, and the percent of the unaffected August flow in the withdrawal subbasin as summarized in Table 5-6.

Table 5-6. Tier Designation

Tier	Withdrawal Request
1	No additional water above baseline
2	Additional water above baseline <5% of subbasin's unaffected August flow
3	Additional water above baseline >5% of subbasins unaffected August flow
4	Additional water above baseline will result in a change in Flow Level or Biological Category

The baseline demand for a system is determined by the greater of the 2003 – 2005 annual average demand or the 2005 actual demand plus a growth factor of 8%. If the 8% factor would result in a change in the subbasin's FL, the growth factor is limited to 5%. Furthermore, the baseline cannot be lower than existing registered volume or higher than the existing total authorized volume. In addition, the baseline demand cannot be more than the Department of Conservation and Recreation's (DCR's) 20-year demand projection for the community. Table 5-7 illustrates the baseline demand calculation for Amherst.

Table 5-7. Amherst – Baseline Demand

Item	Quantity (mgd)
Registered Volume	3.34
Total Authorized Volume	4.55
DCR Projection	NA
2003 Demand	3.64
2004 Demand	3.62
2005 Demand	3.58
2003 – 2005 Avg. Demand	3.62
2003-2005 + 8%	3.91
Proposed Baseline	**3.91**

As shown in the Table, Amherst's proposed Baseline Demand is 3.91 mgd based on the 2003-2005 average annual demand plus 8%. This increase would not result in a change in the FL of the subbasin from which Amherst's wells withdraw. The subbasins are all FL 5 and would remain FL 5 with this proposed increase.

DCR demand projections are not available for Amherst. In lieu of these projections Amherst requested that a permit request equal to their current total authorized amount (4.55 mgd) be utilized for this Pilot Project. The permit request of 4.55 mgd would be 0.64 mgd above baseline, which is 28% (>5%) of the unaffected August flow in subbasin 14061. Because the subbasin is a FL 5 the additional withdrawal request would not increase the basin FL. This permit would therefore require a Tier 3 review.

5.2.4 Permit Requirements

The Draft SWMI Framework Tiers Table (Table 5 in Draft Framework) presents the permit review requirements based on subbasin flow level and withdrawal request Tier. The piloted Amherst WMA permit is a Tier 3/FL 5 review with a quality natural resource in the subbasin and therefore requires that Amherst:

- Comply with applicable provisions of standard permit conditions 1-8
    1. Source Protection
    2. Firm yield for surface water supplies
    3. Wetlands and vernal pool monitoring (if applicable)
    4. Residential use less than 65 gallons/capita/day
    5. Unaccounted for water less than 10%
    6. Seasonal limits on nonessential outdoor water use
    7. Water conservation measures
    8. Offset Feasibility Study

  Note that the minimization measures developed through the SWMI process are already being applied in standard conditions 6 and 7, and it is expected that the mitigation measures will be incorporated into standard condition 8.

- Minimize the impact of their existing withdrawals on streamflow to the greatest extent feasible considering cost, level of improvement achievable, and ability to implement.

- Demonstrate that there is no feasible alternative source that is less environmentally harmful. Less environmentally harmful is defined as a source that is in a FL 1, 2, or 3 subbasin and doesn't cause that subbasin to change FL.

- Implement mitigation measures that are commensurate with impact of their increased withdrawals (0.64 mgd).

In addition, Amherst would need to comply with the Surface Water Transition Rule. This rule requires the same actions described above, and specifically includes development of a drought and demand management plan and evaluation of the feasibility of implementing reservoir releases. The focus of this Pilot Project is groundwater supplies, while surface water supply issues may be addressed in a subsequent phase.

The report sections below discuss the minimization and mitigation alternatives identified through this Pilot Project for the Amherst Water Division. This is not expected to be an exhaustive listing, nor have the feasibility of implementing these actions been fully investigated. The discussion does, however, provide a basis for assessing the potential requirements of the Draft SWMI Framework on an Amherst permit application.

5.3 Minimization of Impacts

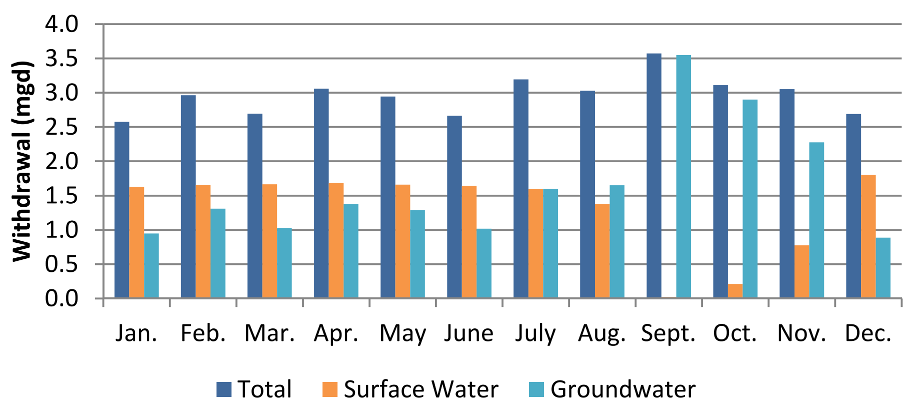
5.3.1 Optimization of Existing Sources

5.3.1.1 Use of Reservoir Storage

Systems that operate a combination of surface water and groundwater sources, like Amherst, sometimes have the opportunity to optimize the operation of their existing sources by utilizing their groundwater withdrawals and storing water in reservoirs during higher flow periods and then using surface water from reservoir storage during critical low flow periods. The Draft SWMI Framework identifies August flow alteration as a critical metric for fish assemblages based on the USGS Factors Influencing Riverine Fish Communities study. Source optimization evaluations, however, should not just focus on this single month metric.

Figures 5-8 and 5-9 illustrate Amherst's monthly withdrawals of groundwater and surface water in 2009 and 2010.

Figure 5-8
Amherst 2010 Withdrawals



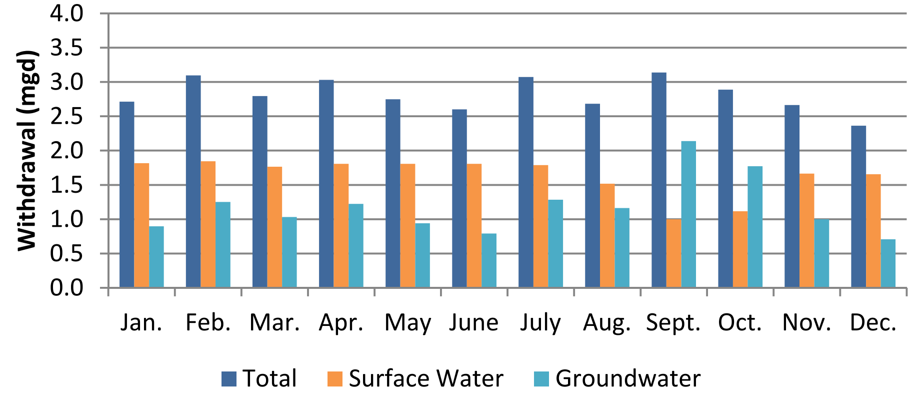


Figure 5-9
Amherst 2011 Withdrawals

As shown, Amherst preferentially utilizes its surface water supplies through most of the year. In September, groundwater withdrawals increase significantly as demands increase due to students returning to UMASS and the reservoirs become unavailable as the result of reduced storage and poor water quality. Because of its limited storage, it is not unusual for the Centennial WTP in Pelham to be shut off in September and October. It should be noted that 2010 was a unique year in that the Atkins Reservoir also ran out of storage and needed to be removed from service, resulting in unusually high groundwater pumping.

Because the Pelham (Centennial) Reservoirs have limited storage capacity and are typically spilling there is no significant opportunity to store more water in this system during high stream flows to avoid the late summer shutdown and corresponding increase in groundwater withdrawals. Atkins reservoir has additional storage, but the treatment plant typically runs within 0.5 mgd of its capacity through the low streamflow months. This provides limited opportunity to increase withdrawals from storage to offset groundwater withdrawals, without expansion of the treatment plant.

In summary, Amherst's source operations strategy already minimizes groundwater withdrawals during the low flow periods through August when the surface water supplies typically become unavailable. Modest improvement may be possible with more detailed analysis of opportunities to utilize the Atkins Reservoir storage. However, impacts on the Atkins Reservoir firm yield and flow in the Dean and Nurse Brooks feeding Atkins Reservoir would need to be analyzed and compared to the benefit of reducing the September increase in groundwater withdrawals. Given the hydrogeology of Lawrence Swamp it would likely require a site specific study to quantify this benefit.

5.3.1.2 Well Operation

Amherst preferentially utilizes Wells No. 1, 2 and 3 for year round groundwater withdrawals. Well No. 4 has large capacity but is more difficult and expensive to operate because it requires manual operation of another treatment facility for iron and manganese removal. Amherst stated that it does not have adequate staff to operate Well No. 4 concurrently with both the Centennial and Atkins water treatment plants. Well No. 5 is furthest from the stream and does not withdraw from the same confined aquifer as the other wells, but is utilized last due to poor water quality. Other than potentially investigating the increased use of Well No. 5 there is no evidence to suggest that modifying the sequence of Amherst's well operations would reduce their impact on stream habitat, particularly given the storage and attenuation provided by Lawrence Swamp.

5.3.2 Alternative Sources of Water Supply

Amherst's pilot permit request is equivalent to their current authorized volume. Development of alternative sources is therefore not required to meet system demands, but may be helpful to improve system reliability and minimize or mitigate withdrawal impacts on streamflow.

Based on a review of documents provided by the Town, several potential alternative source opportunities were identified. The Town is currently evaluating the possibility of partnering with the Town of Sunderland to develop a new municipal water supply well located on the Nielsen property in Sunderland, MA to provide redundancy for both systems. Additionally, interconnection opportunities with neighboring communities and MWRA were evaluated. These options are described below in greater detail and are depicted on the Amherst Alternative Source Map, Figure 5-10. The adjacent town of Pelham is serviced primarily by private wells; thus an interconnection with Pelham is not a viable option and was not further evaluated.

5.3.2.1 Develop Well in Sunderland

Amherst is evaluating the possibility of partnering with the Town of Sunderland to develop a well on the Nielsen property in Sunderland; located approximately 1,500 feet north of the Amherst town line and west of Route 116. As part of this evaluation, two test wells were installed on the property by Maher Drilling & Pump Services. Based on a pump test conducted at the site, the maximum yield of a permanent production well installed at either location was estimated to be approximately 1.5 mgd (Nielsen Property Memo 2012).

The Sunderland well would be located in subbasin 14041. The USGS Indicators of Streamflow Alteration study indicated that the subbasin's August flow alteration is 30% resulting in a FL 4 designation. The unaffected August median flow in the subbasin is 0.61 mgd. The available August withdrawal without increasing the subbasin to a FL 5 is therefore only 0.155 mgd, or approximately 10% of the well's estimated capacity. Considering Amherst's peak groundwater withdrawal period, the unaffected October flow in the subbasin is 1.1 mgd. The Draft SWMI Framework does not provide guidance for September or October alteration of FL 4 subbasins. However, the subbasin already exceeds the maximum October flow alteration for a FL 3 subbasin. Additional guidance is needed for evaluating the available withdrawal from the Sunderland well during Amherst's peak groundwater withdrawal period in September and October.

If the Sunderland Well is developed, it is anticipated that permanent facilities would include a building and electrical, pumping, chemical feed, HVAC, and instrumentation and control equipment. In addition, it is anticipated that approximately 7,000 feet of water main and appurtenances would be required to connect the well to Amherst's distribution system (Nielsen Property Memo 2012). Verification that the well is 1,500 feet north of town line is needed.

The new source would be required to proceed through MassDEP's New Source Approval process in addition to the Water Management Act process. Because the well is anticipated to withdraw greater than 100,000 gpd, the project would also require an Environmental Notification Form (ENF) and review by the Massachusetts Environmental Policy Act (MEPA) office.

An Opinion of Probable Costs prepared for the Town as part of their on-going investigations (Nielsen Property Memo 2012), estimated the well development cost at approximately $3.6 million, excluding land acquisition.

5.3.2.2 Purchase Water from Sunderland

An interconnection to purchase water from Sunderland independent of the potential Nielsen property well was also considered. This alternative was not considered feasible for meeting Amherst's increased request above baseline (0.64 mgd) due to the small size of Sunderland's total authorized withdrawal volume (0.24 mgd).

5.3.2.3 Purchase Water from Hadley

Another option for the Town of Amherst is to purchase water from the Town of Hadley, possibly by activating existing emergency interconnections. Hadley's primary drinking water supply is groundwater; drawn mainly from the Callahan Wells located in the Connecticut River Basin subbasins 14048 (FL 3) and 14064 (FL 4). In 2011 Hadley had 0.29 mgd difference between the WMA authorized withdrawal volume (0.92 mgd) and the daily average water use (0.63 mgd) (Hadley ASR 2011).

5.3.2.4 Purchase Water from Belchertown

Amherst may also consider purchasing water via an interconnection with the adjacent community of Belchertown. Belchertown's water supply consists of five groundwater sources located in both the Connecticut and Chicopee River Basins. Belchertown's permitted Connecticut Basin well is in the same subbasin as Amhersts' withdrawals so this would not provide any benefit. Taking water from the registered wells in the Chicopee River Basin would require an Interbasin Transfer Act (IBTA) Permit. In 2011, Belchertown withdrew less than the WMA Authorized withdrawal volume from both the Connecticut and Chicopee River Basins, with a surplus of 0.25 mgd and 0.3 mgd respectively (Belchertown ASR 2011).

5.3.2.5 Purchase Water from MWRA

Amherst is not currently an MWRA community; however it has the ability to connect to the MWRA through the South Hadley Fire District #1 Water District, which is entirely supplied water via MWRA. The South Hadley District #1 obtains a maximum of 600 MG annually and a maximum of 3.8 mgd from the MWRA and primarily serves the southern portion of South Hadley (S. Hadley MWRA Agreement).

The most geographically direct route to connect to South Hadley's Fire District #1 water system would follow Route 116 south from Amherst, however the hydraulic issues associated with crossing the Mount Holyoke range eliminate this route from consideration. The second most direct route, accounting for the Mount Holyoke mountain range, would likely start at the Hadley/Amherst town line at Route 116/Route 9 (Northampton Road in Amherst and Russell Street in Hadley). The water line would then follow Route 9/Russell Street to Route 47. It would continue to follow Route 47 south to Route 116 in South Hadley. The interconnection would tie into the South Hadley Fire District #1 system via the existing 16” diameter main line at the intersection of Brainerd Street and Route 116/Newton Street. There is an existing main line valve at this location and an interconnection between Water District #1 and Water District #2. While this route is not as hydraulically challenging as directly following Route 116 south from Amherst, there are still significant elevation changes and it is likely that pump stations and pressure reducing valves would be required to address differences in hydraulic grade.

Water purchased from the MWRA would be subject to the IBTA as MWRA water water supplies are located outside of the Connecticut River Basin. As such, all purchased water would be subject to the IBTA. The project would also be subject to review by the MEPA office as it consists of the construction of new water service across a municipal boundary. An Environmental Notification Form (ENF) and Environmental Impact Report (EIR) would need to be provided to MEPA. The project would also trigger MEPA review as it involves the installation of a pipeline that is greater than five miles long. A Permit to Access State Highway would be required from MassDOT to address the water main work on Route 9 and Route 116 and the Bay Road Bridge crossing over the Fort River.

Assuming a pipeline construction cost of $250 per linear foot and approximately 65,000 feet of pipeline, the cost of constructing just the pipeline for Amherst to purchase water from MWRA would be more than $16 million. This cost excludes land acquisition, pumping, storage and permitting costs and MWRA’s entrance fee.

5.4 Mitigation and Offsets to Withdrawals

5.4.1 Summary Matrix

Using the credit approach outlined in section 4.2.1, quantified offsets to mitigation and offsets to withdrawals were calculated for wastewater, stormwater, habitat and demand management improvements. A summary of the mitigation and offset volumes is provided in Table 5-8, compared with the withdrawal request above baseline. Potential mitigation and offsets to withdrawals represent the maximum mitigation/offset a PWS could achieve if these actions were implemented town-wide (where applicable) and include both direct and indirect offset calculations. Note that although the indirect offset calculation methodology in Appendix E discusses a cap of the withdrawal request on the portion that can be obtained from indirect offsets, a cap has not been included in the summary matrix. Phase 2 could provide further consideration of how the indirect mitigation/offsets could be applied to the existing and future permit terms. For example, can unused indirect mitigation/offsets associated with the cap be carried over into a future permit term and withdrawal request?

Table 5-8. Mitigation/Offset Summary Matrix for Amherst				
	Existing	Potential		
	Volume (gpd)	Volume (gpd)	Cost ($)	
Wastewater Offsets				
septic systems	18,705	-	$	-
groundwater discharges	-	-	$	-
infiltration	77,397	28,260	$	79,240
inflow		241		
water reuse - irrigation		120,000	$	-
private inflow removal program				
sewer bank (I/I offset) program				
wastewater enterprise account	6,930			
Wastewater Offset Total	103,032	148,501	$	79,240
Stormwater/Impervious Cover Improvement Offsets				
recharge impervious surfaces				
leaching catch basins				
reduce impervious surfaces				
roof leader disconnection				
rain barrels		16,793	$	2,074,800
stormwater bylaw with recharge requirements				
stormwater utility meeting environmental requirements	-	6,930		
implement MS4 requirements	-	6,930		
Stormwater Offset Total	-	30,653	$	2,074,800
Habitat Improvement Offsets				
install and maintain a fish ladder	-	-		
remove a dam or other flow barrier	-	9,818		
acquire/protect lands	-	-		
culvert replacement	-	-		
streambank restoration	-	-		
tree canopy	-	-		
mitigation fund	-	-		
Habitat Improvement Total	-	9,818		-
Water Supply Improvement / Demand Management				
outdoor watering restrictions	-	892,832	$	-
irrigation audits	-			
irrigation sensors	-			
irrigation bylaw	-			
faucet aerators	-	65,329	$	123,480
low flow faucets	-	-	$	-
low flow showerheads	-	571,630	$	164,640
low flow toilets (1.6 gpf)	-	-	$	-
HE toilets (1.28 gpf)	-	228,877	$	617,400
watersmart washing machines	-	87,958	$	823,200
watersmart dishwashers	-	9,698	$	823,200
commercial water audits	-			
municipal building retrofits	-	5,775		
pistol grip hose nozzles	-	5,775		
water bank	-	6,930		
water supply enterprise account	-	6,930		
water conservation rates	-	5,775		
monthly billing/radio-read meters	-	5,775		
conservation education/outreach	-	5,775		
Demand Management Total	-	1,899,059	$	2,551,920
Total Potential Mitigation/Offset	**103,032**	**2,088,031**	**$**	**4,705,960**
Total Withdrawal Request Above Baseline		**640,000**		

Notes:

1. All mitigation options discussed in this report are included in the table. Values are only provided for those options that could be quantified for the PWS using available information.

2. Indirect offsets are shaded and are included in the total. A cap has not been applied to indirect offsets.

3. Demand management offsets assume assumed that demand management options could be applied to all 'applicable' households (e.g., where not currently applied). Refer to Section 5.4.6. Actual savings should be based on the actual number of households the options are applied to.

4. Stormwater/impervious cover improvement offsets include those that could be readily quantified under Phase 1. Other stormwater options could be considered under Phase 2.

5. Habitat improvement offsets include those that could be readily quantified under Phase 1 and include removal of the Bartlett FishRod Company dam.

The purpose of this matrix is to provide the PWS with an understanding of what options are available to them, the cost associated with these options and provide them with a tool to select those that work best for the PWS to meet its mitigation requirements. For additional information on the offset calculations, refer to the following sections, the methodology in Appendix E and the Amherst specific worksheet calculations in Appendix F.

5.4.2 Instream Flow/Surface Water Releases

Withdrawals from Dean and Nurse Brooks to fill Atkins Reservoir are made through flood skimming to maintain flow in the source brooks. A more detailed analysis may identify limited opportunities to better utilize storage and maintain flow in the Atkins Reservoir. Dams and surface water impoundments in and around Amherst were inventoried and a screening analysis conducted to evaluate potential mitigation scenarios. Factors that were considered included proximity to current water supply, ownership and feasibility or status issues related to dam removal, management of releases and downstream impacts.

In the Amherst area, 11 dams were identified, four of which were automatically eliminated due to private ownership (see Table 5-9). Of the remaining 7 dams, 2 were in a different subbasin and have limited storage capacity and are used for recreation, one is already scheduled to be removed, and the remaining four dams are already associated with the Amherst water supply system including the Pelham Reservoir System and Atkins Reservoir System.

An analysis of the feasibility of releases from the Pelham (Centennial) Reservoir System and Atkins Reservoir would be evaluated as part of the Surface Water Transition Rule. The Pelham Reservoir System has limited storage and typically spills into Amethyst Brook. Additional releases are not likely to be sustainable without emptying storage and increasing groundwater withdrawals. The Atkins Reservoir is considered off-line storage with a limited watershed of its own. When the reservoir is not being filled from Dean and Nurse Brooks it is not significantly impacting streamflow. USGS evaluated the impact of making controlled releases from Amherst's reservoirs on the reservoir system firm yield. The release scenarios modeled included no releases and year round controlled releases equal to the tenth and twenty fifth percentile monthly inflow. These release scenarios reduced firm yield to below historical average annual usage. (USGS Refinement and Evaluation of the Massachusetts Firm-Yield Estimator Model Version 2.0). More study would be needed to determine if there is a feasible release scenario and to balance the benefits of that scenario against the resulting increase in groundwater withdrawals.

Table 5-9. Amherst Surface Water Release Summary			
Dam	**Ownership**	**Proximity to Water Supply**	**Feasibility**
Puffer's Pond Dam (Factory Hollow Dam)	Amherst ConCom	Different Subbasin	Different Subbasin Limited Storage
Owens Farm Pond Dam	Amherst ConCom	Different Subbasin	To be Removed
Market Pond Dam	Amherst DPW	Different Subbasin	Different Subbasin Limited Storage
Hill Reservoir Dam	Amherst DPW	Pelham Reservoir System	Reduces available surface water supply
Hawley Reservoir Dam	Amherst DPW	Pelham Reservoir System	Reduces available surface water supply
Intake Reservoir Dam	Amherst DPW	Pelham Reservoir System	Reduces available surface water supply
Akins Reservoir Dam	Amherst DPW	Atkins Reservoir System	Reduces available surface water supply
University Pond Dam	Mass-DHE	Different Subbasin	Not in Amherst's control
Epstein Pond Dam	Balderwood Realty Trust	Different Subbasin	Not in Amherst's control
Ice Pond Dam	Privately Owned	Different Subbasin	Not in Amherst's control
Echo Hill Association Pond Dam	Privately Owned	Different Subbasin	Not in Amherst's control

5.4.3 Wastewater

As noted above, the majority of development in Amherst is connected to the municipal sewer system. The Amherst WWTP discharges directly to the Connecticut River, downstream of the PWS groundwater withdrawal wells. There are a few areas that are served by on-site septic systems, which provide groundwater recharge within the Connecticut River Basin. These systems, and opportunities for I/I reduction are described below. In addition, UMass plans to further treat wastewater effluent from the Amherst WWTP for reuse to irrigate its athletic fields. The potential credits for wastewater in Amherst, based on the wastewater credit methodology described in Section 4.2, are summarized in Table 5-10 and further described in the table below.

TABLE 5-10. Wastewater Credit Methodology			
Potential Wastewater Credit Summary Amherst		Total Wastewater Flow (gpd)	Total Flow Offset Volume (gpd)
1	Septic Systems	74,820	18,705
2	Groundwater Discharges	0	0
3	Infiltration	845,258	105,657
4	Inflow	1,927	241
5	Water Reuse - Irrigation	120,000	120,000
6	Indirect Offsets: Wastewater Enterprise Fund		6,930
	Total Potential Wastewater Credit		251,533

5.4.3.1 Groundwater Recharge to Connecticut River Basin

Based on Amherst's Draft 2011 Sewer Extension Master Plan, approximately 800 developed lots in Amherst are currently served by septic systems. The 2011 plan assessed 15 study areas for wastewater needs and consideration for sewer extension or increased capacity needs. Two of the study areas were already sewered. Three of the remaining areas were proposed to be sewered, including Harkness Road Area (Study Area 2), Wildflower Drive Area (Study Area 6) and the Centennial Water Treatment Plant Areas (Study Area 15) in Pelham. These areas were not considered for groundwater recharge credit. The remaining areas, comprising approximately 555 developed lots that are currently served by on-site septic systems, were considered for wastewater-related credit based on the methodology described in Section 4. All of these study areas are located within the Connecticut River Basin, but are not located within the PWS groundwater withdrawal subbasins (14056 and 14061). See Amherst Wastewater Infrastructure Figure 5-4.

In Amherst's 2005 Sewer Extension Master Plan, the High Point Drive Area (subarea 8) was considered for a decentralized groundwater treatment and discharge system due its distance from existing sewer system. A collection system would need to be constructed to convey flows to a package treatment plant for treatment and disposal. The new treatment and groundwater disposal facility would be designed for an estimated existing and future flow of approximately 20,460 gpd. A siting analysis was not performed, but due to the additional infrastructure needs to construct a collection system and new treatment and disposal system, a decentralized system was not considered to be cost effective. This potential groundwater discharge was not considered for wastewater credit.

One option for potential groundwater recharge that was discussed at the first meeting with the PWS, was groundwater recharge of treated wastewater via well injection at the site of an abandoned wellfield located in the Brickyard Conservation area. This wellfield consists of 13 shallow wells, and is located 0.5 miles west of the capped Amherst Landfill. The wellfield was closed in 1980 for several reasons including its shallow depth, poor water quality and high operating costs. This well field is located downstream of the Amherst's active wellfields. This option has not been assessed; however, costs associated with this option include approximately $5 Million for extension of a treated effluent return line approximately 4 miles from the Amherst WWTP to the wellfield. There may be potential additional treatment costs to meet MassDEP's groundwater discharge requirements.

5.4.3.2 Infiltration/Inflow Removal

Since 2003, Amherst has been addressing I/I into the sewer system. In 2007, Amherst purchased a new camera, and typically performs TV inspections of some portion of their sewer system one day a week to identify I/I issues. The Town DPW also has a pipe patching system for slip lining sections of mains and joints and equipment for manhole grouting to address infiltration and inflow into the municipally-owned sewer system. Based on information provided by Amherst, the infiltration/inflow removal efforts have removed 266 million gallons per year of peak flow from the wastewater treatment plant at a cost of $39,620. This equates to approximately 0.5 mgd (assuming average flow is 75% of peak flow/ 365 days per year). The town is currently focusing on improvements to the system in downtown Amherst, targeting an additional 0.23 mgd of infiltration entering the sewer system. See Amherst Wastewater Infrastructure Figure 5-4 for the target I/I locations.

The Town identified approximately 42 houses in the Orchard Valley subdivision with drains or sump pumps connected to the sanitary sewer systems. The Town may be eligible for credit if these drains and sump pumps are disconnected from the sanitary sewer system and directed to the ground or infiltrated.

5.4.3.3 Water Reuse - Irrigation

The Amherst WWTP is located adjacent to the UMass Amherst campus. UMass currently takes approximately 100,000 to 120,000 gpd of treated effluent, and further treats the wastewater through a reverse osmosis system. This treated effluent is then used for boiler feed and generator make-up water at UMass' Central Heating Plant. UMass is looking to expand its use of treated wastewater for the Central Heating Plant's cooling towers and for irrigating its athletic fields. UMass anticipates that these uses would require an additional 100,000 to 120,000 gpd of treated effluent. UMass is in the permitting process with MassDEP for water reuse. The water quality for reuse for cooling tower water and irrigation need to meet the most stringent Class A standards due to the potential for human contact. At this time, it is unknown what percentage of the additional 120,000 gpd of reuse water would be used for irrigation. The potential credit for water reuse for irrigation assumes the full 120,000 gpd would be used for irrigation purposes.

5.4.3.4 Surface Water Discharge

There are no surface water discharges upstream or within the Zone II of Amherst's groundwater withdrawals.

5.4.3.5 Other Potential Wastewater Credits

The Amherst sewer department operates under a wastewater enterprise fund. They do not currently have an I/I offset program (sewer bank).

5.4.4 Stormwater/Impervious Cover

Section 4.2.2.3 outlines stormwater mitigation options to help offset withdrawal requests. Table 5-11 summarizes those that are applicable to Amherst and could be readily quantified under Phase 1 of the Pilot Project. These include the distribution of rain barrels, implementation of a stormwater utility, and implementation of MS4 requirements.

Table 5-11. Stormwater/Impervious Cover Improvement Offsets in Amherst

	Offsets Completed to Date		Potential Offsets		
	Quantity	Volume (gpd)	Quantity	Volume (gpd)	Cost
Rain barrels			8,645 households[1]	16,793	$2,074,800
Stormwater utility				6,930	
Implement MS4 requirements				6,930	

[1]Estimated households on the public water supply in 2010. For the purposes of estimating potential water savings through future mitigation actions, it was assumed that all households could receive rain barrels to reduce water demands. Actual savings should be based on the actual number of households receiving rain barrels.

Currently, about 36% of the Town remains to be developed. Figure 5-11 shows undeveloped land and hydrologic soil groups (HSGs). The soil groups determine the recharge potential for future development, with A and B soils offering high recharge potential and C and D soils less recharge potential. The figure shows there is still a significant amount of undeveloped land in A and B soils, particularly in the northern and eastern portions of Town. Requiring more stringent recharge regulations as discussed in Section 4.2.2.3, that apply town-wide, could help offset future withdrawal requests, as well as help to minimize peak stormwater flows to streams, which have other negative environmental impacts.

For demonstration purposes, more stringent recharge regulations were applied to two of the four pilot PWSs, Danvers-Middleton and Shrewsbury, and revealed potential water savings due to recharge of 2.59 mgd and 2.36 mgd, respectively. Similarly, potential water savings due to recharge could be quantified for Amherst under Phase 2 of the Pilot Project.

Other stormwater mitigation options could be considered in Phase 2. For example, potential savings may be realized from a roof leader disconnection program; the potential savings could be explored using a GIS overlay analysis and the assumptions outlined in the methodology presented in Section 4.2.2.3. The applicability of other mitigation options (e.g., sites where existing impervious surfaces can be eliminated or directed to recharge) may require specific site evaluations.

UMass Amherst has a program to implement stormwater controls throughout the campus, however, specific information was not available during this Pilot Project to estimate mitigation credits. Amherst could work with UMass Amherst to collect more detailed information for supporting existing and future mitigation credits.

5.4.5 Habitat Improvements

There are two dams in the area currently in the process of obtaining approval for removal. These include the publicly owned Owens Farm Pond Dam in Amherst and the privately owned Bartlett Fishrod Company Dam on Amethyst Brook in Pelham. Both are outside of the subbasin where the water supply wells are located, but within the Connecticut River Basin.

In conjunction with the dam removal at Owens Farm Pond, a natural stream channel outlet will be constructed to replace the existing control structure and associated pipe and a single vegetated wetland creation area (1,800 s.f.) will be constructed to compensate for permanent impacts to wetland resource areas.

Of the estimated 149 stream culverts within the town, 14 have been evaluated for habitat and stream continuity and included in the New England Road Stream Crossing Inventory Database. Under the offset criteria established in Section 4.0, only those culverts posing a "moderate" or greater barrier to habitat continuity are eligible for an offset credit if replaced. Of the 14 evaluated in Amherst, only one was identified as posing a "moderate" barrier or greater as identified in Table 5-12. This culvert is located on Southeast Street on the Fort River. Information regarding any planned culvert replacement projects was not reviewed at this time.

Table 5-12. Results of Culvert Assessments in Amherst, Massachusetts

Location	Qty.	Type	Barrier	Stream Name
Belchertown Rd	1	Bridge with abutments	Full Passage	Fort River
Main St	1	Bridge with side slopes & abutments	Minor	West Brook
Main St	1	Bridge with side slopes	Minor	West Brook
Main St	1	Bridge with abutments	Minor	West Brook
Main St	1	Elliptical culvert	Minor	West Brook
Main St	1	Box culvert	Minor	West Brook
Main St	1	Open bottom arch	Minor	West Brook
Main St	1	Round culvert	Minor	West Brook
Off Stanley St	1	Bridge with side slopes	Insignificant	Fort River
Pelham Rd	2	Bridge with abutments	Insignificant	Fort River
Railroad/Boston MA	1	Bridge with abutments	Insignificant	Fort River
Railroad/Vermont Central	1	Bridge with side slopes	Full Passage	Fort River
Rt 116/Mill Valley	1	Bridge with abutments	Insignificant	Fort River
Southeast St	4	Elliptical Culverts	Moderate	Fort River

Based on the number of dams and culverts located within the Town, there is the potential to obtain mitigation credits through improvements to these structures, however, this would require further assessment to determine the need for (e.g., is it currently a detriment to habitat) and the level of improvement needed. This is beyond the scope of this Pilot Project.

5.4.6 Demand Management

The Town of Amherst has been very fortunate in that it has sufficient supply to meet the demands of its customers without the need for an extensive water conservation program. Residential gallons per capita day (RGPCD) has been maintained at about 58 RGPCD between 2008 and 2010 and most recently reported at 51 RGPCD. Unaccounted-for-water has ranged between 14 and 18% between 2008 and 2010 and most recently reported at 13%.

The Town has retrofitted many of its municipal buildings with low-flow devices through a program that started in 2003.

UMass Amherst provided information regarding its demand management efforts on campus. This information documented that UMass Amherst has installed low flow devices including 2,300 low-flow toilets, 238 low-flow urinals, and 2,950 low-flow faucets, and has a proposal in place to retrofit residence hall showerheads for an estimated savings of almost 3 million cubic feet per year (or over 22 million gallons per year).

Amherst DPW Water Division is currently in the process of a meter change-out program to install radio-read meters. About 1,000 meters have been replaced at this time and complete change-out is expected within the next five years. Amherst DPW Water Division is considering changing from quarterly to monthly billing once the meter change-out program is complete.

The mitigation credit available from existing demand management activities is included in Table 5-13, along with potential credits. As shown in Table 5-13, the Town has a lot of demand management options available to help offset the 0.64 mgd additional withdrawal request in this pilot. Note that these potential savings would be higher than the requested withdrawal increase, allowing the Town to pick and choose the options that best fit their needs to meet the 0.64 mgd offset.

Note that the summer to winter ratio of demand could be added in a chart for each town in Phase 2 to indicate how much is potentially related to outdoor water use.

Table 5-13. Demand Management Offsets in Amherst							
	Existing		Potential				
Water Supply Improvement / Demand Management	**Number of Households (#)**	**Volume (gpd)**	**Number of Households (#)**	**Volume (gpd)**	**Cost ($)**	**Revenue Loss ($/year)**	**Notes**
outdoor watering restrictions	-	-	9,259	892,832	$0	$424,988	
irrigation audits	-	-					
irrigation sensors	-	-					
irrigation bylaw	-	-					
faucet aerators	-	-	8,232	65,329	$123,480	$95,381	
low flow faucets	-	-	-	-	-	-	
low flow showerheads	-	-	8,232	571,630	$164,640	$834,580	
low flow toilets (1.6 gpf)	-	-	-	-	-	-	
HE toilets (1.28 gpf)	-	-	8,232	228,877	$617,400	$334,160	
watersmart washing machines	-	-	8,232	87,958	$823,200	$128,419	
watersmart dishwashers	-	-	8,232	9,698	$823,200	$14,159	
commercial water audits	-	-					
municipal building retrofits	-	-		5,775			indirect
pistol grip hose nozzles	-	-	8,232	5,775			indirect
water bank	-	-		6,930			indirect
water supply enterprise account	-	-		6,930			indirect
water conservation rates	-	-		5,775			indirect
monthly billing/radio-read meters	-	-		5,775			indirect
conservation education/outreach	-	-		5,775			indirect
TOTAL		0		1,899,059	$2,551,920	$1,831,687	

Notes:

1. All mitigation options discussed in this report are included in the table. Values are only provided for those options that could be quantified for the PWS using available information. For the purposes of estimating potential water savings through future mitigation actions, it was assumed that demand management options could be applied to all ‘applicable’ households (e.g., where not currently applied). Actual savings should be based on the actual number of households the options are applied to.

2. Potential demand management offsets were based on the following:

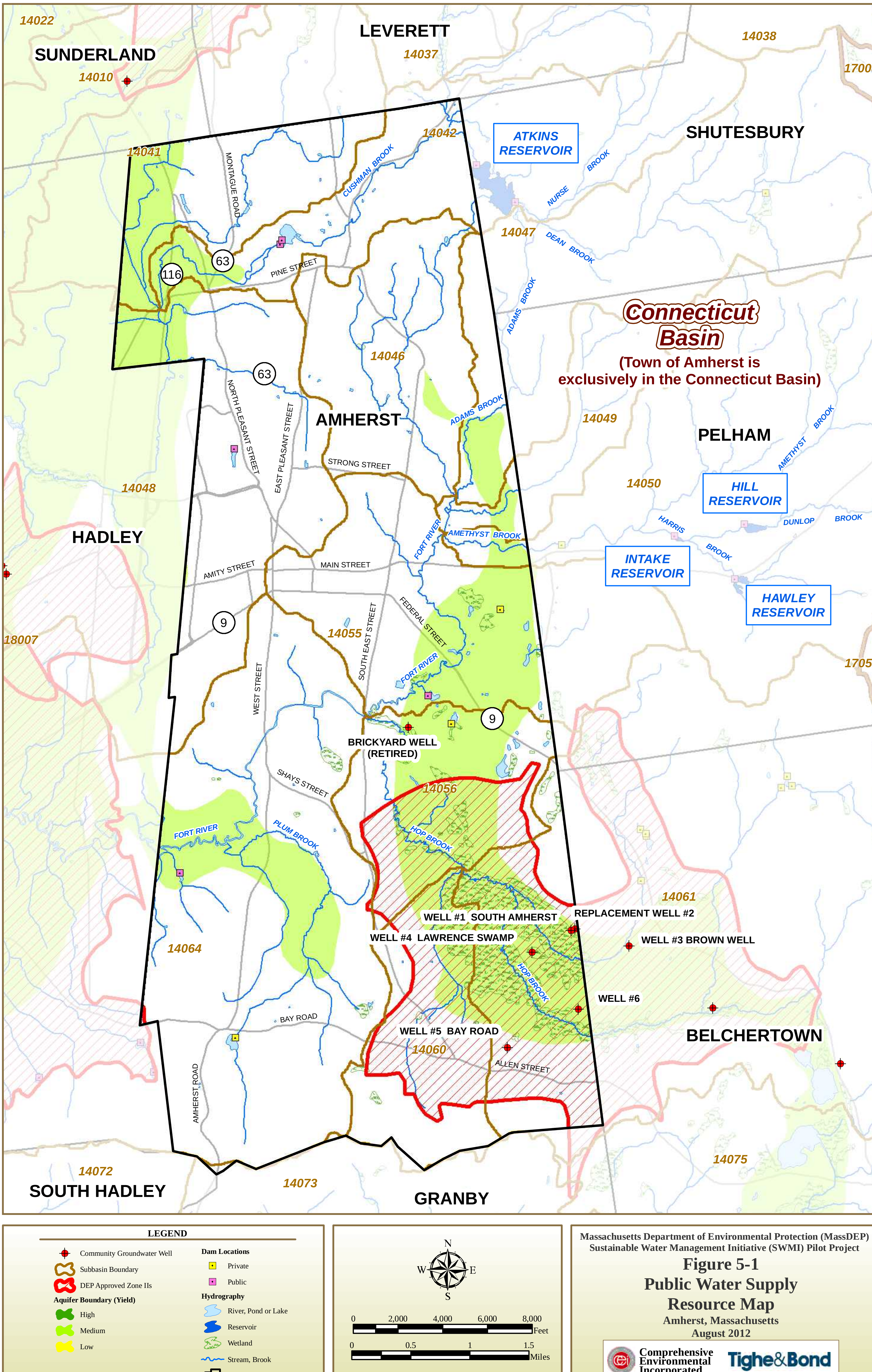
   a. outdoor watering restrictions would be applied to all households (9,259), whether or not on the public water supply. There were 9,259 households in Amherst in 2010 according to U.S. Census at factfinder2.census.gov. 8,645 households were estimated to be on the public water supply (2010 population served from ASR report divided by average household size from U.S. Census – 21,095/2.44 = 8,645). Assumes watering restricted to 2 days/week (mid-May through mid-September).

   b. water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,232 households on the public water supply in 1990 (calculated using same ratio as 2010 = 8,645 households on PWS/9,259 total households x 8,816 households in 1990 (from U.S, Census) = 8,232 households on PWS in 1990.

   c. the greater water savings and less expensive options were selected for implementation where more than one option existed (e.g., aerators are cheaper than faucets, HE toilets are more efficient than low flow.

3. Revenue losses are calculated as the reduced water demand volume multiplied by the water rate, assuming the full potential is achieved. Actual revenue losses will be based on actual reduced water demand volume. Amherst Water Division's rate as of July 1, 2012 was $3.35 per 100 cubic feet. This calculates to $0.004 per gallon.

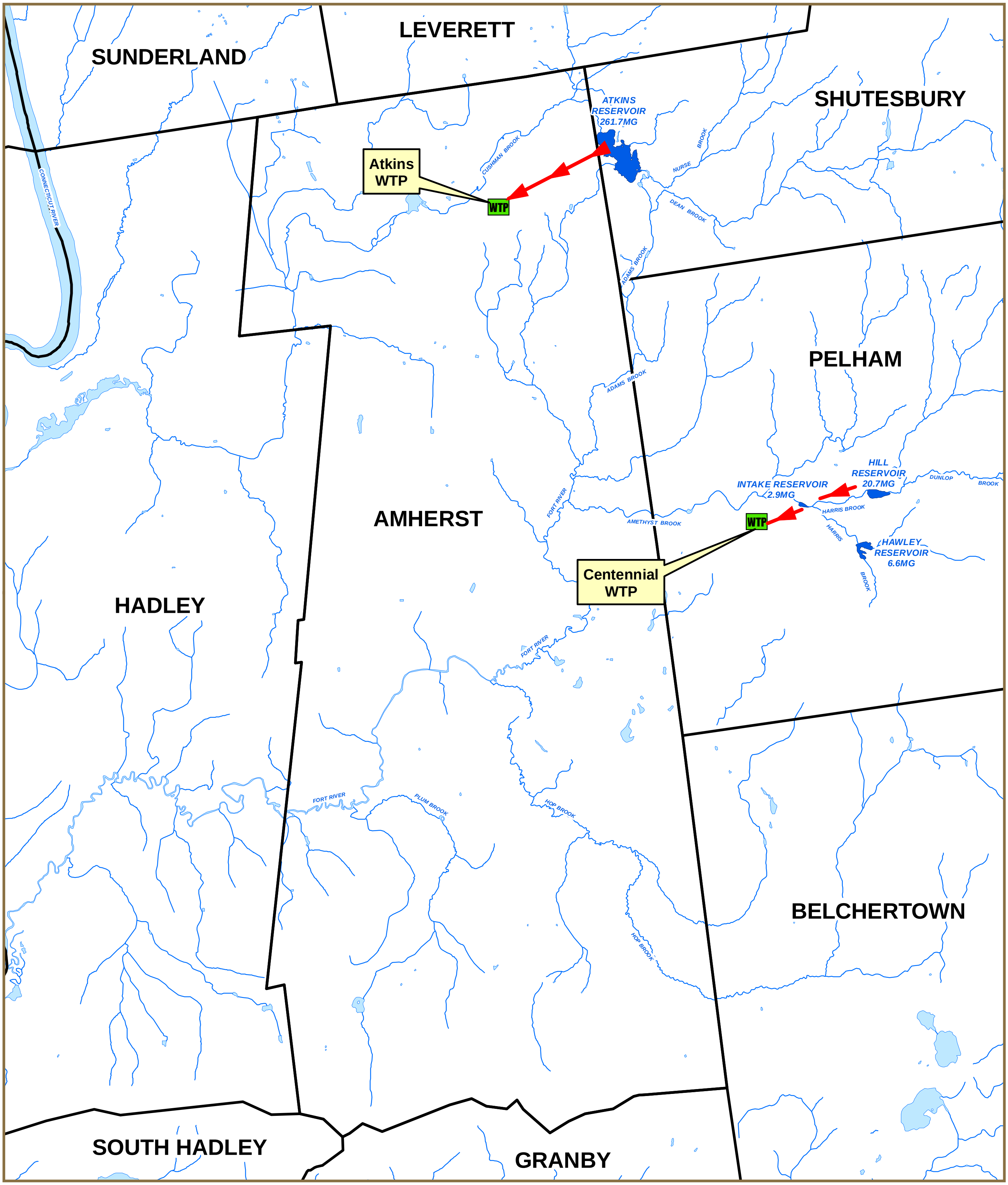
4. Note that water volume savings calculated using the indirect method in Appendix E will result in the same volumes for many items.



Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 5-1
Public Water Supply Resource Map
Amherst, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Town Boundary

Note: MG = Usable Storage

N W E S

0 6,000 Feet

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 5-2
Amherst Reservoir Map

Amherst, Massachusetts
August 2012

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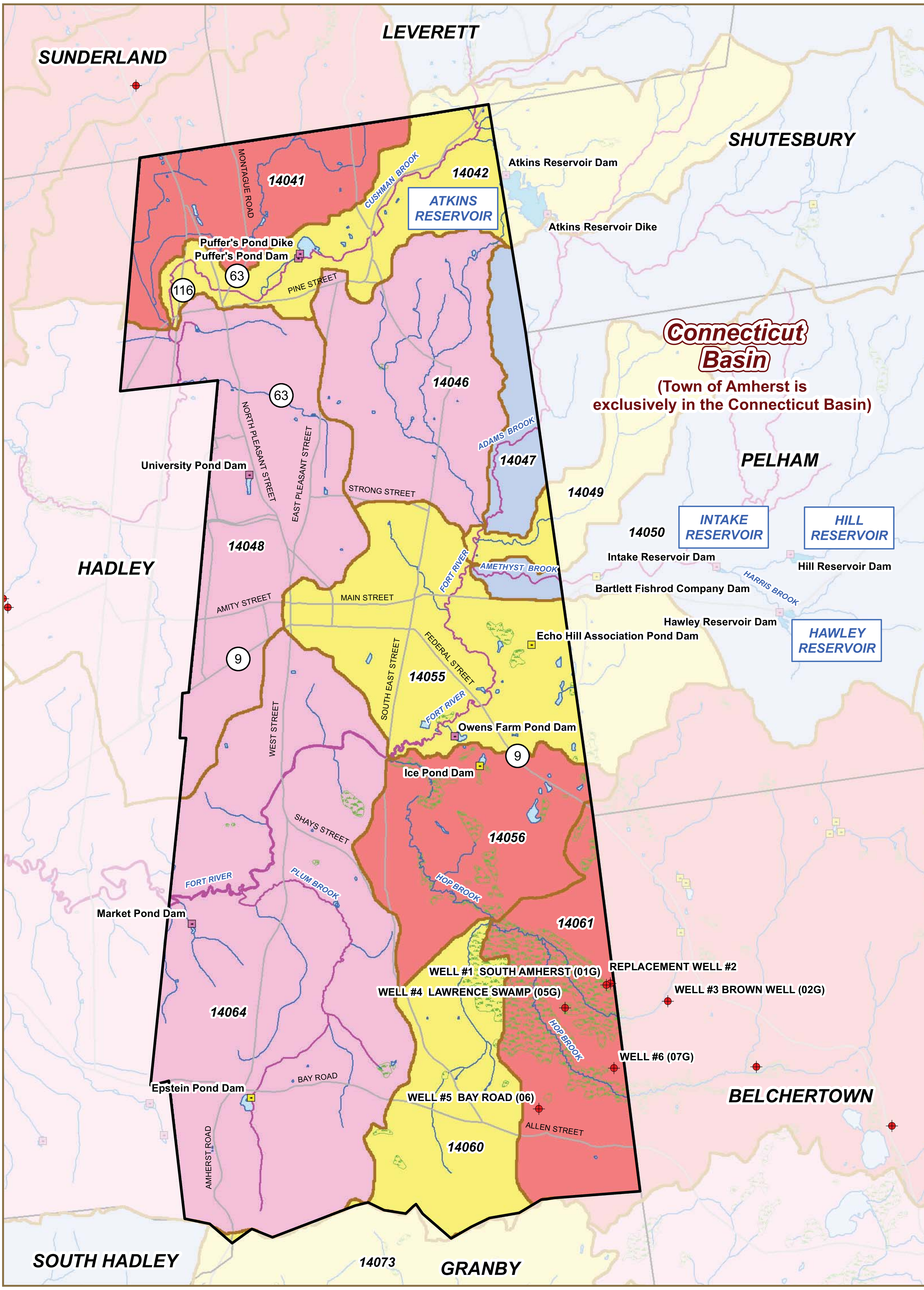
Tighe&Bond



LEGEND

- Community Groundwater Well
- Coldwater Fishery Resource
- Subbasin Boundary

Biological Categories

- No Data Available
- 1
- 2
- 3
- 4
- 5

Dam Locations

- Private
- Public

Hydrography

- River, Pond or Lake
- Reservoir
- Wetland
- Stream, Brook
- Town Boundary

N W E S

0 2,000 4,000 6,000 8,000 Feet

0 0.5 1 1.5 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 5-3

Natural Resources and Habitat

Amherst, Massachusetts
August 2012

Comprehensive Environmental Incorporated
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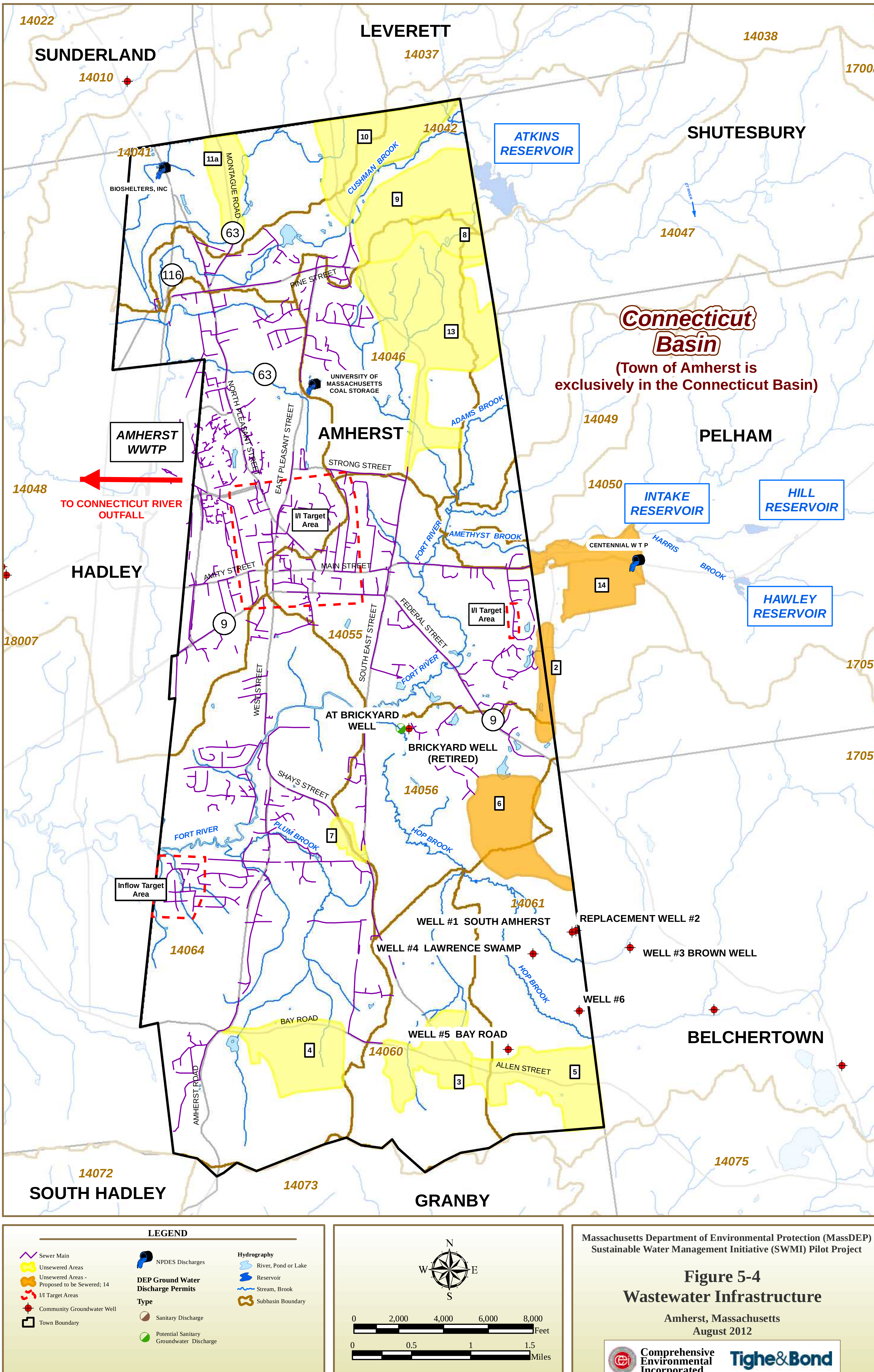
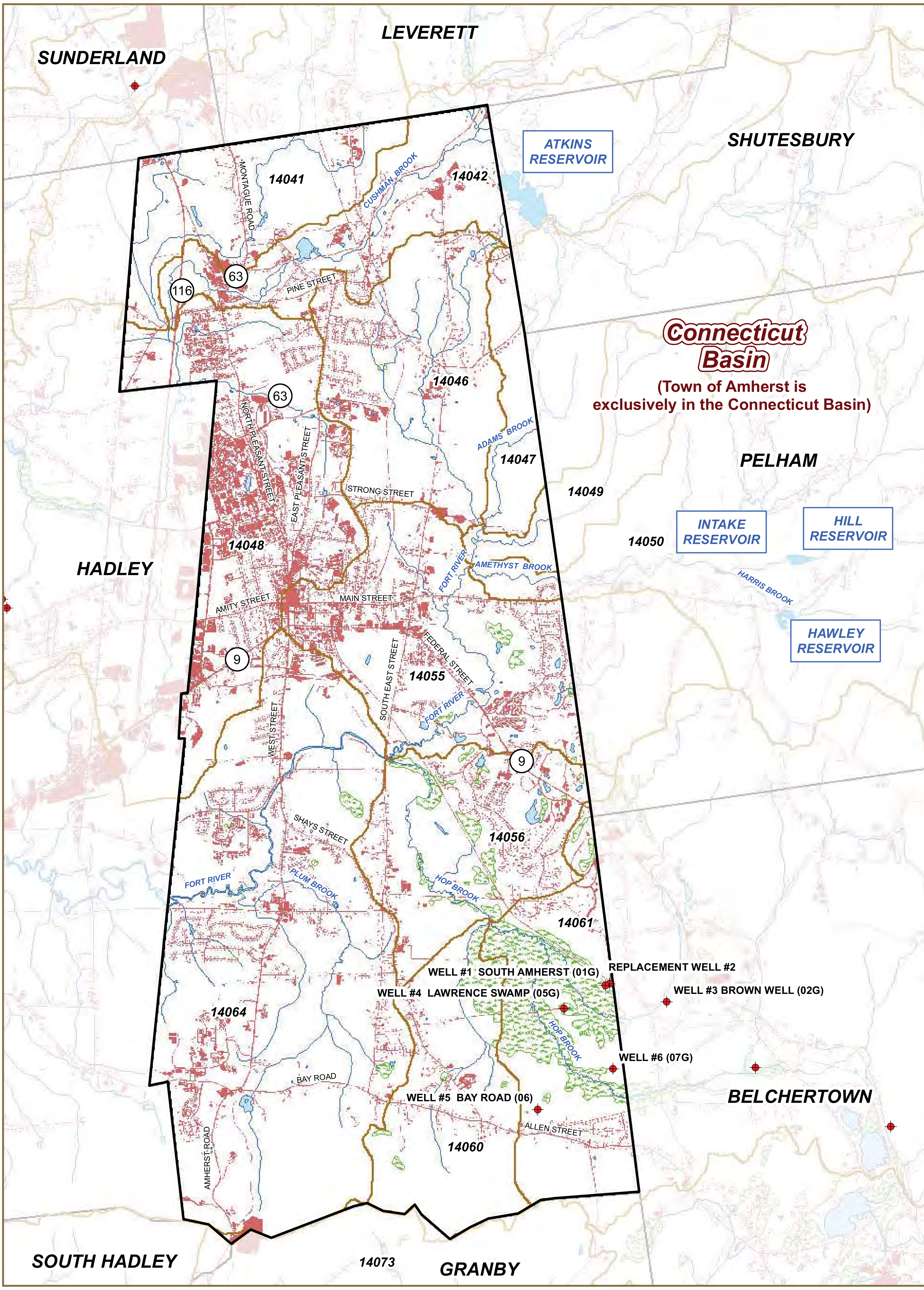


Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 5-4
Wastewater Infrastructure

Amherst, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Subbasin Boundary
- Impervious Cover
- Town Boundary

Hydrography

- River, Pond or Lake
- Reservoir
- Wetland
- Stream, Brook

N
W E
S

0 2,000 4,000 6,000 8,000 Feet

0 0.5 1 1.5 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

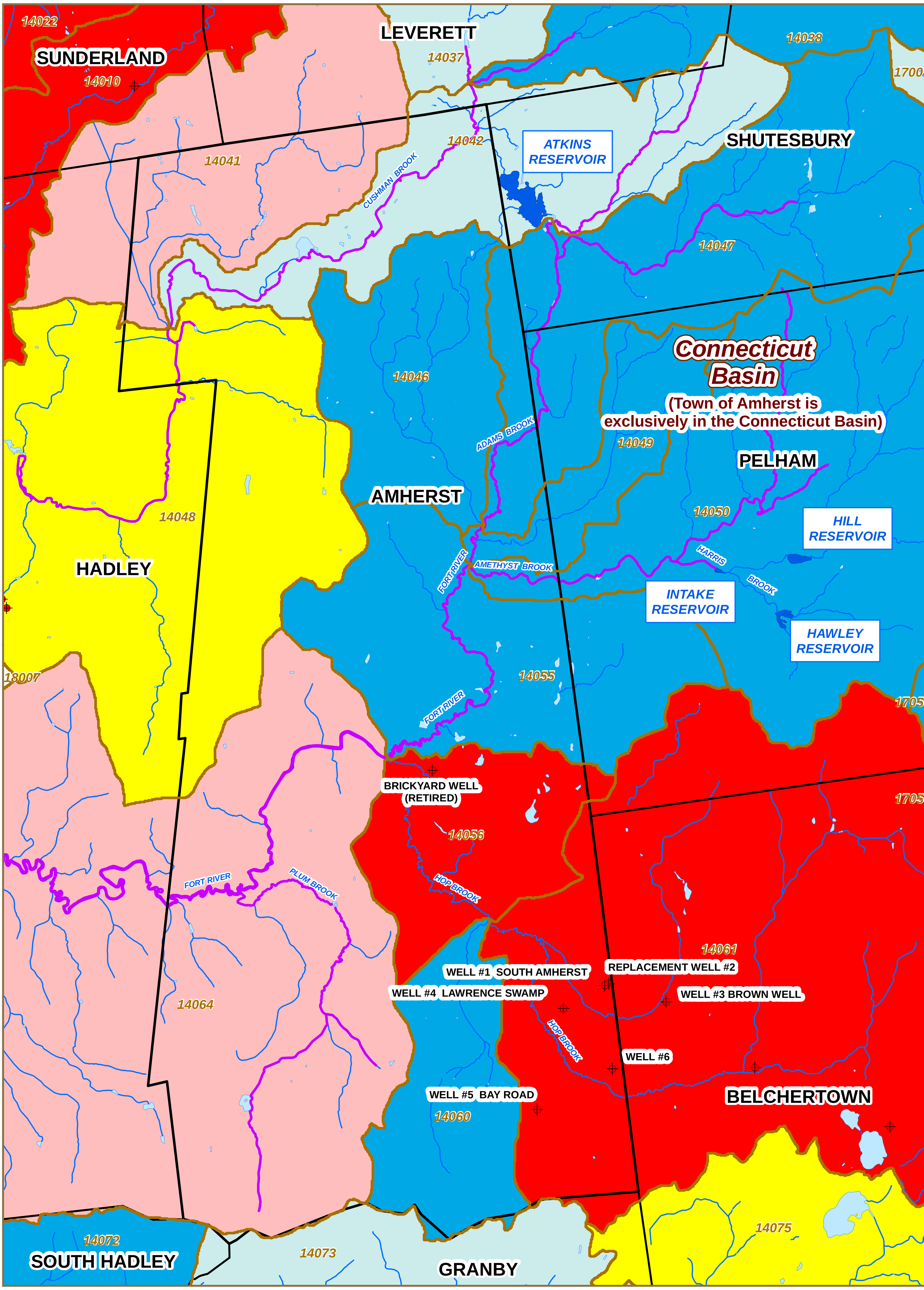
Figure 5-5

Impervious Cover

Amherst, Massachusetts
August 2012

Comprehensive Environmental Incorporated

Tighe&Bond



LEGEND

Flow Level, % GW Alteration

- No Data
- 1 0 - 3%
- 2 3 - 10%
- 3 10 - 25%
- 4 25 - 55%
- 5 >55%
- Subbasin Boundary

- Community Groundwater Well
- Coldwater Fishery Resource

Hydrography

- Pond, Lake
- Reservoir
- Stream, Brook
- Town Boundary

N W E S

0 2,000 4,000 6,000 8,000 Feet

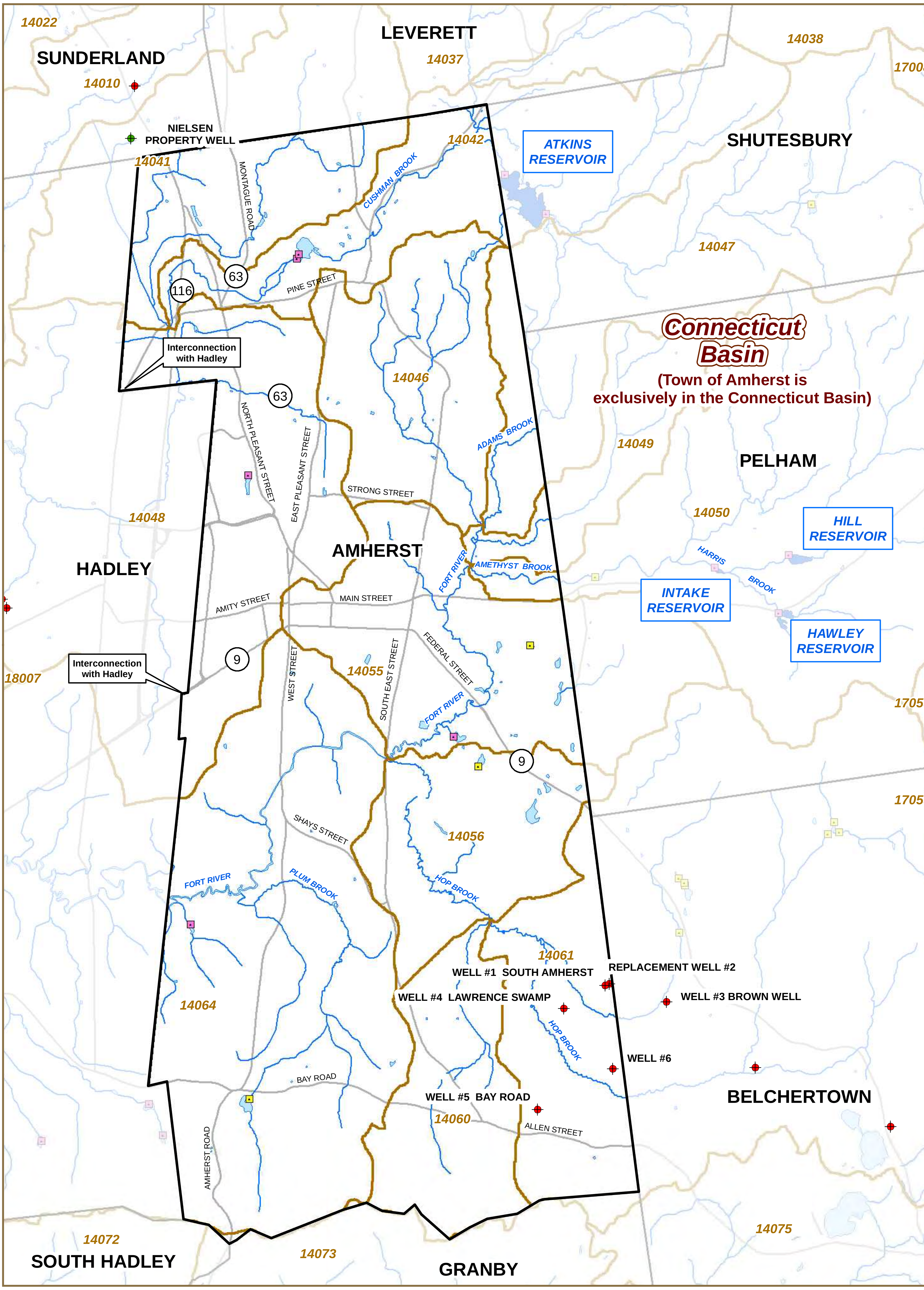
0 0.5 1 1.5 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 5-6
Flow Levels Map

Amherst, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Potential Community Groundwater Well
- Subbasin Boundary

Dam Locations

- Private
- Public

Hydrography

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Town Boundary

N E S W

0 2,000 4,000 6,000 8,000 Feet

0 0.5 1 1.5 Miles

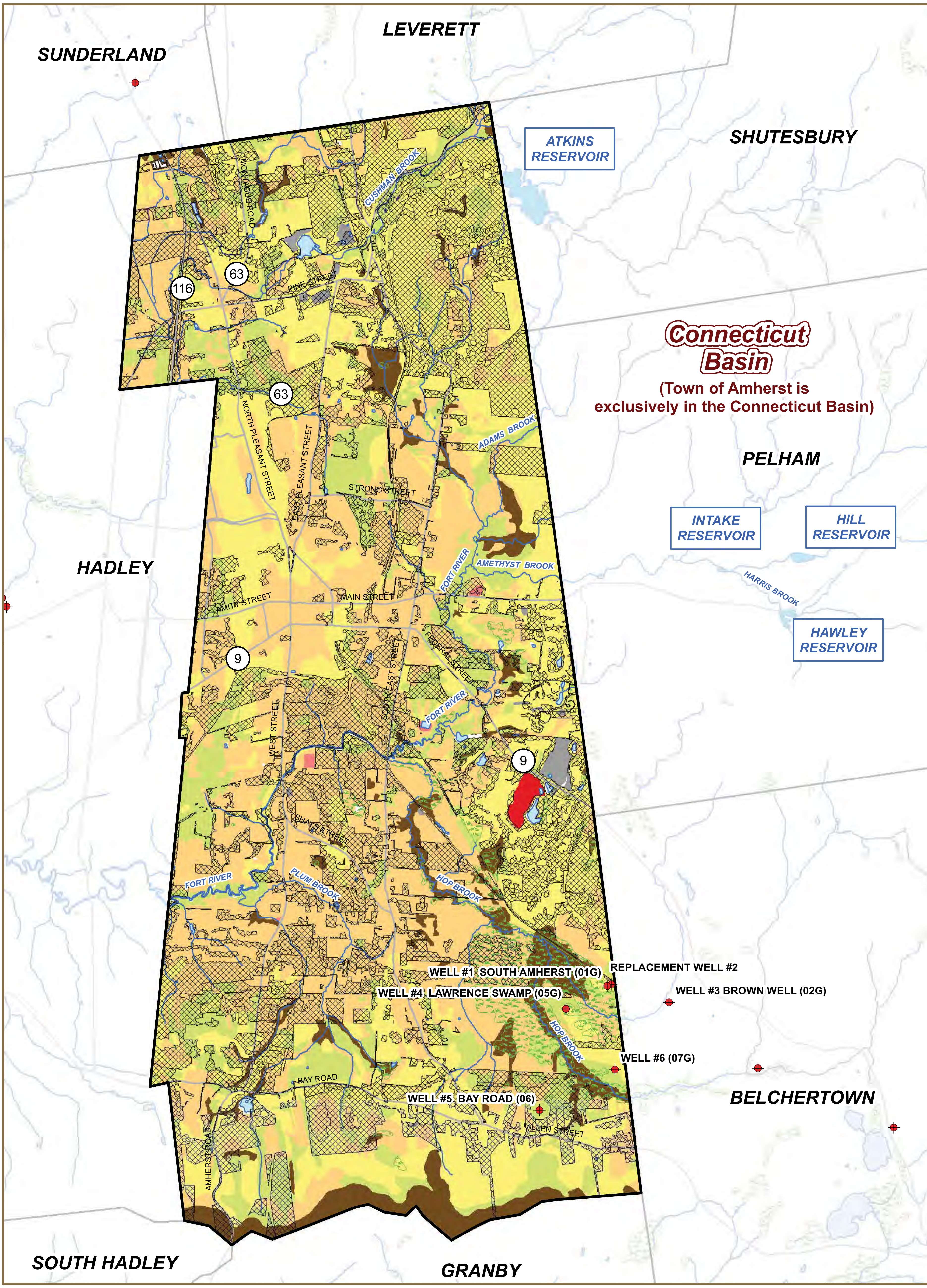
Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 5-10
Alternative Sources Map

Amherst, Massachusetts
August 2012

Comprehensive Environmental Incorporated

Tighe&Bond



LEGEND

- Community Groundwater Well
- Potentially Developable Land

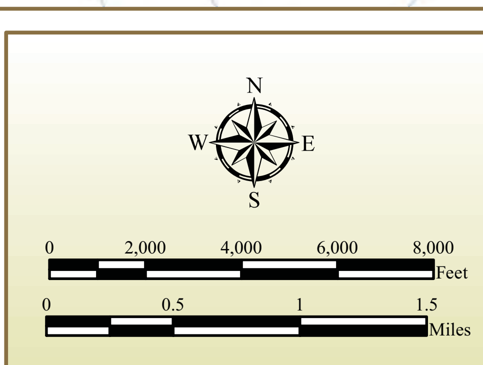
Hydrography

- River, Pond or Lake
- Reservoir
- Wetland
- Stream, Brook

Soils - Hydrologic Group

- A
- B
- C
- D
- Landfill
- Pits, quarry
- Urban Fill
- Town Boundary

Note: Potentially Developable Land excludes Protected and Recreational Open Space properties.



Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 5-11

Soils Characteristics, Undeveloped and Protected Lands

Amherst, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond

Section 6 Danvers-Middleton

The Pilot Project has applied the Draft Sustainable Water Management Initiative (SWMI) Framework to each of the Public Water Suppliers (PWSs) included in the study. This section describes its application to the Danvers-Middleton Water System. The application of the Draft SWMI Framework is based on review of data collected from the Massachusetts Department of Environmental Protection (MassDEP), the Towns of Danvers and Middleton, and the Massachusetts Division of Ecological Restoration (DER) as outlined in the annotated bibliography included in Appendix C.

The following summary describes relevant characteristics of the water system and its service area, discusses permitting considerations and requirements under the Draft SWMI Framework, identifies measures for minimizing impacts of withdrawals, and identifies potential mitigation and offset actions.

6.1 Town Characteristics

Understanding existing town characteristics is an essential step in identifying and applying the Draft SWMI Framework minimization and mitigation options discussed in Section 4.0. Existing conditions pertaining to water supply sources, local water resources and habitat, wastewater and stormwater is provided below, followed by specific discussions on the application of the Draft Framework.

6.1.1 Water Supply Sources

The primary supply for the Danvers-Middleton system is the Vernon C. Russell Water Treatment Plant (WTP). As illustrated on Figure 6-1, the treatment plant draws raw water from Middleton Pond. Storage in Middleton Pond can be supplemented with water pumped from Emerson Brook Reservoir in Middleton and a small seasonal amount from Swan Pond in North Reading. Swan Pond is upstream of, and in the same subbasin as, Middleton Pond. The combined usable storage in Emerson Brook Reservoir and Middleton Pond is approximately 710 MG. Danvers-Middleton's Water Management Act (WMA) permit indicates that the Firm Yield of the reservoir system is 3.51 mgd.

In addition to these surface water supplies, the Danvers-Middleton system has two water supply wells, as illustrated on Figure 6-2. Both of these wells were constructed during 1960–1961 and are in subbasin 21019 of the Ipswich River Basin. In 2003, a greensand filtration plant was built at Well No. 2 to remove iron and manganese. In 2004, Well No. 1 was rehabilitated with two new replacement wells. If necessary, water may also be purchased from the cities of Beverly and Peabody through several interconnections (Danvers 2010 Water Quality Report).

Danvers-Middleton's current WMA Permit was approved as the result of a Settlement Agreement between the Towns of Danvers and Middleton, MassDEP, the Ipswich River Watershed Association, the Essex County Greenbelt Association, and twelve private citizens (Danvers WMA Settlement, Danvers WMA Permit). The negotiated permit includes:

- Annual and maximum daily withdrawal volumes
- Source protection requirements
- Approved firm yield for the Middleton Pond reservoir system
- A Streamflow Maintenance Plan that incorporates operating restrictions for groundwater withdrawals based on flow at the USGS stream gauge on the Ipswich River at South Middleton. The plan includes seasonal threshold flows which determine if and when the wells must be shut off, pumped only every other day, or may be used at their full approved rates.
- Streamflow triggered outdoor/nonessential water use restrictions, including non-regulated private irrigation wells.
- Performance standards:
    - Unaccounted for Water <10%
    - Residential per capita consumption < 65 gpcd
    - May 1 – Sept 30 total water use < 587.52 MG (avg. = 3.84 mgd)
    - Restriction of unregulated irrigation wells in the Ipswich River Basin based on streamflow thresholds.
- Enhanced water conservation and water use mitigation plan

Table 6-1 summarizes pertinent information regarding the authorized withdrawal volumes of Danvers-Middleton's sources of supply. As indicated, the system has a registered volume of 3.14 mgd and a permitted volume of 0.58 mgd for a total authorized withdrawal volume of 3.72 mgd.

Table 6-1. Danvers-Middleton - Sources of Supply

Source	MassDEP ID	Subbasin	WMA Permit Limits (mgd)		WMA Permit + Registration Annual Average (mgd)
			Annual Average	Maximum Day	
Well 1	3071000-01G	21019			
Well 1 North Replacement	3071000-03G	21019		0.86	
Well 1 South Replacement	3071000-04G	21019			
Well 2	3071000-02G	21019	0.58	0.98	3.72
Middleton Pond	3071000-01S	21018			
Swan Pond	3071000-02S	21018		6.5	
Emerson Brook Reservoir	3071000-03S	21020			
		Total	0.58	8.34	3.72

The average annual withdrawal from each supply over the past three years is summarized in Table 6-2. (Danvers ASRs).

Table 6-2. Danvers – Annual Production			
	Average Annual Production (mgd)		
Source	2009	2010	2011
Well 1 (emergency service)	0.26	0.43	0.41
Well 1 North Replacement			
Well 1 South Replacement			
Well 2	0.05	0.09	0.17
Middleton Pond	2.82	3.38	3.26
Swan Pond(1)	0	0.129	0.052
Emerson Brook Reservoir(1)	NA(2)	1.57	0.840
Total(3)	3.13	3.90	3.84

1. Transfers to Middleton Pond
2. Data not included in 2009 ASR
3. Excludes transfers to Middleton Pond

6.1.2 Local Water Resources and Habitat

Danvers' and Middleton's natural resources, habitat and infrastructure influencing habitat (e.g., dams and culverts) are shown on Figure 6-3.

Danvers-Middleton's sources are located within the Ipswich River Basin. The Ipswich River forms the westerly border separating Danvers and Middleton. Danvers-Middleton's groundwater sources are all located along the Ipswich River at the Middleton town line in subbasin 21019, which is designated as Biological Category 5 and Flow Level 5. There are no Coldwater Fishery Resources located within the subbasins that supply Danvers and Middleton.

Surface water supplies for the Danvers-Middleton Water System include Middleton Pond Reservoir which is augmented by Emerson Brook and seasonally by Swan Pond. Middleton Pond Reservoir is located in central Middleton and has a storage capacity of 705 million gallons (MG). It has a watershed area of 1.5 square miles and is located in subbasin 21018. Emerson Brook Reservoir is a 240-acre manmade impoundment located in western Middleton in subbasin 21020 with a storage capacity of 340 MG and a watershed area of 4.3 square miles. Emerson Brook Reservoir has a 90-foot long dam with a 6-foot wide spillway that discharges through two concrete channels to the Ipswich River. Swan Pond is also a manmade impoundment of limited capacity located in North Reading, Massachusetts in subbasin 21018. The reservoir for the cities of Salem and Beverly, the Putnamville Reservoir, is located in the Town of Danvers.

On the east side of Town, Danvers has over nine miles of coastline and is within the Salem Sound Watershed. Many local streams discharge to the southeast and eventually feed the Crane, Waters, and Porter Rivers. These three tidal rivers join to form the Danvers River which then discharges into Salem Harbor. Numerous wetlands and freshwater rivers are located throughout the Town and provide open space, wildlife habitat, stormwater detention, and limited recreation. Danvers is not home to any known rare, threatened, or endangered species. (Danvers 2009 OSRP)

There is one privately-owned dam and eight publicly-owned dams in Danvers. Three are owned by Danvers and five of the nine dams are located on the Salem-Beverly drinking water supply reservoir. These are summarized in Table 6-3 along with ownership information and location.

Table 6-3. Dams in Danvers

Dam Name	Location	Owner	Major Basin	Subbasin
Culvert at Mill Pond	Danvers	Town of Danvers	North Coastal Basin	21229
Ferncroft Road Dam	Danvers	Private	North Coastal Basin	21229
Meadow Dam	Danvers	Town of Danvers	North Coastal Basin	21229
Mill Pond Dam	Danvers	Town of Danvers	North Coastal Basin	21229
Putnamville Reservoir Dam	Danvers	Salem-Beverly WSB	Ipswich River Basin	21006
Putnamville Reservoir East Dike	Danvers	Salem-Beverly WSB	Ipswich River Basin	21006
Putnamville Reservoir South Dike	Danvers	Salem-Beverly WSB	Ipswich River Basin	21006
Putnamville Reservoir West Dike	Danvers	Salem-Beverly WSB	Ipswich River Basin	21006
Salem Reservoir Dam	Danvers	Town of Salem	North Coastal Basin	21230

There are 10 dams in Middleton. Four are owned by Danvers, one is owned by Middleton and the remaining dams are private.

Table 6-4. Dams in Middleton

Dam Name	Location	Owner	Major Basin	Subbasin
Coppermine Road Dam	Middleton	Town of Middleton	Ipswich River Basin	21071
Creighton Pond Dam	Middleton	Private	Ipswich River Basin	21072
Curtis Pond Dam	Middleton	Town of Danvers	Ipswich River Basin	21069
Emerson Brook Dam at Lake St.	Middleton	Town of Danvers	Ipswich River Basin	21020
Ipswich River Dam	Middleton	Private	Ipswich River Basin	21013
Middleton Pond Outlet Dam	Middleton	Town of Danvers	Ipswich River Basin	21018
Middleton Pond Southeast Dike	Middleton	Town of Danvers	Ipswich River Basin	21018
Mill Pond Dam	Middleton	Private	Ipswich River Basin	21020
Paradise Park Dam	Middleton	Private	Ipswich River Basin	21019
Prichard Pond Dam	Middleton	Private	Ipswich River Basin	21069

Using GIS mapping, about 17 stream culverts were identified in Danvers, and 40 in Middleton. It was assumed that all culverts that cross the Ipswich River were in the Town of Danvers, as they actually lie along the Town border.

6.1.3 Wastewater

Danvers is 99% sewered, and is part of the South Essex Sewerage District (SESD) along with Beverly, Peabody, Salem, Marblehead and a limited area in Middleton. The SESD wastewater treatment plant discharges to Salem Sound. The SESD plant has a National

Pollutant Discharge Elimination System (NPDES) permit for 29.7 mgd average monthly flows.

Danvers wastewater collection system is comprised of approximately 108 miles of gravity sewers, 4 miles of force main, and 17 pump stations. Currently, the town services 7,416 residential and 1,477 commercial accounts. In calendar year 2011, the estimated total average annual wastewater discharge from Danvers was approximately 4.66 mgd. Approximately 72% of the Town of Danvers is located within the North Coastal Basin, and approximately 28% is located within the Ipswich River Basin.

Middleton's wastewater needs are primarily served by on-site septic systems. The Middleton health agent estimates approximately 2,155 on-site systems are in use throughout town. Middleton has been experiencing rapid growth in the past decade, and wastewater disposal site constraints include ledge, high groundwater, wetland, and steep slopes. Localized advanced wastewater treatment has been proposed to accommodate new growth, but political and cost factors have hindered that option.

The Ferncroft area in the northeastern corner of Middleton, located along the Danvers border, is connected to the Danvers collection system, with an average discharge of 89,281 gpd. The Essex County Industrial Camp (jail) in Middleton also connects to the SESD interceptor through Danvers. The total combined flow to Danvers collection system for all uses within Middleton is 215,181 gpd. One additional area, the Bostik Industrial Property, located in southwestern Middleton is connected to the Peabody sewer system (Peabody sewage is also treated and disposed of at the SESD wastewater treatment facility). See Danvers/Middleton Wastewater Infrastructure Figure 6-4 for the location of sewered and unsewered areas.

6.1.4 Stormwater

6.1.4.1 Summary of Phase II Program

Danvers

Danvers is a NPDES Municipal Separate Storm Sewer System (MS4) Phase II regulated community and performs the following actions under its stormwater management program:

- Public education and outreach includes publishing news articles, distributing flyers and information at public events, making information available on its website, incorporating a school education program, and performing a direct mailing of stormwater information to residents in an attempt to educate residents on the importance of reducing stormwater pollution. Danvers also provides public participation opportunities, particularly to schoolchildren.
- The Town has continued efforts to remove illicit discharges by testing its storm and sanitary systems as needed to identify and eliminate improper connections. Its stormwater map is also updated as needed, currently showing the locations of approximately 3,600 catch basins and 300 outfalls.

- The most recent annual report indicates that Danvers has adopted bylaws to address illicit discharges, construction site runoff and post-development stormwater issues. Town departments, including the Board of Health and Planning Board also review proposed developments and perform inspections during construction to ensure erosion controls are in place.
- The Town practices maintenance and good housekeeping for its municipal operations, in part by sweeping streets, cleaning catch basins, performing vehicle maintenance inside, and only washing vehicles at approved locations to reduce potential pollution impacts to stormwater. The Town typically cleans all streets annually, and hires a contractor to clean approximately one-third of the catch basins each year (approximately 1,200 structures a year). Also, the Town minimizes salt use by calibrating equipment and training drivers, and tries to minimize application of pesticides, herbicides and fertilizers.

Middleton

Middleton is also a NPDES MS4 Phase II regulated community and performs the following actions under its stormwater management program:

- Public education and outreach includes distributing brochures in public places, making stormwater information available on its website, performing a direct mailing of stormwater brochures to residents, and televising stormwater-related videos on public television to educate residents on the importance of reducing stormwater pollution. Public participation events include holding household hazardous waste events, stenciling storm drains, and hosting stream cleanup events.
- The Middleton Conservation Commission has continued efforts to identify illicit discharges by inspecting stormwater outfalls as needed. Storm system mapping is approximately 95% complete, and shows the location of approximately 810 catch basins and 130 outfalls.
- The most recent annual report indicates that Middleton has drafted bylaws to address illicit discharges, construction site runoff and post-development stormwater issues for review by Town departments and committees. The Town has also drafted stormwater management regulations related to the bylaw, which include requirements related to the MassDEP Stormwater Handbook. Review is currently ongoing.
- Construction activity is also monitored by the Conservation Agent, including inspections during construction to verify that erosion controls are in place, and post-construction inspections to verify the presence and maintenance of stormwater BMPs. The Town also practices maintenance and good housekeeping for its municipal operations by sweeping streets and cleaning catch basins. The Town typically sweeps all streets annually, encompassing approximately 105 lane miles; this activity generated 180 cubic yards of material in 2011. Catch basins are also cleaned annually, generating 110 cubic yards of material from 810 structures.

6.1.4.2 Infrastructure

Danvers

The most recent NPDES MS4 Phase II annual report, dated March 29, 2012 indicates that the Town has confirmed the locations of approximately 3,600 catch basins and 300 outfalls.

Middleton

The most recent NPDES MS4 Phase II annual report, dated April 26, 2012 indicates that the Town has confirmed the locations of approximately 810 catch basins and 130 outfalls, the bulk of which flow through stormwater BMPs.

6.1.4.3 Impervious Cover

Danvers

Based on information obtained from U.S. Environmental Protection Agency (EPA) Region 1, Danvers encompasses 13.82 square miles, of which 3.78 square miles (27.37%) is impervious. Of the impervious area in town, 2.73 square miles (19.78%) is considered to be directly connected to waterbodies in the community. Figure 6-5 depicts the impervious cover for Danvers-Middleton.

Danvers is relatively heavily developed. About 25% of the town remains as undeveloped land such as open space or forest.

Middleton

Based on information obtained from EPA Region 1, Middleton encompasses 14.48 square miles, of which 1.43 square miles (9.87%) is impervious. Of the impervious area in town, 0.80 square miles (5.49%) is considered to be directly connected to waterbodies in the community. Figure 6-5 depicts the impervious cover for Danvers-Middleton.

Middleton is relatively lightly developed. About 50% of the town remains as undeveloped land such as open space or forest, offering potential for significant mitigation credits through regulatory changes that require more recharge as new development occurs.

6.1.4.4 Stormwater Regulations

Danvers

The Pilot Project Team reviewed Danvers' regulations for stormwater control requirements that could be considered as mitigation measures for groundwater withdrawals, particularly recharge requirements. Danvers' regulations include the following requirements:

- The wetland bylaw and regulations require applicants to mitigate the quantity and quality of stormwater for new point-source discharges. Applicants are encouraged to use the most feasible and best available stormwater runoff control strategies to reduce project impacts. Detention basins, infiltration basins, leaching catch basins, drainage dry wells, upland discharge of storm flows, and the use of other innovative and creative runoff control strategies are recommended.

- Zoning bylaws establish a Groundwater Protection District which occupies a small portion of the town outskirts. Requirements in the Groundwater Protection District include:

    - All new construction, reconstruction, renovation or expansion which will render impervious more than 15% of the lot or 2,500 square feet, whichever is greater must apply for a permit. These facilities must include a system for groundwater recharge which will not degrade groundwater quality.
    - For non-residential uses, recharge must be by stormwater infiltration basins or similar system covered with natural vegetation. Drywells are only allowed when other methods are infeasible. All basins and wells must be preceded by oil, grease, and sediment traps. A stormwater management plan must also be prepared in compliance with the Stormwater Management Policy set forth by MassDEP. Onsite drainage must handle the peak stormwater runoff and not impact abutting properties.

- The stormwater management and land disturbance bylaw requires any development that disturbs at least one acre to apply for a permit before construction. Applicants must meet all standards, including minimum recharge requirements, of the MassDEP Stormwater Management Handbook by using BMPs as necessary.

Middleton

The Pilot Project Team reviewed Middleton's regulations for stormwater control requirements that could be considered as mitigation measures for groundwater withdrawals, particularly recharge requirements. Middleton's regulations include the following requirements:

- The town has established a Watershed Protection Overlay District (WPOD) to protect the headwaters of the Emerson Brook Reservoir. Lots must be at least 40,000 square feet, buildings cannot cover more than 10% of the lot area, and at least 75% of the lot area must be free of impervious areas.

- A Conservancy Overlay District (COD) has been established to preserve and maintain the groundwater table, protect against flooding, and conserve natural resources. Certain types of construction are restricted and require a permit, and buildings cannot cover more than 25% of the area of any lot.

- Zoning bylaws and regulations require:
  - at least 25% of lot areas in the business and light industry districts remain open and pervious. All businesses must also maintain the front yards as open space and landscaped. At least 5% of the interior of any parking lot having 20 or more spaces must be landscaped in plots at least eight feet wide, and additional tree plantings may be required.
  - Multifamily or attached dwellings must maintain at least 30% of the parcel as open space and 40% as open area.
  - Development along North Main Street is further regulated to preserve the character of the area in ways that preserve infiltration and recharge. For businesses and industry along North Main Street, buildings must be set back at least 100 feet and the front yard must be maintained and planted as open space. On properties located along the North Main Street, parking lots with 10 or more spaces must have at least one tree per eight parking spaces.

Middleton is also reviewing new stormwater bylaws that would address construction and post-construction development. In particular, stormwater regulations addressing post-construction would likely outline more stringent requirements to ensure stormwater infiltration and groundwater recharge is maintained wherever possible. The stormwater bylaw with more stringent recharge requirements discussed in Section 4.2.2.3 is a good candidate for Middleton.

6.1.4.5 Impaired Waters and TMDL Status

Danvers

The final Massachusetts Year 2010 Integrated List of Waters defines the following Danvers waterbodies as impaired (Category 5 – Waters requiring a Total Maximum Daily Load (TMDL)):

Table 6-5. Danvers Impaired Waters and TMDL Status

Category	Waterbody	Waterbody ID	Length	Impairment	EPA TMDL No.
Category 5	Norris Brook	MA92-11	1.5 miles	Oxygen, Dissolved	-
				Total Suspended Solids	-
				Turbidity	-
Category 5	Waters River	MA93-01	0.1 sq miles	Fecal Coliform	-
Category 5	Crane Brook	MA93-02	1.8 miles	Fecal Coliform	-
Category 5	Porter River	MA93-04	0.1 sq miles	Fecal Coliform	-
Category 5	Ipswich River	MA92-06	20.4 miles	Mercury in Fish Tissue	-
				Oxygen, Dissolved	-
				(Low Flow Alterations)	-
Category 5	Danvers River	MA93-09	0.5 sq miles	Fecal Coliform	-
Category 5	Frost Fish Brook	MA93-36	1.0 miles	Fecal Coliform	-
Category 5	Beaver Brook	MA93-37	2.7 miles	Oxygen, Dissolved	-
Category 5	Crane River	MA93-41	0.1 sq miles	Fecal Coliform	-

Notes:
Category 5: Waters requiring a TMDL
Impairments shown entirely in parentheses are designated as "TMDL not required (non-pollutant)", (e.g., Low Flow Alterations)

To date, no TMDLs have been prepared for Danvers waterbodies.

Middleton

The final Massachusetts Year 2010 Integrated List of Waters defines the following Middleton waterbodies as impaired (Category 5 – Waters requiring a TMDL):

Table 6-6. Middleton Impaired Waters and TMDL Status

Category	Waterbody	Waterbody ID	Length	Impairment	EPA TMDL No.
Category 5	Ipswich River	MA92-06	20.4 miles	Mercury in Fish Tissue	-
				Oxygen, Dissolved	-
				(Low Flow Alterations)	-
Category 5	Norris Brook	MA92-11	1.5 miles	Oxygen, Dissolved	-
				Total Suspended Solids	-
				Turbidity	-
Category 5	Unnamed Trib.	MA92-12	1.4 miles	Fecal Coliform	-

Notes:
Category 5: Waters requiring a TMDL
Impairments shown entirely in parentheses are designated as "TMDL not required (non-pollutant)" (e.g., Low Flow Alterations)

To date, no TMDLs have been prepared for Middleton waterbodies.

6.2 Permit Tier Designation

As described in Section 2.1 of this report, the Draft SWMI Framework proposes WMA Permit requirements based upon the Flow Level and Biological Category of the subbasins from which withdrawals are to be permitted and the volume of the community's withdrawal request.

6.2.1 Biological Category

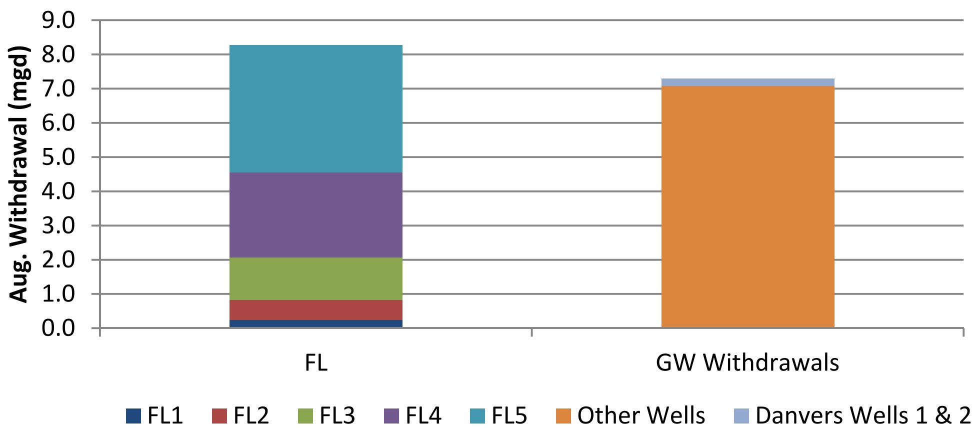
All of Danvers-Middleton's groundwater sources are located in a Biological Category (BC) 5 subbasin; therefore, no increase in withdrawal volume requested could cause a change in the BC and the subbasin is not considered a Quality Natural Resource as a result of its BC. No additional evaluation related to BCs was conducted for Danvers-Middleton.

6.2.2 Flow Level

The Flow Level (FL) of each subbasin in the State was determined by MassDEP based upon the estimated percent alteration of the subbasins unaffected August median flow. The unaffected flow was determined utilizing the Sustainable Yield Estimator (SYE) at the pour point (exit) of the subbasin and includes the flow from any upstream subbasins. Withdrawals were based on 2000 – 2004 annual average withdrawals for all WMA regulated wells and estimated private well withdrawals in the subbasin and upstream subbasins. Annual average withdrawals were adjusted by a peaking factor of 115.5% to determine August monthly withdrawals. The percent alteration of August flow was determined by dividing the August withdrawals by the August unaffected flow, which presumes a 1:1 relationship between withdrawals and streamflow reduction.

Figure 6-6 depicts the FL designations for each subbasin located within and proximate to Danvers-Middleton. Figure 6-7 presents the FL designations for subbasin 21019, where all of Danvers-Middleton's groundwater withdrawals are located. Subbasin 21019 is estimated to have greater than 55% alteration of unaffected August median flow and is therefore a FL 5 subbasin. Figure 6-7 and Table 6-7 present the data used in determining the FL for subbasin 21019.

Figure 6-7
Subbasin 21019 FL Determination



The FL bar in the Figure shows that the unaffected August flow at the pour point of this subbasin is approximately 8.3 mgd. Withdrawals greater than 55%, or approximately 4.6 mgd, result in an FL 5 designation for this subbasin. The GW Withdrawals bar in the Figure illustrates the estimated 2000 – 2004 August groundwater withdrawals used in the FL determination, and the portion of those estimated withdrawals attributed to Danvers' wells. As illustrated, Danvers-Middleton's groundwater withdrawals have very little impact on the FL determination in this subbasin.

Other withdrawals in the Figure consist of all WMA regulated groundwater withdrawals and private wells in and upstream of this subbasin, including recently retired withdrawals by the Town of Reading and reduced withdrawals in Wilmington. The Reading withdrawals utilized in the subbasin's FL determination were 2.4 mgd and the Wilmington withdrawals were 3.2 mgd. The impact of these reduced withdrawals on the subbasin's Flow Level, and Danvers' permit review could be considered. One approach would be to utilize the reduced withdrawals to re-determine the subbasin's FL. Without changing any other assumptions, a reduction in August withdrawals of approximately 2.75 mgd would change the subbasin to a FL 4.

Table 6-7. Danvers-Middleton – FL Determination	
Criterion	**Wells 1 & 2**
2000–2004 Estimated August Withdrawal (mgd)	0.208
2009-2011 Actual August Withdrawal (mgd)	0.207
Subbasin	21019
Unaffected August Flow (mgd)	8.3
Estimated Total August Withdrawals (mgd)	7.3
August Flow Alteration (%)	88
Flow Level	5

6.2.3 Tier Designation

As described in Section 2.1, the permit review tier is based upon the volume of water that a community is requesting authorization to withdraw above the baseline volume, and the percent of the unaffected August flow of the withdrawal subbasin as summarized in Table 6-8.

Table 6-8. Tier Designation	
Tier	**Withdrawal Request**
1	No additional water above baseline
2	Additional water above baseline <5% of subbasin's unaffected August flow
3	Additional water above baseline >5% of subbasin's unaffected August flow
4	Additional water above baseline will result in a change in Flow Level or Biological Category

The baseline demand for a system is determined by the greater of the 2003 – 2005 annual average demand or the 2005 actual demand plus a growth factor of 8%. If the 8% factor would result in a change in the subbasin's FL, the growth factor is limited to 5%. Furthermore, the baseline cannot be lower than existing registered volume or higher than the existing total authorized volume. In addition, the baseline demand cannot be more than the Department of Conservation and Recreation's (DCR's) 20-year demand projection for the community. Table 6-9 illustrates the baseline demand calculation for Danvers-Middleton.

Table 6-9. Danvers-Middleton – Baseline Demand	
Item	**Quantity (mgd)**
Registered Volume	3.14
Total Authorized Volume	3.72
DCR Projection	4.07
2003 Demand	3.24
2004 Demand	3.11
2005 Demand	3.19
2003 – 2005 Avg. Demand	3.18
2005 Demand + 8%	3.45
Proposed Baseline	**3.45**

As shown in the Table, Danvers-Middleton's proposed Baseline Demand is 3.45 mgd based on the 2005 average annual demand plus 8%. This increase would not result in a change in the FL of the subbasin from which Danvers-Middleton's wells withdraw because it is already a FL 5.

DCR's latest (2009), 20-year demand projections for the Danvers-Middleton system is 4.07 mgd. For purposes of this Pilot Project, however, Danvers Water Division suggested that the assumed requested authorization be equal to the current total authorized withdrawal volume (3.72 mgd). The permit request of 3.72 mgd would be 0.27 mgd above baseline, which is 3.2% (<5%) of the unaffected August flow in subbasin 21019. Because the subbasin is a FL 5 the additional withdrawal request would not increase the basin FL. This permit would therefore require a Tier 2 review.

One unlikely, although interesting, potential outcome if the reduced withdrawals in Reading and Wilmington result in changing the subbasin's flow level to FL 4 is that Danvers-Middleton's requested increase could bump the subbasin back to a FL 5 resulting in the need for a Tier 4 permit review.

6.2.4 Permit Requirements

The Draft SWMI Framework WMA Permitting Tiers Table (Table 5 of Draft Framework) presents the permit review requirements based on subbasin flow level and withdrawal request Tier. The piloted Danvers-Middleton WMA permit is a Tier 2/FL 5 review and therefore requires that Danvers-Middleton:

- Comply with applicable provisions of standard permit conditions 1-8
    1. Source Protection
    2. Firm yield for surface water supplies
    3. Wetlands and vernal pool monitoring (if applicable)
    4. Residential use less than 65 gallons/capita/day
    5. Unaccounted for water less than 10%
    6. Seasonal limits on nonessential outdoor water use
    7. Water conservation measures
    8. Offset Feasibility Study

  Note that the minimization measures developed through the SWMI process are already being applied in standard conditions 6 and 7, and it is expected that the mitigation measures will be incorporated into standard condition 8.

- Minimize the impact of their existing withdrawals on streamflow to the greatest extent feasible considering cost, level of improvement achievable, and ability to implement.

- Implement mitigation measures that are commensurate with impact of their increased withdrawals (0.27 mgd).

In addition, Danvers-Middleton would need to comply with the Surface Water Transition Rule. This rule requires the same actions described above, and specifically includes development of a drought and demand management plan and evaluation of the feasibility of implementing reservoir releases. The focus of this Pilot Project is groundwater supplies, while surface water supply issues may be addressed in a subsequent phase.

The report sections below discuss the minimization and mitigation alternatives identified through this Pilot Project for the Town of Danvers. This is not expected to be an exhaustive listing, nor have the feasibility of implementing these actions been fully investigated. The discussion does, however, provide a basis for assessing the potential impact of the proposed SWMI process on a Danvers-Middleton permit application.

6.3 Minimization of Impacts

6.3.1 Optimization of Existing Sources

As described above, Danvers-Middleton's current WMA permit includes groundwater withdrawal constraints based on actual flows at the Ipswich River gauge at South Middleton. This negotiated plan for conjunctive use of Danvers-Middleton's groundwater and surface water supplies is considered a source optimization plan for purposes of this Pilot Project.

6.3.2 Alternative Sources of Water Supply

Danvers-Middleton's pilot permit request is equivalent to their current authorized amount. Development of alternative sources is therefore not required to meet system demands, but may be helpful to improve system reliability and minimize or mitigate withdrawal impacts on stream habitat.

Several alternatives for developing new sources locally or through interconnection with neighboring communities were identified and evaluated through a review of existing reports and discussions with Danvers and MassDEP. Field investigations or detailed feasibility studies were not performed as part of this Pilot Project. Each of the new source alternatives identified are discussed briefly below and are depicted on the Danvers-Middleton Alternative Source Map, Figure 6-8.

6.3.2.1 Richardson Farm Well

In 2001, Danvers Water Division undertook a test well program in Danvers and Middleton to identify additional alternative sources of water supply. Test well #19-01 was identified as being one of the most promising sites. Based upon the results of a five day pumping test, a large diameter well at this site would be capable of delivering approximately 300 gpm; approximately 0.43 mgd (Earth Tech Report 2011).

Water sampling indicated the water is slightly acidic (pH of 6.1 to 6.3), however, neither VOCs nor SOCs were detected. Nitrate levels ranged from 24 to 15 mg/l and coliform bacteria was detected. According to the Earth Tech report, this was suspected to be the result of a recent application of manure and fertilizers on surrounding cornfields. The nitrate levels decreased during the pumping test; however, the nitrate level on the last day of pumping (15 mg/l) remained above the drinking water limit of 10 mg/l. Manganese and radon were also significantly above allowable limits. To pursue well development on this site, treatment for nitrate, manganese, bacteria, and possibly radon would be required unless significant changes to the land use were made.

The Richardson Farm Well would be located in subbasin 21021 of the Ipswich River Basin. This subbasin is listed as a FL 5 subbasin with an unaffected August flow of 8.93 mgd and current (2000-2004) August flow alteration of 82%. Based on the Draft SWMI Framework criteria, the Richardson Farm Well would have similar streamflow impact as the existing Danvers-Middleton wells. The well would additionally require significant investment for development, permitting and treatment.

6.3.2.2 State Hospital Sand & Gravel Well

The 2001 groundwater investigation also identified test well #9-0 as a promising site. Based upon the results of a 6 day pumping test, a large diameter well would be capable of producing 500 to 600 gpm; between 0.7-0.86 mgd (Earth Tech Report 2011).

Water sampling indicated the water is slightly acidity (pH of 6.7 to 6.9). It is likely that pH would have to be adjusted for corrosion control if a permanent well is installed. VOCs and SOCs were not detected. Nitrate and iron concentrations were well below the drinking water limit. Manganese was above the secondary drinking water limit. Both iron and manganese levels increased during the pumping test, suggesting this trend could continue under periods of heavy pumping. The water may need to be treated for manganese and perhaps iron and radon if a permanent well is installed.

The State Hospital well is located further downstream, but in the same Ipswich River subbasin as Danvers Wells No. 1 and 2. Because of the large unaffected flow in the Ipswich River flowing through this subbasin, little environmental benefit would be expected from relocating a portion of the well withdrawal further downstream in the same subbasin. The State Hospital Well is therefore not considered a feasible alternative for minimizing or mitigating the impact of Danvers-Middleton withdrawals.

6.3.2.3 Purchase Water from Salem-Beverly Water District

The Danvers Water Division has previously investigated an interconnection with the Salem-Beverly Water District. However, the Salem-Beverly Water Supply Board has discontinued water sales due to their own low surplus supply. Furthermore, the Salem-Beverly system is also located in the Ipswich Basin and therefore is subject to the same stringent permit restrictions and withdrawal limits as Danvers-Middleton; particularly in the summer when Danvers-Middleton would have the most need of water.

6.3.2.4 Purchase Water from Peabody

As noted earlier, Danvers-Middleton has several existing emergency connections with Peabody. Peabody's water supply comes from four surface water sources located within the North Coastal and Ipswich River Basins. Interbasin Transfer issues between the North Coastal and Ipswich Basins would also need to be considered. Furthermore, to meet demand, Peabody is currently obtaining some water from MWRA. Since they have no surplus water to sell, purchasing water from the Peabody distribution system would not be considered feasible.

6.3.2.5 Purchase Water from Andover

The Danvers-Middleton has also considered purchasing water from Andover in the past. Andover currently supplies water to North Reading, which is located adjacent to Middleton along its western border. The Danvers-Middleton indicated that purchasing water from Andover would require a direct connection to Andover as relaying the water to Middleton/Danvers via North Reading's distribution system would cause hydraulic issues to North Reading's system.

Andover's drinking water comes from Haggetts Pond and is supplemented with additional waters from Fish Brook and the Merrimack River, all within the Merrimack River Basin. As Andover's water supply is all withdrawn from surface water sources, there is potential to utilize their reservoir storage to offset Danvers-Middleton's groundwater withdrawals. An Interbasin Transfer Act Permit would be required to transfer water from the Merrimack to the Ipswich and North Coastal basins. Unaffected flow and flow alteration estimates were not prepared for the Merrimack River as part of the USGS Indicators of Streamflow Alteration study, however it is anticipated that significant flows are available. The costs of interconnecting with Andover would likely outweigh the minor improvement in August flow alteration achieved by reducing Danvers-Middleton's groundwater withdrawals. Much more complex and expensive analysis would be required to perform a site specific evaluation of the impact of reducing Danvers' surface water withdrawals.

6.3.2.6 Purchase Water from MWRA

Danvers and Middleton are not MWRA communities; however, the water system has the ability to connect directly to the MWRA system via a water main MWRA is currently installing to the south of Danvers along Route 1 in Peabody. Danvers Water Division indicated that this would require approximately five miles of new pipeline in addition to the entrance fee to become an MWRA community (R. Rodgers interview). For the purpose of estimating construction costs, the Pilot Project Team has assumed that five miles of water main at $250/l.f. and a meter pit with meter and control valve would be required. The estimated MWRA entrance fee of $5M/mgd is included in the estimated construction costs (MWRA email). Should it be determined that pressure reducing valves or booster stations are needed to transport MWRA water to Danvers-Middleton, the cost for such equipment would be added to the cost estimate. The estimated construction costs also do not include any additional costs that may be imposed by the Town of Peabody to act as the transporting community. Based on this preliminary screening method, an order of magnitude estimate of construction costs to connect Danvers-Middleton to the MWRA system is approximately $8 million, inclusive of the MWRA connection fee for the desired 0.27 mgd capacity. A site specific investigation of this alternative could result in costs that are significantly higher than this amount.

Operating costs for purchasing MWRA water were based on a demand of 0.27 mgd; the difference between Danvers-Middleton's water withdrawal baseline and Pilot Project water withdrawal request. This is equivalent to an average quarterly use of approximately 25 MG. MWRA's current prevailing rate of $2,760 per million gallons was assumed (MWRA Rate Interview). Based on this approach, the estimated annual cost for Danvers-Middleton to offset their increased demand over baseline from MWRA would be approximately $276,000.

6.3.3 Other Minimization

Bostik Adhesives is located in subbasin 21013 upstream of Danvers-Middleton's groundwater withdrawals. Bostik has a WMA registration to withdraw up to 0.79 mgd from a combination of four groundwater and three surface water sources. The total withdrawal from this registration during the 2000-2004 period utilized for determining Biological Categories and Flow Levels was only 0.01 mgd. However, if Danvers-Middleton could retire the Bostik registration it could contribute to mitigation of Danvers-Middleton's increased withdrawal request.

6.4 Mitigation & Offsets to Withdrawals

6.4.1 Summary Matrix

Using the credit approach outlined in section 4.2.1, quantified offsets to mitigation and offsets to withdrawals were calculated for wastewater, stormwater, habitat and demand management improvements. A summary of the mitigation and offset volumes is provided in Table 6-10, compared with the withdrawal request above baseline. Potential mitigation and offsets to withdrawals represent the maximum mitigation/offset a PWS could achieve if these actions were implemented town-wide (where applicable) and include both direct and indirect offset calculations. Note that although the indirect offset calculation methodology in Appendix E discusses a cap of the withdrawal request on the portion that can be obtained from indirect offsets, a cap has not been included in the summary matrix. Phase 2 could provide further consideration of how the indirect mitigation/offsets could be applied to the existing and future permit terms. For example, can unused indirect mitigation/offsets associated with the cap be carried over into a future permit term and withdrawal request?

The purpose of this matrix is to provide the PWS with an understanding of what options are available to them, the cost associated with these options and provide them with a tool to select those that work best for the PWS to meet its withdrawal request. For additional information on the offset calculations, refer to the following sections, the methodology in Appendix E and the Danvers-Middleton specific worksheet calculations in Appendix G.

6.4.2 Instream Flow/Surface Water Releases

The dams and surface water impoundments in Danvers and Middleton were identified for assessment for potential releases to augment stream flows during low flow periods. A screening analysis was conducted to evaluate the potential for surface water releases to mitigate water withdrawals. Factors that were considered included impoundment use, location with respect to the water withdrawal, ownership, status of proposed dam removals, and current management of releases. The level of analysis needed to confirm

Table 6-10. Mitigation/Offset Summary Matrix for Danvers-Middleton				
	Existing	Potential		
	Volume (gpd)	Volume (gpd)	Cost ($)	
Wastewater Offsets				
septic systems	107,980	-	$	-
groundwater discharges	46,125	-	$	-
infiltration	-	14,340	$	136,700
inflow	-	615	$	3,000,000
water reuse - irrigation	-	-	$	-
private inflow removal program				
sewer bank (I/I offset) program				
wastewater enterprise account	24,810			
Wastewater Offset Total	178,915	14,955	$	3,136,700
Stormwater/Impervious Cover Improvement Offsets				
recharge impervious surfaces				
leaching catch basins				
reduce impervious surfaces				
roof leader disconnection				
rain barrels		24,282	$	3,000,000
stormwater bylaw with recharge requirements		2,586,222		
stormwater utility meeting environmental requirements	-	24,810		
implement MS4 requirements		24,810		
Stormwater Offset Total	-	2,660,123	$	3,000,000
Habitat Improvement Offsets				
install and maintain a fish ladder	-	-		
remove a dam or other flow barrier	-	7,030		
acquire/protect lands	-	-		
culvert replacement	-	-		
streambank restoration	-	-		
tree canopy	-	-		
mitigation fund	-	-		
Habitat Improvement Total	-	7,030		-
Water Supply Improvement / Demand Management				
outdoor watering restrictions	868,693	434,346	$	-
irrigation audits	-	-		
irrigation sensors	195	195		
irrigation bylaw	-	-		
faucet aerators	-	81,733	$	18,600
low flow faucets	476	-	$	-
low flow showerheads	1,458	717,871	$	24,800
low flow toilets (1.6 gpf)	2,284	-	$	-
HE toilets (1.28 gpf)	2,224	285,790	$	93,000
watersmart washing machines	6,528	104,157	$	124,000
watersmart dishwashers	-	12,204	$	124,000
commercial water audits	-	-		
municipal building retrofits	-	20,675		
pistol grip hose nozzles	-	20,675		
water bank	-	24,810		
water supply enterprise account	-	24,810		
water conservation rates	-	20,675		
monthly billing/radio-read meters	-	20,675		
conservation education/outreach	-	20,675		
Demand Management Total	-	152,995	$	-
Total Potential Mitigation/Offset	**178,915**	**2,835,103**	**$**	**6,136,700**
Total Withdrawal Request Above Baseline		**270,000**		

Notes:

1. All mitigation options discussed in this report are included in the table. Values are only provided for those options that could be quantified for the PWS using available information.
2. Indirect offsets are shaded pink and are included in the total. A cap has not been applied to indirect offsets.
3. Demand management offsets assume assumed that demand management options could be applied to all 'applicable' households (e.g., where not currently applied). Refer to Section 6.4.6. Actual savings should be based on the actual number of households the options are applied to.
4. Stormwater/impervious cover improvement offsets include those that could be readily quantified under Phase 1. Other stormwater options could be considered under Phase 2.
5. Habitat improvement offsets include those that could be readily quantified under Phase 1 and include removal of the Curtis Pond dam.
6. "Danvers-Middleton cannot receive credit for any of the items required under the negotiated WMA permit based on the settlement agreement. These are shown in the grey shaded cells, but are not included in the totals.

availability of water for potential releases, including modeling of potential release scenarios, is outside of the scope of the Phase 1 Pilot Project.

Within the Towns of Danvers and Middleton, 14 dams were identified (see Table 6-11). Five dams are under private control, and were not considered further as the Town does not have control over these facilities. Two dams are associated with the Salem-Beverly water supply, and were also not considered further as the Town does not have control over these facilities. The five dams controlled by Danvers or Middleton that are not related to the public water supply were not feasible for augmenting stream flows, as they were either in a different major basin, or they were located several subbasins downstream of the withdrawals.

Danvers controls three dams related to its surface water supplies. The feasibility of releases from these dams are required as part of the Surface Water Transition Rule. Scheduling releases from these dams would reduce the available surface water supply, which would limit the use of the surface water supply to augment the groundwater sources. USGS evaluated the impact of making controlled releases from the Danvers-Middleton reservoir system on firm yield. The release scenarios modeled included no releases and year round controlled releases equal to the tenth and twenty fifth percentile monthly inflow. These release scenarios significantly reduced firm yield further below historical average annual usage. (USGS Refinement and Evaluation of the Massachusetts Firm-Yield Estimator Model Version 2.0). More study would be needed to determine if there is a feasible release scenario and to balance the benefits of that scenario against the resulting increase in groundwater withdrawals.

No significant feasible surface water release was identified within Danvers or Middleton that would offset groundwater withdrawals.

Table 6-11. Danvers and Middleton Surface Water Release Summary

Dam	Ownership	Proximity to Water Supply	Feasibility
Middleton Reservoir Dam	Danvers	Enters Ipswich River downstream of wells	Reduces available surface water supply.
Emerson Brook Reservoir Dam	Danvers	Enters Ipswich River further downstream of wells than Middleton	Reduces available surface water supply
Curtis Pond Dam	Danvers	Boston Brook to Ipswich River downstream of withdrawals	Several subbasins downstream of withdrawal
Mill Pond Dam (Danvers)	Danvers	North Coastal Basin	Different basin
Meadow Dam	Danvers	North Coastal Basin	Different basin
Coppermine Road Dam	Middleton	Nichols Brook downstream of withdrawals	Several subbasins downstream of withdrawal
Mill Pond Dam (Ipswich)	Middleton	Downstream of withdrawals	Several subbasins downstream of withdrawal Not controlled by Danvers or Middleton
Putnamville Reservoir System Dam	Salem-Beverly Water Board	Enters Ipswich River from Salem-Beverly Canal	Far downstream of withdrawal Not controlled by Danvers or Middleton
Salem Reservoir Dam	Salem	North Coastal Basin	Different Basin Not controlled by Danvers or Middleton
Ipswich River Dam	Private - Bostik	On Ipswich River upstream of withdrawals	Not controlled by Danvers or Middleton
Creighton Pond Dam	Private - Boys and Girls Club of Lynn	Discharges to Boston Brook Downstream of withdrawals	Not controlled by Danvers or Middleton
Prichard Pond Dam	Private	Boston Brook to Ipswich River downstream of withdrawals	Several subbasins downstream of withdrawal Not controlled by Danvers or Middleton
Paradise Park Dam	Private	Small impoundment	Not controlled by Danvers or Middleton
Ferncroft Road Dam	Private	North Coastal Basin	Different Basin Not controlled by Danvers or Middleton

6.4.3 Wastewater

As noted above, the majority of Danvers is connected to the municipal sewer system, which discharges flows to Salem Sound through the South Essex Sewerage District (SESD). The Ferncroft area of Middleton is also sewered through the South Essex Sewerage District. The majority of Middleton is served by on-site septic systems, which provide groundwater recharge within the Ipswich River Basin. These systems, and opportunities for I/I reduction in Danvers are described below. The potential credits for wastewater in Danvers and Middleton, based on the wastewater credit methodology described in Section 4.2, are summarized in Table 6-12.

Table 6-12. Potential Wastewater Credit Summary – Danvers-Middleton

	Wastewater Category	Total Wastewater Flow (gpd)	Total Flow Offset Volume (gpd)
1	Septic Systems	301,322	107,980
2	Groundwater Discharges	61,500	46,125
3	Infiltration	249,954	28,680
4	Inflow	11,159	615
5	Water Reuse - Irrigation	0	0
6	Indirect Offsets: Wastewater Enterprise Fund		24,810
	Total Potential Wastewater Credit		208,210

6.4.3.1 Groundwater Recharge Options to the Ipswich River Basin

The majority of Danvers is sewered. Therefore, options for groundwater recharge within Danvers and Middleton and the Ipswich Basin are focused primarily within Middleton.

All of the 2,155 on-site septic systems in Middleton are recharging groundwater in the Ipswich River Basin. Of these, approximately 2,000 properties are served by both on-site septic systems and public water. These systems account for approximately 301,000 gpd of wastewater discharged to the ground. In addition, there are two developments in Middleton with Groundwater Discharge Permits (GDP); Fuller Pond Village has a GDP for 48,000 gpd, and Middleton Marketplace has a GDP 13,500 gpd. The combined groundwater recharge in Middleton from localized wastewater recharge is approximately 0.36 million gallons per day. (See Danvers-Middleton Wastewater Infrastructure Figure 6-4.)

6.4.3.2 Infiltration/Inflow Removal

Danvers has been addressing I/I contributions to their system since the 1980s. Recommended repairs and improvements, including construction of interceptor sewers, were implemented. Danvers continues to address I/I issues. A March 2003 I/I Investigation prepared by CDM identified 278 sump pumps discharging to the sewer system, 107 manholes for rehabilitation and seven areas for further investigation, including TV inspection. Peak day infiltration entering manholes was estimated at 254,000 gpd. Of this, approximately 24,000 gpd was located within the Ipswich River Basin. As the majority of Danvers is in the North Coastal basin, the majority of I/I issues identified are within the North Coastal Basin. Recommendations from the I/I investigation included rehabilitating manholes to remove approximately 254,000 gpd of infiltration at a cost of $116,000. Recommendations for rehabilitating sewer laterals are estimated to remove an additional 108,000 gpd of infiltration at a cost of $20,300.

Based on a 2003 House-to-House Inspection Program Report prepared by CDM, the 278 sump pumps that are connected to Danvers' sanitary sewer system contribute an estimated 2,400,000 gpd of infiltration. Approximately 19 sump pumps with direct discharge to the sewer system are located in the Ipswich River Basin within Danvers. Estimated flow from theses sump pumps is 164,000 gpd. The total cost for redirection of the 278 sump pumps is estimated at $2.9 million. If the sump pumps were removed from the collection system, they could be redirected to groundwater infiltration systems or to the municipal storm drain system. The credit offset assumes that the sumps would be redirected to groundwater infiltration systems and not the municipal storm drain system. As the sump pumps are located on private property, the Town has not yet disconnected the sump pumps from the sewer system.

Danvers continues to address I/I issues. The 2012 Danvers Town Meeting approved $400,000 to continue inspection and repairs to remove additional I/I. These funds included $150,000 for flushing, cleaning and CCTV inspection of 56 miles (about 50%) of the system and $250,000 for I/I repairs.

Middleton does not have public sewers. The areas of Middleton that are sewered are private, County or State properties that have a direct connection to SESD.

The potential credit for infiltration and inflow includes the total flows observed in the system. This number presents an opportunity for future credits, but the Town would need to identify specific projects and estimated I/I removed to be granted credit.

6.4.3.3 Surface Water Discharge

There are no surface water discharges of treated wastewater upstream or within the Zone II of Danvers-Middleton's groundwater withdrawals.

6.4.3.4 Other Potential Wastewater Credits

Danvers Sewer Division operates under a sewer enterprise fund. They do not currently have an I/I offset program (sewer bank).

6.4.4 Stormwater/Impervious Cover

Section 4.2.2.3 outlines stormwater mitigation options to help offset withdrawal requests. Tables 6-13 and 6-14 summarize those options that are applicable to Danvers and Middleton and could be readily quantified under Phase 1 of the project. These include the distribution of rain barrels, implementation of a stormwater utility, and implementation of MS4 requirements.

Table 6-13. Stormwater/Impervious Cover Improvement Offsets in Danvers

	Offsets Completed to Date		Potential Offsets		
	Quantity	Volume (gpd)	Quantity	Volume (gpd)	Cost
Rain barrels			10,615 households[1]	20,620	$2,547,600
Stormwater bylaw with recharge requirements				278,277	
Stormwater utility[2]				19,489	
Implement MS4 requirements[2]		19,489			

[1]Estimated households on the public water supply in 2010. For the purposes of estimating potential water savings through future mitigation actions, it was assumed that all households could receive rain barrels to reduce water demands. Actual savings should be based on the actual number of households receiving rain barrels.

[2]One credit was applied for the water supply (includes both Danvers and Middleton) and then weighted between Danvers and Middleton based on population. Both the 'stormwater utility' and 'Implement MS4 requirements' were calculated using the indirect method in Appendix E and resulted in the same volume offset.

Table 6-14. Stormwater/Impervious Cover Improvement Offsets in Middleton

	Offsets Completed to Date		Potential Offsets		
	Quantity	Volume (gpd)	Quantity	Volume (gpd)	Cost
Rain barrels			1,885 households[1]	3,662	$452,400
Stormwater bylaw with recharge requirements				2,307,945	
Stormwater utility[2]				5,321	
Implement MS4 requirements[2]		5,321			

[1]Estimated households on the public water supply in 2010. For the purposes of estimating potential water savings through future mitigation actions, it was assumed that all households could receive rain barrels to reduce water demands. Actual savings should be based on the actual number of households receiving rain barrels.

[2]One credit was applied for the water supply (includes both Danvers and Middleton) and then weighted between Danvers and Middleton based on population. Both the 'stormwater utility' and 'Implement MS4 requirements' were calculated using the indirect method in Appendix E and resulted in the same volume offset.

Other stormwater mitigation options could be considered in Phase 2. For example, potential savings may be realized from a roof leader disconnection program; the potential savings could be explored using a GIS overlay analysis and the assumptions outlined in the methodology presented in Section 4.2.2.3. The applicability of other mitigation options (e.g., sites where existing impervious surfaces can be eliminated or directed to recharge) may require specific site evaluations.

Most mitigation actions would need to be implemented by both Danvers and Middleton to maximize mitigation potential. Activities in Middleton would have greater credit potential since it is relatively undeveloped and is located completely in the Ipswich River Basin, where the impacts of withdrawal are occurring. Danvers is more developed and mostly located in the North Coastal Basin. Potential credits evaluated for each Town under the Phase 1 project are discussed below. Note that all mitigation actions in either Danvers or Middleton would help offset the withdrawal request by Danvers-Middleton.

Danvers

Danvers is currently looking into the feasibility and development of a stormwater utility to help fund stormwater activities.

A simple overlay of existing land use and protected lands shows about 1,500 acres of land in Danvers remain to be developed. This information was overlaid with hydrologic soil groups (HSGs) to help determine the recharge potential for future development, with A and B soils offering high recharge potential and C and D soils less. Refer to Figure 6-9 for hydrologic soil groups (HSGs) and undeveloped and protected land.

Table 6-15 presents a breakdown of the areas of undeveloped lands by soil type based on these overlays. The resulting data demonstrate the potential mitigation that can be achieved by applying more stringent stormwater bylaws to future development.

Table 6-15. Danvers Available Land Area per HSG

Hydrologic Group	Area (acres)
A	153.65
B	216.55
C	647.66
C/D	0.13
D	131.50
Landfill	27.19
Pits, quarry	45.55
Urban Fill	309.86
Total Area	1532.07

To demonstrate the potential impact of uncontrolled development, and the potential effectiveness of more stringent recharge requirements, the Pilot Project Team developed the following analysis.

- The estimated percent impervious cover at buildout is 43%. This figure was determined using town zoning information obtained from GIS and applying literature based impervious values to each zoning type. While simplistic, this analysis provides an illustrative estimate of future impervious area without performing a more detailed buildout analysis.

- Applying the 43% to the 1,532 developable acres results in an additional 665 acres of impervious area that could be added to the Town

- Absent stringent controls over stormwater management, this entire new impervious acreage would hinder or prevent stormwater infiltration, with a corresponding impact on groundwater.

- Since Danvers already requires recharge following the Stormwater Management Handbook, the more stringent bylaw requirements were applied to the potential impervious area in each soil group to estimate the additional recharge that could be obtained. The result is an additional 0.28 mgd over what the existing regulation provides. This demonstrates the benefits of more stringent recharge regulations. For the current discussion, the analysis has not applied the location adjustment factors discussed in Section 4.0 to estimate the actual mitigation credits. A more refined analysis of this mitigation action and the location adjustment factors, could be completed under Phase 2 of the Pilot Project.

Middleton

A simple overlay of existing land use and protected lands shows about 50% or 3,500 acres of land remain to be developed. This information was overlaid with HSGs to help determine the recharge potential for future development, with A and B soils offering high recharge potential and C and D soils less. Refer to Figure 6-9 for HSGs and undeveloped and protected land.

Table 6-16 presents a breakdown of the areas of undeveloped lands by soil type based on these overlays. The resulting data demonstrate the potential mitigation that can be achieved by applying more stringent stormwater bylaws to future development

Table 6-16. Middleton Available Land Area per HSG

Hydrologic Group	Area (acres)
A	317.75
B	1854.90
C	877.27
D	292.40
Landfill	19.69
Pits, quarry	34.07
Urban Fill	145.20
Total Area	3541.27

To demonstrate the potential impact of uncontrolled development, and the potential effectiveness of more stringent recharge requirements, the Pilot Project Team developed the following analysis.

- The estimated percent impervious cover at buildout is 28%. This figure was determined using town zoning information obtained from GIS and applying literature based impervious values to each zoning type. While simplistic, this analysis provides an illustrative estimate of future impervious area.

- Applying the 28% to the 3,541 developable acres results in an additional 984 acres of impervious area that could be added to the Town

- Absent stringent controls over stormwater management, this entire new impervious acreage would hinder or prevent stormwater infiltration, with a corresponding impact on groundwater.

- The more stringent recharge requirements were applied to the potential impervious area in each soil group to estimate the additional recharge that could be obtained. The result is an additional 2.31 mgd over no recharge requirements. This demonstrates the benefits of more stringent recharge regulations. For the current discussion, the analysis assumes the difference between no recharge and that achieved through implementation of the bylaw and has not applied the location adjustment factors discussed in Section 4.0 to estimate the actual mitigation credits. A more refined analysis of this mitigation action and the location adjustment factors, can be completed under Phase 2 of the Pilot Project.

6.4.5 Habitat Improvements

The Curtis Pond Dam located in the Ipswich Basin on Boston Brook is scheduled for removal in late-2012. In addition, a Partial Feasibility Study was completed in 2010 for the removal of the South Middleton Dam. This is a privately-owned dam located on the Ipswich River upstream of Danvers' groundwater supply wells.

The four dams located on the Beverly-Salem drinking water supply reservoir are unlikely candidates for removal since they impound the reservoir water.

Of the estimated 17 stream culverts in Danvers and 40 stream culverts in Middleton, nine in Middleton have been evaluated for habitat and stream continuity and included in the New England Road Stream Crossing Inventory Database. Under the offset criteria established in Section 4.0, only those culverts posing a "moderate" or greater barrier to habitat continuity are eligible for an offset credit if replaced. Of the nine evaluated in Middleton, three were identified as posing a "moderate" barrier or greater as identified in Table 6-17. Information was not available regarding planned culvert replacement projects at this time.

Table 6-17. Results of Culvert Assessments in Middleton, Massachusetts				
Location	**Qty.**	**Type**	**Barrier**	**Stream Name**
Coppermine Road	1	Elliptical culvert	Minor	Nicholls Brook
Coppermine Road	1	Elliptical culvert	Moderate	Nicholls Brook
East Street	1	Bridge with abutments	Minor	Ipswich River
Essex Street	2	Round culvert	Moderate	Boston Brook
Ferncroft Golf Cart Path	1	Elliptical culvert	Moderate	Nicholls Brook
North Liberty Street	1	Elliptical culvert	Minor	Boston Brook
Peabody Street	2	Box culvert	Insignificant	Boston Brook
Route 114 South Main Street	1	Bridge with abutments	Minor	Ipswich River
Sharpner's Pond	1	Box culvert	Minor	Boston Brook

Based on the number of dams and culverts located within the Town, there is the potential to obtain mitigation credits through improvements to these structures, however, this requires further assessment to determine the need for (e.g., is it currently a detriment to habitat) and the level of improvement needed. This is beyond the scope of this Pilot Project.

6.4.6 Demand Management

The Town of Danvers has a very active and progressive demand management and water conservation program. Many of the current actions were written into the Danvers-Middleton WMA Permit as the result of a Settlement Agreement between the Towns of Danvers and Middleton, MassDEP, the Ipswich River Watershed Association, the Essex County Greenbelt Association, and twelve private citizens (Danvers WMA Settlement, Danvers WMA Permit). The following demand management/conservation measures were included in the negotiated permit:

- Streamflow triggered outdoor, nonessential water use restrictions
- Restriction of unregulated irrigation wells in the Ipswich River Basin based on streamflow thresholds.
- Enhanced water conservation and water use mitigation plan

Middleton had included restrictions on private irrigation wells into its 2008 bylaw, however, this was overturned at the 2011 Middleton Annual Town Meeting. Specifically, this 2011 vote overturned the portion with any references to private well users as having to comply with the bylaw.

The Town of Danvers does not allow new irrigation systems to be connected to the public water supply. Any new irrigation system would require use of a private well as well as the installation of a soil moisture and rainfall sensor.

Danvers implements outdoor watering restrictions based on drought triggers as outlined in its Drought Management Plan. Specific water usage restrictions are employed for each drought condition during the months of May through October. At drought condition

"Mild," voluntary 3 day per week outdoor watering is implemented. At drought condition "Moderate," mandatory 3 day per week watering is enforced. At drought condition "Severe," there is a total ban on outdoor water use. Middleton follows the same outdoor watering restrictions.

In 2009, Danvers implemented a Water Use Mitigation Program (WUMP) as required per its WMA permit and Settlement Agreement. Under the WUMP, Danvers enacted a Water Bank which requires new connections to the water supply to offset their water demands at a ratio of 2:1 through payment to the water bank. Water bank funds are used to offer rebates on low-flow faucets, showerheads, and toilets; watersmart washing machines; and rain sensors. From 2009 through 2011, these rebates were available for residential customers in Danvers. In 2012, the program was expanded to commercial water customers in Danvers. The program is not offered in Middleton. Table 6-18 includes a summary of the rebates provided from 2009 through 2011. The water saving calculations provided for this Pilot Project include through the 2011 calendar year.

Table 6-18. Rebates Provided Through Danvers' WUMP

Item	2009	2010	2011	Total	Rebate
High Efficiency Washing Machines	171	261	179	611	$200
High Efficiency Toilets (1.28 gpf)	0	29	51	80	$200
Low Flow Toilets (1.6 gpf)	46	31	19	96	$150
Low Flow Shower Heads (2.0 gpm or less)	4	13	4	21	$50
Low Flow Faucets (1.5 gpm or less)	10	35	15	60	$50
Rain Sensors	0	4	5	9	$100

Danvers DPW Water Division operates under an Enterprise Account. It also uses conservation rates for both residential and commercial customers.

Danvers is currently in the process of replacing existing meters with radio-read meters. Upon completion, they would be capable of monthly meter reading and billing.

As a result of its aggressive demand management program, Danvers residential water use was at 54 RGPCD in 2011. Danvers reported a combined unaccounted for water for Danvers and Middleton at 6.5% in 2011. Middleton reported 63 RGPCD in 2011. Middleton cannot track unaccounted for water separately because the water is not metered where it enters the Middleton from Danvers.

The mitigation credit available from existing demand management activities is included in Table 6-17, along with potential credits. At MassDEP's direction, existing and potential credits do not include any of the items required under the negotiated permit based on the settlement agreement. As shown in Table 6-17, the Town has a lot of demand management options available to help offset its 0.27 mgd additional withdrawal request. Note that these potential savings would be higher than the requested withdrawal increase, allowing the Town to pick and choose the options that best fit their needs to meet the 0.27 mgd offset.

Table 6-19. Demand Management Offsets in Danvers-Middleton														
	Existing				Potential									
	Danvers		Middleton		Danvers				Middleton				Danvers-Middleton	
Water Supply Improvement / Demand Management	Number of Households (#)	Volume (gpd)	Number of Households (#)	Volume (gpd)	Number of Households (#)	Volume (gpd)	Cost ($)	Revenue Loss ($/year)	Number of Households (#)	Volume (gpd)	Cost ($)	Revenue Loss ($/year)	Volume (gpd)	Notes
outdoor watering restrictions	10,615	682,393	2,898	186,300	10,615	341,196	-	$284,217	2,898	93,150	-	$77,594		
irrigation audits														
irrigation sensors	9	195			9	195	$ 450	$162						
irrigation bylaw														
faucet aerators					9,059	71,892	$ 135,885	$183,685	1,240	9,841	$ 18,600	$25,143		
low flow faucets	60	476			0	0	-	-	-	-	-	-		
low flow showerheads	21	1,458			9,098	631,765	$ 181,960	$1,614,160	1,240	86,106	$ 24,800	$220,000		
low flow toilets (1.6 gpf)	96	2,284			0	0	-	-	-	-	-	-		
HE toilets (1.28 gpf)	80	2,224			9,039	251,314	$ 677,925	$642,107	1,240	34,476	$ 93,000	$88,086		
watersmart washing machines	611	6,528			8,508	90,907	$ 850,800	$232,268	1,240	13,249	$ 124,000	$33,852		
watersmart dishwashers					9,119	10,743	$ 911,900	$27,448	1,240	1,461	$ 124,000	$3,732		
commercial water audits														
municipal building retrofits													20,675	indirect - applies to entire service communities
pistol grip hose nozzles													20,675	indirect - applies to entire service communities
water bank													24,810	indirect - applies to entire service communities
water supply enterprise account													24,810	indirect - applies to entire service communities
water conservation rates													20,675	indirect - applies to entire service communities
monthly billing/radio-read meters													20,675	indirect - applies to entire service communities
conservation education/outreach													20,675	indirect - applies to entire service communities
TOTAL													152,995	

Notes:

1. "Danvers-Middleton cannot receive credit for any of the items required under the negotiated WMA permit based on the settlement agreement (shaded cells). These were not included in the 'existing' total or in the potential offset calculations.

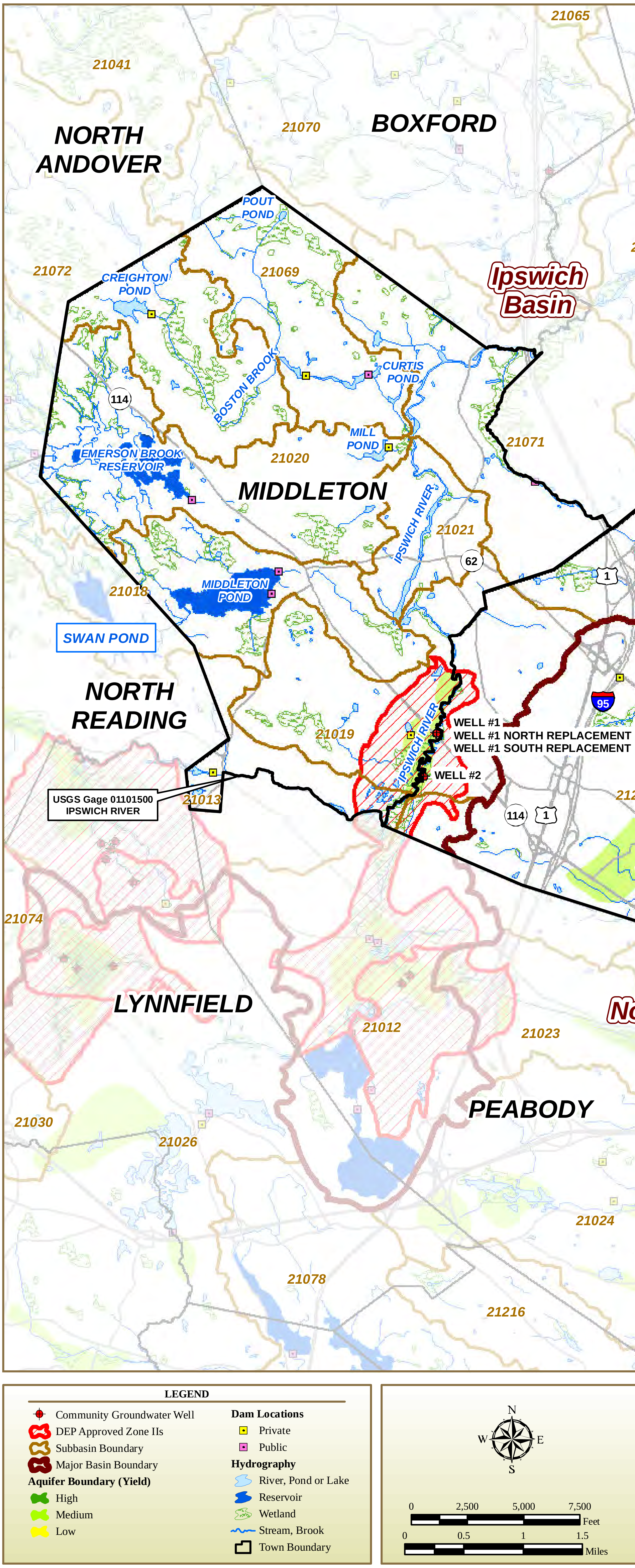
2. Potential demand management offsets were based on the following:
   a. outdoor watering restrictions would be applied to all households (13,513), whether or not on the public water supply. There were 10,615 households in Danvers and 2,898 households in Middleton in 2010 according to U.S. Census at factfinder2.census.gov. Al 2,898 households in Danvers are assumed to be on the public water supply. 1,885 households in Middleton were estimated to be on the public water supply (2010 population served from ASR report divided by average household size from U.S. Census – 5,052/2.68 = 1,885). Represents the additional water savings achieved by going from 3 days/week (existing) to 2 days/week (potential).
   b. water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danve assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water supply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.
   c. the greater water savings and less expensive options were selected for implementation where more than one option existed (e.g., aerators are cheaper than faucets, HE

3. Potential demand management offsets were based on the following: the greater water savings and less expensive options were selected for implementation where more than one option existed (e.g., aerators are cheaper than faucets, HE toilets are more efficient than lov flow.

4. Costs and revenue loss are provided for potential mitigation options only.

5. Revenue losses are calculated as the reduced water demand volume multiplied by the water rate, assuming the full potential is achieved. Actual revenue losses will be based on actual reduced water demand volume. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

6. Note that water volume savings calculated using the indirect method in Appendix E will result in the same volumes for many items.

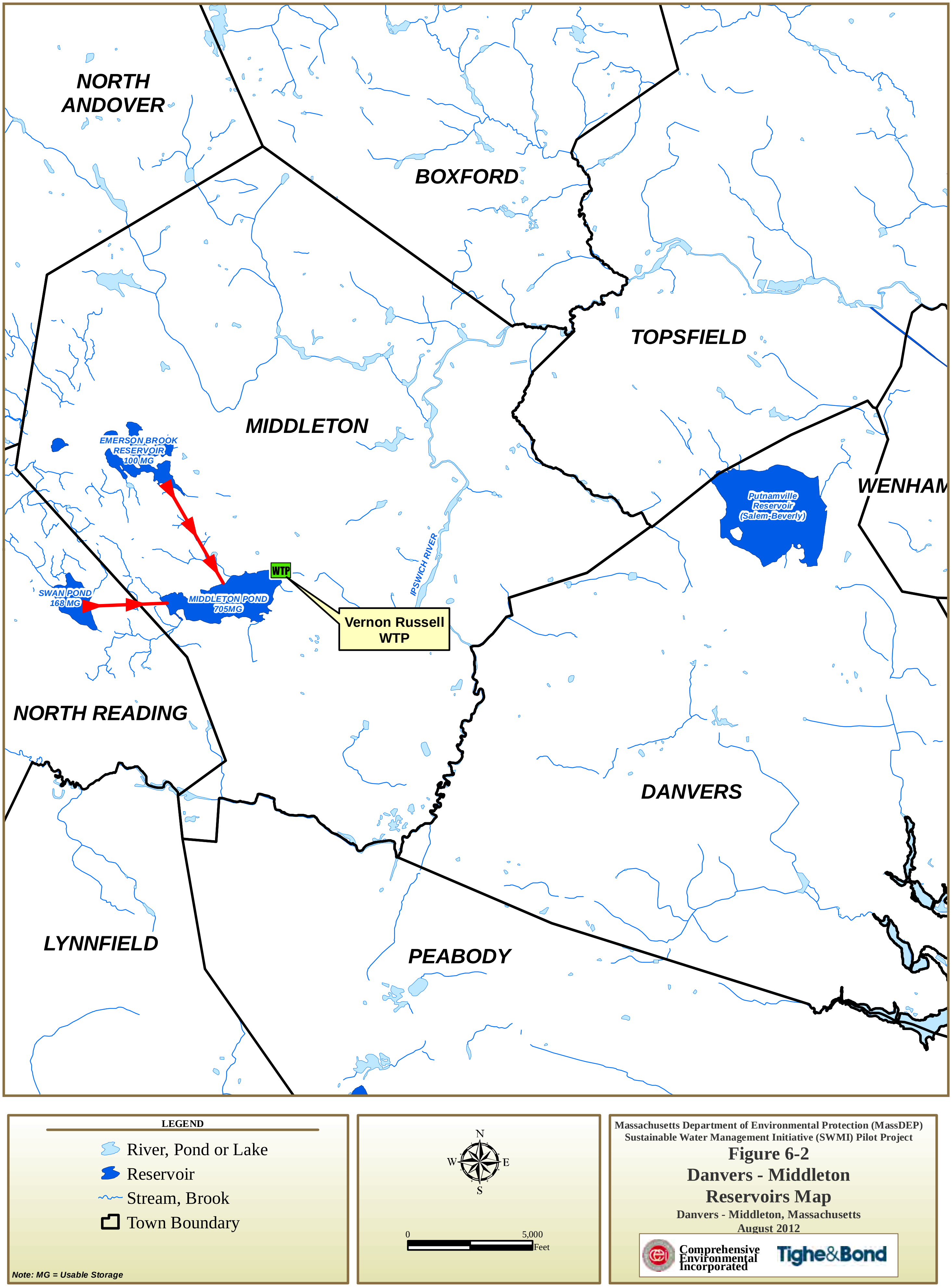


Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-1
Public Water Supply Resource Map

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond

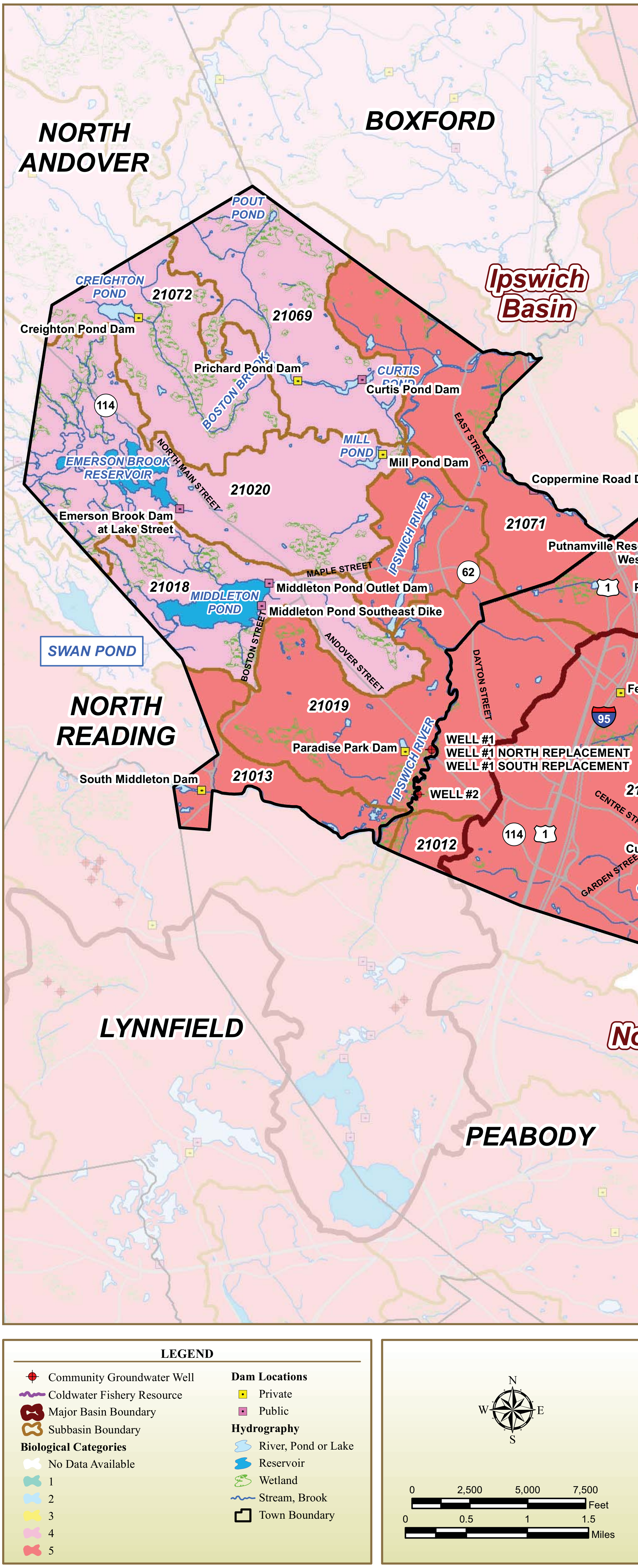


Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-2
Danvers - Middleton
Reservoirs Map

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



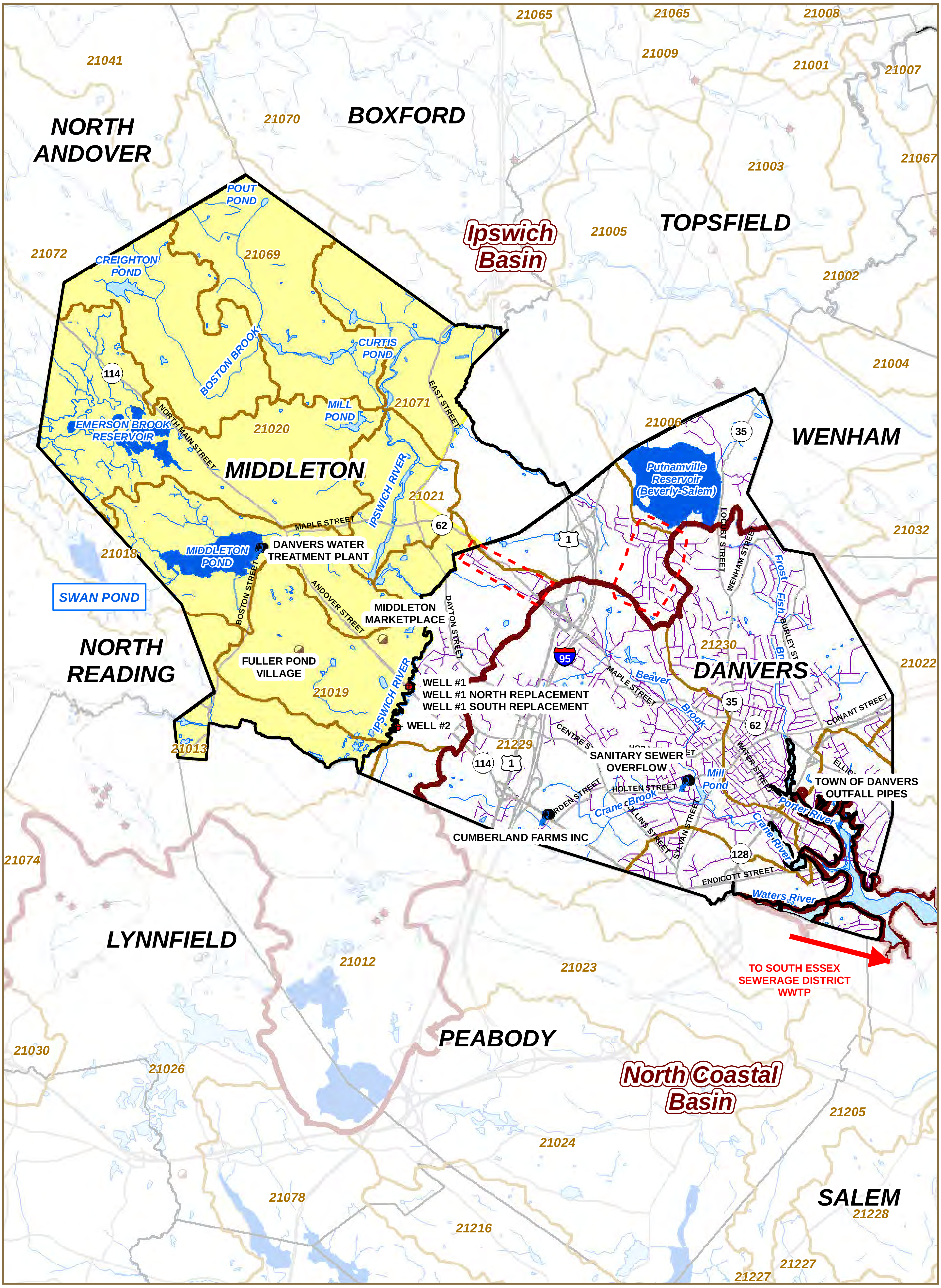
Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-3

Natural Resources and Habitat

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Sewer Main
- Unsewered Areas
- I/I Target Areas
- Community Groundwater Well
- NPDES Discharges

DEP Ground Water Discharge Permits

- Sanitary Discharge

Hydrography

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Major Basin Boundary
- Subbasin Boundary
- Town Boundary

N W E S

0 2,500 5,000 7,500 Feet

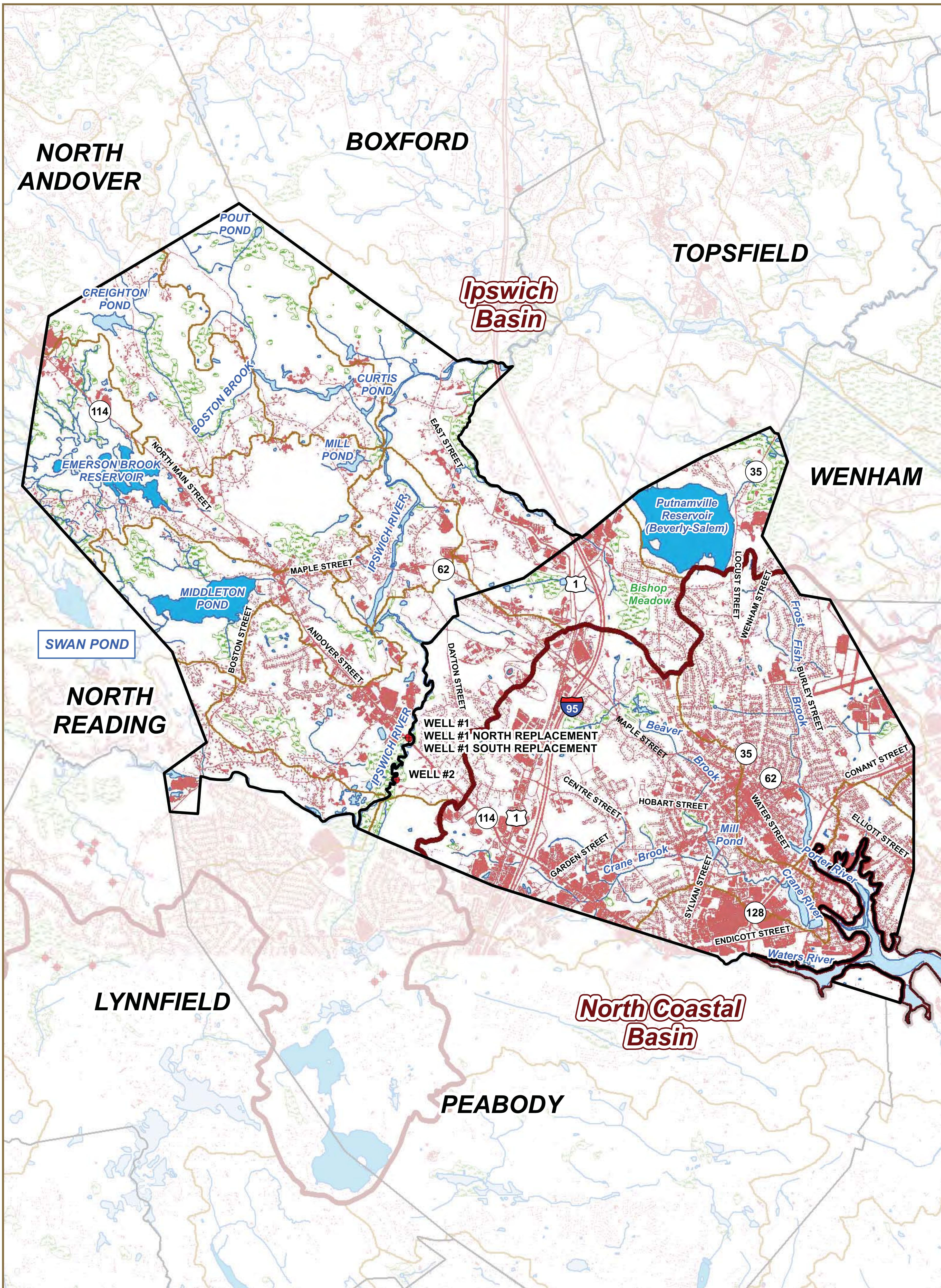
0 0.5 1 1.5 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-4
Wastewater Infrastructure

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Major Basin Boundary
- Subbasin Boundary
- Impervious Cover
- Town Boundary

Hydrography

- River, Pond or Lake
- Reservoir
- Wetland
- Stream, Brook

N W E S

0 2,500 5,000 7,500 Feet

0 0.5 1 1.5 Miles

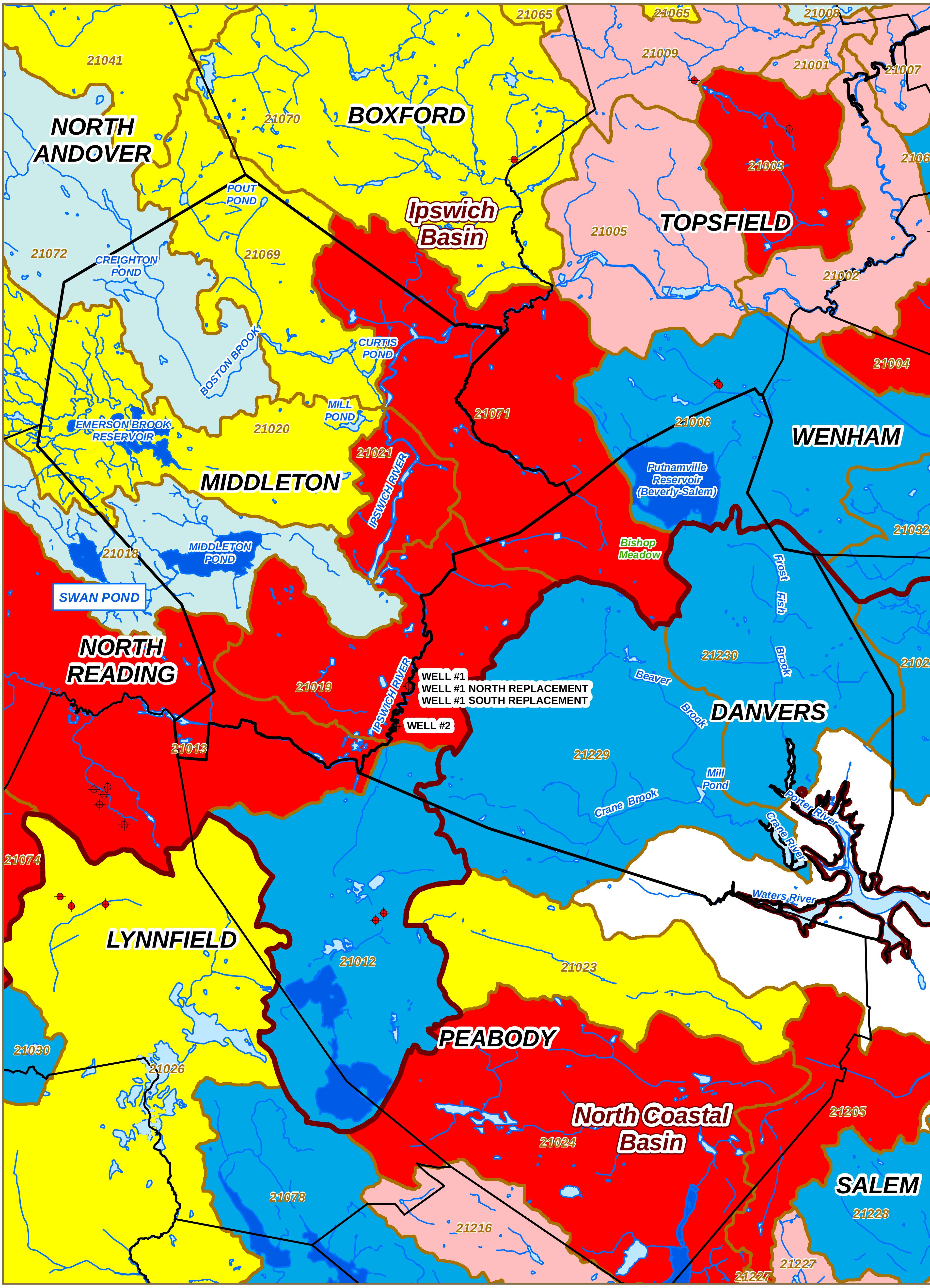
Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-5
Impervious Cover

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated

Tighe&Bond



LEGEND

Flow Level, % GW Alteration

- No Data
- 1 0 - 3%
- 2 3 - 10%
- 3 10 - 25%
- 4 25 - 55%
- 5 >55%
- Major Basin Boundary
- Subbasin Boundary

- Community Groundwater Well
- Coldwater Fishery Resource

Hydrography

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Town Boundary

N W E S

0 2,500 5,000 7,500 Feet

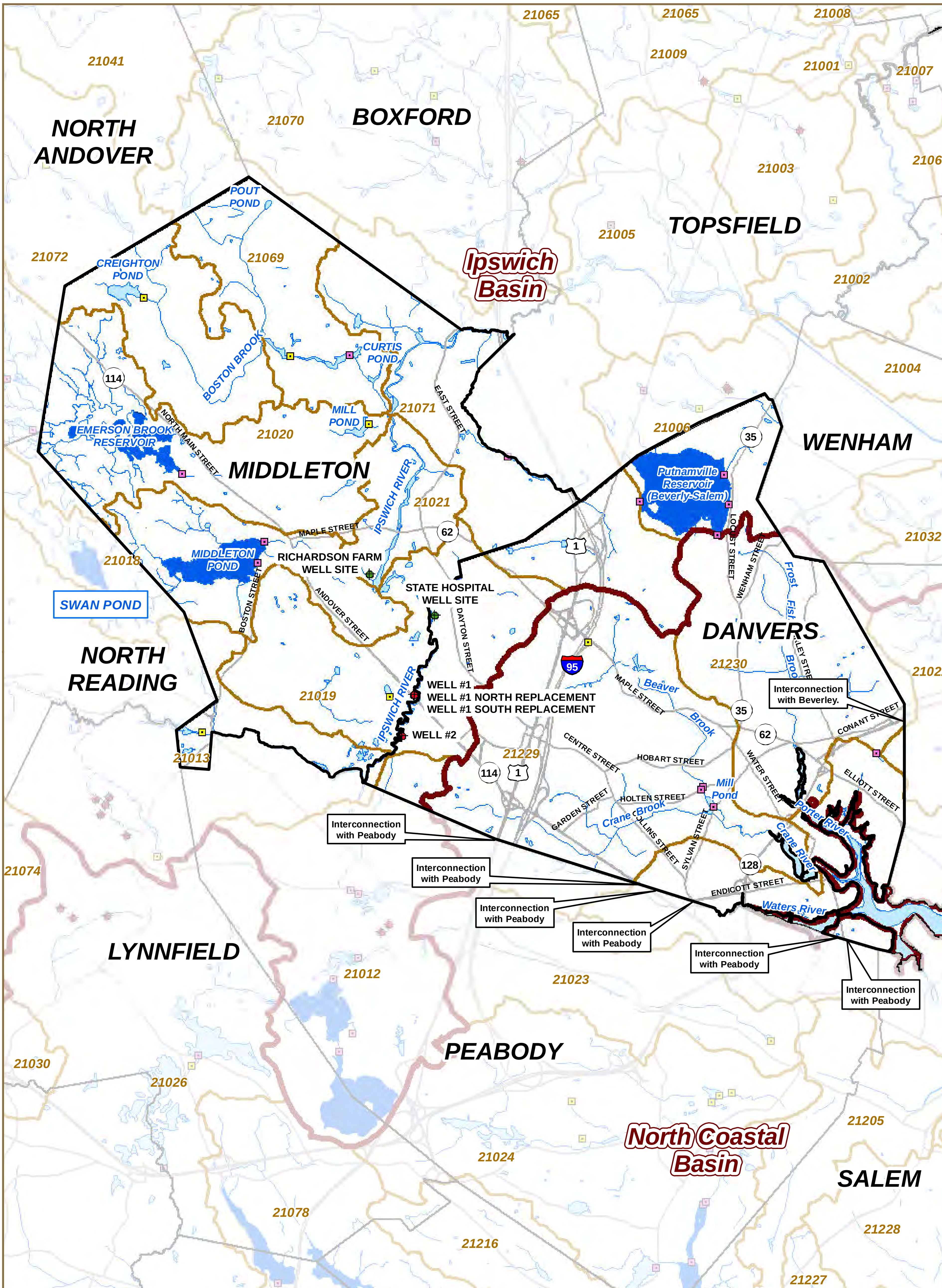
0 0.5 1 1.5 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-6
Flow Levels Map

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated Tighe&Bond



LEGEND

- Community Groundwater Well
- Potential Community Groundwater Well
- Subbasin Boundary
- Major Basin Boundary

Dam Locations

- Private
- Public

Hydrography

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Town Boundary

N
W E
S

0 2,500 5,000 7,500 Feet

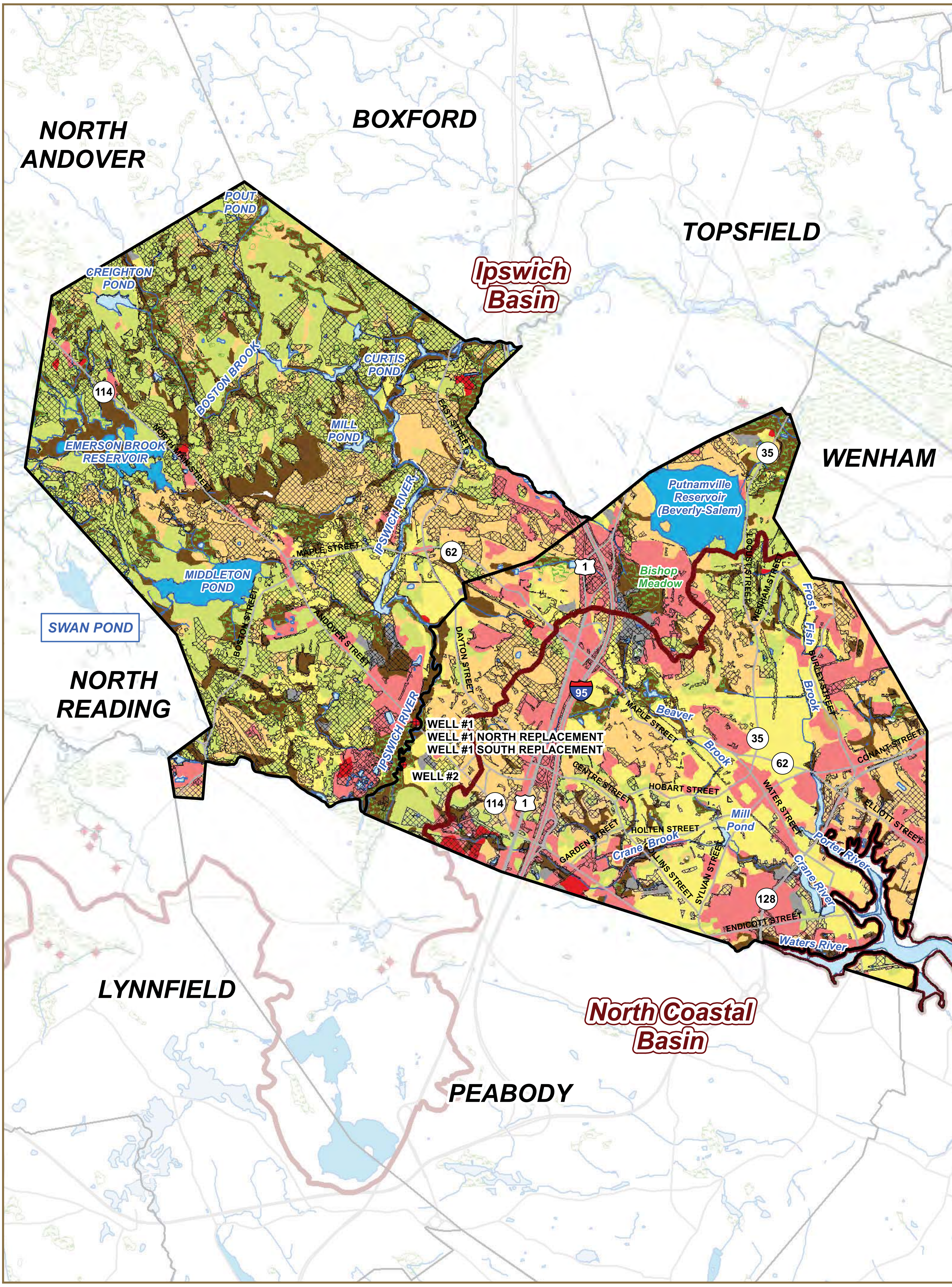
0 0.5 1 1.5 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-8
Alternative Sources Map

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Potentially Developable Land
- Major Basin Boundary

Hydrography

- River, Pond or Lake
- Reservoir
- Wetland
- Stream, Brook

Soils - Hydrologic Group

- A
- B
- C
- C/D
- D
- Landfill
- Pits, quarry
- Urban Fill
- Town Boundary

Note: Potentially Developable Land excludes Protected and Recreational Open Space properties.

N / W / E / S

0 2,500 5,000 7,500 Feet

0 0.5 1 1.5 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 6-9

Soils Characteristics, Undeveloped and Protected Lands

Danvers - Middleton, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond

Section 7 Dedham-Westwood

The Pilot Project has applied the Draft Sustainable Water Management Initiative (SWMI) Framework to each of the Public Water Suppliers (PWSs) included in the study. This section describes its application to the Dedham-Westwood Water District (DWWD). The application of the Draft SWMI Framework is based on review of data collected from Massachusetts Department of Environmental Protection (MassDEP), DWWD, the Towns of Dedham and Westwood, and the Massachusetts Division of Ecological Restoration (DER) as outlined in the annotated bibliography included in Appendix C.

The following summary describes relevant characteristics of the water system and its service area, discusses permitting considerations and requirements under the Draft SWMI Framework, identifies measures for minimizing impacts of withdrawals, and identifies potential mitigation and offset actions for credits against requested withdrawals.

7.1 Town Characteristics

Understanding existing town characteristics is necessary to identify and apply the Draft SWMI Framework minimization and mitigation options discussed in Section 4.0. Existing conditions pertaining to water supply sources, local water resources and habitat, wastewater and stormwater is provided below, followed by specific discussions on the application of the Draft SWMI framework.

7.1.1 Water Supply Sources

DWWD serves the entire towns of Dedham and Westwood. Water is supplied from fourteen groundwater wells in the Charles and Neponset River Basins, as illustrated on Figure 7-1. The wells in the Charles River Basin are operated under a Water Management Act (WMA) Registration and the Neponset River wells are operated under a registration with permitted supplemental volume.

The Bridge Street well field, located in Dedham, includes eight wells which draw groundwater from the Charles River Basin. Wells in the Bridge Street well field were installed between 1957 and 2003. Wells B2, D2, E1, E2 were installed as supplemental wells to restore lost yields. Water from the Bridge Street wells are treated with aeration for radon and carbon dioxide removal (pH adjustment), filtered for iron removal and chemically treated with chlorine for disinfection, phosphate for corrosion control, and fluoride. Backwash from the treatment plant is settled and recycled to the head of the treatment plant. Settled solids are discharged to the sewer.

Rock Meadow Well No. 11 is located in the Charles River Basin in Westwood. The yield of this well is estimated to be 0.6 mgd. Water from the Rock Meadow well is high in iron, manganese, and color and is therefore rarely utilized. When in service, water from the well is chemically treated with chlorination, fluoridation, pH adjustment and phosphate for corrosion control and pumped directly into the Westwood High Service zone and. The Rock Meadow Tubular Wells, located in the same wellfield, have been inactive for greater than five years.

The White Lodge Wellfield, located primarily in Westwood, includes five wells installed between 1954 and 1997 and draws from the Boston Harbor/Neponset River Basin. White Lodge Well #3A and White Lodge Well #4A were installed as replacement wells for White Lodge Wells #3 and #4 respectively. Use of the White Lodge Well #5 (a.k.a. the Fowl Meadow Well) is governed by an Interbasin Transfer Act (IBTA) Permit from the Massachusetts Water Resources Commission. As a condition of the IBTA Permit, and DWWD's WMA Permit, Well No. 5 must be shut off when flow in the Neponset River falls below 0.15 cubic feet per second per square mile of watershed (cfsm) or when the flow is less than one foot in depth, or 95 cfs (whichever is greater) below the Milton Lower Falls dam (at the Neponset River Greenlodge Gage) during the months of March, April, or May. (DWWD IBTA Approval, DWWD WMA Permit) Water from the White Lodge Wellfield is treated with aeration for removal of carbon dioxide and low levels of Volatile Organic Chemicals (VOCs) and then filtered through greensand filters for manganese removal. Effluent from the filters is treated with chlorination, fluoridation and pH adjustment before being discharged into the system.

Since approximately 2007, DWWD has also had the ability to purchase water from MWRA. The purchase water agreement allows DWWD to purchase up to 0.1 mgd on an annual average basis and 2.0 mgd on any given day. (DWWD MWRA Agreement).

Table 7-1 summarizes pertinent information regarding the authorized withdrawal volumes of DWWD's sources of supply. As indicated, the system has a registered volume of 4.53 mgd and a permitted volume of 0.49 mgd for a total authorized withdrawal volume of 5.02 mgd. (DWWD WMA Neponset, DWWD WMA Charles).

<table>
<tr><th colspan="6">Table 7-1. Dedham-Westwood Water District - Sources of Supply</th></tr>
<tr><th rowspan="2">Source</th><th rowspan="2">MassDEP ID</th><th rowspan="2">Subbasin</th><th colspan="2">WMA Permit Limits (mgd)</th><th rowspan="2">WMA Permit + Registration Annual Average (mgd)</th></tr>
<tr><th>Annual Average</th><th>Maximum Day</th></tr>
<tr><td colspan="6">Charles River Basin</td></tr>
<tr><td>Well B1</td><td>3073000-02G</td><td>21113</td><td rowspan="8">N/A</td><td rowspan="8">N/A</td><td rowspan="8">1.91</td></tr>
<tr><td>Well D1</td><td>3073000-03G</td><td>21113</td></tr>
<tr><td>Well E</td><td>3073000-04G</td><td>21113</td></tr>
<tr><td>Well F</td><td>3073000-05G</td><td>21113</td></tr>
<tr><td>Well B2</td><td>3073000-14G</td><td>21113</td></tr>
<tr><td>Well D2</td><td>3073000-15G</td><td>21113</td></tr>
<tr><td>Well E1</td><td>3073000-16G</td><td>21113</td></tr>
<tr><td>Well E2</td><td>3073000-17G</td><td>21113</td></tr>
<tr><td colspan="6">Neponset River Basin</td></tr>
<tr><td>White Lodge Well #1</td><td>3073000-06G</td><td>21107</td><td rowspan="5">0.49</td><td rowspan="4">3.78</td><td rowspan="5">3.11</td></tr>
<tr><td>White Lodge Well #2</td><td>3073000-07G</td><td>21040</td></tr>
<tr><td>White Lodge Well #3A</td><td>3073000-18G</td><td>21040</td></tr>
<tr><td>White Lodge Well #4A</td><td>3073000-19G</td><td>21040</td></tr>
<tr><td>White Lodge Well #5</td><td>3073000-13G</td><td>21107</td><td>1.15</td></tr>
<tr><td></td><td></td><td>Sub-Total</td><td>0.49</td><td>4.93</td><td>3.11</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Total:</td><td>5.02</td></tr>
</table>

The average annual withdrawal from each supply over the past three years is summarized in Table 7-2. (DWWD ASRs).

Table 7-2. Dedham-Westwood Water District – Annual Production			
Source	Average Annual Production (mgd)		
	2009	2010	2011
Charles River Basin			
Well B1	0.121	0.136	0.142
Well D1	0.225	0.218	0.223
Well E	0.024	0.137	0.172
Well F	0.199	0.200	0.124
Well B2	0.039	0.039	0.083
Well D2	0.096	0.166	0.129
Well E1	0.198	0.130	0.130
Well E2	0.216	0.202	0.162
Rock Meadow Well 11	0	0	0
Rock Meadow Tubular Wells	0	0	0
Charles Basin Sub-Total:	1.12	1.23	1.17
Neponset River Basin			
White Lodge Well #1	0.220	0.326	0.422
White Lodge Well #2	0.236	0.372	0.370
White Lodge Well #3A	0.765	0.762	0.745
White Lodge Well #4A	0.436	0.430	0.430
White Lodge Well #5	0.974	0.805	0.644
Neponset Basin Sub-Total:	2.63	2.70	2.61
MWRA	0.001	0.047	0.026
Total:	3.75	3.97	3.80

As indicated in the Table, DWWD's withdrawals have been below their authorized quantities in both the Charles and Neponset Basins.

7.1.2 Local Water Resources and Habitat

Dedham's and Westwood's natural resources, habitat and infrastructure influencing habitat (e.g., dams and culverts) are shown on Figure 7-2.

DWWD's sources are located within the Charles River Basin and the Neponset River portion of the Boston Harbor Basin. Ten groundwater sources for the DWWD are located in the Charles River Basin with nine located adjacent to the Charles River in Dedham in Subbasin 21113. One additional groundwater source is located along a tributary to the Charles River in Westwood in Subbasin 21036. Subbasin 21113 is designated as Biological Category 5 and Flow Level 4 and Subbasin 21036 is designated as Biological Category 5 and Flow Level 3. The Charles River Watershed is approximately 308 square miles and includes parts of 35 cities and towns.

Six groundwater sources for the DWWD are located adjacent to the Neponset River with five located in southeast Westwood in Subbasin 21040 and one in southeast Dedham in Subbasin 21107. Both of these Subbasins are designated as Biological Category 5 and Flow Level 5. The Neponset River Watershed is approximately 130 square miles and includes parts of 14 cities and towns. The Neponset River forms the easterly border between Dedham and Canton.

There are two Coldwater Fishery Resources located in Westwood, including Purgatory Brook and Mill Brook, both located upstream of the groundwater withdrawal points.

Dedham and Westwood are located in an urbanized region of the state, but the watershed areas contain a number of protected parks and conservation areas and the Charles and Neponset Rivers provide significant wildlife habitat. Other brooks and streams located in Dedham include Mother Brook (originally a mile long canal constructed by the Town to divert a portion of the flow from the Charles to the Neponset River), Lowder Brook, Rocky Meadow Brook, and Little Wigwam Stream. Dedham contains approximately 900 acres of wetlands. (Dedham OSRP 2010)

There are four dams in Dedham. One is owned by the Town of Dedham. Table 7-3 provides a summary of dams including ownership and its location.

Table 7-3. Dams in Dedham				
Dam Name	**Location**	**Owner**	**Major Basin**	**Subbasin**
Centennial Dam	Dedham	DCR	Neponset River Basin	21107
Colburn St. Dam	Dedham	Town of Dedham	Neponset River Basin	21107
Mother Brook Dam at Maverick St.	Dedham	DCR	Neponset River Basin	21107
Weld Pond Dam	Dedham	Private	Charles River Basin	21113

There are four dams in Westwood, all are privately owned. Table 7-4 provides a summary of dams including ownership and its location.

Table 7-4. Dams in Westwood				
Dam Name	**Location**	**Owner**	**Major Basin**	**Subbasin**
Lee Pond Dam	Westwood	Private	Charles River Basin	21036
Noannet Pond Dam	Westwood	Private	Charles River Basin	21035
Stevens Pond Dam	Westwood	Private	Charles River Basin	21036
Storrow Pond Dam	Westwood	Private	Charles River Basin	21035

Using GIS mapping, about 38 stream culverts were identified in Dedham, and 41 in Westwood.

7.1.3 Wastewater

Dedham and Westwood are both members of the MWRA wastewater community. Wastewater collected from the communities is transported to the Deer Island Sewage Treatment Plant in Boston, where it is treated and discharged to Boston Harbor through an ocean outfall. Dedham is 100% sewered, with approximately 90 miles of gravity sewer main and over 2,600 manholes and one pump station. Most of Dedham is located within the Charles River Basin; the southwest corner drains to the Neponset River Basin.

Westwood is about 95% sewered and discharges approximately 2 mgd to the MWRA system. The collection system consists of approximately 77 miles of predominantly gravity sewer, more than half of which is over 30 years old. Westwood straddles the two watersheds; approximately two-thirds of the town is in the Neponset River Basin, and one third in the Charles River Basin. Three flow meters interconnect the Westwood collection system to the MWRA interceptor. There are few streets in Westwood that are not sewered. See Dedham-Westwood Wastewater Infrastructure Figure 7-3 for the approximate locations of unsewered areas.

7.1.4 Stormwater

7.1.4.1 Summary of Phase II Program

Dedham

Dedham is a National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase II regulated community and performs the following actions under its stormwater management program:

- Public education and outreach includes creation of a dedicated stormwater page on the Town's website with links to regulations, brochures and notices, and links via the Charles River Watershed Association webpage. Stormwater information is also periodically made available at the Farmer's Market. Public participation events include stenciling storm drains with Eagle Scout volunteers, hosting an Earth Day cleanup event, organizing a hazardous waste collection day, and utilizing a school education program.
- The Town has continued efforts to remove illicit discharges by evaluating its stormwater outfalls as needed to determine improper connections. The Town has established an internal GIS division which manages stormwater system mapping. The stormwater map is approximately 99% complete and is updated as needed, currently showing the locations of 374 outfalls.
- The most recent annual report indicates that Dedham has adopted bylaws to address illicit discharges, construction site runoff and post-development stormwater issues. Bylaws and regulations have been periodically updated throughout the years to keep them current with the best available methods. The Conservation Commission also reviews proposed projects, including subdivisions and site plans as necessary to enforce stormwater bylaws and regulations.
- The Town practices maintenance and good housekeeping for its municipal operations, in part by sweeping streets and cleaning catch basins. Arterial roads are swept approximately every 3 days, and all other roads are swept twice a year.

The Town also cleans approximately one-third of its catch basins every year, and most recently cleaned approximately 3,000 linear feet of storm drain pipe.

Westwood

Westwood is also a NPDES MS4 Phase II regulated community and performs the following actions under its stormwater management program:

- Public education and outreach includes providing links to stormwater education materials from the Town website, publishing articles in the local newspaper, and utilizing a school education program as part of the curriculum. Public participation events include a volunteer water quality monitoring program, volunteer catch basins stenciling, and a system for volunteer roadside cleanups.
- The Town has continued efforts to remove illicit discharges by evaluating its stormwater and sewer systems as needed to determine improper connections. Storm system mapping is 100% complete and is updated as needed, currently showing the locations of approximately 2,205 catch basins and 227 outfalls.
- The most recent annual report indicates that existing Town bylaws are under review to incorporate illicit discharges, construction site runoff and post-development stormwater issues. The Engineering Department and Conservation Commission conduct inspections during construction using an established checklist to ensure compliance with industry best management practices.
- The Town practices maintenance and good housekeeping for its municipal operations, in part by sweeping streets and cleaning catch basins. Major roads were swept twice during permit year 9, with secondary roads swept once a year and again as needed, generating a total of 400 tons of street sweeps material. The Town also cleaned 2,205 catch basins during 2011, and approximately 2,000 linear feet of storm drain pipe.

7.1.4.2 Infrastructure

Dedham

The most recent NPDES MS4 Phase II annual report, dated May 1, 2012 indicates that the Town has confirmed the locations of approximately 374 outfalls.

Westwood

The most recent NPDES MS4 Phase II annual report, dated April 27, 2012 indicates that the Town has confirmed the locations of approximately 2,205 catch basins and 227 outfalls.

7.1.4.3 Impervious Cover

Dedham

Based on information obtained from the U.S. Environmental Protection Agency (EPA) Region 1, Dedham encompasses 10.68 square miles, of which 2.38 square miles (22.31%) is impervious. Of the impervious area in town, 1.63 square miles (15.30%) is considered to be directly connected to waterbodies in the community. Refer to Figure 7-4 for the impervious cover in Dedham/Westwood.

Currently, Dedham is relatively heavily developed. About 30% of the town remains as undeveloped land such as open space or forest.

Westwood

Based on information obtained from EPA Region 1, Westwood encompasses 11.15 square miles, of which 2.00 square miles (17.93%) is impervious. Of the impervious area in town, 1.16 square miles (10.43%) is considered to be directly connected to waterbodies in the community. Refer to Figure 7-4 for the impervious cover in Dedham/Westwood.

Westwood is moderately developed. About 35% of the town remains as undeveloped land such as open space or forest.

7.1.4.4 Stormwater Regulations

Dedham

The Pilot Project Team reviewed Dedham's regulations for stormwater control requirements that could be considered as mitigation measures for groundwater withdrawals, particularly recharge requirements. Dedham's regulations include the following requirements:

- Zoning bylaws establish an Aquifer Protection Overlay District to preserve and maintain the quality and volume of groundwater supply and groundwater recharge areas within the town. Residential development is permitted within this District, provided that no more than 25% of a building lot is impervious. For new land uses greater than 25% impervious, a system for artificial recharge of precipitation must be approved by a Special Permit. Larger parking areas must be constructed with permeable paving. All new dwellings in the Aquifer Protection Overlay District must be connected to the public sewer system if sewer systems are installed in the street.
- Commercial and industrial activities may be permitted with a Special Permit site plan to address loss of recharge and/or adverse impacts on groundwater recharges. Except for single family dwellings, a Special Permit must address drainage, and all runoff from impervious surfaces must be recharged on-site and diverted towards areas covered with vegetation for surface infiltration to the extent possible. Dry wells may be used only where other methods are not feasible, and must be preceded by oil, grease, and sediment traps.
- For major residential developments situated anywhere in town, stormwater should be directed into the ground and discharges to storm sewers minimized where possible.
- Dedham has also adopted a stormwater management bylaw, rules and regulations, and design standards for use during design. The bylaw requires most projects that will increase impervious area to obtain a Stormwater Management Permit. Accompanying rules and regulations require that MassDEP stormwater management standards be adhered to during design. Post-development surface runoff must approximate predevelopment conditions, and loss of annual groundwater recharge must be minimized through the use of infiltration measures to the maximum extent practicable. Annual recharge from the post-development

site should approximate annual recharge from predevelopment conditions based on soil types. Stormwater pollution must also be minimized and an operation and maintenance plan in place. New development must remove 80% of the average annual post-development pollutant loadings of total suspended solids (TSS).

Westwood

The Pilot Project Team reviewed Westwood's regulations for stormwater control requirements that could be considered as mitigation measures for groundwater withdrawals, particularly recharge requirements. Westwood's regulations include the following requirements:

- Zoning bylaws outline a number of requirements to preserve greenspace and promote infiltration. All parking lots must be surrounded by pervious landscaping on all sides. Lots larger than 40 spaces must have pervious landscaped islands dividing the lot into sections. An Environmental Impact and Design Review (EIDR) is required for construction, alteration or expansion of a municipal, institutional, commercial, industrial or multifamily structure. Applicants should generally preserve existing landscape and natural features. The EIDR also requires that stormwater be removed from roofs and paved areas as outlined by the MassDEP stormwater management standards.
- Zoning bylaws also include an Open Space Residential Development (OSRD) program to conserve natural resources by establishing minimum lot sizes, encourages cluster developments, preserving natural landscaping, trees and vegetation, promoting the creation of open space, etc. which applies to approximately 80% of the Town. Any new or redevelopment occurring within Single Residence Zones B, C, and E are subject to the OSRD program, and must undergo an EIDR. Roads and driveways must be designed per the usual design requirements; however designers are encouraged to explore alternate designs that vary from the standards, including narrower streets, etc. To the extent practicable, the use of LID and soft drainage techniques must be used in the design of an OSRD project, subject to compliance with regulations.
- Westwood has 3 Watershed Resource Protection Overlay Districts, generally located at the far eastern end of town, and a large area in the western end of town. This district seeks to protect, preserve and maintain existing and potential groundwater supply and recharge areas, and protect against degradation. Development in this area must keep at least 20% of lot areas within the WRPOD vegetated. If impervious cover is greater than 15%, all stormwater must be recharged onsite. All drainage shall meet stormwater management standards as outlined by MassDEP.
- Flexible Multiple Use Overlay Districts encourages multiple use development and requires that existing open space areas be preserved. Stormwater development must conform to MassDEP stormwater management standards. Development must efficiently collect runoff from all impervious surfaces, roofs and canopies in a way that avoids impacts on neighboring properties. Where practical, LID that captures and recharges runoff may be used in place of closed systems.
- Multiple Use Overlay District developments larger than 50 acres may be authorized by an Area Master Plan, part of which must include a water budget

analysis for affected sub-basins, analyzing net flows as a result of inflows and outflows. The water budget must be performed for the current condition and for the post-development condition to reflect proposed mitigations.

7.1.4.5 Impaired Waters and TMDL Status

Dedham

According to the final Massachusetts Year 2010 Integrated List of Waters, the following Dedham waterbodies are impaired and listed as Category 5 waters, or waters requiring preparation of a TMDL:

Table 7-5. Dedham Impaired Waters and TMDL Status

Category	Waterbody	Waterbody ID	Length	Impairment	EPA TMDL No.
Category 5	Charles River	MA72-07	24.8 miles	Fishes Bioassessments	-
				Nutrient/Eutriphication Biological Indicators	-
				DDT	-
				(Fish Passage Barrier)	-
				(Non-Native Aquatic Plants)	-
				Escherichia coli	32370
				Phosphorus (Total)	-
				PCB in Fish Tissue	-
				(Other Flow Regime Alterations)	-
Category 5	Rock Meadow Brook	MA72-21	3.8 miles	Aquatic Plants (Macrophytes)	-
				Aquatic Macroinvertebrate Bioassessments	-
				Excess Algal Growth	-
				Nutrient/Eutriphication Biological Indicators	-
				Oxygen, Dissolved	-
				Phosphorus (Total)	-
Category 5	Neponset River	MA73-02	8.4 miles	Other	-
				(Debris/Floatables/Trash)	-
				Fecal Coliform	2592
				Foam/Flocs/Scum/Oil Slicks	-
				Oxygen, Dissolved	-
				PCB in Fish Tissue	-
				Turbidity	-
Category 5	Mother Brook	MA73-28	3.6 miles	(Low flow alterations)	-
				Phosphorus (Total)	-
				Taste and Odor	-
				PCB in Fish Tissue	-
				Color	-
				Fecal Coliform	2592
				Oxygen, Dissolved	-

Notes:
Category 5: Waters requiring a TMDL
Impairments shown entirely in parentheses are designated as "TMDL not required (non-pollutant)", e.g. (Fish Passage Barrier)

Waterbodies with an entry in the "EPA TMDL No." column above have a TMDL prepared as follows:

Table 7-6. Dedham TMDLs		
EPA TMDL No.	Approval Date	TMDL Name
2592	June 21, 2002	TMDLs of Bacteria for Neponset River Basin
32370	May 22, 2007	TMDLs for Pathogens within the Charles River Watershed

Although neither TMDL specifically addresses stormwater sources in Dedham, both identify stormwater runoff as a major source of fecal coliform to the rivers. Both the Charles River and Neponset River TMDLs identify the need for “intensive application of non-structural BMPs” throughout the watershed to reduce loads of fecal coliform and other pollutants such as nutrients to the Neponset River. Both TMDLs also identify the possible need for structural BMPs, should non-structural components prove ineffectual. All affected communities, including Dedham, must “develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from their storm drainage systems to the maximum extent practicable to protect water quality” by implementing the six minimum measures required under the NPDES program.

Westwood

The final Massachusetts Year 2010 Integrated List of Waters defines the following Westwood waterbodies as either are impaired (Category 5 – Waters requiring a TMDL), or waters for which a TMDL has been completed (Category 4a):

Table 7-7. Westwood Impaired Waters and TMDL Status					
Category	Waterbody	Waterbody ID	Size	Impairment	EPA TMDL No.
Category 4a	Willet Pond	MA73062	205.6 acres	Mercury in Fish Tissue	33880
				Fecal Coliform	2592
	Mill Brook	MA73-12	3.1 miles	Fecal Coliform	2592
	Purgatory Brook	MA73-24	5.9 miles	Fecal Coliform	2592
	Ponkapog Brook	MA73-27	3.1 miles	Fecal Coliform	2592
Category 5	Powissett Brook	MA72-20	1.8 miles	Combined Biota/Habitat Bioassessments	-
	Rock Meadow Brook	MA72-21	3.8 miles	Aquatic Plants (Macrophytes)	-
				Aquatic Macroinvertabrate Bioassessments	-
				Excess Algal Growth	-
				Nutrient/Eutrophication Biological Indicators	-
				Oxygen, Dissolved	-
				Phosphorus (Total)	-
	Neponset River	MA73-02	8.4 miles	Other	-
				(Debris/Floatables/Trash)	-
				Fecal Coliform	2592
				Foam/Flocs/Scum/Oil Slicks	-
				Oxygen, Dissolved	-
				PCB in Fish Tissue	-
				Turbidity	-
	Germany Brook	MA73-15	2.0 miles	Color	-
				(Debris/Floatables/Trash)	-
				Fecal Coliform	2592
				pH, High	-
				Phosphorus (Total)	-

Notes:
Impairments shown entirely in parentheses are designated as "TMDL not required (non-pollutant)", e.g. (Debris/Floatables/Trash)
Category 4a: TMDL is completed
Category 5: Waters requiring a TMDL

Waterbodies with an entry in the "EPA TMDL No." column above have a TMDL prepared as follows:

Table 7-8. Westwood TMDLs

EPA TMDL No.	CN No.	Approval Date	TMDL Name
2592	121	June 21, 2002	TMDLs of Bacteria for Neponset River Basin
33880	N/A	December 20, 2007	Northeast Regional Mercury TMDL

The Bacteria TMDL for the Neponset River Basin is the same as discussed under Dedham. The Northeast Regional Mercury TMDL focuses on control of atmospheric deposition of mercury, therefore, there are no stormwater controls directly related to mercury control. However implementation of the six minimum measures identified under the NPDES Phase II program will help to reduce mercury pollution.

7.2 Permit Tier Designation

As described in Section 2.1 of this report, the Draft SWMI Framework proposes WMA Permit requirements based upon the Flow Level and Biological Category of the subbasins from which withdrawals are to be permitted and the volume of the community's withdrawal request. DWWD's withdrawals from the Charles River Basin are fully authorized by its WMA Registration and therefore not subject to Permit review. The Pilot Project permit review therefore only focuses on withdrawals from the Neponset River Basin.

7.2.1 Biological Category

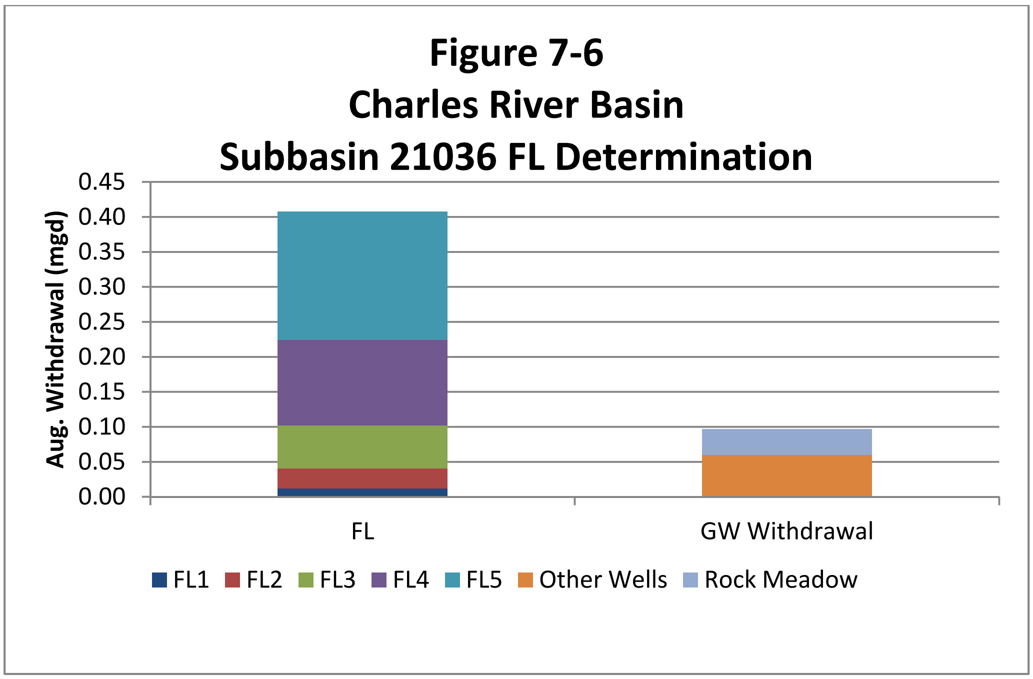
All of DWWD's groundwater sources are located in a Biological Category (BC) 5 subbasin; therefore, no increase in withdrawal volume requested could cause a change in the BC and the subbasin is not considered a Quality Natural Resource as a result of its BC. No additional evaluation related to BCs was conducted for DWWD.

7.2.2 Flow Level

The Flow Level (FL) of each subbasin in the State was determined by MassDEP based upon the estimated percent alteration of the subbasins unaffected August median flow. The unaffected flow was determined utilizing the Sustainable Yield Estimator (SYE) at the pour point (exit) of the subbasin and includes the flow from any upstream subbasins. Withdrawals were based on 2000 – 2004 annual average withdrawals for all WMA permitted wells and estimated private well withdrawals in the subbasin and upstream subbasins. Annual average withdrawals were adjusted by a peaking factor of 115.5% to determine August monthly withdrawals. The percent alteration of August flow was determined by dividing the August withdrawals by the August unaffected flow, which presumes a 1:1 relationship between withdrawals and streamflow impacts.

Figure 7-5 (DWWD Flow Level Map) depicts the FL designations for each subbasin located within and proximate to Dedham and Westwood. Figure 7-5 presents the FL designations for the four subbasins from which DWWD withdraws groundwater. Subbasins 21036 and 21113 are located in the Charles River Basin and subbasins 21040 and 21107 are located in the Boston Harbor/Neponset Basin. The two subbasins from which DWWD has permitted withdrawals (21107 and 21040) have greater than 55% alteration of unaffected August median flow and are therefore FL 5 subbasins. The Bridge Street Wells are along the main stem of the Charles River in a FL 4 subbasin and the seldom used Rock Meadow Well is in a FL 3 subbasin.

Figures 7-6 and 7-7 present the data used in determining the FL for the Charles River subbasins from which DWWD has withdrawals.



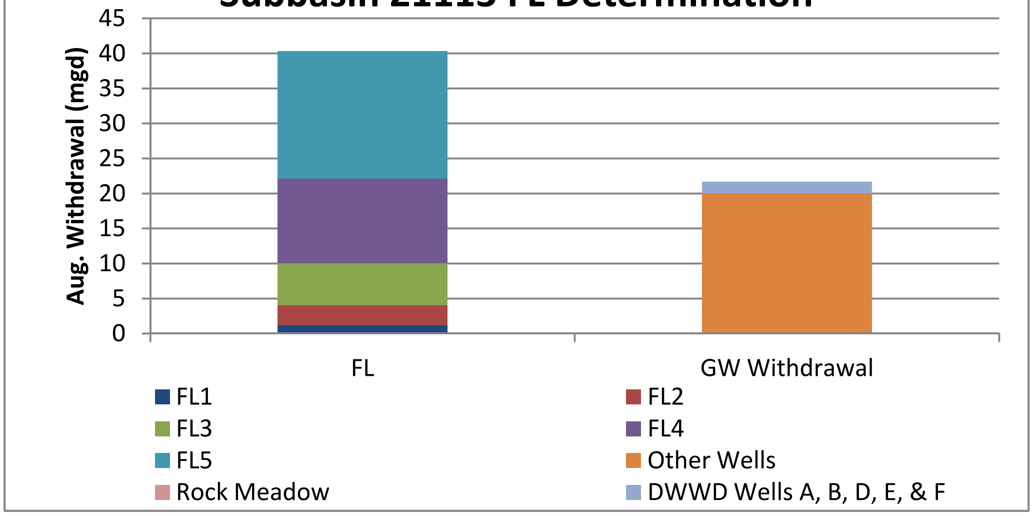
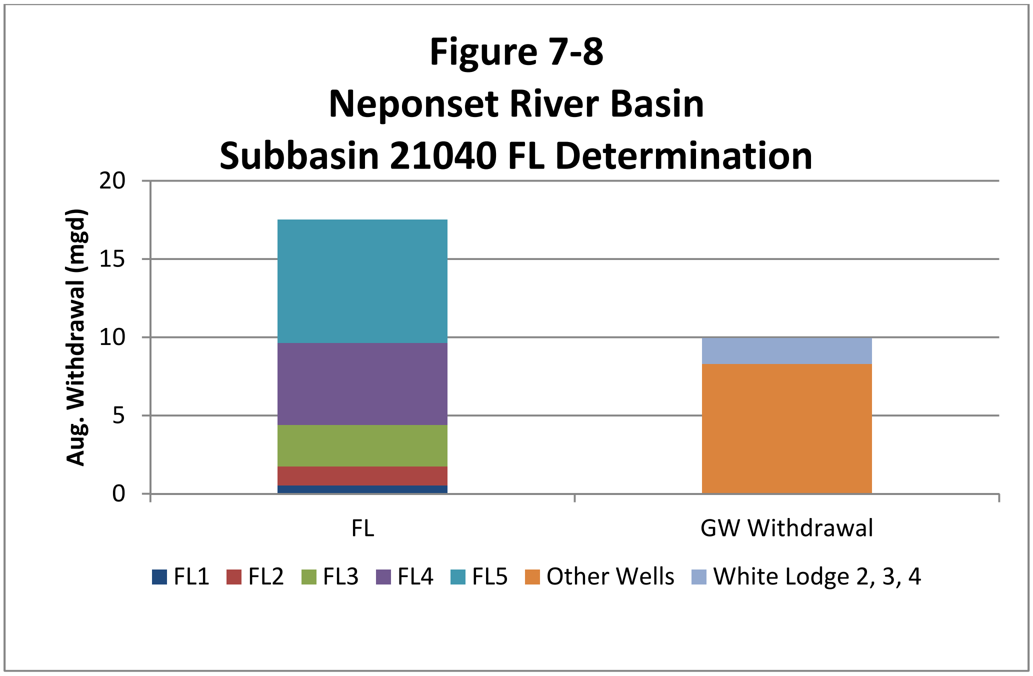


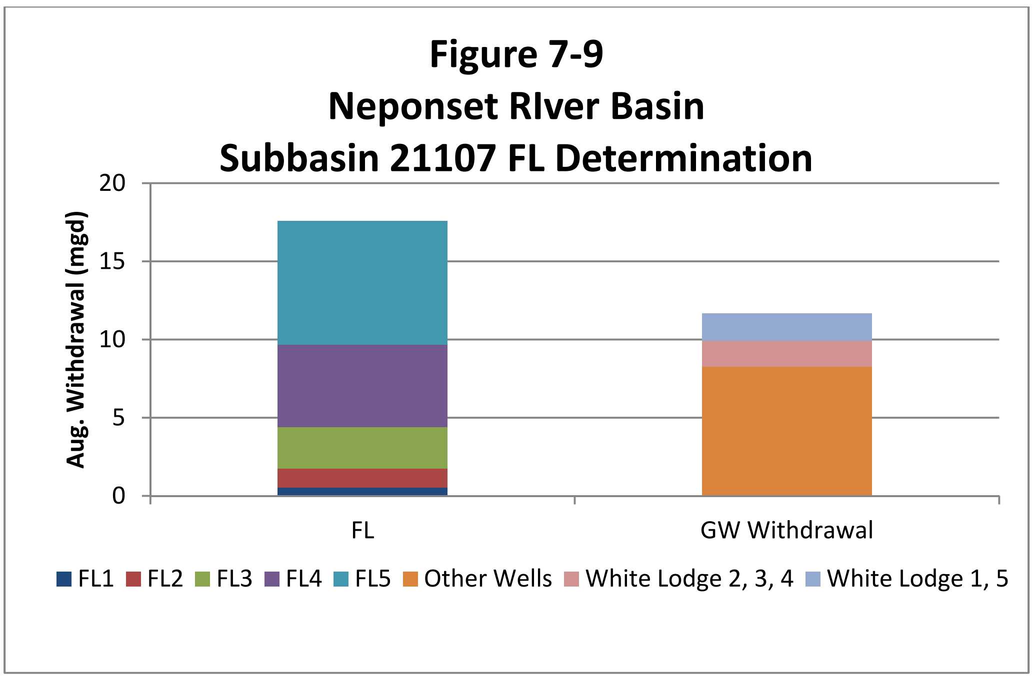
Figure 7-7
Charles River Basin
Subbasin 21113 FL Determination

The FL bar in the Figures shows the unaffected August flow at the pour point of these subbasins and quantifies the amount of August withdrawal available in each FL. The withdrawal bars in the Figures illustrates the estimated 2000 – 2004 August withdrawals used in the FL determination, and the portion of those estimated withdrawals attributed to DWWD's wells. "Other" withdrawals in the Figures consist of all WMA permitted groundwater withdrawals and private wells in and upstream of this subbasin.

Note that because subbasin 21036 flows into subbasin 21113, the Rock Meadow Well withdrawals affect flow alteration in both subbasins. As illustrated in the Figures, the Rock Meadow Well is in a FL 3 subbasin. The Bridge Street Wells (A, B, D, E &F) are along the main stem of the Charles River and therefore the subbasin they are in has an order of magnitude greater flow than the Rock Meadow Well subbasin. However, there are also more withdrawals upstream of the Bridge Street Wells resulting in a FL 4 determination. Both of these subbasins have existing withdrawals that are near the August withdrawal limit that shift into the next Flow Level designation.

Figures 7-8 and 7-9 present the data used in determining the FL for the Neponset River subbasins from which DWWD has withdrawals.





In the Neponset Basin subbasin 21040 flows into subbasin 21107. The upstream subbasin is impacted by withdrawals from White Lodge Wells 2, 3 and 4 and the downstream subbasin is impacted by all of the White Lodge Well withdrawals. In addition, the Figures show that the downstream subbasin does not contribute significant unaffected August flow on its own. The 2000-2004 withdrawals resulted in FL 5 determinations for both of these subbasins.

Table 7-9 presents additional flow and withdrawal data from the four subbasins in which DWWD has supplies.

Table 7-9. Dedham-Westwood Water District – FL Determination				
Criterion	Charles		Neponset/Boston Harbor	
	Bridge St.	Rock Meadow	White Lodge # 2, 3A, 4A	White Lodge #1, 5
2000–2004 Estimated August Withdrawal (mgd)	1.55	0.03	1.58	1.70
2009-2011 Actual August Withdrawal (mgd)	1.30	0	1.64	1.04
Subbasin	21113	21036	21040	21107
Unaffected August Flow (mgd)	40.3	0.41	17.5	17.6
Estimated Total August Withdrawals (mgd)	21.7	0.10	9.93	11.7
August Flow Alteration (%)	54	24	57	66
Flow Level	4	3	5	5
Available Flow before shifting to next Flow Level (mgd)	0.50	0.01	NA	NA

As indicated, the Bridge Street Wells are in the subbasin with the largest unaffected August flow. Withdrawals from this subbasin would therefore result in the lowest percent alteration of flow. However, there is very little additional withdrawal available in this subbasin before it would become a FL 5.

7.2.3 Tier Designation

As described in Section 2.1, the permit review tier is based upon the volume of water that a community is requesting authorization to withdraw above the baseline volume, and the percent of the unaffected August flow in the withdrawal subbasin as summarized in Table 7-10.

Table 7-10. Tier Designation	
Tier	Withdrawal Request
1	No additional water above baseline
2	Additional water above baseline <5% of subbasin's unaffected August flow
3	Additional water above baseline >5% of subbasin's unaffected August flow
4	Additional water above baseline will result in a change in Flow Level or Biological Category

The Baseline demand for a system is determined by the greater of the 2003 – 2005 annual average demand or the 2005 actual demand plus a growth factor of 8%. If the 8% factor would result in a change in the subbasin's FL, the growth factor is limited to 5%. Furthermore, the baseline cannot be lower than the system's existing registered volume or higher than the existing total authorized volume. In addition, the baseline demand cannot be more than DCR's 20-year demand projection for the community. Table 7-11 presents the basis for the baseline demand determination for DWWD in each river basin.

Table 7-11. Dedham-Westwood Water District – Baseline Demand		
Item	**Charles River Basin (mgd)**	**Neponset River Basin (mgd)**
Registered Rate	1.91	2.62
Total Authorized Volume	1.91	3.11
DCR Projection	NA	NA
2003 Demand	1.18	2.93
2004 Demand	1.53	3.10
2005 Demand	1.28	3.14
2003 – 2005 Avg. Demand	1.34	3.06
2003 – 2005 Avg. Demand + 8%	1.45	3.39
Proposed Baseline	**1.91**	**3.11**

As shown in the Table, DWWD's proposed Baseline Demand for the Charles River Basin is 1.91 because the baseline cannot be less than the currently registered rate. For the Neponset Basin the proposed Baseline is 3.11 mgd, because the baseline cannot be greater than the current Total Authorized Withdrawal rate.

DCR demand projections are not available for DWWD. For purposes of this Pilot Project, DWWD elected to utilize 3.22 mgd as the requested withdrawal amount from the Neponset Basin based on 20-year demand projections prepared by Weston and Sampson in 2006. This withdrawal request is based on system-wide demand projections (5.13 mgd) minus the registered quantity available from the Charles River Basin (1.91 mgd).

A requested withdrawal of 3.22 mgd represents a 0.11 mgd increase over the District's baseline demand in the basin. This increase is significantly less than 5% of the natural August flow in both Neponset River basins, therefore requiring a Tier 2 permit review.

7.2.4 Permit Requirements

The Draft SWMI Framework WMA Permitting Tiers Table (Table 5 of Draft Framework) presents the permit review requirements based on subbasin flow level and withdrawal request Tier. The piloted DWWD WMA permit for the Boston Harbor/Neponset requires a Tier 2/FL 5 review and therefore requires that DWWD:

- Comply with applicable provisions of standard permit conditions 1-8
    1. Source Protection
    2. Firm yield for surface water supplies
    3. Wetlands and vernal pool monitoring (if applicable)
    4. Residential use less than 65 gallons/capita/day
    5. Unaccounted for water less than 10%
    6. Seasonal limits on nonessential outdoor water use
    7. Water conservation measures
    8. Offset Feasibility Study

  Note that the minimization measures developed through the SWMI process are already being applied in standard conditions 6 and 7, and it is expected that the mitigation measures will be incorporated into standard condition 8.

- Minimize the impact of their existing withdrawals on stream flow to the greatest extent feasible considering cost, level of improvement achievable, and ability to implement.
- Implement mitigation measures that are commensurate with the impact of their increased withdrawals (0.11 mgd).

The report sections below discuss the minimization and mitigation alternatives identified through this Pilot Project for DWWD. This is not expected to be an exhaustive listing, nor have the feasibility of implementing these actions been fully investigated. The discussion does, however, provide a basis for assessing the potential impact of the proposed SWMI process on a DWWD permit application.

7.3 Minimization of Impacts

7.3.1 Optimization of Existing Sources

7.3.1.1 Maximize Purchases from MWRA

MWRA supply comes from the Quabbin (412 billion gallon) and Wachusett (65 billion gallon) reservoirs. These large supplies and available storage mean that DWWD can purchase water from MWRA with less impact on streamflow than local groundwater withdrawals. One alternative for DWWD to minimize the impact of their withdrawals on local stream ecology is to maximize their purchases from MWRA during the critical low flow period of the year. Figures 7-10 and 7-11 illustrate DWWD's monthly withdrawals from the Neponset wells that are the subject of this pilot permit review and from MWRA in 2010 and 2011.

Figure 7-10
2010 Neponset & MWRA Production

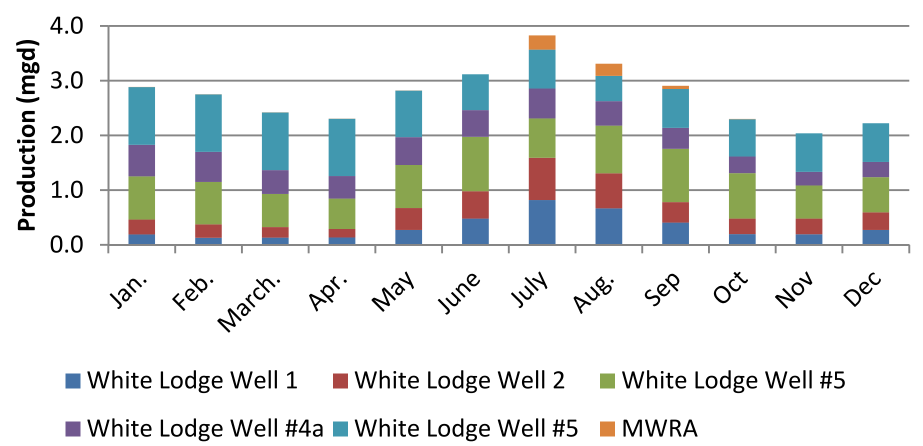
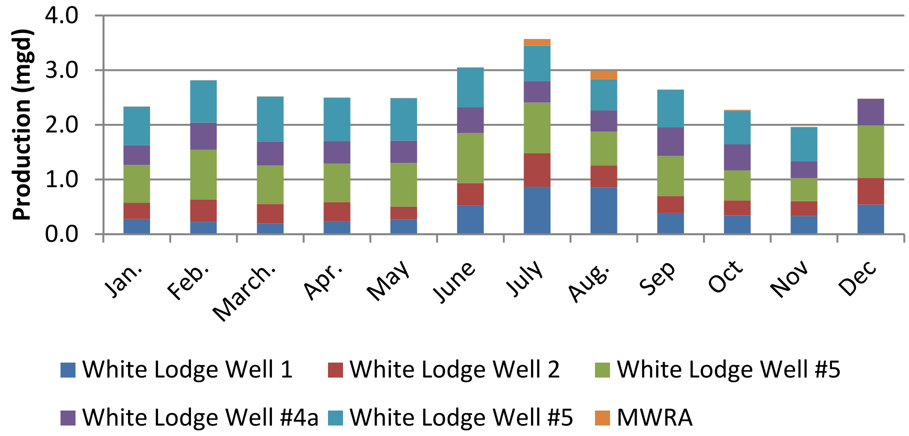


Figure 7-11
2011 Neponset & MWRA Production



As indicated in both years, a small amount of water is purchased from MWRA in most months and purchases are increased to meet peak demands in the summer. For purposes of this example, if DWWD were to purchase their full contracted amount of water from MWRA during a three month period (e.g. June, July and August), they could reduce local groundwater withdrawals during this period by an average of 0.4 mgd (36.5 MG/yr over 3 months).

In 2010 and 2011, DWWD purchased an average of 13.2 MG from MWRA. Based on a purchased price of MWRA water of $2,760/MG and the unit cost of producing water locally of $577/MG, the increased average cost of maximizing purchases from MWRA would be approximately $50,000 per year.

7.3.1.2 Well Selection

Using minimization of unaffected August flow alteration as a metric for minimization of streamflow impact, DWWD could preferentially withdraw water from the Bridge Street Wellfield on the banks of the Charles River. The unaffected August flow in this subbasin is more than double that in the White Lodge Wellfield subbasins so a unit withdrawal of water would have less impact on percent alteration. Based on 2000-2004 withdrawals however, the Bridge Street Wellfield subbasin was near the withdrawal limit for a FL 4 basin. The SWMI Framework discourages allowing subbasins to “backslide” in Flow Level, which could occur with increased withdrawals in this subbasin. More careful consideration is therefore recommended before increasing withdrawals from the Bridge Street Wellfield, even within current registration limits, as a minimization or mitigation alternative for increased withdrawals at the White Lodge Wellfield.

The results of pump testing at individual wells within the White Lodge Wellfield were not reviewed as part of this Pilot Project. However, none of the information reviewed suggested an opportunity to prioritize well selection within the wellfield to minimize impact on streamflow.

7.3.1.3 Utilize Rock Meadow Well

The Rock Meadow Well has an estimated capacity of 0.6 mgd and is not currently utilized by DWWD due to poor water quality. A study performed by Weston and Sampson in 1989 suggested that full scale treatment including coagulation and filtration would be required to remove organics, iron and manganese from the well to avoid disinfection by-product and customer complaint issues. The Rock Meadow Well is a registered supply and would not require additional WMA authorization to be returned to service. However, as summarized in Table 7-4, Rock Meadow Well is in a FL 3 subbasin with very little additional withdrawal capacity available before shifting to FL 4. The SWMI framework discourages allowing sub-basins to "backslide" in flow level, which could occur with increased withdrawals in this subbasin. Given the significant cost to return this well to active service and the potential impact on streamflow in its subbasin, this is not considered a feasible alternative for minimizing or mitigating impacts from withdrawals at the White Lodge Wellfield.

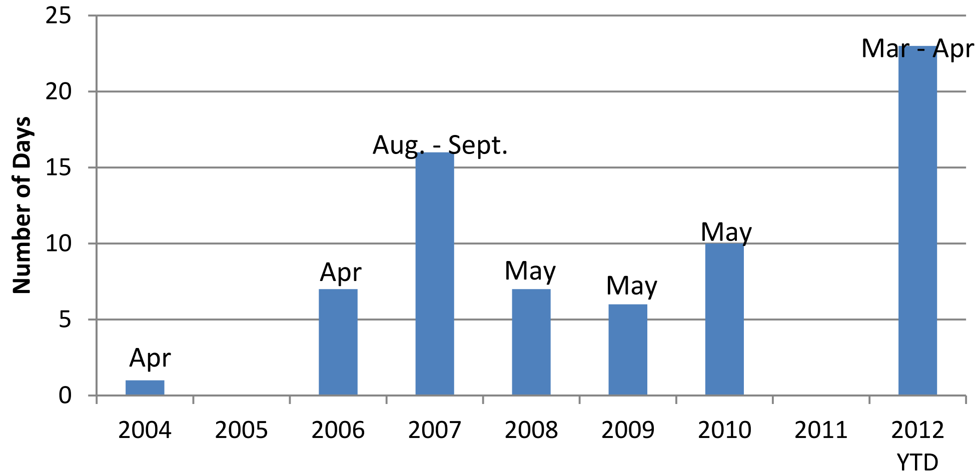
7.3.2 Alternative Sources of Water Supply

DWWD evaluated several available options for developing new supplies before executing their current contract to purchase water from MWRA. If additional source capacity is required, increasing the purchase from MWRA is therefore likely to be the most feasible alternative, rather than new source development. See Figure 7-12 (Dedham-Westwood Water District Alternative Sources Map) for the location of the existing MWRA interconnection and emergency interconnection.

Increased purchases from MWRA could be used to reduce the streamflow impact of DWWD's withdrawals by extending the low-flow cut-offs currently in place for the Fowl Meadow Well (White Lodge Well #5) to the remaining White Lodge Wells. For this alternative to work the maximum day capacity of the MWRA connection would need to be increased to be able to replace the full capacity of the White Lodge Wellfield. Looking at Figures 7-10 and 7-11 this could have been accomplished over the last two years by doubling the maximum day supply obtained from MWRA from 2.0 to 4.0 mgd.

Figure 7-13 summarizes the number of days the Fowl Meadow Well has been shut-off due to low flow in the Neponset River from 2004 through May 2012. As shown, over this short period low flow conditions have occurred from zero to almost twenty five days per year. Based on the average production from the White Lodge wells during the months that the Fowl Meadow shut-offs have occurred and the historical length of those shutoffs, increased MWRA purchases of approximately 35 MG/year would have been required in 2007 and year to date in 2012. Although additional analyses over a longer period of time is required to assess the feasibility of this alternative, doubling the average annual capacity of DWWD's MWRA contract from 36.5 MG to 73 MG would have been sufficient to extend the Neponset River low flow cut-off to the remaining White Lodge Wells.

Figure 7-13
Fowl Meadow Shut-off History



In addition to more detailed flow analysis, an evaluation of the required infrastructure improvements to DWWD and MWRA's distribution systems to support this increased capacity is required to assess the feasibility of this alternative. A new Interbasin Transfer Act approval would also be required. Excluding those potentially, significant infrastructure and permitting requirements, the increased cost for doubling DWWD's capacity from MWRA would include an increased MWRA entrance fee estimated to be equivalent to the fee paid for the existing agreement ($550,000) and increased purchase water costs. Based on the water purchase pattern illustrated in Figure 7-13, the increased purchase water cost would range from zero to approximately $75,000 per year, with an average over the period of approximately $30,000 per year.

7.3.3 Other Minimization

Although not a minimization alternative, an alternative permitting strategy for DWWD to consider is to use their purchased water agreement with MWRA to reduce their request for water from the Neponset Basin back to the Baseline Demand of 3.11 mgd, making their WMA Permit a Tier 1 review and eliminating the need to invest in mitigation actions. Renewing the currently authorized capacity in the Neponset Basin of 3.11 mgd plus the District's registered capacity in the Charles Basin of 1.91 mgd and adding the 0.1 mgd available from MWRA would provide a total authorized capacity of 5.13 mgd which would meet Weston and Sampson's demand projections through 2025. Increased purchases from MWRA could similarly be used if necessary to replace lost capacity in the registered Charles River Basin sources. The District would still be required to comply with Standard Conditions 1 – 8 and to minimize the impact of existing sources, but this approach could reduce the cost and complexity of permitting and compliance.

7.4 Mitigation & Offsets to Withdrawals

7.4.1 Summary Matrix

Using the credit approach outlined in section 4.2.1, quantified offsets to mitigation and offsets to withdrawals were calculated for wastewater, stormwater, habitat and demand management improvements. A summary of the mitigation and offset volumes is provided in Table 7-12, compared with the withdrawal request above baseline. Potential mitigation and offsets to withdrawals represent the maximum mitigation/offset a PWS could achieve if these actions were implemented town-wide (where applicable) and include both direct and indirect offset calculations. Note that although the indirect offset calculation methodology in Appendix E discusses a cap of the withdrawal request on the portion that can be obtained from indirect offsets, a cap has not been included in the summary matrix. Phase 2 could provide further consideration of how the indirect mitigation/offsets could be applied to the existing and future permit terms. For example, can unused indirect mitigation/offsets associated with the cap be carried over into a future permit term and withdrawal request?

The purpose of this matrix is to provide the PWS with an understanding of what options are available to them, the cost associated with these options and provide them with a tool to select those that work best for the PWS to meet its withdrawal request. For additional information on the offset calculations, refer to the following sections, the methodology in Appendix E and the Dedham-Westwood specific worksheet calculations in Appendix H.

7.4.2 Instream Flow/Surface Water Releases

The dams and surface water impoundments in Dedham and Westwood were identified for assessment for potential releases to augment stream flows during low flow periods. A screening analysis was conducted to evaluate the potential for surface water releases to mitigate water withdrawals. Factors that were considered included impoundment use, location with respect to the water withdrawal, ownership, status of proposed dam removals, and current management of releases. The level of analysis needed to confirm availability of water for potential releases, including modeling of potential release scenarios, is outside of the scope of the Phase 1 Pilot Project.

Five dams were identified within Dedham as summarized in Table 7-13. One dam is under private control. One dam is under the Town’s control, but provides no storage. Two dams are under control of the Massachusetts DCR, but do not provide storage. The fifth structure noted in Dedham is a diversion of Mother Brook from the Charles River to the Neponset River. This diversion was originally constructed to serve the mill buildings in Dedham. The Massachusetts DCR maintains this diversion. Although this dam discharges downstream from DWWD’s withdrawals it could be used to mitigate the withdrawal impacts for most of the Neponset River downstream of the wells. This alternative is not likely to be feasible given the need to balance impacts between two basins and that the transfer is outside of the DWWD’s control.

Table 7-12. Mitigation/Offset Summary Matrix for Dedham-Westwood			
	Existing	Potential	
	Volume (gpd)	Volume (gpd)	Cost ($)
Wastewater Offsets			
septic systems	76,798		
groundwater discharges	28,000		
infiltration	303,625	206,879	$ 7,039,300
inflow		89,883	
water reuse - irrigation			
private inflow removal program			
sewer bank (I/I offset) program	52,740		
wastewater enterprise account	52,740		
Wastewater Offset Total	513,903	296,762	$ 7,039,300
Stormwater/Impervious Cover Improvement Offsets			
recharge impervious surfaces			
leaching catch basins			
reduce impervious surfaces			
roof leader disconnection			
rain barrels	657	27,963	$ 3,454,800
stormwater bylaw with recharge requirements			
stormwater utility meeting environmental requirements	-	52,740	
implement MS4 requirements	52,740	-	
Stormwater Offset Total	53,397	80,703	$ 3,454,800
Habitat Improvement Offsets			
install and maintain a fish ladder	-	-	
remove a dam or other flow barrier	-	-	
acquire/protect lands	-	-	
culvert replacement	-	-	
streambank restoration	-	-	
tree canopy	-	-	
mitigation fund	-	-	
Habitat Improvement Total	-	-	-
Water Supply Improvement / Demand Management			
outdoor watering restrictions	957,857	478,929	$ -
irrigation audits			
irrigation sensors	5,783		
irrigation bylaw			
faucet aerators		105,557	$ 199,515
low flow faucets		-	$ -
low flow showerheads		923,621	$ 266,020
low flow toilets (1.6 gpf)	22,891	-	$ -
HE toilets (1.28 gpf)	3,906	345,094	$ 930,900
watersmart washing machines	11,465	130,890	$ 1,225,000
watersmart dishwashers		15,670	$ 1,330,100
commercial water audits			
municipal building retrofits		43,950	
pistol grip hose nozzles		43,950	
water bank		52,740	
water supply enterprise account		52,740	
water conservation rates		43,950	
monthly billing/radio-read meters		43,950	
conservation education/outreach		43,950	
Demand Management Total	1,001,903	2,324,991	$ 3,951,535
Total Potential Mitigation/Offset	**1,569,203**	**2,702,456**	**$ 14,445,635**
Total Withdrawal Request Above Baseline		**110,000**	

Notes:

1. All mitigation options discussed in this report are included in the table. Values are only provided for those options that could be quantified for the PWS using available information.
2. Indirect offsets are shaded pink and are included in the total. A cap has not been applied to indirect offsets.
3. Demand management offsets assume assumed that demand management options could be applied to all 'applicable' households (e.g., where not currently applied). Refer to Section 7.4.6. Actual savings should be based on the actual number of households the options are applied to.
4. Stormwater/impervious cover improvement offsets include those that could be readily quantified under Phase 1. Other stormwater options could be considered under Phase 2.
5. Habitat improvement offsets include those that could be readily quantified under Phase 1. None were identified in Dedham-Westwood.

Four dams are located in the Town of Westwood. All four dams are located downstream of the Rock Meadow wells. Three of the four dams are under private control, and the ownership of one dam, the Noannet Dam, is unknown. These private dams were not considered further as the DWWD does not have control over these facilities.

No significant feasible surface water release was identified within Dedham or Westwood that would offset groundwater withdrawals.

Table 7-13. Dedham and Westwood Surface Water Release Summary

Dam	Ownership	Proximity to Water Supply	Feasibility
Colburn Street Dam (Dedham)	Dedham	Same subbasin downstream of White Lodge Wells	No storage
Centennial Dam (Dedham)	MA- DCR	Same subbasin downstream of White Lodge Wells	No storage
Mother Brook Dam @ Maverick St (Dedham)	MA- DCR	Same subbasin downstream of White Lodge Wells	No storage
Mother Brook Diversion @ Charles River (Dedham)	MA- DCR	Same subbasin downstream of White Lodge Wells	Inter-basin transfer Downstream of wells Impact on Charles (21014)
Weld Pond Dam (Dedham)	Private	Charles River Basin up-stream of Bridge St. wells	Private Ownership
Noannet Pond Dam (Westwood)	Unknown	Outlets to Powissett Brook Same subbasin downstream of Rock Meadow wells	Downstream of wells Private Ownership
Storrow Pond Dam (Westwood)	Private	Outlets to Powissett Brook Same subbasin downstream of Rock Meadow wells	Downstream of wells Private Ownership
Lee Pond Dam (Westwood)	Private	Same subbasin downstream of Rock Meadow wells	Downstream of wells Private Ownership
Stevens Pond Dam (Westwood)	Private	Same subbasin downstream of Rock Meadow wells	Downstream of wells Private Ownership

7.4.3 Wastewater

All of Dedham is sewered, and the majority of Westwood is sewered. Both towns are tied into the MWRA sewer system, which treats collected wastewater at Deer Island and discharges to Boston Harbor. There are still approximately 500 septic systems in Westwood, and one groundwater discharger. Groundwater recharge through on-site wastewater systems in Dedham is negligible; however, there are opportunities for I/I reduction as described below. The potential credits for wastewater in Dedham and Westwood, based on the wastewater credit methodology described in Section 4.2, are summarized in Table 7-14. The septic system and groundwater discharges are for sites in Westwood. The infiltration and inflow potential flows are combined flows that include I/I removal efforts in Dedham since 2007, and potential I/I to be removed in both Dedham's and Westwood's systems as summarized in I/I studies.

Table 7-14. Potential Wastewater Credit Summary – Dedham/Westwood

	Wastewater Category	Total Wastewater Flow (gpd)	Total Flow Offset Volume (gpd)
1	Septic Systems	76,798	8,094
2	Groundwater Discharges	28,000	2,800
3	Infiltration	5,626,581	510,504
4	Inflow	900,124	89,883
5	Water Reuse - Irrigation	0	0
	Indirect Offsets: Wastewater Enterprise Fund and I/I Bank		22,000*
	Total Potential Wastewater Credit		633,281

* The totals for indirect offsets related to wastewater are 13,185 gpd for Dedham's 1:1 I/I Bank, and 52,740 gpd for Dedham's and Westwood's wastewater enterprise fund. The indirect credit offset is capped at 20% of the withdrawal increase (110,00 gpd) which is 22,000 gpd.

7.4.3.1 Groundwater Recharge to Neponset River

The Westwood Board of Health estimates that approximately 500 on-site systems remain in use. These systems are generally in isolated areas throughout town. A few streets were identified by the town as not being sewered, including Carby Street, Grove Street, Summer Street and Longwood Avenue in the northwest corner of Westwood in the Charles River Basin. Development on septic system in these areas was estimated at approximately 6 houses in subbasin 21035 and 18 houses in subbasin 21036. There are three areas within the Neponset River Basin with on-site systems, including portions of Clapboard Tree Street, Gay Street and Fox Meadow Drive, consisting of approximately

18 houses in subbasin 21126. The Hale Reservation, located in the Charles River Basin, utilizes a 28,670 gpd package treatment plant for its predominantly seasonal wastewater needs. See Dedham-Westwood Wastewater Infrastructure Figure 7-3 for location of the regulated groundwater discharge and approximate location of septic systems.

7.4.3.2 Infiltration/Inflow Removal

A comprehensive infiltration/inflow removal effort has been ongoing in Dedham since 2007. The I/I program has involved testing, sealing, installing cured-in-place pipe, and rehabilitating manholes. From 2007-2011 the program estimates removal of nearly 3.47 mgd of infiltration from the collection system. Table 7-15 provides a summary of Dedham's I/I removal efforts from 2007 to 2012. In spite of this aggressive I/I program, a 2011 report by Weston & Sampson summarizing the Town Wide Flow Monitoring Program identified 3.1 mgd of peak infiltration, or an approximate value of 4,188 gpdim over the town's sewer system metered as a part of the 2011 study. Peak Design Storm inflow was calculated at 7.73 mgd. Using MassDEP guidelines, both infiltration and inflow remain a town wide problem. The FY2011 MWRA report indicates that the three year (2008-2010) Annual Average I/I for Dedham was 2.22 mgd.

Table 7-15. Summary of Dedham's I/I Removal Efforts
(Dedham I/I Website)

Year	Mains Inspected (I) Repaired (R) (Linear Feet)	Manholes Inspected (I) Repaired (R) (Vertical feet)	Infiltration removed (mgd)	Cost
2007	151,315 (I)			$357,375
2008	48,356 (I) 23,013 (R)	3,252 (R)	1.44	$2,046,954
2009	110,000 (I) 15,994 (R)	750 (I) 1,077 (R)	0.34	$1,101,311
2010	255,000 (I) 21,240 (R)	553 (I) 820 (R)	1.04	$1,468,120
2011	99,900 (I) 20,014 (R)	449 (I)	0.65	$1,033,414
2012	80,000 (I)	500 (I)	NA	NA
		TOTAL:	**3.47**	**$6,007,174**

According to MWRA Annual I/I Reduction Report for FY11, the three year (2008-2010) Annual Average I/I for Westwood was 0.8 mgd. The Town has financed five I/I reduction projects through MWRA funding assistance. Of the $1,425,300 allocated by MWRA, $386,000 remains for future projects. The results of I/I studies of Westwood's wastewater collection system are described below.

A June 2009 Wastewater Flows Analysis/Metering Data Review report developed by CDM indicated that as much as 30% of Westwood's MWRA sewer discharge is clean water from infiltration and inflow. The 2009 report documented that infiltration is highly seasonal, nearly doubling in the winter months. The target area for I/I removal is in the center of town, where infiltration was observed to be 801,263 gpd. Inflow from this area also contributed up to 79% of the total inflow observed during the monitoring period. Future work planned includes spot gauging at up to 6 locations, inspection of the 500 manholes, flow isolation and smoke testing in one priority area.

According to MWRA Annual I/I Reduction Report for FY11, a Westwood Town Wide I/I study conducted in 2010/2011 included the results of a house-to-house inspection survey. Of the 1,880 residences inspected, 135 suspect sump pump connections were identified. Additional work included cleaning and TV inspection of 117,000 linear feet of sewer in preparation of town-wide I/I study. The design phase for lining of 2 miles of pipes and 11 manholes is ongoing.

Dedham has performed a number of infiltration removal projects since 2007, and credit for the volume removed is identified in Table 7-12 above. The potential future credit for infiltration and inflow includes the total flows observed in the system for Westwood and for Dedham. This number presents an opportunity for future credits, but the DWWD would need to identify specific projects and estimated I/I removed for credit consideration.

7.4.3.3 Surface Water Discharge

There is a total surface water discharge of 0.12 mgd within subbasin 21107 upstream of Dedham's groundwater withdrawals. As the ratio of surface water discharge to unaffected August flow is less than 0.1, no credit for surface water discharges is proposed.

7.4.3.4 Other Potential Wastewater Credits

Both Dedham and Westwood have adopted enterprise funding for sewer operations.

Dedham's Sewer Connection Permit Fee was established to develop a fund dedicated to removing I/I from the Town's sanitary system. Dedham charges $4.50 per gallon per day for the estimated wastewater flows for the proposed use. The wastewater flows are estimated using the "Sewage Flow Estimates" from 314 CMR 7.15. In cases where an existing building existed on the same lot where a new building is proposed, existing flows are credited.

Westwood does not currently have an I/I offset program (sewer bank).

7.4.4 Stormwater/Impervious Cover

Section 4.2.2.3 outlines stormwater mitigation options to help offset withdrawal requests. Tables 7-16 and 7-17 summarize those that are applicable to Dedham and Westwood and could be readily quantified under Phase 1 of the Pilot Project. These include the distribution of rain barrels, implementation of a stormwater utility, and implementation of MS4 requirements.

Table 7-16. Stormwater/Impervious Cover Improvement Offsets in Dedham					
	Offsets Completed to Date		Potential Offsets		
	Quantity	Volume (gpd)	Quantity	Volume (gpd)	Cost
Rain barrels	169 households[1]	328	9,482 households[2]	18,419	$2,275,680
Stormwater utility[3]				34,161	
Implement MS4 requirements[3]		34,161			

[1]337 rain barrels were given away. Since the credit calculations assume two per household, this figure was divided by two to obtain the number of households.
[2]Estimated households on the public water supply in 2010, minus those that have already received rain barrels. For the purposes of estimating potential water savings through future mitigation actions, it was assumed that all households could receive rain barrels to reduce water demands. Actual savings should be based on the actual number of households receiving rain barrels.
[3]One credit was applied for the water supply (includes both Dedham and Westwood) and then weighted between Dedham and Westwood based on population. Both the 'stormwater utility' and 'Implement MS4 requirements' were calculated using the indirect method in Appendix E and resulted in the same volume offset.

Table 7-17. Stormwater/Impervious Cover Improvement Offsets in Westwood					
	Offsets Completed to Date		Potential Offsets		
	Quantity	Volume (gpd)	Quantity	Volume (gpd)	Cost
Rain barrels	169 households[1]	328	4,913 households[2]	9,544	$1,179,120
Stormwater utility[3]				18,579	
Implement MS4 requirements[3]		18,579			

[1]337 rain barrels were given away. Since the credit calculations assume two per household, this figure was divided by two to obtain the number of households.
[2]Estimated households on the public water supply in 2010, minus those that have already received rain barrels. For the purposes of estimating potential water savings through future mitigation actions, it was assumed that all households could receive rain barrels to reduce water demands. Actual savings should be based on the actual number of households receiving rain barrels.
[3]One credit was applied for the water supply (includes both Dedham and Westwood) and then weighted between Dedham and Westwood based on population. Both the 'stormwater utility' and 'Implement MS4 requirements' were calculated using the indirect method in Appendix E and resulted in the same volume offset.

The Dedham-Westwood Water District currently distributes rain barrels as part of its water conservation efforts. The Neponset River Watershed Association (NepRWA) is also very active in the watershed and is in the process of evaluating potential sites in both towns for stormwater retrofits to help increase recharge.

Both Towns are proactive with stormwater management and have incorporated design standards into their regulations and have held developers to these standards. The Westwood Station project in Westwood is an example where stringent stormwater requirements were enforced to promote recharge and reuse of water and minimize demands. However, the project has not been finalized at this point and could not be included in the mitigation credit calculations. There are likely other projects where credits may be available; however, this information was not available for inclusion in the project.

A simple overlay of existing land use and protected lands shows about 22% of land remains to be developed in Dedham-Westwood. Refer to Figure 7-14 for undeveloped land and hydrologic soil groups (HSGs). The soil groups help show the recharge potential for future development, with A and B soils offering high recharge potential and C and D soils less. The Figure shows most of the remaining developed land is located on C and D soils in Dedham and B and C soils in Westwood, therefore, Dedham-Westwood may not see as significant a benefit as the other pilot PWSs for implementing more stringent recharge requirements for new development due to the soil types and the fact that both communities already apply the Stormwater Management Handbook standards to many types of development. However, more stringent regulations would offer some mitigation credit and help improve water quality, which is required for the TMDLs and impaired waters. The regulations could also be applied to redevelopment projects.

For demonstration purposes, more stringent recharge regulations were applied to two of the pilot PWSs, Danvers-Middleton and Shrewsbury and revealed potential water savings of 2.59 mgd and 2.36 mgd, respectively. Similarly, potential water savings could be quantified for Dedham and Westwood under Phase 2 of the project.

Other stormwater mitigation options could be considered in Phase 2. For example, potential savings may be realized from a roof leader disconnection program; the potential savings could be explored using a GIS overlay analysis and the assumptions outlined in the methodology presented in Section 4.2.2.3. The applicability of other mitigation options (e.g., sites where existing impervious surfaces can be eliminated or directed to recharge) may require specific site evaluations.

7.4.5 Habitat Improvements

There are currently no known scheduled or planned dam removals, culvert replacements or other habitat improvements in Dedham or Westwood.

None of the stream culverts have been evaluated for habitat and stream continuity at this point, however, based on the number of dams and culverts located within these communities, there is the potential to obtain mitigation credits through improvements to these structures. However, this requires further assessment to determine the need for (e.g., is it currently a detriment to habitat continuity?) and the level of improvement needed. This is beyond the scope of this Pilot Project.

7.4.6 Demand Management

Dedham-Westwood Water District (DWWD) has been implementing demand management and water conservation activities for several years. Current actions include:

- DWWD does not allow new irrigation systems to be connected to the public water supply. The Town of Dedham does not allow the installation of private wells in the Aquifer Protection Overlay District.
- The Rules and Regulations of the DWWD include a Water Conservation Plan which outlines water use restrictions based on drought conditions. Restrictions include voluntary odd/even outside water use, mandatory odd/even outside water use, mandatory 2 day per week lawn watering, mandatory 1 day per week lawn

watering, and no outside water use. These Rules do not apply to private well users.

- Since 2007, the DWWD has offered rebates on various water conservation devices and appliances including low-flow toilets, waterless urinals, watersmart washing machines, and rain sensors.
- DWWD is not a municipally-owned water system, but rather a water district whose budget operates the same as if it were a municipal Enterprise Account.
- DWWD uses conservation rates for both residential and commercial customers. Currently, large commercial users are billed monthly and all other customers are billed quarterly. Approximately 75% of DWWD's customers are metered with radio-read devices. There has been interest in moving to monthly billing but at this time there are no definite plans to do so.

The mitigation credit available from existing demand management activities is included in Table 7-18, along with potential credits. As shown in Table 7-18, the DWWD has numerous demand management options available to help offset its 0.11 mgd additional withdrawal request. Note that these potential savings would be higher than the requested withdrawal increase, allowing the PWS to pick and choose the options that best fit their needs to meet the 0.11 mgd offset.

Table 7-18. Demand Management Offsets in Dedham-Westwood									
Dedham-Westwood Offsets	Existing				Potential				
	Dedham		Westwood		Dedham/Westwood				
Water Supply Improvement / Demand Management	Number of Households (#)	Volume (gal/day)	Number of Households (#)	Volume (gal/day)	Number of Households (#)	Volume (gal/day)	Cost ($)	Revenue Loss ($/year)	Notes
outdoor watering restrictions	14,900	957,857			14,900	478,929	$ -	512,933	
irrigation audits	-	-							
irrigation sensors	107	2,318	160	3,466					
irrigation bylaw	-	-							
faucet aerators	-	-			13,301	105,557	$ 199,515	346,754	
low flow faucets	-	-			-	-	-	-	
low flow showerheads	-	-			13,301	923,621	$ 266,020	3,034,096	
low flow toilets (1.6 gpf)	633	15,071	329	7,820	-	-	-	-	
HE toilets (1.28 gpf)	71	1,960	70	1,946	12,412	345,094	$ 930,900	1,133,635	
watersmart washing machines	547	5,842	526	5,623	12,250	130,890	$ 1,225,000	429,975	
watersmart dishwashers	-	-			13,301	15,670	$ 1,330,100	51,475	
commercial water audits	-	-							
municipal building retrofits	-	-				43,950			indirect - applies to entire service communities
pistol grip hose nozzles	-	-				43,950			indirect - applies to entire service communities
water bank	-	-				52,740			indirect - applies to entire service communities
water supply enterprise account	-	-				52,740			indirect - applies to entire service communities
water conservation rates	-	-				43,950			indirect - applies to entire service communities
monthly billing/radio-read meters	-	-				43,950			indirect - applies to entire service communities
conservation education/outreach	-	-				43,950			indirect - applies to entire service communities
TOTAL		983,048		18,855		2,324,991	$ 3,951,535	$ 5,508,867	

Notes:

1. All mitigation options discussed in this report are included in the table. Values are only provided for those options that could be quantified for the PWS using available information. For the purposes of estimating potential water saving through future mitigation actions, it was assumed that demand management options could be applied to all 'applicable' households (e.g., where not currently applied). Actual savings should be based on the actual number of households the options are applied to.

2. Potential demand management offsets were based on the following:

a. outdoor watering restrictions would be applied to all households (14,900), whether or not on the public water supply. There were 9,651 households in Dedham and 5,249 households in Westwood in 2010 according to U.S. Census at factfinder2.census.gov, all of which are assumed to be on the public water supply. Represents the additional water savings achieved by going from 3 days/week (existing) to 2 days/week (potential).

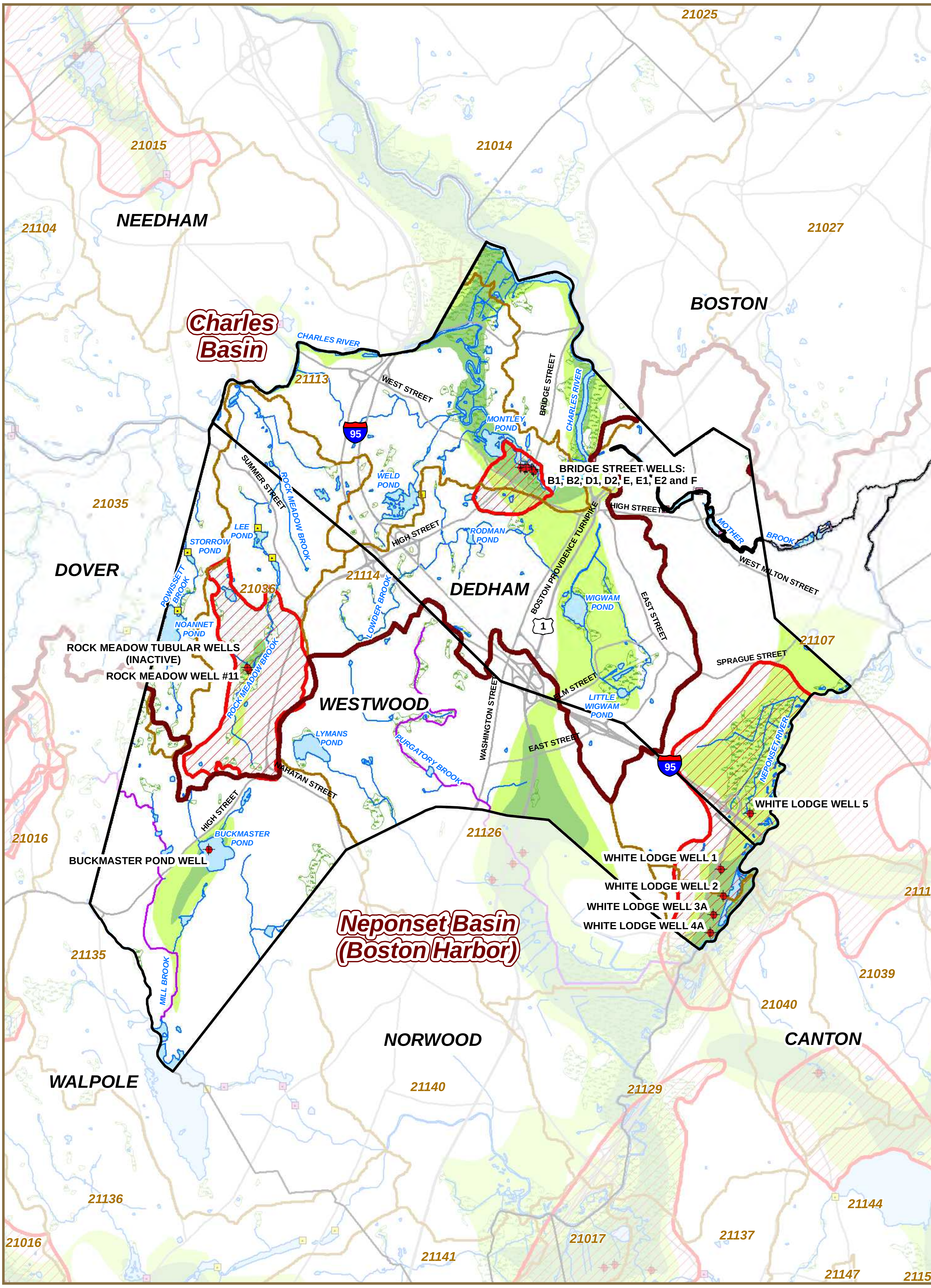
b. water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,750 households in Dedham and 4,551 households in Westwood (13,301 total) in 1990, all of which are assumed to be on the public water supply.

c. the greater water savings and less expensive options were selected for implementation where more than one option existed (e.g., aerators are cheaper than faucets, HE toilets are more efficient than low flow

3. Costs and revenue loss are provided for potential mitigation options only

4. Revenue losses are calculated as the reduced water demand volume multiplied by the water rate, assuming the full potential is achieved. Actual revenue losses will be based on actual reduced water demand volume. DWWD uses a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

5. Note that water volume savings calculated using the indirect method in Appendix E will result in the same volumes for many items.



LEGEND

- Community Groundwater Well
- Coldwater Fishery Resource
- DEP Approved Zone IIs
- Major Basin Boundary
- Subbasin Boundary

Aquifer Boundary (Yield)

- High
- Medium
- Low

Dam Locations

- Private
- Public

Hydrography

- River, Pond or Lake
- Reservoir
- Wetland
- Stream, Brook
- Town Boundary

N E S W

0 2,000 4,000 6,000 8,000 Feet

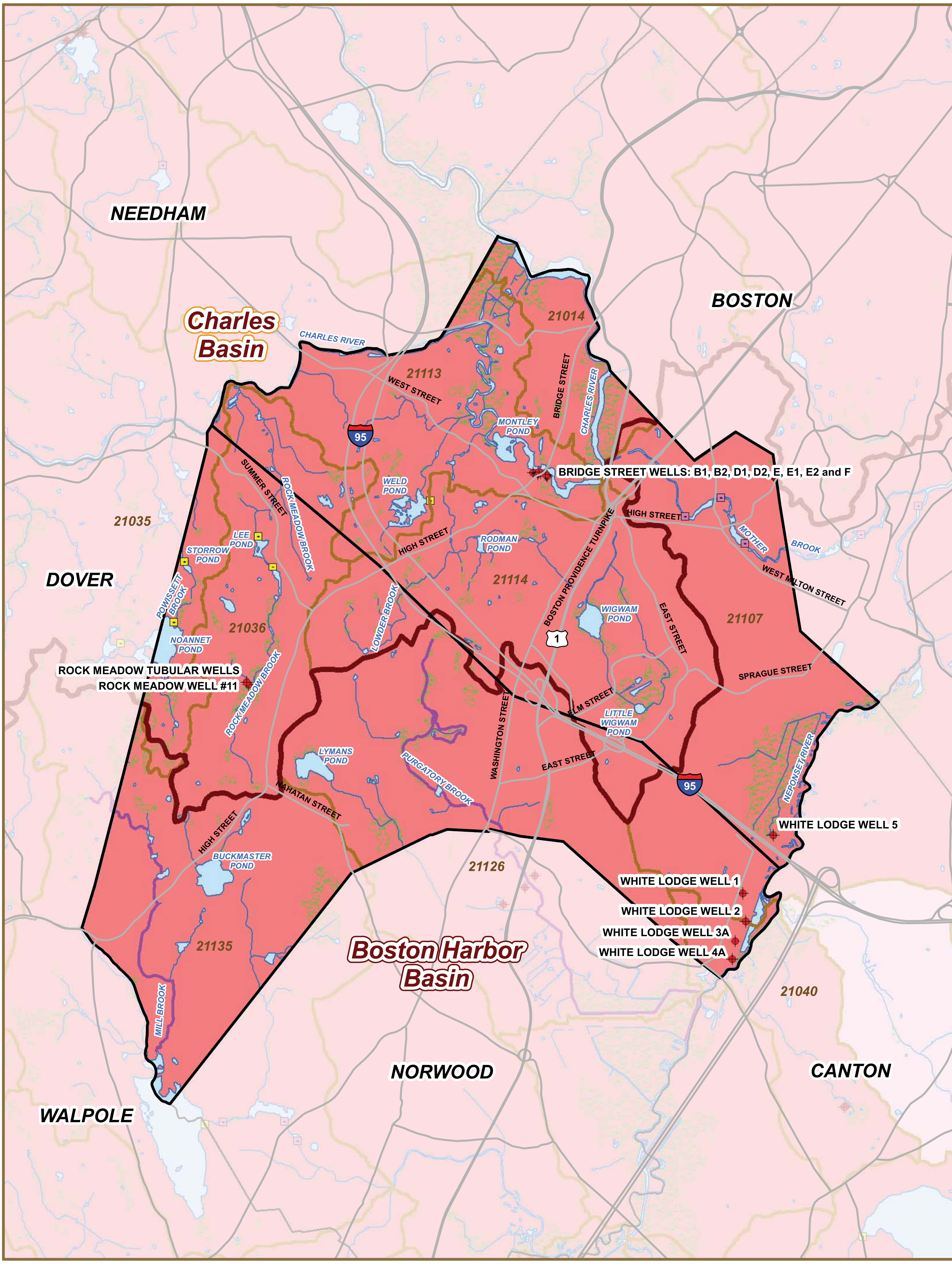
0 0.25 0.5 0.75 1 1.25 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 7-1
Public Water Supply Resource Map

Dedham - Westwood, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Coldwater Fishery Resource
- Major Basin Boundary
- Subbasin Boundary

Biological Categories

- No Data Available
- 1
- 2
- 3
- 4
- 5

Dam Locations

- Private
- Public

Hydrography

- River, Pond or Lake
- Reservoir
- Wetland
- Stream, Brook
- Town Boundary

N / W / E / S

0 2,000 4,000 6,000 8,000 Feet

0 0.25 0.5 0.75 1 1.25 Miles

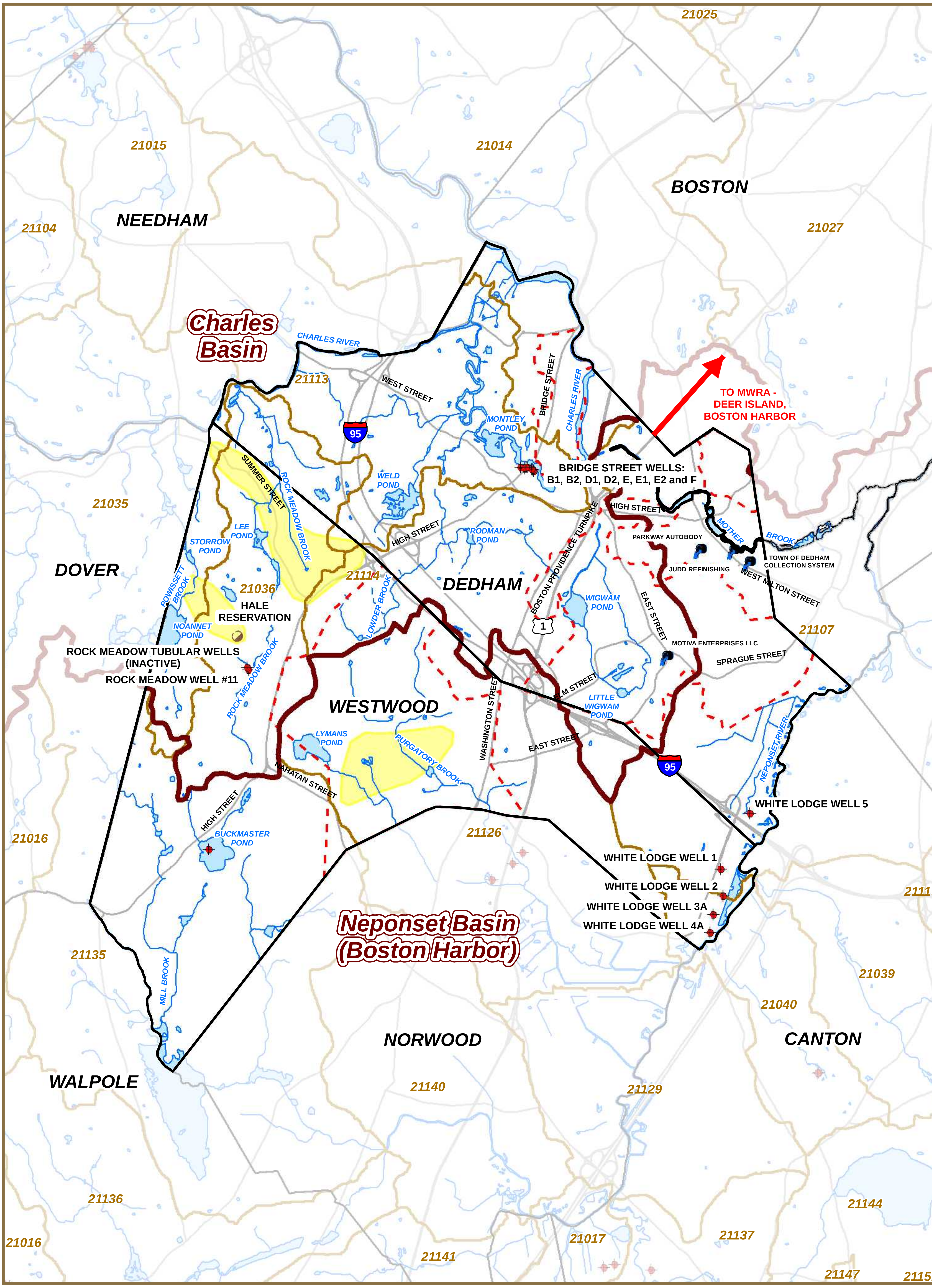
Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 7-2

Natural Resources and Habitat

Dedham - Westwood, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Unsewered Areas
- I/I Target Areas
- Community Groundwater Well
- NPDES Discharges

DEP Ground Water Discharge Permits

Type

- Sanitary Discharge

Hydrography

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Major Basin Boundary
- Subbasin Boundary
- Town Boundary

N W E S

0 2,000 4,000 6,000 8,000 Feet

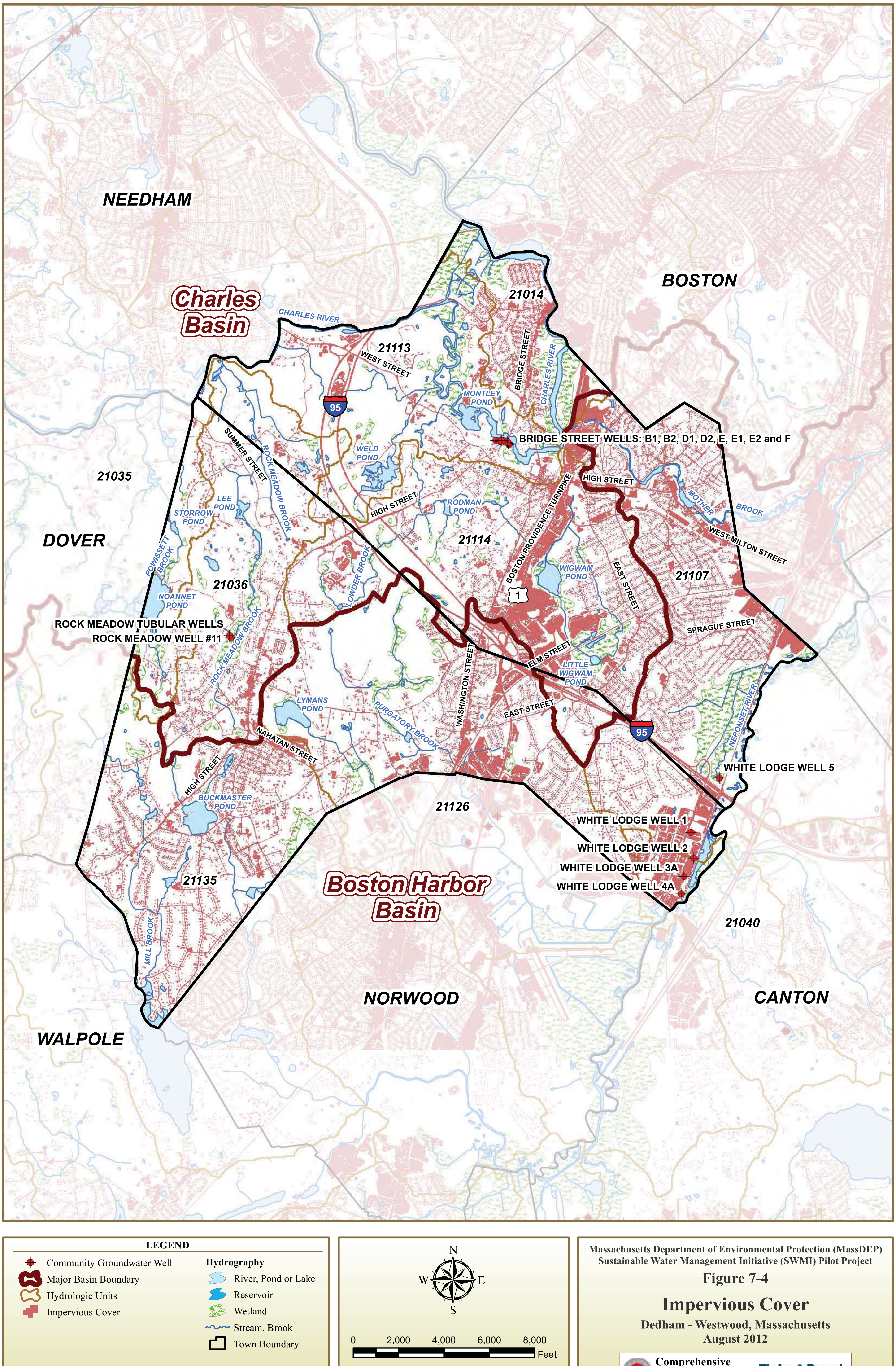
0 0.25 0.5 0.75 1 1.25 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 7-3
Wastewater Infrastructure

Dedham - Westwood, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



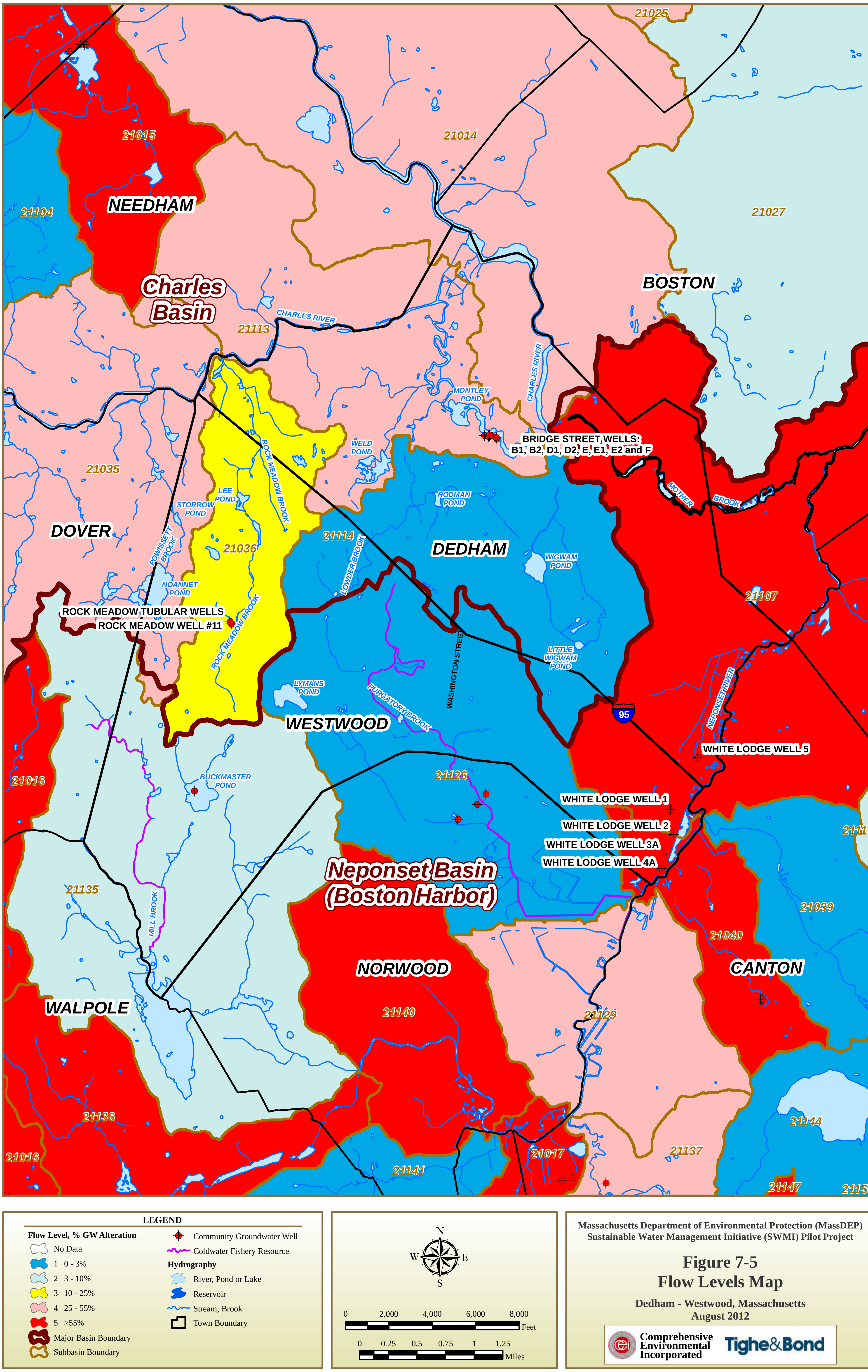
Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 7-4

Impervious Cover

Dedham - Westwood, Massachusetts
August 2012

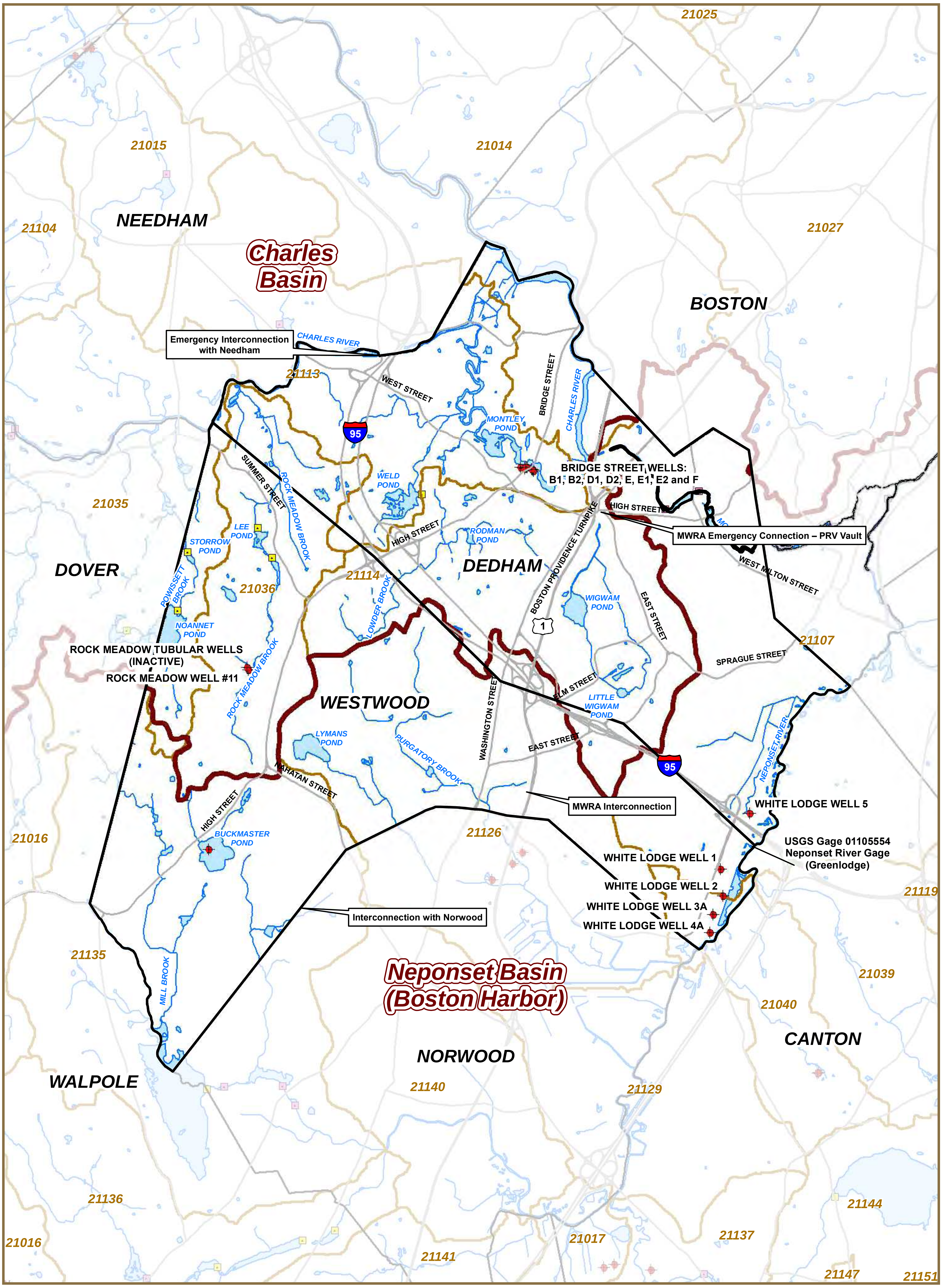
Comprehensive Environmental Incorporated
Tighe&Bond



Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 7-5
Flow Levels Map

Dedham - Westwood, Massachusetts
August 2012



LEGEND

- Community Groundwater Well
- Major Basin Boundary
- Subbasin Boundary

Dam Locations

- Private
- Public

Hydrography

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Town Boundary

N S E W

0 2,000 4,000 6,000 8,000 Feet

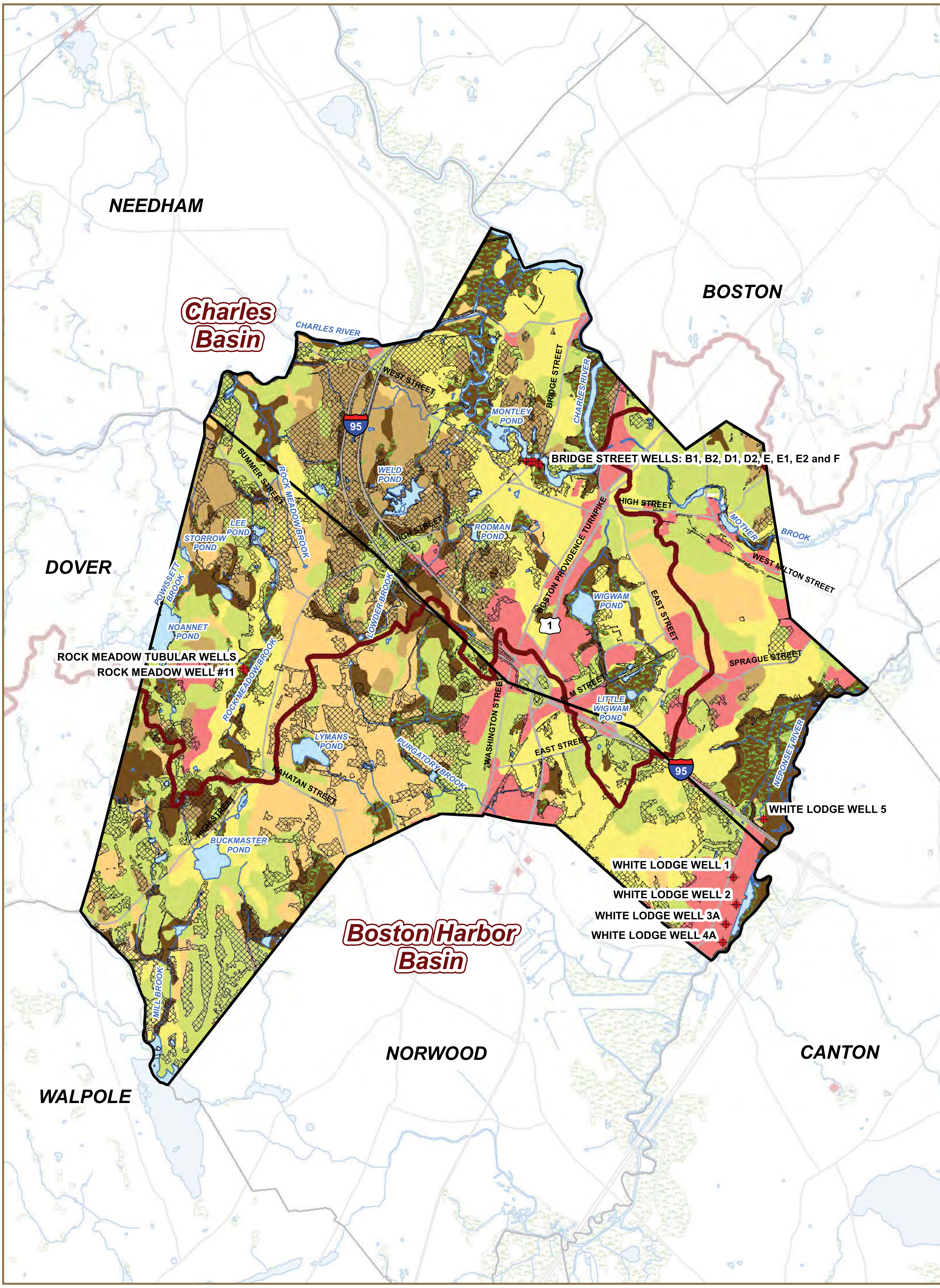
0 0.25 0.5 0.75 1 1.25 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 7-12
Alternative Sources Map

Dedham - Westwood, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 7-14

Soils Characteristics, Undeveloped and Protected Lands

Dedham - Westwood, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond

Section 8 Shrewsbury

The Pilot Project has applied the Draft Sustainable Water Management Initiative (SWMI) Framework to each of the Public Water Suppliers (PWSs) included in the study. This section describes its application to the Shrewsbury Water Department. The application of the Draft SWMI Framework is based on review of data collected from the Massachusetts Department of Environmental Protection (MassDEP), the Town of Shrewsbury, and the Massachusetts Division of Ecological Restoration (DER) as outlined in the annotated bibliography included in Appendix C.

The following summary describes relevant characteristics of the water system and its service area, discusses permitting considerations and requirements under the Draft SWMI Framework, identifies measures for minimizing impacts of withdrawals, and identifies potential mitigation and offset actions for credits against requested withdrawals.

8.1 Town Characteristics

Understanding existing town characteristics is necessary to identify and apply the Draft SWMI Framework minimization and mitigation options discussed in Section 4.0. Existing conditions pertaining to water supply sources, local water resources and habitat, wastewater and stormwater is provided below, followed by specific discussions on the application of the Draft SWMI Framework.

8.1.1 Water Supply Sources

The Town of Shrewsbury's water supply comes from six active gravel packed wells in the Hart Farm (3), Lambert (2) and Sewell Wellfields, as illustrated on Figure 8-1. All of these supplies are located in the Lake Quinsigamond aquifer in the Blackstone River basin. The reported safe yield of this aquifer is between 10 and 15 mgd. Shrewsbury has a written agreement with the neighboring City of Worcester that entitles the Town to approximately 58% of the aquifers safe yield. The potential volume of water available to the Town from this aquifer is therefore 6 to 9 mgd (Alternate Supply Report 2010).

Shrewsbury also has three inactive groundwater supplies. The South Street and Oak Street wells were removed from service due to low yield, water quality issues and the presence of a sewer easement in the South Street Zone I radius. Sewell Well No. 5 was similarly abandoned due to poor yield. The authorized withdrawal volumes from the Oak Street Wells and Sewell Well No. 5 have been transferred to the Home Farm wells and the wells have been abandoned (Alternate Supply Report 2010). The South Street Well, which was in the Concord River Basin, has also been abandoned (Shrewsbury WMA Permit).

Water from the Home Farm and Lambert Wellfields are treated at the Home Farm Water Treatment Plant (WTP). Water from the Sewell well is treated by blending with effluent from the Home Farm WTP prior to entering the distribution system. The Sewell well can therefore only operate in conjunction with at least one of the Town's other wells.

Table 8-1 summarizes pertinent information regarding the authorized withdrawal volumes of Shrewsbury's sources of supply. As indicated, the system has a registered volume of 2.64 mgd and a permitted volume of 1.27 mgd for a total authorized withdrawal volume of 3.91 mgd.

Table 8-1. Shrewsbury - Sources of Supply

Source	MassDEP ID	Subbasin	WMA Permit Limits (mgd)		WMA Permit + Registration Annual Average (mgd)
			Annual Average	Maximum Day	
Sewall #4	2271000-02G	23008	1.27	1.14	3.91
Lambert #3.1	2271000-04G	23002		0.75	
Lambert #3.2	2271000-05G	23002		0.58	
Home Farm 6.1*	2271000-07G	23002		4.32	
Home Farm 6.2*	2271000-08G	23002		3.02	
Home Farm 6.3*	2271000-09G	23002		4.32	
		Total	1.27	7.87	3.91

*Maximum combined daily volume for Home Farm Wells is 5.4 mgd.

Shrewsbury's water supply wells are located in the Blackstone River Basin and the Town's wastewater is treated and discharged at the Westborough Wastewater Treatment Plant in the Concord River Basin. Prior to 1983 Shrewsbury had grandfathered capacity to transfer up to 7.8 mgd from the Blackstone River Basin to the Concord River Basin without an Interbasin Transfer Act (IBTA) permit. Home Farm Well No. 6.2 was constructed after 1983 and is therefore not grandfathered under the IBTA. (Shrewsbury WMA Permit). The Water Resources Commission (WRC) has ruled that total withdrawals from the Home Farm Wellfield must remain below 5.4 mgd to be in compliance with the IBTA.

The average annual withdrawal from each supply over the past three years is summarized in Table 8-2. (Shrewsbury ASRs).

Table 8-2. Shrewsbury – Annual Production

Source	Average Annual Production (mgd)		
	2009	2010	2011
Sewall #4	0.561	0.632	0.780
Lambert #3.1	0.177	0.272	0.184
Lambert #3.2	0.264	0.193	0.115
Home Farm 6.1	0.938	1.003	0.983
Home Farm 6.2	1.282	1.152	0.890
Home Farm 6.3	0.417	0.387	0.720
Total	3.64	3.64	3.67

8.1.2 Local Water Resources and Habitat

Shrewsbury's natural resources, habitat and infrastructure influencing habitat (e.g., dams and culverts) are shown on Figure 8-2.

Shrewsbury's sources are all located within the Blackstone River Basin in the northwest portion of Town. Shrewsbury Water Department has six groundwater sources located Subbasins 23002 and 23008, both of which are classified as Biological Category 5 and Flow Level 5.

The eastern portion of Shrewsbury is located within the Concord River Basin. There are several small tributaries to the Assabet, Sudbury, and Concord Rivers located in this area of Town. Shrewsbury also contains Lake Quinsigamond in the western portion of Town, which serves as a recreational resource for Shrewsbury and its surrounding cities and towns. Slocum Meadow is the largest wetlands complex in Shrewsbury at over 300 acres and is located in the northwest part of the Town. There are no large rivers that run through Shrewsbury but there are 19 named ponds and streams, including Poor Farm Brook which is located in the vicinity of Shrewsbury's water supply wells. The City of Worcester owns the Poor Farm Pond dam and is planning on removing it if funding can be obtained.

Including the Poor Farm Pond Dam, there are 16 dams in Shrewsbury. Four are owned by the Town of Shrewsbury. A summary of the dams in Shrewsbury, including ownership and location is included in Table 8-3.

Within the Blackstone Basin, there are two Coldwater Fishery Resources (CFR) located upstream of Shrewsbury's groundwater withdrawal points, and one additional CFR located downstream of them. Within the Concord River Basin on the east side of Town, there is one CFR that flows from Shrewsbury into Northborough, Massachusetts.

Using GIS mapping, about 78 stream culverts were identified in Shrewsbury.

Table 8-3. Dams in Shrewsbury				
Dam Name	**Location**	**Owner**	**Major Basin**	**Subbasin**
Dean Pond Dam	Shrewsbury	Town of Shrewsbury	Concord River Basin	12017
Eaton Pond Dam	Shrewsbury	Town of Shrewsbury	Concord River Basin	12017
Harlow Mill Pond Dam	Shrewsbury	Private	Blackstone River Basin	23008
Lake Quinsigamond Dam	Shrewsbury	DCR	Blackstone River Basin	23002
Newton Pond Dam	Shrewsbury	Town of Shrewsbury	Blackstone River Basin	23008
Northborough Reservoir Dam	Shrewsbury	Town of Northborough	Concord River Basin	12037
Old Mill Pond Dam	Shrewsbury	Town of Shrewsbury	Blackstone River Basin	23001
Poor Farm Pond Dam	Shrewsbury	City of Worcester	Blackstone River Basin	23007
Rawson Hill Dam & Dike	Shrewsbury	DCR	Concord River Basin	12037
Shrewsbury Sportsmens Pond Dam	Shrewsbury	Private	Concord River Basin	12037
St. Pierre Farm Pond Dam	Shrewsbury	Town of Shrewsbury	Blackstone River Basin	23030
Steinhilber Skating Pond Dam	Shrewsbury	Private	Concord River Basin	12037
Wyman Lower Pond Dam	Shrewsbury	Private	Concord River Basin	12017
Wyman Middle Pond Dam	Shrewsbury	Private	Concord River Basin	12017
Wyman Upper Pond Dam	Shrewsbury	Private	Concord River Basin	12017
Stringer Dam	Shrewsbury	DCR	Blackstone River Basin	23002

8.1.3 Wastewater

The majority of the wastewater from Shrewsbury is collected by the municipal sewer system and treated at the Westborough Wastewater Treatment Plant (WWTP) under an Interbasin Transfer Agreement. The Town is 85% sewered with 9,463 sewer customers. Shrewsbury's wastewater collection system consists of 165 miles of gravity sewer and 34 pump stations. Approximately 1,700 properties rely on on-site septic systems for wastewater disposal including 116 commercial and 1,582 residential systems. See Shrewsbury Wastewater Infrastructure Figure 8-3 for the location of the sewershed and unsewered areas.

Wastewater from the towns of Shrewsbury, Hopkinton and Westborough is treated at the Westborough WWTP. The treated effluent is discharged to the Assabet River, in the Sudbury-Assabet-Concord River Basin. The Westborough WWTP is limited by permit to a maximum average daily flow of 7.68 mgd. Shrewsbury's flow to the Westborough WWTP is limited to 4.39 mgd. Based upon build out estimates, capacity for approximately 4.97 mgd would be needed to accommodate future growth.

Because of the discharge permit limitations at the Westborough WWTP, the town has looked at several options to allocate capacity for future wastewater needs. Legislation was passed giving the Town the ability to refuse sewer extensions, so as to limit the extension of future sewer to the Town's priorities of infill or commercial growth. The town is also looking at options for groundwater discharge to the Blackstone River Basin, or diversion to adjacent wastewater systems including the Upper Blackstone WWTP. Shrewsbury also has an inter-municipal agreement with Grafton to service the Centec East industrial park at the Grafton WWTP. The agreement is for existing and future flows up 45,000 gpd, to accommodate the full build out of that industrial park.

8.1.4 Stormwater

8.1.4.1 Summary of Phase II Program

Shrewsbury is a National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase II regulated community and performs the following actions under its stormwater management program:

- Public education and outreach includes an informational mailing to residents. Residents also assisted with periodic water quality sampling at Lake Quinsigamond.
- Production of a GIS-based stormwater map is currently ongoing.
- The most recent annual report indicates that Shrewsbury has adopted bylaws to address illicit discharges, construction site runoff and post-development stormwater issues.
- The Conservation Commission and/or Planning Board also review proposed projects as necessary to enforce stormwater bylaws and regulations.
- The Town practices maintenance and good housekeeping for its municipal operations, in part by sweeping streets and cleaning catch basins. All streets are swept annually, and a portion of catch basins are cleaned each year depending on available budget.

8.1.4.2 Infrastructure

The most recent NPDES MS4 Phase II annual report, dated April 25, 2012 indicates that the Town has confirmed the locations of approximately 5,000 catch basins. Shrewsbury has also documented the installation of a number of infiltration BMPs at sites throughout the Town, including approximately 26 sites equipped with drywells and 7 sites equipped with other infiltration systems such as an infiltration basins, trenches, etc.

8.1.4.3 Impervious Cover

Based on information obtained from U.S. Environmental Protection Agency (EPA) Region 1, Shrewsbury encompasses 21.73 square miles, of which 4.02 square miles (18.48%) is impervious. Of the impervious area in town, 2.54 square miles (11.71%) is considered to be directly connected to waterbodies in the community. Refer to Figure 8-4 for the impervious cover in Shrewsbury.

Shrewsbury is moderately developed. About 40% of the town remains as undeveloped land such as open space or forest.

8.1.4.4 Stormwater Regulations

The Pilot Project Team reviewed Shrewsbury's regulations for stormwater control requirements that could be considered as mitigation measures for groundwater withdrawals, particularly recharge requirements. Shrewsbury's regulations include the following requirements:

- General bylaws include a stormwater management bylaw that applies to construction disturbances greater than 1 acre of land, and requires obtaining a Stormwater Management Permit. Shrewsbury is also reviewing new stormwater bylaws that would address construction and post-construction development. In particular, stormwater regulations addressing post-construction would likely outline more stringent requirements to ensure stormwater infiltration and groundwater recharge is maintained wherever possible.
- Zoning bylaws establish an Aquifer Protection Overlay District to protect aquifers and recharge areas serving an existing or potential public water supply from contamination. Areas within Zone I of a public waters supply well are essentially limited to passive recreation only, while areas within Zone II are limited to residential or non-residential use permitted in the underlying zoning district, provided that new or redevelopment projects have no more than 15% of the lot area or 2,500 square feet rendered impervious. Areas with greater than 15% or 2,500 square feet of impervious area are required to recharge stormwater using onsite stormwater BMPs.

8.1.4.5 Impaired Waters and TMDL Status

The final Massachusetts Year 2010 Integrated List of Waters defines the following waterbodies as either are impaired (Category 5 – Waters requiring a TMDL), or waters for which a TMDL has been completed (Category 4a).

Table 8-4. Shrewsbury Impaired Waters and TMDL Status					
Category	**Waterbody**	**Waterbody ID**	**Size**	**Impairment**	**EPA TMDL No.**
Category 4a	Flint Pond	MA51050	92 acres	(Eurasian Water Milfoil)	-
				(Non-Native Aquatic Plants)	-
				Aquatic Plants (Macrophytes)	444
				Turbidity	444
Category 4a	Jordan Pond	MA51078	18 acres	Turbidity	2385
Category 4a	Mill Pond	MA51105	12 acres	Turbidity	804
Category 4a	Newton Pond	MA51110	54 acres	(Non-Native Aquatic Plants)	-
				Aquatic Plants (Macrophytes)	862
Category 4a	Lake Quinsigamond	MA51125	471 acres	Excess Algal Growth	938
				(Non-Native Aquatic Plants)	-
Category 4a	Flint Pond	MA51188	173 acres	Aquatic Plants (Macrophytes)	444
				(Eurasian Water Milfoil)	-
				(Myriophyllum spicataum)	-
				(Non-Native Aquatic Plants)	-
Category 4a	Shirley Street Pond	MA51196	19 acres	Aquatic Plants (Macrophytes)	2392
Category 5	Poor Farm Brook	MA51-17	3.6 miles	Sedimentation/Siltation	-
				(Aquatic Plants (Macrophytes))	-
Category 5	Muddy Brook	MA81-28	0.8 miles	Aquatic Macroinvertebrate Bioassessments	-

Notes:
Impairments shown entirely in parentheses are designated as “TMDL not required (non-pollutant)”, e.g. (Eurasian Water Milfoil)
Category 4a: TMDL is completed
Category 5: Waters requiring a TMDL

Waterbodies with an entry in the “EPA TMDL No.” column above have a TMDL prepared as follows:

Table 8-5. Shrewsbury TMDLs		
EPA TMDL No.	**Approval Date**	**TMDL Name**
444	June 28, 2002	TMDLs of Phosphorus for Lake Quinsigamond and Flint Pond
804	May 2, 2002	TMDLs of Phosphorus for Selected Northern Blackstone Lakes
862	May 2, 2002	TMDLs of Phosphorus for Selected Northern Blackstone Lakes
938	May 2, 2002	TMDLs of Phosphorus for Selected Northern Blackstone Lakes
2385	May 2, 2002	TMDLs of Phosphorus for Selected Northern Blackstone Lakes
2392	May 2, 2002	TMDLs of Phosphorus for Selected Northern Blackstone Lakes

The Lake Quinsigamond and Flint Pond TMDL states that towns subject to MS4 Phase II stormwater regulations, including Shrewsbury, should prepare and implement a Stormwater Management Plan (SWMP) as required under Phase II to reduce discharge of pollutants to the “maximum extent practicable”. The TMDL also proposes that Shrewsbury initiate a program to reduce sediments and nutrient loadings by targeting roadways within the watershed area (e.g., street sweeping, catch basin cleaning, maintenance of drainage system).

The TMDL for Phosphorous for Selected Northern Blackstone Lakes indicates that Shrewsbury should incorporate residential BMPs, urban BMPs, and a public education program to help reduce phosphorous loads to the lakes. BMPs include techniques to reduce impervious area, street and catch basin cleaning, structural BMP installation, etc.

Both TMDLs recommend that the town take a proactive approach to future development, for example by limiting the types of construction activities allowed in sensitive areas, changes in zoning laws and lot sizes, reductions in impervious surfaces, requirements that new developments and new roadways include BMPs for stormwater runoff control, and installation and maintenance of structural stormwater BMPs.

8.2 Permit Tier Designation

As described in Section 2.1 of this report, the Draft SWMI Framework proposes Water Management Act (WMA) Permit requirements based upon the Flow Level and Biological Category of the subbasins from which withdrawals are to be permitted and the volume of the community's withdrawal request.

8.2.1 Biological Category

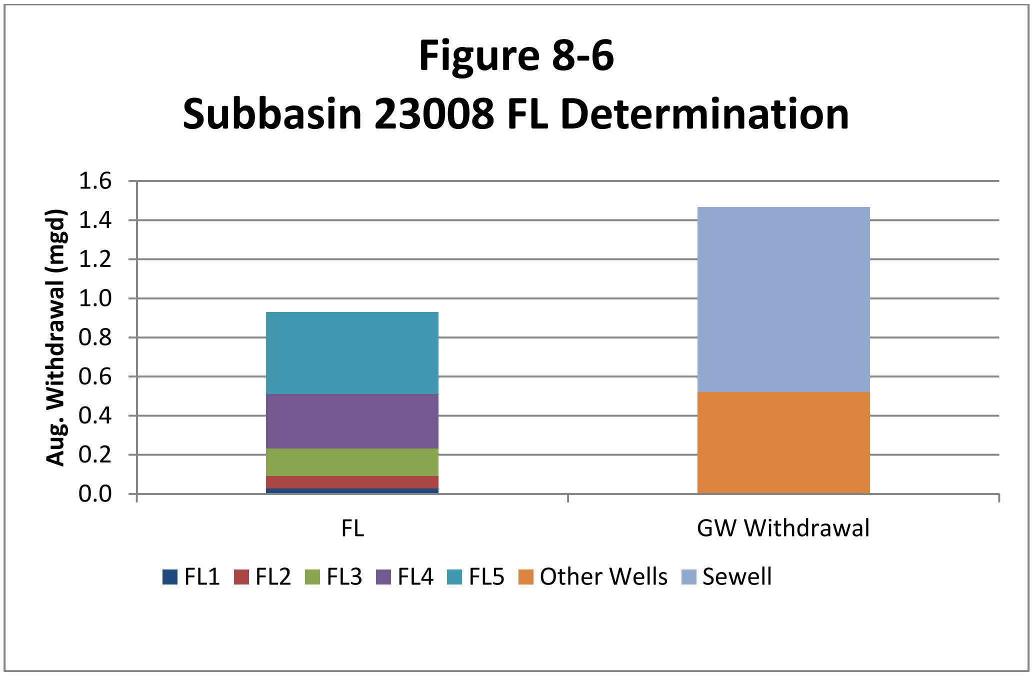
All of Shrewsbury's groundwater sources are located in a Biological Category (BC) 5 subbasin; therefore, no increase in withdrawal volume requested could cause a change in the BC and the subbasin is not considered a Quality Natural Resource as a result of its BC. No additional evaluation related to BCs was conducted for Shrewsbury.

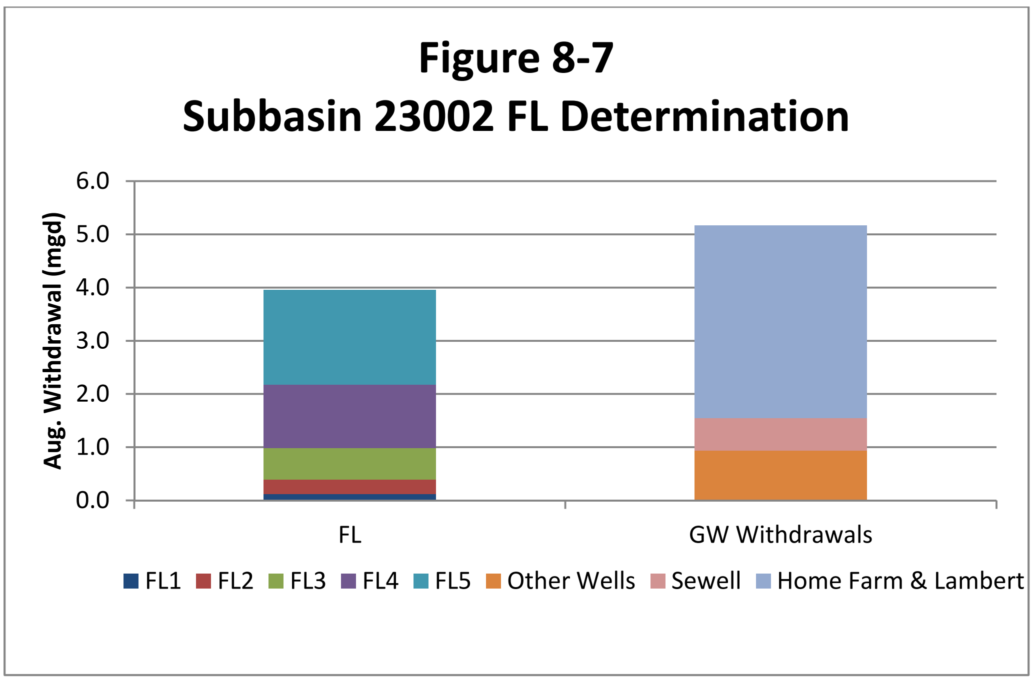
8.2.2 Flow Level

The Flow Level (FL) of each subbasin in the State was determined by MassDEP based upon the estimated percent alteration of the subbasins unaffected August median flow. The unaffected flow was determined utilizing the Sustainable Yield Estimator (SYE) at the pour point (exit) of the subbasin and includes the flow from any upstream subbasins. Withdrawals were based on 2000 – 2004 annual average withdrawals for all WMA permitted wells and estimated private well withdrawals in the subbasin and upstream subbasins. Annual average withdrawals were adjusted by a peaking factor of 115.5% to determine August monthly withdrawals. The percent alteration of August flow was determined by dividing the August withdrawals by the August unaffected flow, which presumes a 1:1 relationship between withdrawals and streamflow impacts.

Figure 8-5 depicts the FL designations for each subbasin located within and proximate to Shrewsbury. Figure 8-5 presents the FL designations for the two subbasins from which Shrewsbury withdraws groundwater. As shown, Shrewsburys' groundwater withdrawals are in subbasins 23008 (Sewell) and 23002 (Home Farm and Lambert), which are both estimated to have greater than 55% alteration of unaffected August median flow and are therefore FL 5 subbasins. Also note that both subbasins contain Coldwater Fisheries, although in both cases the Coldwater Fisheries are upstream of Shrewsbury's withdrawals and separated from the withdrawals by a surface water impoundment.

Figures 8-6 and 8-7 and Table 8-6 present the data used in determining the FL for Shrewsbury's subbasins.





The FL bar in the Figures shows the unaffected August flows in these subbasins and quantifies the amount of August withdrawal available in each FL. The withdrawal bars in the Figures illustrates the estimated 2000 – 2004 August withdrawals used in the FL determination, and the portion of those estimated withdrawals attributed to Shrewsbury's wells. Note that because subbasin 23008 flows into subbasin 23002, the Sewell Well withdrawals affect flow alteration in both subbasins. As illustrated, both of these subbasins have August withdrawals that exceed the August natural median flow. This results in both subbasins being designated as FL 5, but should not be interpreted to mean that withdrawals are drying up the streams in these subbasins. Site specific hydrogeology of each well, aquifer flow, and aquifer storage can all result in continued surface water flow under these conditions.

Other withdrawals in the Figure consist of all WMA permitted groundwater withdrawals and private wells in and upstream of this subbasin including, for example, withdrawals in Boylston and the Worcester Sand and Gravel well.

Table 8-6. Shrewsbury – FL Determination

Criterion	Home Farm & Lambert	Sewell
2000–2004 Estimated August Withdrawal (mgd)	3.62	0.946
2009-2011 Actual August Withdrawal (mgd)	3.28	0.609
Subbasin	23002	23008
Unaffected August Flow (mgd)	3.95	0.930
Estimated Total August Withdrawals (mgd)	5.16	1.47
August Flow Alteration (%)	131	158
Flow Level	5	5

Note that, despite increasing population, Shrewsbury's withdrawals have decreased from the time of the data used for the FL determination. This is likely attributable to the Town's efforts in demand management.

8.2.3 Tier Designation

As described in Section 2.1, the permit review tier is based upon the volume of water that a community is requesting authorization to withdraw above the baseline volume, and the percent of the unaffected August flow in the withdrawal subbasin as summarized in Table 8-7.

Table 8-7. Tier Designation

Tier	Withdrawal Request
1	No additional water above baseline
2	Additional water above baseline <5% of subbasin's unaffected August flow
3	Additional water above baseline >5% of subbasin's unaffected August flow
4	Additional water above baseline will result in a change in Flow Level or Biological Category

The Baseline demand for a system is determined by the greater of the 2003 – 2005 annual average demand or the 2005 actual demand plus a growth factor of 8%. If the 8% factor would result in a change in the subbasin's FL, the growth factor is limited to 5%. Furthermore, the baseline cannot be lower than the system's existing registered volume or higher than the existing total authorized volume. In addition, the baseline demand cannot be more than the Department of Conservation and Recreation's (DCR's) 20-year demand projection for the community. Table 8-8 illustrates the baseline demand calculation for Shrewsbury.

Table 8-8. Shrewsbury – Baseline Demand	
Item	**Quantity (mgd)**
Registered Volume	2.64
Total Authorized Volume	3.91
DCR Projection	5.28
2003 Demand	3.51
2004 Demand	3.62
2005 Demand	3.89
2003 – 2005 Avg. Demand(1)	3.65
2005 Demand + 8%	4.20
Proposed Baseline	**3.91**

1. Limited by 2005 compliance volume

As shown in the Table, Shrewsbury's proposed Baseline Demand is 3.91 mgd, as limited by the current Total Authorized Withdrawal rate. This would not result in a change in the FL of the either of the subbasins from which Shrewsbury's wells withdraw.

DCR's latest (2008) 20-year demand projection for the Shrewsbury system is 5.28 mgd. Although historical demands have not been anywhere near that amount, and the recent demand trend is declining, for purposes of this Pilot Project, Shrewsbury elected to consider a withdrawal request equal to the full DCR projection of 5.28 mgd. This withdrawal request would be 1.37 mgd above baseline, which is more than 5% of the unaffected August flow in both subbasins from which Shrewsbury withdraws water. Because the subbasins are both Flow Level 5 the additional withdrawal request would not increase the basin FL. This permit would therefore require a Tier 3 review.

8.2.4 Permit Requirements

The Draft SWMI Framework WMA Permitting Tiers Table (Table 5 of Draft Framework) presents the permit review requirements based on subbasin flow level and withdrawal request Tier. The piloted Shrewsbury WMA permit is a Tier 3/FL 5 review with a quality natural resource in the subbasin and therefore requires that Shrewsbury:

- Comply with applicable provisions of standard permit conditions 1-8
    1. Source Protection
    2. Firm yield for surface water supplies
    3. Wetlands and vernal pool monitoring (if applicable)
    4. Residential use less than 65 gallons/capita/day
    5. Unaccounted for water less than 10%
    6. Seasonal limits on nonessential outdoor water use
    7. Water conservation measures
    8. Offset Feasibility Study

Note that the minimization measures developed through the SWMI process are already being applied in standard conditions 6 and 7, and it is expected that the mitigation measures will be incorporated into standard condition 8.

- Minimize the impact of their existing withdrawals on streamflow to the greatest extent feasible considering cost, level of improvement achievable and ability to implement.
- Demonstrate that there is no feasible alternative source that is less environmentally harmful. Less environmentally harmful is defined as a source that is in a FL 1, 2, or 3 subbasin and doesn't cause that subbasin to change FL.
- Implement mitigation measures that are commensurate with impact of their increased withdrawals (1.37 mgd).

The report sections below discuss the minimization and mitigation alternatives identified through this Pilot Project for the Town of Shrewsbury. This is not expected to be an exhaustive listing, nor have the feasibility of implementing these actions been fully investigated. The discussion does, however, provide a basis for assessing the potential impact of the proposed SWMI process on a Shrewsbury permit application.

8.3 Minimization of Impacts

8.3.1 Optimization of Existing Sources

Shrewsbury has limited opportunity to modify the operation of their existing sources to reduce the impact on stream flow and habitat. The Home Farm and Lambert Wells are in a downstream subbasin to the Sewell well and therefore withdrawals from these wells result in less August flow alteration when applying the Draft SWMI Framework FL designation methodology. Similarly, the Lambert Wells are further from the surface water and therefore theoretically have a less immediate and direct impact on surface water flow in the subbasin. These slight differences in theoretical stream impact are not expected to equate to significant differences in fish habitat, particularly because of the attenuating effect of Lake Quinsigamond. Historically, Shrewsbury has been encouraged to minimize withdrawals from the Home Farm wellfield to reduce local impacts on Poor Farm Brook which is also impacted by withdrawals at the Worcester Country Club and high impervious cover.

8.3.2 Alternative Sources of Water Supply

Information regarding alternative sources of water supply was obtained from documents provided by the Town of Shrewsbury, notably an Alternate Water Supply Study (dated January 2010) and a Water Distribution System Study Update (April 2012) both conducted by Tata & Howard Inc. The reports summarize evaluations of several supply alternatives including developing new sources within the Town of Shrewsbury, purchasing raw water from the City of Worcester, and developing treated water interconnections with Boylston, Northborough and MWRA. Each of these opportunities is described below and depicted on Figure 8-8, the Shrewsbury Alternative Source Map.

The Opinion of Probable Cost presented for each water supply alternative option was obtained from the 2010 Alternative Supply report (2010 Alternative Supply Report) and updated utilizing the Engineering News Record Construction Cost Index. Capital costs include the cost of distribution system improvements and required permitting. Estimated operating costs assume that Shrewsbury would purchase its entire demand above baseline (1.37 mgd) from these alternative sources.

For purposes of this Pilot Project, Shrewsbury is projecting demands that exceed the capacity of their current sources of supply. It would therefore be necessary for the Town to invest in development of new sources regardless of the WMA or the Draft SWMI Framework. The estimated costs for development of alternative supplies would not, therefore, be interpreted as a cost for compliance with potential future SWMI regulations. If, however, applying the SWMI standards changes the feasibility of available alternatives, the incremental cost between alternatives would be attributed to the potential regulations.

8.3.2.1 Purchase Raw Water from Worcester (Shrewsbury Well)

The City of Worcester owns a well in Shrewsbury known as the Shrewsbury Well (also known as the Home Farm Well). Worcester believes that it can provide up to an annual average of 0.46 mgd of raw water to Shrewsbury based upon their current WMA registration (2010 Alternative Supply Report). Worcester also indicated that the well could provide higher withdrawals during peak use in the summer. Worcester's Shrewsbury Well is located outside of the Poor Farm Brook subbasin in subbasin 23007. This subbasin is designated as FL 1 and contains an upstream coldwater fishery. The unaffected August flow in the subbasin estimated by the SYE is only 0.67 mgd. An additional 0.01 mgd is available in the subbasin within FL 1 and withdrawing 0.46 mgd would shift the subbasin to FL 5. This alternative is therefore not considered feasible within the Draft SWMI Framework.

Pump tests performed at Worcester's Shrewsbury Well indicated iron and manganese levels which exceed secondary maximum contaminant levels. At the time of the pump test, VOCs were below maximum contaminant levels; however historic data in the area shows that VOC levels have exceeded maximum contaminant levels in the past. Assuming the raw water does not contain VOCs the water would likely be pumped to Sewell Well No. 4 through the Sewell raw transmission line. In this case, 1,000 ft of new 12" diameter water main would be required to connect the well to the existing main. Modifications to the Sewell system (larger storage tanks and pumps) would likely need to be made to account for the increase in flow. If the water does contain VOCs, treatment through the air strippers at the Home Farm WTP would be required. Under this scenario the Home Farm WTP treatment capacity would limit the amount of water from Worcester's Shrewsbury Well that can be treated to approximately 0.46 mgd. Significant improvements to the WTP would be required to treat additional water from the well during maximum day demand conditions.

The Alternative Water Supply Study notes that a water source not used in over five years would require some level of permitting through the new source approval process; which would likely require pumping the well for up to five days and the completion of new water quality sampling. Additionally, any improvements at the well and water treatment plant would require submittal of a BRP WS 32-Distribution Modifications for Systems that serve more than 3,300 people application to MassDEP. Additional MassDEP approval would be necessary if treatment improvements are required. It may also require permitting from the Shrewsbury Conservation Commission due to the proximity of wetlands. The water would also be subject to permitting under the Interbasin Transfer Act (IBTA) because Shrewsbury withdraws water from, and transports its wastewater out of, the Blackstone River Basin.

Assuming expansion of the Home Farm WTP is not required, the estimated capital cost for development and permitting of Worcester's Shrewsbury Well as a raw water supply to the Town of Shrewsbury is approximately $500,000.

The City of Worcester has never sold raw water to others so there is no precedent for a raw water rate. For purposes of this Pilot Project, the City's in-city water of $3.25 per hundred cubic feet was utilized. Though the cost for raw water would likely be less than the current in-city water rate; this rate was used to conservatively estimate operating cost. Based on these assumptions, the annual cost for purchase of 0.46 mgd of raw water from Worcester would be approximately $725,000.

8.3.2.2 Purchase Treated Water from Worcester

The City of Worcester obtains its supply from multiple surface water sources in the Blackstone and Nashua River Basins. The City has excess supply capacity and could potentially sell treated water to Shrewsbury. This excess supply would come from surface water sources likely to be in FL1-3 subbasins and would therefore be considered a less environmentally harmful alternative to meet Shrewsbury's additional supply needs. Worcester could not determine whether the full 1.37 mgd required by Shrewsbury above its baseline for this Pilot Project could be made available without more detailed discussion and evaluation of the City's and Town's needs and contract terms.

Shrewsbury could purchase treated water from Worcester via a new interconnection at Sunderland Road/Route 20 or at Lincoln Street/Main Street. There is already an existing meter pit at the Route 20 location, however a new meter and control valve would be required. Due to differences in grade lines between the two systems a pressure reducing valve would also likely be required. The existing 12" water main on Route 20 would transmit water from the meter pit to the Shrewsbury System. The Lincoln/Main Street interconnection would require a new meter pit and control valve, installation of approximately 1,100 feet of 12-inch diameter interconnection main and up-sizing of approximately 1,600 feet of main in Worcester and Shrewsbury's distribution systems.

Shrewsbury's water is currently fluoridated and Worcester's is not. Shrewsbury's Board of Health may therefore require fluoride addition to treated water purchased from Worcester which would require the siting and construction of a chemical addition system at the interconnection point, significantly increasing the complexity and cost of this alternative.

Similar to above, this interconnection would be subject to the IBTA. Additionally, new water service constructed across a municipal boundary is subject to review by the Massachusetts Environmental Policy Act (MEPA) office and must submit an Environmental Notification Form (ENF) and Environmental Impact Report (EIR). Should the addition of fluoride be required at the point of interconnection, a Treatment Permit would be required as well as local permitting through the Board of Health. Local permitting from the Conservation Commission may also be required due to the proximity of the required improvements to surface water and wetlands.

The estimated cost for development and permitting of the Worcester treated water interconnection to the Town of Shrewsbury is approximately $300,000 to $900,000 depending on the location chosen and excluding fluoridation facilities and potential system development or connection permit charges from the City.

The City of Worcester's 2012 Out-Of-City water rate for treated water is $3.40 per hundred cubic feet. This rate is expected to increase after July 1, 2012 to $3.60 per hundred cubic feet. As such, $3.60 per hundred cubic feet was utilized to calculate operating costs. Based on these assumptions, the annual cost for purchase of 1.37 mgd of treated water from Worcester at their normal metered rate would be approximately $2.4 million. For comparison, the incremental cost of production at Shrewsbury's wells is approximately $0.34 per hundred cubic feet ($450/MG). At this rate, the annual cost to produce 1.37 mgd locally would be approximately $225,000 per year.

8.3.2.3 Purchase Water from Boylston (Route 70/Town Line Interconnection)

Shrewsbury has purchased water from Boylston in the past; however, more recently Boylston has indicated that they don't have excess water to sell (6/14/12 SWMI Meeting Notes). The lack of excess supply in Boylston was supported by a comparison of their WMA Authorized Capacity to 2011 actual withdrawals.

8.3.2.4 Purchase Water from MWRA

Shrewsbury is not currently an MWRA community; however, it has the option to connect to the system through Northborough. MWRA utilizes surface water storage and would therefore be considered a less environmentally harmful alternative than increased groundwater withdrawals in Shrewsbury's existing subbasins.

Shrewsbury would be required to connect to the MWRA system downstream of the John J. Carroll Water Treatment Plant. The previously referenced 2010 Alternative Supply Report identified two options to connect to MWRA system. The first option is that water can be purchased from MWRA through Northborough at an interconnection with Northborough. In this instance, water would be transferred from MWRA through Northborough's distribution system. The interconnection would likely occur on West Main Street. We note that discussions with the Town of Shrewsbury (May 16, 2012, see SWMI meeting notes) indicated that Northborough is considering disconnecting from the MWRA due to the high cost; which may eliminate this option from future consideration.

The second option is to connect directly to MWRA through Northborough. This would occur if Northborough is not able to transfer water through their system from MWRA or if Northborough is no longer an MWRA community. The most direct route for a water main through Northborough is as follows: Main Street/Route 20 to Bartlett Street, along Bartlett Street to connection point. For this option, Shrewsbury would need approval from Northborough to install water mains in Northborough's public roads.

Purchasing water from MWRA through Northborough via Northborough's distribution system would require approximately 1,200 l.f. of 12" diameter main (along Main Street in Shrewsbury) and 2,300 l.f. of 12" diameter main in Northborough to connect the two systems. A booster pump station would also be required to transfer water from Northborough to Shrewsbury and improvements would be required in Shrewsbury's system to distribute the purchased water to Shrewsbury's three pressure zones.

Connecting directly to the MWRA system would require 1,200 feet of 12" diameter main (in Shrewsbury) and 28,000 feet of 12" diameter main (in Northborough). Both interconnection options would also require installation of a meter pit (with meter and control valve), a booster pump station, and a pressure reducing valve.

There are potential water quality concerns with mixing MWRA water with Shrewsbury water related to water chemistry. MWRA maintains a pH of approximately 9.0 while Shrewsbury maintains a pH of 7.5 (2010 Alternative Supply Report). Elevated pH levels could cause the iron and manganese in the Shrewsbury system to precipitate out. MWRA also utilizes chloramines for disinfection and Shrewsbury utilizes chlorine. Mixing of these disinfectants may cause taste and odor problems, difficulty controlling disinfectant residuals in the distribution system and impact Shrewsbury's corrosion control program. As MWRA water would represent a small percentage of water in the Shrewsbury system, significant changes to Shrewsbury's treatment process are not anticipated; however the water chemistry would be reviewed more closely before this option is pursued.

Similar to other interconnection alternatives, permits would likely be required from the following agencies: MassDEP (Interbasin Transfer Act and BRP WS 32 – Distribution Modifications for Systems that serve more than 3,300 people required due to addition of Booster Pump Station) and MEPA (new water service constructed across a municipal boundary and installation of greater than 5 mile of pipeline. Local Conservation Commissions/Army Corps of Engineers may be required dependent upon the project's proximity to wetlands.

The estimated capital costs for construction and permitting an MWRA interconnection to Shrewsbury would be approximately $7 million if water is transferred through Northborough's system and $13 million for a direct connection. The 2009 water rates for MWRA reported by Northborough are $2,820 per million gallons of water purchased. Per the 2010 Alternate Water Supply Report, a 2013 anticipated MWRA rate of $3,125 per million gallons of water was used to calculate operating costs. Note that additional costs could be imposed by Northborough to act as a transfer system. Based on these assumptions the estimated annual cost to purchase the 1.37 mgd Shrewsbury is requesting above their baseline demand would be approximately $1.6 million.

8.3.2.5 Masonic Property Bedrock Wells

The Town has installed bedrock test wells at the Masonic Hill tank site located in subbasin 12037 in the Concord River Basin. The biggest advantage to this supply is that it would not require Interbasin Transfer Act approval. The estimated yield from these wells is approximately 0.20 mgd (5/16/12 SWMI Meeting Notes). This is an FL4 subbasin with an additional 0.21 mgd of August flow alteration available before becoming FL5. The Masonic property is in the headwaters of the subbasin but the impact of bedrock wells on streamflow is not necessarily local to the point of withdrawal.

The 2010 Alternate Water Supply Study estimated capital costs for development of a new bedrock well at approximately $1 Million including test well exploration, installation of a production well, infrastructure, pump station, chemical feed system, electrical service, instrumentation and controls. The estimated costs are based on approximately 1,000 l.f. of 12" water main required to connect to the system and pH adjustment and fluoride and chlorine injection as the only required chemical treatment. The costs also include new source approval from MassDEP, MEPA review, a new Water Management Act permit, and a distribution modifications permit. Recently, the necessary change of land use article for the Masonic bedrock wells property did not get approved at Town Meeting. As a result, the Masonic bedrock wells are no longer considered a feasible supply alternative.

8.3.2.6 Oak Island and SAC Wells

According to the 2010 Alternate Water Supply Report, a groundwater exploration program was completed in 2002 which sought to determine the potential for water supply sites that could be developed and utilized as an additional supply source for the Town. The 2002 assessment evaluated the existing South Street Well, Sewell well site, the Scandinavian Athletic Club (SAC) Park, and Oak Island. The study determined that replacement wells at the existing South Street and Sewell Street well sites would not be beneficial.

The SAC site was recommended as a potential new source site. The site was proposed to MassDEP as a potential water source but MassDEP's initial reaction was discouraging because the site is located in a stressed basin. Shrewsbury did not pursue an application for the SAC site due to MassDEP's initial reaction. The potential yield of the SAC well was estimated at 0.75 mgd. The well would be in subbasin 23023 which is an FL2 subbasin with limited additional withdrawal available before "backsliding" to FL3. Furthermore, the SAC site is located in the Blackstone Basin and would be subject to the Interbasin Transfer Act.

The Oak Island site is located off of Route 20 in the southern portion of the Town. It was identified as a potential supply source, however portions of the land in the vicinity of the test well site are owned by the State and permission would be required to access the site to perform additional testing. Because the well is located within the Blackstone River

Basin and subject to the Interbasin Transfer Act and partially located on State-owned property, well development on the site may be difficult.

8.4 Mitigation & Offsets to Withdrawals

8.4.1 Summary Matrix

Using the credit approach outlined in section 4.2.1, quantified offsets to mitigation and offsets to withdrawals were calculated for wastewater, stormwater, habitat and demand management improvements. A summary of the mitigation and offset volumes is provided in Table 8-9, compared with the withdrawal request above baseline. Potential mitigation and offsets to withdrawals represent the maximum mitigation/offset a PWS could achieve if these actions were implemented town-wide (where applicable) and include both direct and indirect offset calculations. Note that although the indirect offset calculation methodology in Appendix E discusses a cap of the withdrawal request on the portion that can be obtained from indirect offsets, a cap has not been included in the summary matrix. Phase 2 could provide further consideration of how the indirect mitigation/offsets could be applied to the existing permit and future permit terms. For example, can unused indirect mitigation/offsets associated with the cap be carried over into a future permit term and withdrawal request?

The purpose of this matrix is to provide the PWS with an understanding of what options are available to them, the cost associated with these options and provide them with a tool to select those that work best for the PWS to meet its withdrawal request. For additional information on the offset calculations, refer to the following sections, the methodology in Appendix E and the Shrewsbury specific worksheet calculations in Appendix I.

8.4.2 Instream Flow/Surface Water Releases

The dams and surface water impoundments in Shrewsbury were identified for assessment for potential releases to augment stream flows during low flow periods. A screening analysis was conducted to evaluate the potential for surface water releases to mitigate water withdrawals. Factors that were considered included impoundment use, location with respect to the water withdrawal, ownership, status of proposed dam removals, and current management of releases. The level of analysis needed to confirm availability of water for potential releases, including modeling of potential release scenarios, is outside of the scope of the Phase 1 Pilot Project.

Within the Town of Shrewsbury, 16 dams were identified as summarized in Table 8-10. Only three dams are located upstream of Shrewsbury's water supply wells. Poor Farm Pond Dam is owned by the City of Worcester and is a high priority dam for removal. Newton Pond Dam was recently reconstructed, and provides a recreational surface water resource for properties adjacent to the pond. The pond lacks adequate storage for releases. Harlow Mill Pond dam is located upstream of Shrewsbury's Home Farm and Lambert Wells; however, the dam provides limited storage and it is under private control.

Table 8-9. Mitigation/Offset Summary Matrix for Shrewsbury			
	Existing	Potential	
	Volume (gpd)	Volume (gpd)	Cost ($)
Wastewater Offsets			
septic systems	55,014		
groundwater discharges		300,000	$ 12,000,000
infiltration	972	56,177	$ 6,953,968
inflow	169	45,346	
water reuse - irrigation	-		
private inflow removal program			
sewer bank (I/I offset) program	11,850		
wastewater enterprise account	11,850		
Wastewater Offset Total	79,855	401,523	$ 18,953,968
Stormwater/Impervious Cover Improvement Offsets			
recharge impervious surfaces			
leaching catch basins			
reduce impervious surfaces			
roof leader disconnection	881		
rain barrels		26,076	$ 3,221,760.00
stormwater bylaw with recharge requirements		2,356,313	
stormwater utility meeting environmental requirements	-	11,850	
implement MS4 requirements	11,850	-	
Stormwater Offset Total	12,731	2,394,239	$ 3,221,760.00
Habitat Improvement Offsets			
install and maintain a fish ladder	-	-	
remove a dam or other flow barrier	-	67,150	
acquire/protect lands	-	-	
culvert replacement	-	-	
streambank restoration	-	-	
tree canopy	-	-	
mitigation fund	-	-	
Habitat Improvement Total	-	67,150	-
Water Supply Improvement / Demand Management			
outdoor watering restrictions	862,971	431,486	$ -
irrigation audits	-		
irrigation sensors	-		
irrigation bylaw	-		
faucet aerators	5,952	73,844	$ 139,575
low flow faucets	2,232	-	$ -
low flow showerheads	38,192	660,027	$ 190,100
low flow toilets (1.6 gpf)	-	-	$ -
HE toilets (1.28 gpf)	-	279,562	$ 754,125
watersmart washing machines	-	107,437	$ 1,005,500
watersmart dishwashers	-	11,846	$ 1,005,500
commercial water audits	-		
municipal building retrofits	-	9,875	
pistol grip hose nozzles	449	9,426	
water bank	-	11,850	
water supply enterprise account	-	11,850	
water conservation rates	-	9,875	
monthly billing/radio-read meters	-	9,875	
conservation education/outreach	-	9,875	
Demand Management Total	909,796	1,636,828	$ 3,094,800
Total Potential Mitigation/Offset	**1,002,382**	**4,499,740**	**$ 25,270,528**
Total Withdrawal Request Above Baseline		**1,370,000**	

Notes:

1. All mitigation options discussed in this report are included in the table. Values are only provided for those options that could be quantified for the PWS using available information.
2. Indirect offsets are shaded pink and are included in the total. A cap has not been applied to indirect offsets.
3. Demand management offsets assume assumed that demand management options could be applied to all ‘applicable’ households (e.g., where not currently applied). Refer to Section 8.4.6. Actual savings should be based on the actual number of households the options are applied to.
4. Stormwater/impervious cover improvement offsets include those that could be readily quantified under Phase 1. Other stormwater options could be considered under Phase 2.
5. Habitat improvement offsets include those that could be readily quantified under Phase 1. Dam removal provides credit for the removal of the Poor Farm Brook Dam.

Table 8-10. Shrewsbury Surface Water Release Summary			
Dam	**Ownership**	**Proximity to Water Supply**	**Feasibility**
Newton Pond Dam	Shrewsbury	Upstream of Sewell Street Well	Lacks adequate inflow or storage Recently reconstructed
Harlow Mill Pond Dam	Private	Upstream of Home Farm and Lambert Wells	Lacks adequate inflow or storage Not controlled by Shrewsbury
Old Mill Pond Dam	Shrewsbury	Downstream of Shrewsbury's wells	Lacks adequate storage
Poor Farm Pond Dam	Worcester	Upstream of Worcester, Home Farm and Lambert Wells	Scheduled for removal
St Pierre Farm Pond Dam	Shrewsbury	Downstream of Shrewsbury's wells	Downstream of wells
Dean Pond Dam	Shrewsbury	Concord River Basin	Different basin
Eaton Pond Dam	Shrewsbury	Concord River Basin	Different basin
Rawson Hill Dam	MA-DCR	Concord River Basin	Different basin
Lake Quinsigamond Dam	MA-DCR	Downstream of Shrewsbury's wells	Downstream of wells
Stringer Dam	Private	Concord River Basin	Downstream of wells
Steinhilber Skating Pond Dam	Private	Concord River Basin	Different basin Not controlled by Shrewsbury
Wyman Lower Pond Dam	Private	Concord River Basin	Different basin Not controlled by Shrewsbury

Table 8-10. (continued) Shrewsbury Surface Water Release Summary			
Dam	**Ownership**	**Proximity to Water Supply**	**Feasibility**
Wyman Middle Pond Dam	Private	Concord River Basin	Different basin Not controlled by Shrewsbury
Wyman Upper Pond Dam	Private	Concord River Basin	Different basin Not controlled by Shrewsbury
Shrewsbury Sportsmens Pond Dam	Private	Concord River Basin	Different basin Not controlled by Shrewsbury
Northborough Reservoir Dam	Northborough Water & Sewer	Concord River Basin	Different basin Not controlled by Shrewsbury

No significant feasible surface water release was identified Shrewsbury that would offset groundwater withdrawals.

8.4.3 Wastewater

As noted above, approximately 85% of development in Shrewsbury is connected to the municipal sewer system, which discharges to the Westborough Wastewater Treatment Plant in the Concord River Basin. The residential areas that are currently served by on-site septic systems are expected to remain served by on-site systems in the future, as the Town has special legislation that allows restricting connections to the sewer system due to capacity limits at the WWTP. Opportunities for wastewater related credits, including groundwater recharge and I/I reduction are described below. The potential credits for wastewater in Shrewsbury, based on the wastewater credit methodology described in Section 4.2, are summarized in Table 8-11.

Table 8-11. Potential Wastewater Credit Summary – Shrewsbury			
	Wastewater Category	**Total Wastewater Flow (gpd)**	**Total Flow Offset Volume (gpd)**
1	Septic Systems	246,084	55,014
2	Groundwater Discharges	300,000	75,000
3	Infiltration (removable volume)	836,560	57,149
4	Inflow	45,515	3,312
5	Water Reuse - Irrigation	0	0
6	Indirect Offsets: Wastewater Enterprise Fund and I/I Bank		20,738
	Total Potential Wastewater Credit		211,213

8.4.3.1 Groundwater Recharge Options to Blackstone River Basin

To address capacity issues at the Westborough WWTP and improve flows within the Blackstone River Basin, the Town studied multiple groundwater discharge options within the Blackstone River Basin. Westborough assessed over 70 parcels greater than 5 acres for the potential to serve as groundwater disposal sites to except treated effluent from the Westborough WWTP. Screening of these parcels resulted in 2 potential sites for wastewater disposal. However, costs associated with acquisition, pipeline construction, and construction of the disposal fields deemed the sites not feasible for the amount of recharge gained.

Shrewsbury has also assessed sites for construction of a groundwater treatment and disposal facility. The Scandinavian Athletic Club (SAC) site off of Lake Street was assessed for the potential for a new drinking water well (see Figure 8-8). When the permitting hurdles put the plan for a new well on hold, the Town assessed the feasibility of constructing a WWTP with a 305,000 gpd groundwater disposal capacity. The site is located in the Blackstone Basin, downstream from town’s wells, and large enough to accommodate the WWTP and disposal facility and recreation fields. Initial cost estimates are in the $10 to $12 million range. Further assessment of this site is needed.

There are approximately 1,700 septic systems throughout Town. Based on Shrewsbury’s Comprehensive Wastewater Management Plan, approximately 475 septic systems are located in unsewered areas of Town in the Blackstone basin. Because of the capacity limitations at the Westborough Wastewater Treatment Plant, Shrewsbury obtained special legislation (Chapter 51 of the Acts of 2006) providing that *the town of Shrewsbury sewer* *commission shall not be required to connect any residence, facility or lot to the town's sewer system*. Shrewsbury has decided to reserve its remaining wastewater treatment and disposal capacity for infill and commercial and industrial development. Therefore, currently unsewered residential areas of town are anticipated to remain served by on-site systems.

8.4.3.2 Infiltration/Inflow Removal

The interbasin transfer of water from the Blackstone River Basin to the Concord River Basin is exacerbated by infiltration and inflow into the Shrewsbury collection system. Shrewsbury committed to aggressive I/I removal program to create capacity and increase stormwater recharge to the Blackstone River Basin.

Results from the 2011 town wide metering program identified five areas in town with infiltration rates in excess of 4,000 gallons per day per inch diameter of sewer mile (gpdim). Fourteen metered areas in town were considered excessive because they contributed approximately 80% of the total identified inflow. Of the fourteen areas, four of them contributed over half of the total peak design storm inflow.

Shrewsbury has identified the need for a $1 Million a year, 13-year I/I program. However, Town Meeting has only allocated approximately $500,000 in FY 2012 for the program. The Town continues to identify projects to address priority areas for I/I removal. The majority of the target I/I areas are in the lower lying areas of Town within the Concord River Basin. Information on I/I projects completed, including lining of 11 manholes and assessing inflow from houses in the Browning Road and Colton Lane area have been incorporated in the potential credits. Future I/I removal projects are yet to be determined. Potential credit for I/I uses the volumes determined by the studies performed to date and by information provided by the Town's consultant, Weston & Sampson. The credit accounts for the I/I observed, and that 75% of removal activities would occur in the Concord Basin, and 25% of removal activities would occur in the Blackstone Basin. The potential credit also assumes that inflow would be redirected to infiltration basins or the ground, and not to the municipal storm drain system.

8.4.3.3 Surface Water Discharge

There are no surface water discharges upstream or within the Zone II of Shrewsbury's groundwater withdrawals.

8.4.3.4 Other Potential Wastewater Credits

Shrewsbury does not have a wastewater enterprise fund; however, they operate under a "functionally equivalent" wastewater enterprise fund, where all of the revenues collected through rates are dedicated to sewer department expenditures and cannot be used in the general fund.

Shrewsbury has adopted a Sewer Use Regulation to address the costs associated with I/I removal. The regulations require that new development must remove 4 gallons of I/I for each gallon added at cost of $3.00 gallons per gallon to be removed.

8.4.4 Stormwater/Impervious Cover

Section 4.2.2.3 outlines stormwater mitigation options to help offset withdrawal requests. Table 8-12 summarizes those that are applicable to Shrewsbury and could be readily quantified under Phase 1 of the project. These include the distribution of rain barrels, implementation of a stormwater utility, and implementation of MS4 requirements.

Table 8-12. Stormwater/Impervious Cover Improvement Offsets in Shrewsbury

	Offsets Completed to Date		Potential Offsets		
	Quantity	Volume (gpd)	Quantity	Volume (gpd)	Cost
Roof leader disconnection[1]	49 households	881			
Rain barrels			13,424 households	26,076	$3,221,760
Stormwater bylaw with recharge requirements				2,356,313	
Stormwater utility[2]				11,850	
Implement MS4 requirements[2]		11,850			

[1]The adjustment factor was applied to recharge volumes based on the locations of the households disconnected.
[2]Both the ‘stormwater utility’ and ‘Implement MS4 requirements’ were calculated using the indirect method in Appendix E and resulted in the same volume offset.

Shrewsbury currently requires recharge of rooftop runoff for new development in areas where it is feasible (e.g., permeable soils). They have also required it for redevelopment projects. Forty nine household rooftops were directed to recharge during the last five years. Additionally, seven infiltration BMPs were installed within the last five years, as outlined in Table 8-13. Refer to Figure 8-9 for roof leader recharge and stormwater BMP locations.

Table 8-13. Infiltration BMPs Implements in Shrewsbury 2007-2011

Location	BMP Type
495 Hartford Turnpike	Infiltration basin for church sanctuary and parking lot
731 Boston Turnpike	Infiltration system for grocery store and parking lot
411-413 Hartford Turnpike	Recharge trench for parking lot
640-680 Boston Turnpike	Infiltration basin for apartment complex
460 Lake Street	Infiltration basin and trench for grove meadow subdivision
42 Bowditch Drive	Infiltration basin for manufacturing facility
489 Boston Turnpike	Infiltration system for bank and parking lot

Information on the size of these BMPs or the drainage area treated was not available during this Pilot Project, so mitigation credits were not included for these items. However, Shrewsbury may be able to provide the recharge volumes associated with these actions for existing credits when applying for its new permit.

Shrewsbury is currently in the process of developing a stormwater utility and anticipates it will be in effect within three to five years.

A simple overlay of existing land use and protected lands shows about 4,255 acres of land remain to be developed. This was overlaid with hydrologic soil groups (HSGs) to help determine the recharge potential for future development, with A and B soils offering high recharge potential and C and D soils less. Refer to Figure 8-10 for HSGs and undeveloped and protected land.

Table 8-14 presents a breakdown of the areas of undeveloped lands by soil type based on these overlays. The resulting data demonstrate the potential mitigation that can be achieved by applying more stringent stormwater bylaws to future development.

Table 8-14. Shrewsbury Available Land Area per HSG

Hydrologic Group	Area (acres)
A	518.65
B	1273.48
C	1986.92
D	249.17
Pits, quarry	110.43
Urban Fill	116.85
Total Area	4255.48

To demonstrate the potential impact of uncontrolled development, and the potential effectiveness of more stringent recharge requirements, the Pilot Project Team developed the following analysis.

- The estimated percent impervious cover at buildout is 46%. This figure was determined using town zoning information obtained from GIS and applying literature based impervious values to each zoning type. While simplistic, this analysis provides an illustrative estimate of future impervious area.

- Applying the 46% to the 4,255 developable acres results in an additional 1,938 acres of impervious area that could be added to the Town.

- Absent stringent controls over stormwater management, this entire new impervious acreage would hinder or prevent stormwater infiltration, with a corresponding impact on groundwater.

- The more stringent recharge requirements were applied to the potential impervious area in each soil group to estimate the additional recharge that could be obtained. The result is an additional 2.36 mgd. This demonstrates the benefits of more stringent recharge regulations. For the current discussion, the analysis assumes the difference between no recharge and that achieved through implementation of the bylaw and has not applied the location adjustment factors discussed in Section 4.0 to estimate the actual mitigation credits. A more refined analysis of this mitigation action and the location adjustment factors can be completed under Phase 2 of the project.

Other stormwater mitigation options could be considered in Phase 2. For example, potential savings may be realized from a roof leader disconnection program; the potential savings could be explored using a GIS overlay analysis and the assumptions outlined in the methodology presented in Section 4.2.2.3. The applicability of other mitigation options (e.g., sites where existing impervious surfaces can be eliminated or directed to recharge) may require specific site evaluations.

8.4.5 Habitat Improvements

The City of Worcester owns the Poor Farm Pond dam and is planning on removing it if funding can be obtained. Currently, there are no other known scheduled or planned dam removals, culvert replacements or other habitat improvements in Shrewsbury.

None of the stream culverts have been evaluated for habitat and stream continuity at this point, however, based on the number of dams and culverts located within the Town, there is the potential to obtain mitigation credits through improvements to these structures. However, this requires further assessment to determine the need for (e.g., is it currently a detriment to habitat continuity?) and the level of improvement needed. This is beyond the scope of this Pilot Project.

8.4.6 Demand Management

The Shrewsbury Water Department has been implementing demand management and conservation activities for a number of years. These include the following:

- The Shrewsbury Water Department can implement outdoor water restrictions when a State of Water Supply Conservation or a State of Water Supply Emergency is declared. Either declaration may include mandatory 3 day per week outdoor water use restrictions, a ban on filling pools, a ban on the use of lawn sprinklers or sprinkler systems, and/or a ban on all outdoor water use. Shrewsbury typically requires odd/even watering, with no watering on Mondays, between May and September.
- The Town of Shrewsbury has not allowed new irrigation systems to be connected to the public water supply since February 11, 2003.
- Shrewsbury charges a conservation fee to developers with new development connecting to the water supply. The fee is used to pay for conservation kits, including pistol grips, faucet aerators and low flow showerheads that are handed

out to the public and to pay for water conservation education materials. Shrewsbury does not operate a rebate program.

- The Shrewsbury Water Department does not operate with an Enterprise Account; however, according to the Shrewsbury Town Engineer, all revenue collected through rates are dedicated to water department expenditures and cannot be used in the general fund.
- Shrewsbury uses conservation rates for both residential and commercial customers. All customers are billed quarterly. Approximately one third of Shrewsbury's customers are metered with radio-read devices.

The mitigation credit available from existing demand management activities is included in Table 8-15, along with potential credits. As shown in Table 8-15, the Town has numerous demand management options available to help offset its 1.37 mgd additional withdrawal request. Note that these potential savings would be higher than the requested withdrawal increase, allowing the Town to pick and choose the options that best fit their needs to meet the 1.37 mgd offset.

Table 8-15. Demand Management Offsets in Shrewsbury							
	Existing		Potential				
Water Supply Improvement / Demand Management	**Number of Households (#)**	**Volume (gpd)**	**Number of Households (#)**	**Volume (gpd)**	**Cost ($)**	**Revenue Loss ($/year)**	**Notes**
outdoor watering restrictions	13,424	862,971	13,424	431,486	$ -	308,081	
irrigation audits	-	-					
irrigation sensors	-	-					
irrigation bylaw	-	-					
faucet aerators	750	5,952	9,305	73,844	$ 139,575	161,719	
low flow faucets	150	2,232	-	-	-	-	
low flow showerheads	550	38,192	9,505	660,027	$ 190,100	1,445,460	
low flow toilets (1.6 gpf)	-	-	-	-	-	-	
HE toilets (1.28 gpf)	-	-	10,055	279,562	$ 754,125	612,241	
watersmart washing machines	-	-	10,055	107,437	$ 1,005,500	235,287	
watersmart dishwashers	-	-	10,055	11,846	$ 1,005,500	25,942	
commercial water audits	-	-					
municipal building retrofits	-	-		9,875			indirect
pistol grip hose nozzles	610	449	12,814	9,426			indirect
water bank	-	-		11,850			indirect
water supply enterprise account	-	-		11,850			indirect
water conservation rates	-	-		9,875			indirect
monthly billing/radio-read meters	-	-	13,424	9,875			indirect
conservation education/outreach	-	-	13,424	9,875			indirect
TOTAL				1,636,828	$3,094,800		

Notes:

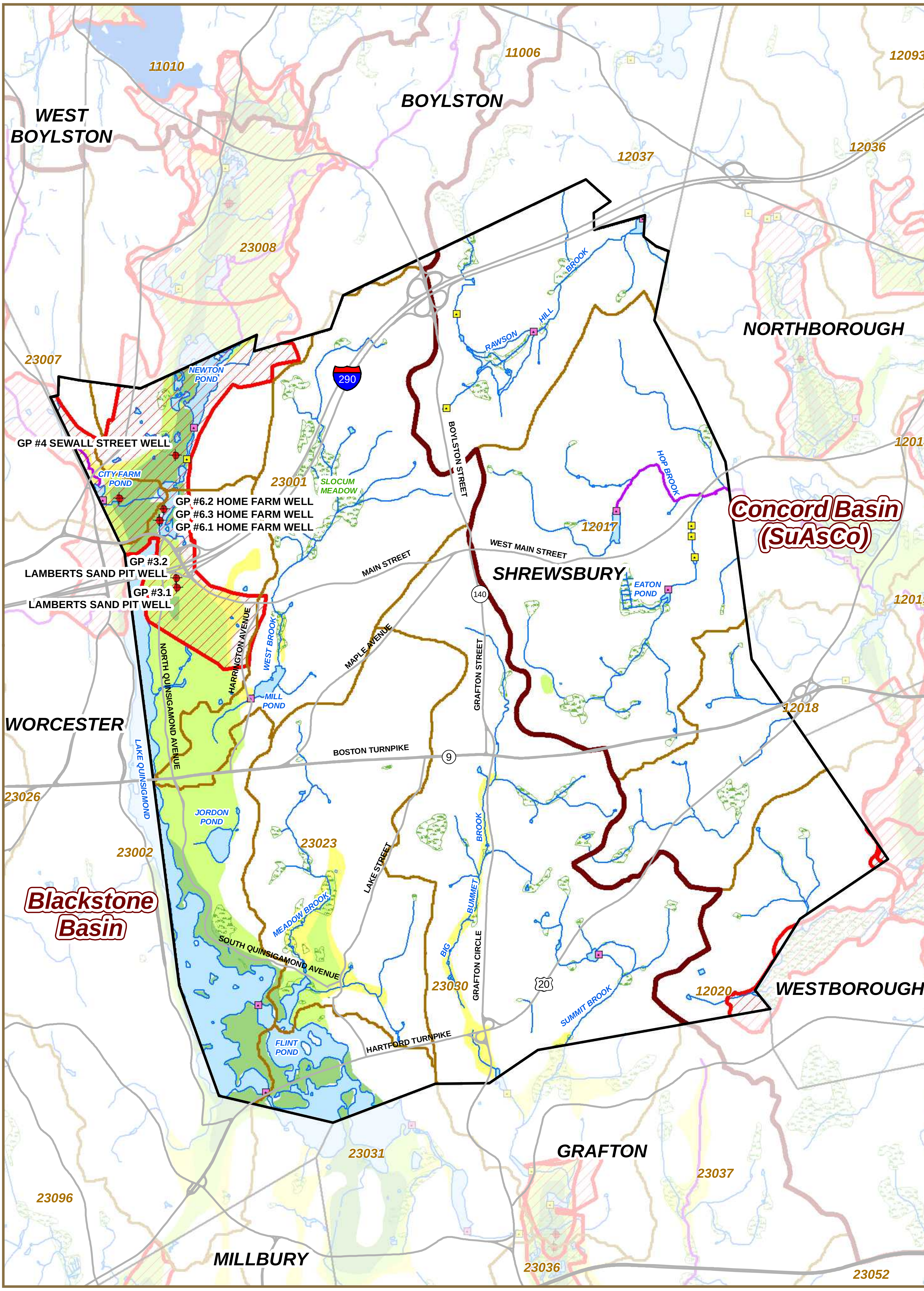
1. All mitigation options discussed in this report are included in the table. Values are only provided for those options that could be quantified for the PWS using available information. For the purposes of estimating potential water savings through future mitigation actions, it was assumed that demand management options could be applied to all 'applicable' households (e.g., where not currently applied). Actual savings should be based on the actual number of households the options are applied to.

2. Potential demand management offsets were based on the following:
    a. outdoor watering restrictions would be applied to all households (13,424), whether or not on the public water supply. There were 13,424 households in Shrewsbury in 2010 according to U.S. Census at factfinder2.census.gov, all of which are assumed to be on the public water supply. Assumes watering restricted to 2 days/week (mid-May through mid-September).
    b. water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 10,055 households in Shrewsbury in 1990, all of which are assumed to be on the public water supply.
    c. the greater water savings and less expensive options were selected for implementation where more than one option existed (e.g., aerators are cheaper than faucets, HE toilets are more efficient than low flow.

3. Costs and revenue loss are provided for potential mitigation options only.

4. Revenue losses are calculated as the reduced water demand volume multiplied by the water rate, assuming the full potential is achieved. Actual revenue losses will be based on actual reduced water demand volume. Shrewsbury uses a 3 step increasing block rate for its residential rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

5. Note that water volume savings calculated using the indirect method in Appendix E will result in the same volumes for many items.



LEGEND

- Community Groundwater Well
- Coldwater Fishery Resource
- DEP Approved Zone IIs
- Major Basin Boundary
- Subbasin Boundary

Aquifer Boundary (Yield)

- High
- Medium
- Low

Dam Locations

- Private
- Public

Hydrography

- Pond, Lake
- Reservoir
- Wetland
- Stream, Brook
- Town Boundary

N W E S

0 1,500 3,000 4,500 6,000 7,500 Feet

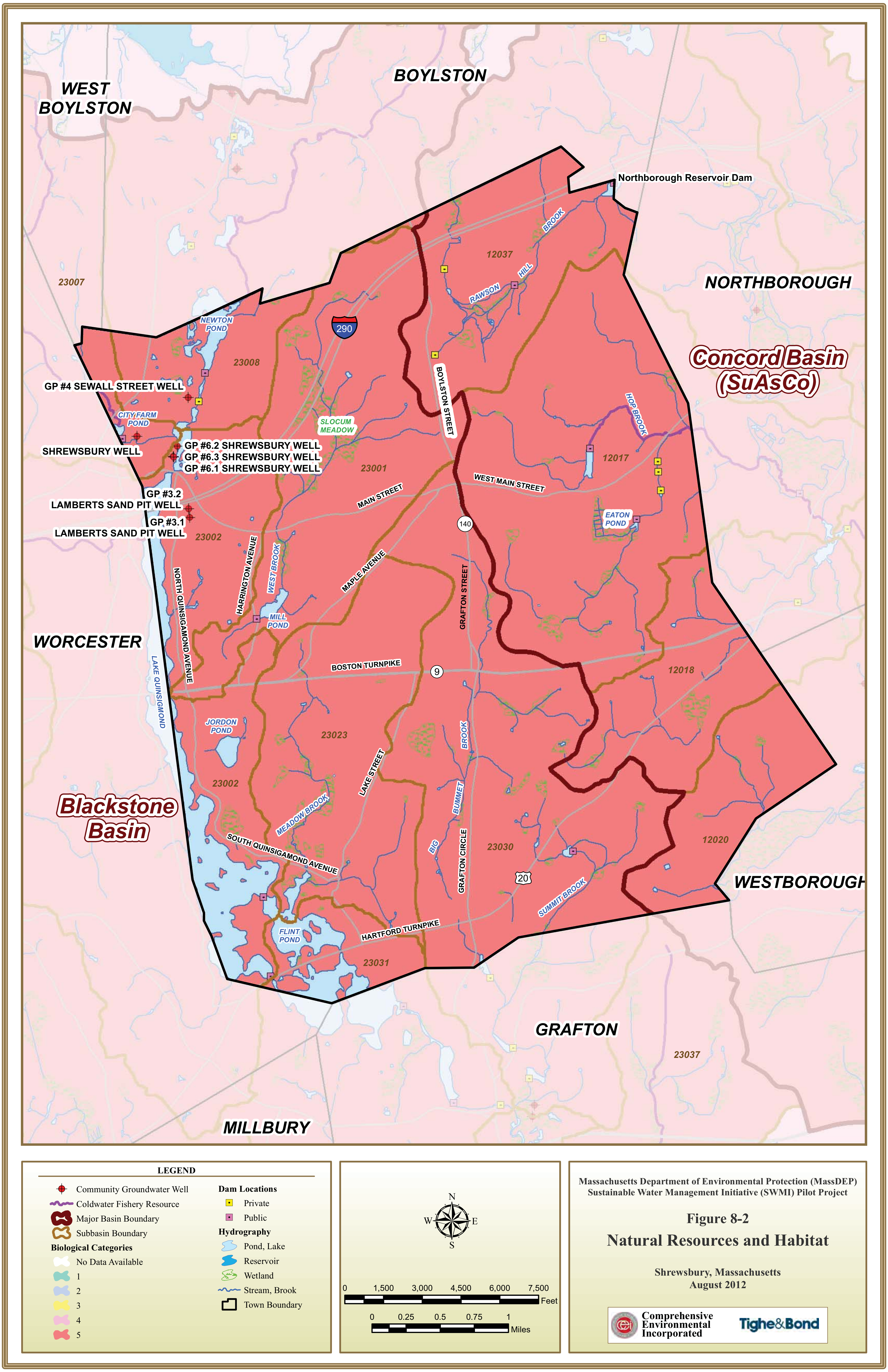
0 0.25 0.5 0.75 1 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 8-1
Public Water Supply Resource Map

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



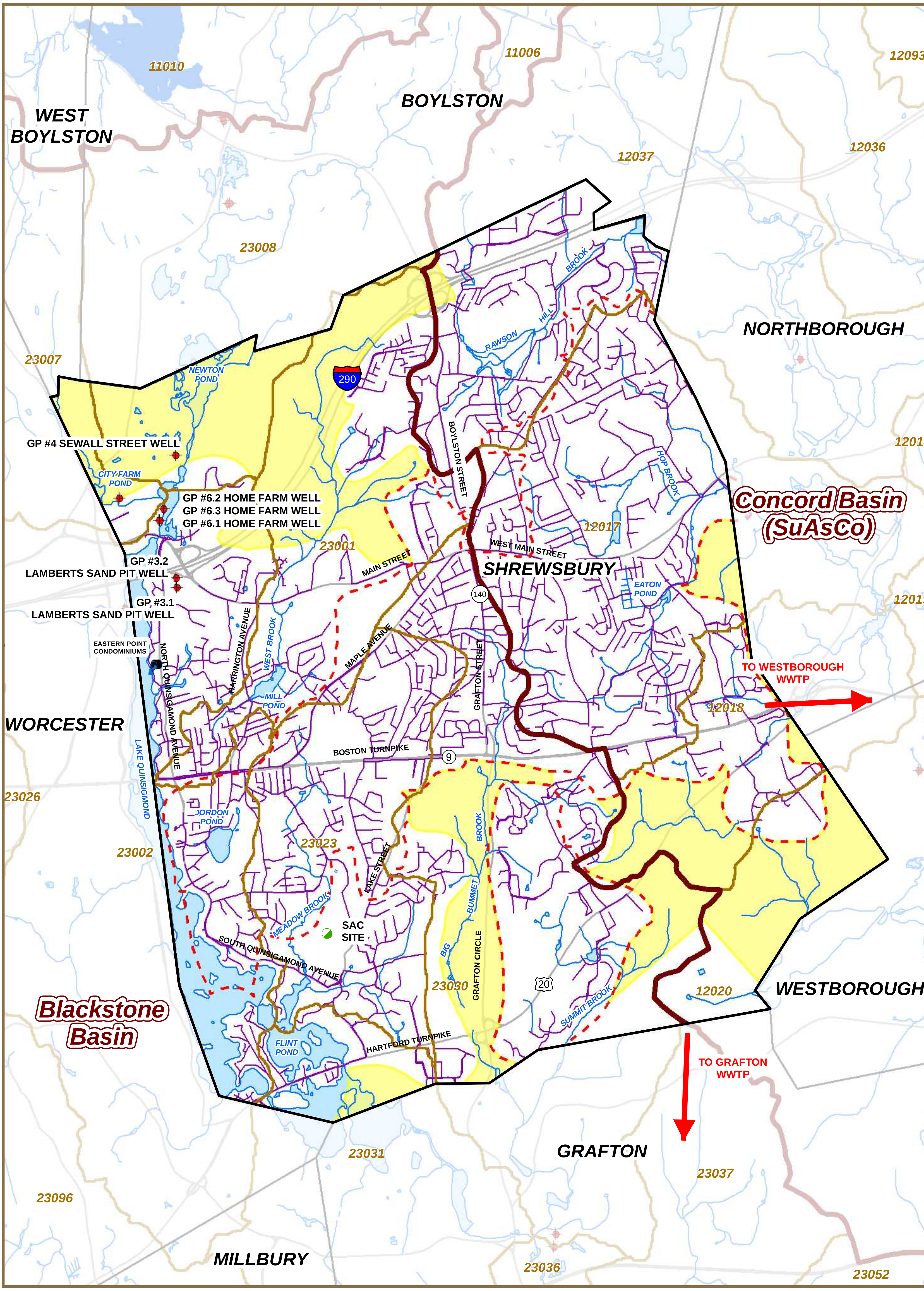
Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 8-2

Natural Resources and Habitat

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Sewer Main
- Unsewered Areas
- I/I Target Areas
- Community Groundwater Well
- Town Boundary
- NPDES Discharges

DEP Ground Water Discharge Permits

Type

- Sanitary Discharge
- Potential Sanitary Groundwater Discharge

Hydrography

- River, Pond or Lake
- Reservoir
- Stream, Brook
- Major Basin Boundary
- Subbasin Boundary

N / W / E / S

0 1,500 3,000 4,500 6,000 7,500 Feet

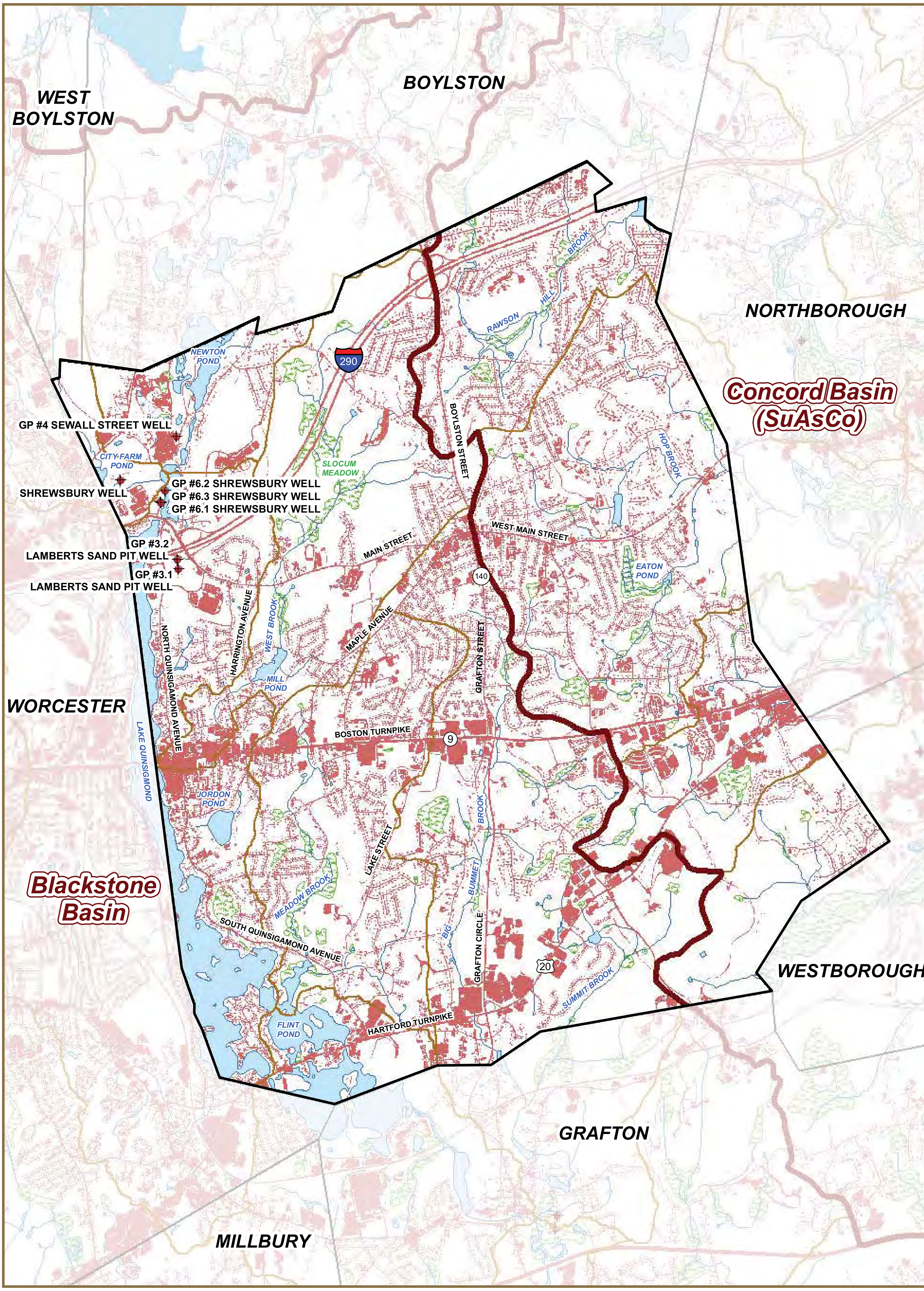
0 0.25 0.5 0.75 1 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 8-3
Wastewater Infrastructure

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Major Basin Boundary
- Subbasin Boundary
- Impervious Cover

Hydrography

- Pond, Lake
- Reservoir
- Wetland
- Stream, Brook
- Town Boundary

N, E, S, W

0 1,500 3,000 4,500 6,000 7,500 Feet

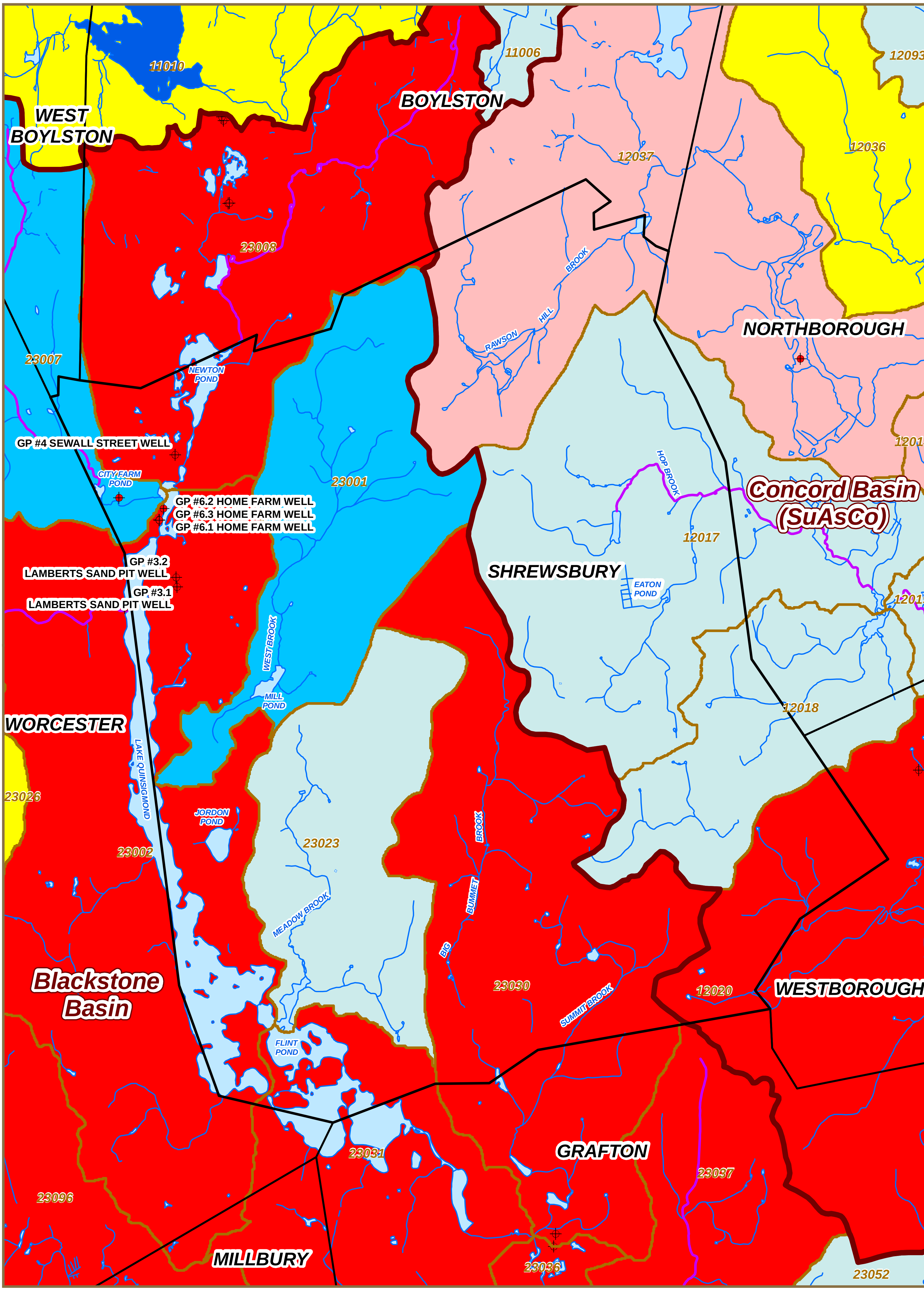
0 0.25 0.5 0.75 1 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 8-4
Impervious Cover

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

Flow Level, % GW Alteration
- No Data
- 1 0 - 3%
- 2 3 - 10%
- 3 10 - 25%
- 4 25 - 55%
- 5 >55%
- Major Basin Boundary
- Subbasin Boundary

- Community Groundwater Well
- Coldwater Fishery Resource

Hydrography
- Pond, Lake
- Reservoir
- Stream, Brook
- Town Boundary

N W E S

0 1,500 3,000 4,500 6,000 7,500 Feet

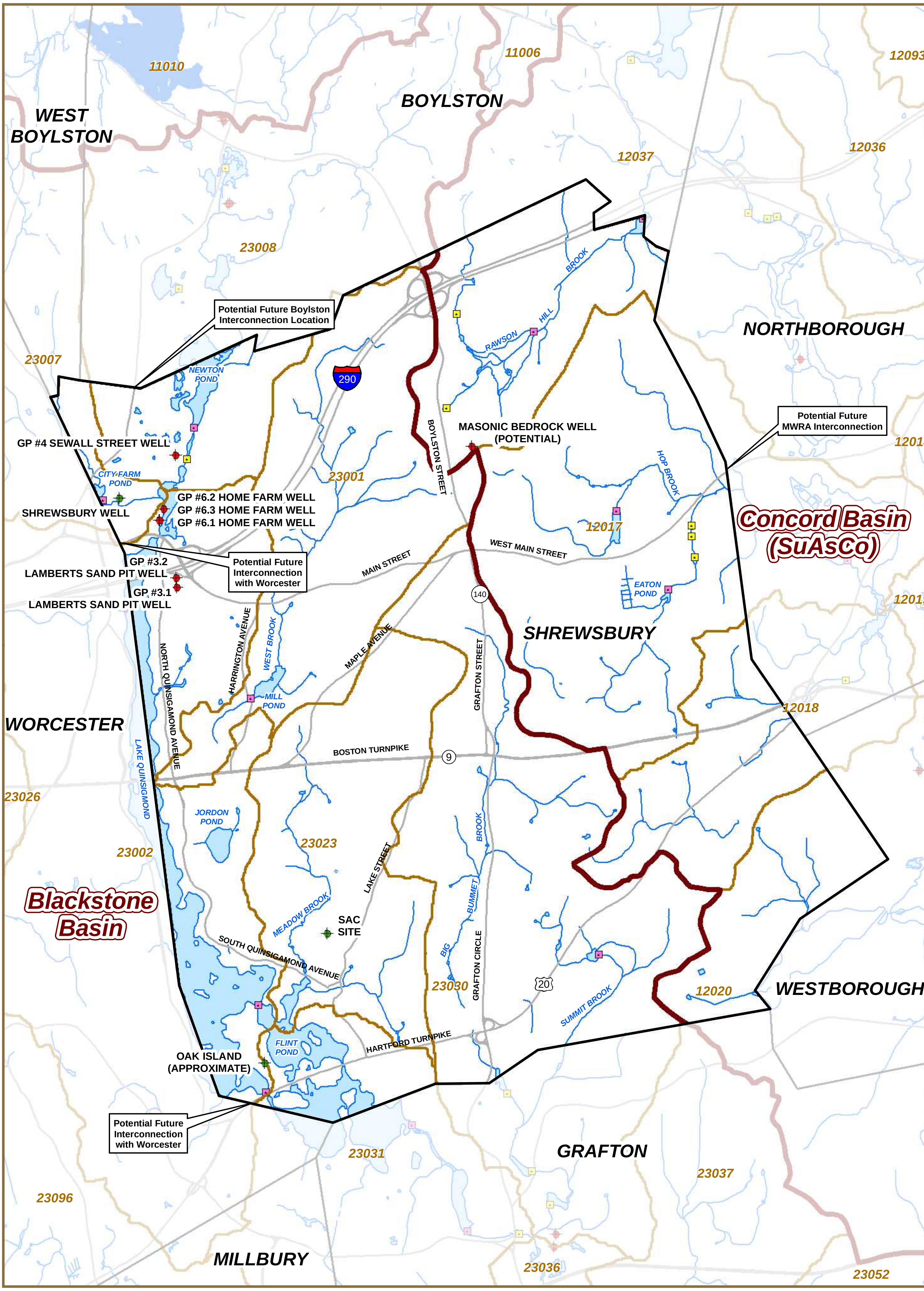
0 0.25 0.5 0.75 1 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 8-5
Flow Levels Map

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Potential Community Groundwater Well
- Major Basin Boundary
- Subbasin Boundary
- Dam Locations
  - Private
  - Public
- Hydrography
  - Pond, Lake
  - Reservoir
  - Stream, Brook
  - Town Boundary

N E S W

0 1,500 3,000 4,500 6,000 7,500 Feet

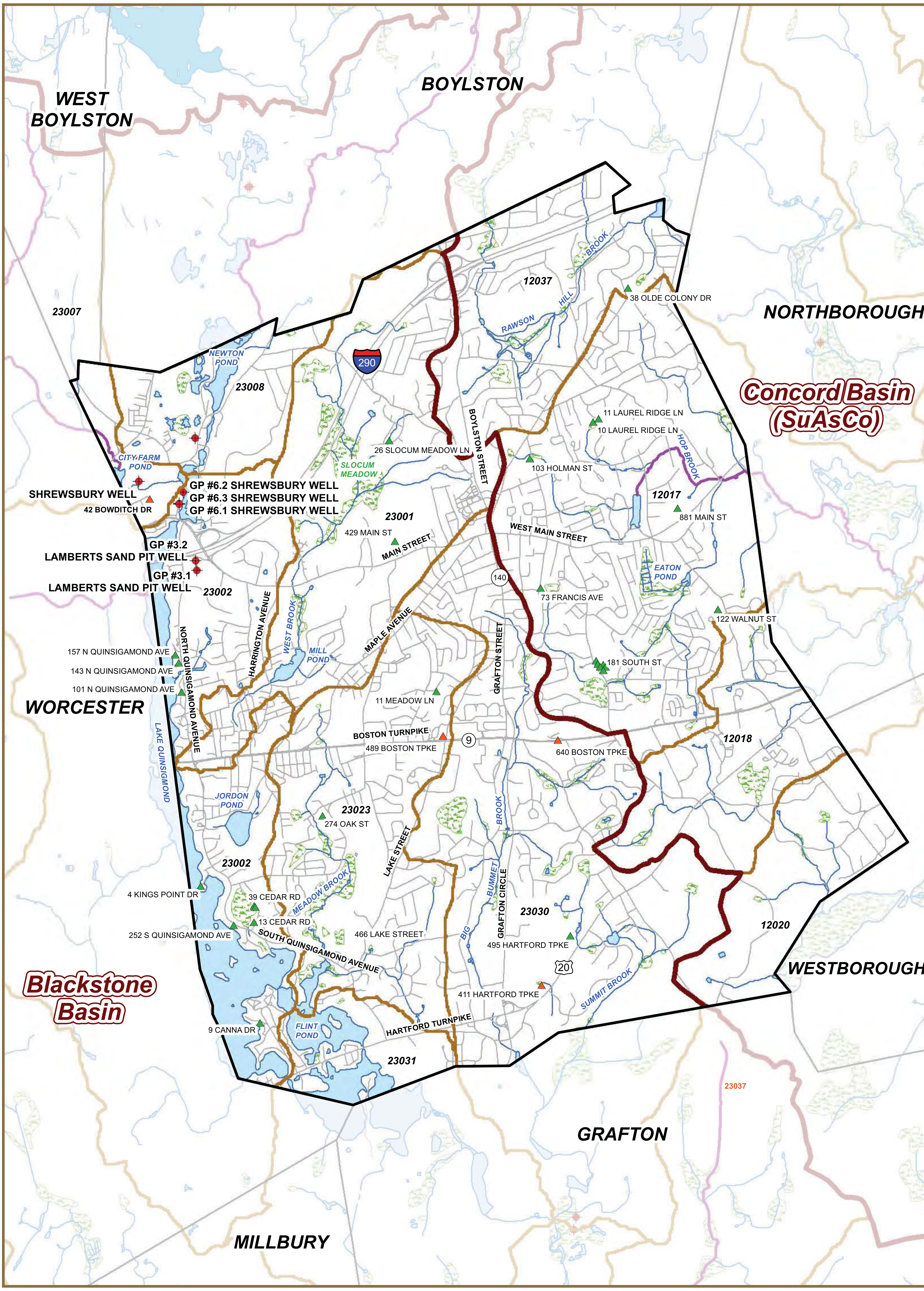
0 0.25 0.5 0.75 1 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 8-8
Alternative Sources Map

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond



LEGEND

- Community Groundwater Well
- Stormwater BMP
- Roof Drain
- Coldwater Fishery Resource
- Major Basin Boundary
- Subbasin Boundary

Hydrography

- Pond, Lake
- Reservoir
- Wetland
- Stream, Brook
- Town Boundary

N W E S

0 1,500 3,000 4,500 6,000 7,500 Feet

0 0.25 0.5 0.75 1 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

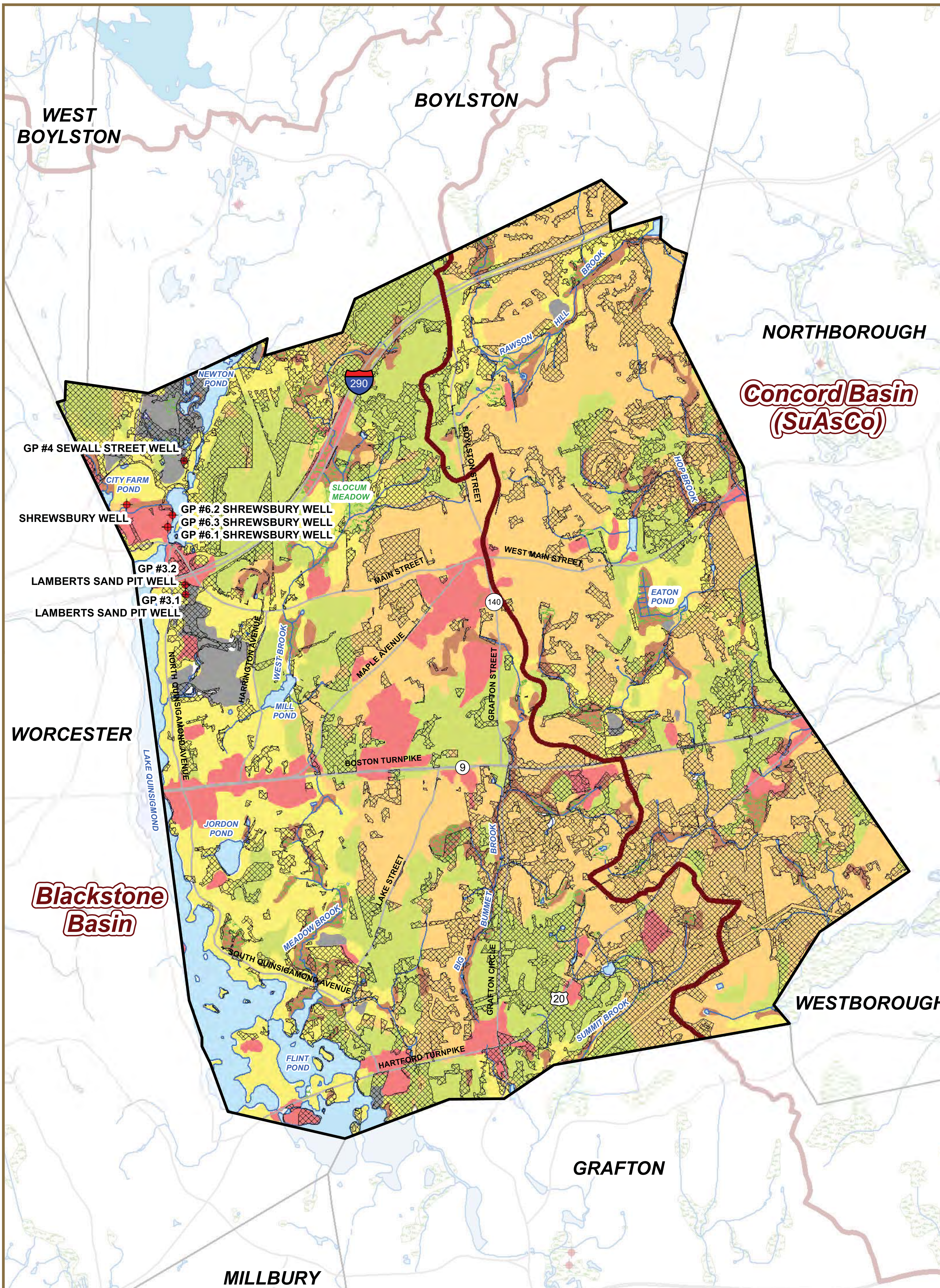
Figure 8-9

Stormwater BMP Locations

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated

Tighe&Bond



LEGEND

- Community Groundwater Well
- Potentially Developable Land
- Major Basin Boundary

Hydrography

- Pond, Lake
- Reservoir
- Wetland
- Stream, Brook

Soils - Hydrologic Group

- A
- B
- C
- D
- Pits, quarry
- Urban Fill
- Town Boundary

Note: Potentially Developable Land excludes Protected and Recreational Open Space properties.

N W E S

0 1,500 3,000 4,500 6,000 7,500 Feet

0 0.25 0.5 0.75 1 Miles

Massachusetts Department of Environmental Protection (MassDEP)
Sustainable Water Management Initiative (SWMI) Pilot Project

Figure 8-10

Soils Characteristics, Undeveloped and Protected Lands

Shrewsbury, Massachusetts
August 2012

Comprehensive Environmental Incorporated
Tighe&Bond

Section 9 Recommendations

9.1 Introduction

The Massachusetts Executive Office of Energy and Environmental Affairs' (EEA's) Draft Sustainable Water Management Initiative (SWMI) Framework focuses on impact to streamflows, arrived at over several years of intensive study and stakeholder interactions. Piloting the Draft Framework did reveal a number of issues that should be addressed before implementation, including how to balance the interests of the different stakeholders so that the Framework will be effective in protecting streamflows.

Public water suppliers (PWSs) must be able to operate their systems for public health and safety, and to supply new customers to preserve or improve the economic health of their communities. Watershed groups and other environmental interests need confidence that the measures taken by water suppliers will actually work and not just be 'window dressing' that is ineffective. The Massachusetts Department of Environmental Protection (MassDEP) and the other EEA agencies must be able to track water systems progress with existing staff, and will also want confidence that the system is working. Everyone needs predictability, replicability and as much simplicity as is possible within a complex framework.

The Phase 1 Pilot Project has been effective in advancing the understanding of how this program could be implemented. However, much more work is needed, as outlined below.

9.2 Wastewater Credit Methodology

Credit offsets for wastewater could be significant, but tracking wastewater returns require significant bookkeeping on the part of the community.

The wastewater credit methodology includes existing septic systems and groundwater discharges. Future credit would be only for additional septic systems and groundwater discharges. The towns would have to keep track of new development with on-site systems for future credits.

Communities using infiltration and inflow (I/I) removal projects for credit would need to determine the estimated amount of I/I to be addressed and where the projects are located with respect to the PWS subbasin. Inflow removal from sanitary sewers can be addressed by directing flows to the ground, to a dry well or infiltration system, or to the storm drain system. Credit is only proposed for those inflow removal projects that redirect flow to the ground or to infiltration systems.

9.3 Additional Quantification Required

Phase 1 of the Pilot Project revealed that quantifying various demand management tools is relatively easy, however, it may not be realistic for water systems to get all of their customers to install low flow toilets, faucet aerators, etc. and these action alone are not likely to get PWSs all of the mitigation credits they need to offset requested withdrawal increases above baseline. A more realistic 'implementation factor' could be identified in Phase 2 so that these numbers are not overly optimistic.

The Stormwater credits are potentially large, and the work to gain them could have the additional benefit of improving streamflow and protecting aquatic habitat, since uncontrolled runoff has the triple threat of heat and pollutant load, velocity, baseflow reduction. It is a direct stream habitat benefit and could be treated as such, but is harder to track than the receipts from purchases of low flow devices. The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase II program has already shown that some municipalities do a great job while others submit reports that have little substance. A better tracking tool is needed for this important aspect of protecting streamflow.

Habitat credits are a work in progress. It seems that these "soft" credits, which the consulting team refers to as "indirect" credits, could be allowed in some cases but would definitely require more agency consultation than the other types of credits.

9.4 Conflicts with Other Regulations

The Draft SWMI Framework has been developed by EEA and stakeholders to enable a comprehensive approach to balancing water supply needs with the environmental sustainability of the Commonwealth's freshwater rivers and streams. The Draft Framework contemplates a holistic approach to the permitting of water withdrawals by MassDEP, based on an evaluation of the safe yield of major basins for both surface and groundwater supply, coupled with measures to conserve water, return wastewater and stormwater to aquifers, and manage water supply and wastewater within communities and between basins in a manner designed to minimize impacts to stream resources. The success of this Framework will depend in large part on the flexibility that MassDEP and water suppliers will have to allocate water and to make operational adjustments to achieve an integrated water supply/environmental protection management system.

In reviewing community options within this Draft Framework, the Pilot Project Team has noted that a number of opportunities for balancing human and environmental needs involve existing or proposed interconnections of water supply and wastewater disposal systems among two or more communities or PWSs. When such interconnections cross both town boundaries and major watershed basin boundaries, these actions become subject to the Interbasin Transfer Act (IBTA).

For example, a town that is located in two major basins (Basins A and B) may have a well in each basin, and export all its wastewater to the neighboring town for disposal in Basin A. The town may seek to increase a withdrawal in Basin B because that basin has adequate safe yield as determined under SWMI. That withdrawal would trigger the IBTA, as it involves an increase in the wastewater transfer across both a town and basin boundary. The PWS would require approvals under IBTA, even though the withdrawal may be fully consistent with SWMI objectives.

The IBTA and its supporting regulations were developed in a regulatory setting that did not include the holistic approach envisioned by SWMI. The Pilot Project Team is concerned that the SWMI Framework and the IBTA would overlap and could be contradictory. This not only poses the potential for duplicative review processes and regulatory requirements, but could also interfere with the management flexibility offered by the Draft SWMI Framework. At the very least, this poses the potential economic, administrative, and time burdens of one more layer of procedure on the permitting process. More of concern is that administration of IBTA regulations could conflict with or inhibit the administration of the SWMI process. As the development of the SWMI Framework moves forward, the Pilot Project Team recommends that the MassDEP and the stakeholders in the administration of the Water Management Act explore the future role of the IBTA relative to SWMI, and whether modifications to the IBTA and/or its procedures and requirements are warranted to assure the effective implementation of SWMI objectives.

9.5 Other Issues

9.5.1 Baseline for Determining Offset Credits

In reviewing the Pilot communities' existing and potential programs, it has become apparent to the Pilot Project Team that the SWMI program needs to consider the question: "What baseline standard are we comparing to?" The baseline for water withdrawal has been defined in the Draft Framework, but not the baseline for implementing offsets. For the initial withdrawal request under the program, do qualifying actions implemented in the past receive credit, or only ones that would be implemented over the life of the permit, the initial 5 years of the permit, or some other time frame?

For example, in allocating credits for adopting stormwater controls, most western Massachusetts towns have little or no development controls that promote recharge, (or for that matter, often little development). Some towns in the population growth centers along the 495 beltway may have more stringent and more sophisticated development controls in place. So the questions arise:

- Should the communities with recharge controls already in place benefit from a credit, or should they be required to make further improvements to the controls, to qualify for an offset?

- Should communities that have little in the way of controls, but that may be required to adopt them under other regulatory programs (e.g., because they are subject to a NPDES MS4 permit), receive credit under SWMI for those actions they are obligated to perform under other regulations?

- Should the credit for stormwater controls start with a baseline of what is actually required by the state, or what is common practice in watersheds like the Charles River Basin where a lot of work has been done? For the current analysis, we have used what's required, because research of and definition for "common practices" has not been done at this point.

9.5.2 Watershed Templates?

The current Pilot Project analysis is based on the Draft SWMI "menu" type listing of potential mitigation/offset actions. PWSs would select items "a la carte" and determine credits for offsets based on quantitative estimates. Another approach could be to provide for a more prescriptive combination of mitigation measures, using a watershed-based standard analogous to the work already done for Total Maximum Daily Loads (TMDLs). Under this approach, watershed-based "templates" might make implementation more predictable, easier and more effective, by providing a specified listing of actions in different categories that if implemented, are presumed to provide required mitigation (similar to the "performance-based BMPs" used in stormwater programs, in lieu of the more quantitative "effluent standards"). Major basins each have different focuses and problems as well as sometimes vastly different levels of development within them. Using perhaps three templates might make the program more effective and site specific, while not being an overwhelming number of templates for the SWMI program to develop. Implementation by MassDEP could then include "blocking" out certain types of credits (or giving some higher values) depending on watershed-specific needs. This could be further explored in Phase 2.

9.5.3 Credits in Advance?

Another reoccurring question was whether to count a credit in advance of its implementation, and how accounting for actions either planned or in progress would fit with the current process of 20-year water demand forecasting? In many cases, the actions and their credits could be specified in the permit conditions and scheduled into the 20 year permit period with 5-year updates. This would provide flexibility for the water supplier, and predictability for both the supplier and the regulator, and is similar to how consent orders now work. Under this approach, the permit-holder agrees in advance to certain conditions and faces fines or other disincentives for non-compliance. Advanced accounting for some proposed offsets – for example, future I/I removal, may be more difficult, because of the uncertainty of results of future actions - so advance counting may only be workable with some types of credits. Future work in Phase 2 could further explore and define how to apply credits for ongoing and future actions, now that Phase 1 has taken an initial look at the tools for identifying and quantifying credits.

9.5.4 Framework Questions & Data Needs

The Draft SWMI Framework focuses on percent August flow alteration as a measure of ecological impact. A tool for assessing impact on FL and BC of various minimization and mitigation options could be developed in Phase 2.

Another question that could be addressed in Phase 2 is how to handle water systems with sources in multiple subbasins. Since baseline demand is determined on a supply basis, including all sources in multiple basins, while permit review Tiers are determined on a subbasin basis, does the full additional demand request get allocated to each subbasin? What if this approach yields different tiers in different subbasins?

Guidance on the benefits of various reservoir release scenarios under the Surface Water Transition Rule should be developed to avoid the need for expensive site specific habitat studies in all cases.

Guidance should be developed on how and when in the process rebuttable presumptions would be handled. This is important for predictability.

Guidance on determining the methodology for apportionment of wastewater credit to multiple PWSs in a surcharged subbasin should be developed.

9.5.5 Credit Trading?

Wastewater discharged to surface water and groundwater contributes to streamflow. However, these flows may influence multiple PWS withdrawals. Determining the apportionment of the wastewater return to multiple PWSs needs to be explored more fully. Similarly, how are activities implemented by other communities credited, if at all? Could one water system “buy” another’s creditable actions?

The current Pilot Project has not applied any of these external credits, except where the town was the customer of another water system as in the case of Middleton-Danvers and Dedham-Westwood. The potential for exchanging credits among communities or suppliers should be further explored, and likely depends on a policy decision, in addition to technical considerations.

Appendix A –

Glossary

Appendix A
Glossary

ASR – Annual Statistical Report

Baseline – The volume withdrawn during calendar year 2005, the average volume withdrawn from 2003 to 2005, or the registered volume, whichever is the highest, plus 5% to the higher of 2003-2005 average use or 2005 use. Proponents may be able to add up to 8% provided it would not result in a drop in Flow Level. If baseline is the registered volume, no additional percentage can be added.

- Small withdrawal request above baseline is small – less than 5% alteration of un-impacted August median flow.
- Large withdrawal request above baseline is large – greater than 5% alteration of un-impacted August median flow.

BC - Biological Categories – Subbasins have been categorized into five biological categories (BCs) that represent existing aquatic habitat integrity of the receiving streams and rivers in these basins. Categories range from Category 1, which represents high quality aquatic habitats, relatively un-impacted by human alteration, to Category 5, which represents a severe decline in fluvial fish populations and aquatic habitat.

BMP – Best Management Practice

CFR - Coldwater Fishery Resource – A water that meets at least one of the following criteria:

1. Brook, brown or rainbow trout reproduction has been determined;
2. Slimy sculpin, longnose sucker, or lake chub are present;
3. The water is part of the Atlantic salmon restoration effort or is stocked with Atlantic salmon fry or parr.

cfs – cubic feet per second

cfsm – cubic feet per second per square mile

CWMP – comprehensive wastewater management plan

DCR – Massachusetts Department of Conservation and Recreation

DER – Massachusetts Division of Ecological Restoration

DWWD – Dedham Westwood Water District

EPA – U.S. Environmental Protection Agency

FL – Flow Level – Subbasins have been categorized into five flow levels (FLs) that represent the percent alteration of natural August median flows due to groundwater withdrawals within the basin. FL1 represents the least impact to or alteration of streamflow, with less than 3% of the streamflow withdrawn, and FL5 represents the greatest impact to or alteration of streamflow, with 55% or more of the streamflow withdrawn. The percent alterations due to groundwater withdrawal used to define each flow level were established based on the level of withdrawal/alteration that caused the BC to backslide one category (e.g., go from BC1 to BC2).

gpd – gallons per day

gpdim – gallons per day per inch-diameter mile. The inch-diameter miles is the length of sewer as miles times the diameter of the pipe in inches..

IBTA – Interbasin Transfer Act

I/I – Infiltration and Inflow

Impervious - Used in reference to surfaces that are resistant to the movement or passage of water. Impervious surfaces can include asphalt, concrete, rooftops, and highly compacted soils.

Infiltration – Extraneous groundwater that enters the sewer system through sources such as defective pipes, pipe joints and manhole walls.

Inflow – Extraneous water that enters a sewer system through direct sources such as catch basins, manhole covers, cross connections with storm drains, sump pumps, foundation drains and downspouts.

MassDEP – Massachusetts Department of Environmental Protection

MG – million gallons

MGD – million gallons per day

MS4 – Municipal Separate Storm Sewer System, a conveyance that is owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.; designed or used to collect or convey stormwater; not a combined sewer; and not part of a sewage treatment plant

MWI – Massachusetts Water Indicators (USGS Scientific Investigations Report 2009-5272)

MWRA – Massachusetts Water Resources Authority

NEWWA – New England Water Works Association

NPDES – National Pollutant Discharge Elimination System, the permit program that controls water pollution by regulating point sources discharging pollutants into waters of the United States, as authorized by the Clean Water Act

Permitting Tiers – MassDEP will calculate a PWS's baseline withdrawal and compare it to the water withdrawal requested to determine the PWS's permit review tier as follows:

- Tier 1 – no additional withdrawal request above baseline.
- Tier 2 – additional withdrawal request above baseline is small and no change in FL or BC.
- Tier 3 – additional withdrawal request above baseline is large and no change in FL or BC.
- Tier 4 – additional withdrawal request above baseline will change FL and/or BC.

PWS – public water supply

Q50 – a flow that is exceeded 50% of the time

Q75 – a flow that is exceeded 75% of the time

Q90 – a flow that is exceeded 90% of the time (a low flow)

Quality Natural Resources – If a source is located in a BC 1, 2, or 3 or in a coldwater fishery resource area.

RGCPD – residential gallons per capita per day, daily consumption of water by the residential sector

SESD – South Essex Sewerage District

sqmi – square mile

SSES – Sanitary Sewer Evaluation Survey

Standard Conditions 1-8 – 1) source protection; 2) firm yield for surface water supplies; 3) wetland and vernal pool monitoring; 4) 65 RGPCD; 5) 10% UAW; 6) seasonal limits on nonessential outdoor water use; 7) water conservation measures; and 8) offset feasibility study for withdrawals that exceed baseline.

SWMI – Sustainable Water Management Initiative

SWTR - Surface Water Transition Rule – Current data do not allow surface water withdrawals to be taken into account in estimates of monthly flow alteration. The SWTR will require applicants to comply with standard conditions 1-8 and mitigate impacts commensurate with withdrawal impacts. A drought and demand management plan and an evaluation of implementing releases will also be required if deviating from standard conditions 1-8 or if requesting a withdrawal amount greater than baseline.

SY - Safe Yield – is calculated as 55% of the drought basin yield (monthly drought year flows) plus reservoir storage volumes. (The environmental protection factor is the remaining 45%.) Safe yields have been calculated for major basins to determine the maximum amount of water that may be withdrawn for water supply use while maintaining sufficient water in streams and rivers for environmental protection.

SYE – Sustainable Yield Estimator

UAW – unaccounted for water

UMass – University of Massachusetts Amherst

USGS – United States Geological Survey

WMA – Water Management Act

WRC – Massachusetts Water Resources Commission

WTP – water treatment plant

WWTF – wastewater treatment facility

WWTP – wastewater treatment plant

Appendix B –

WMA Standard Conditions 1-8

Appendix B
Water Management Act
Standard Condition 1-8

1. Ground Water Supply Protection Requirements/Surface Water Supply Protection Requirements

- PWS ground water sources must have Zone II delineations and Wellhead Protections in place.
- PWS surface water sources must have a Surface Water Supply Protection Plan in place.
- Water companies or authorities must demonstrate best efforts to meet these requirements.

2. Firm Yield Analysis for PWS Surface Water Supply

- PWS surface water sources must have a firm yield analysis based on the drought of record.
- PWS's with a Drought Management Plan may base firm yield on a less severe drought.

3. Wetlands and Vernal Pool Monitoring

- Wells located within an ACEC or Priority Habitat area, may be required to conduct wetlands hydrology monitoring. MassDEP reserves the right to modify the permit to address observed impacts.

4. Performance Standard for Residential Gallons Per Capita Day Water Use (RGPCD)

- The RGPCD performance standard for all PWS permittees is 65 gallons.
    - Not applied on the Cape, Island and in select seasonal communities because large seasonal population fluctuations make calculating RGPCD unreliable
- Permittees that cannot comply within 2 years must implement either their own RGPCD plan or MassDEP's RGPCD Functional Equivalence Plan and comply within 3 additional years.
- Permittees unable to meet the std. within 5 years must implement the MassDEP's RGPCD Plan.

5. Performance Standard for Unaccounted for Water (UAW)

- The UAW performance standard for all PWS permittees is 10% of total water withdrawal.
- Permittees that cannot comply within 2 years must implement either their own UAW plan or MassDEP's UAW Functional Equivalence Plan and comply within 3 additional years.
- Permittees unable to meet the std. within 5 years must implement the MassDEP UAW Plan.

6. Seasonal Limits on Nonessential Outdoor Water Use (see Table 1 in Appendix H of the Draft SWMI Framework for additional detail on the New Proposed Seasonal Limits on Nonessential Outdoor Water Use)

- Seasonal restrictions are in place from May 1st through September 30th.
- Permittees choose either calendar-based restrictions throughout the season, or restrictions implemented whenever streamflow falls below an aquatic base flow (ABF) trigger at an assigned USGS local stream gage
- ABF triggers are based on flow levels that are protective of
    - habitat for fish spawning during the spring, and
    - flows for fish rearing and growth during the summer.
- The restrictions required vary based on the permittee's RGPCD water use.
- A low flow trigger has been proposed in the SWMI process.

7. Water Conservation Requirements (see Table 2 in Appendix H of the Draft SWMI Framework for additional detail regarding Water Conservation Requirements in PWS Water Management Permits)

- Permittees must implement measures based on the Water Resources Commission Water Conservation Standards, July 2006, including:
    - water audits and leak detection, metering, pricing, residential and public sector conservation, industrial/commercial conservation, lawn/landscape conservation, and education/outreach

8. Water Withdrawals that Exceed Baseline Withdrawal Volumes (baseline has been proposed to be redefined through the SWMI process)

- Baseline cannot be lower than the registered volume
- For permittees holding a permit for withdrawals in excess of their registered volume,
    - Baseline cannot be greater than
        - the 2005 permitted volume, or
        - the renewed 20-year WMA permitted volume.
- For permittees whose actual withdrawals between 2003 and 2005 were greater than the registered volume and lower than the lowest applicable permit volume, baseline is the greater of
    - 2005 use +5% (or plus 8% if the additional 3% will not lower the flow level), or
    - 2003-2005 average use +5% (or plus 8% if the additional 3% will not lower the flow level).
- Permittees with withdrawals in two basins will be regulated by baseline withdrawal volumes calculated for each basin, and for system-wide withdrawal volumes.
- Permittees with withdrawals projected to exceed the baseline withdrawal volume will evaluate measures to mitigate withdrawals in excess of the baseline.
    - Implementation of mitigation measures will be required prior to withdrawals exceeding the baseline (see the Offset Feasibility Study discussion and Mitigation BMP list in the Draft SWMI Framework).

Appendix C –

Annotated Bibliography

Appendix C
Annotated Bibliography

<u>Agency/Other Reports and Data</u>

1. **MassDEP. “Guidelines for Performing Infiltration /Inflow Analyses and Sewer Evaluation Survey.” 1993. 81p.**
   This report summarizes guidelines for assessing infiltration and inflow into sanitary sewer systems.

2. **Waldron, M.C., Archfield, S.A. “Factors Affecting Firm Yield and the Estimation of Firm Yield for Selected Streamflow Dominated Drinking Water Supply Reservoirs in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006-5044.” 2006. 39p.**
   This report presents data on reservoir characteristics and firm yield for many public water supply systems in MA

3. **Barlow, Lora K., L.M. Hutchins, and L.A. DeSimone. “Water Withdrawals, Use, and Wastewater Return Flows in the Concord River Basin, Eastern Massachusetts, 1996-2000: U.S. Geological Survey Scientific Investigations Report 2008–5158.” 2009. 134p.**
   A copy of this report, commonly referred to as the “USGS Concord River Basin Report” was downloaded from the USGS website. This report provided detailed information regarding wastewater return flows which provided the basis for determining the percentage of wastewater return for various uses.

4. **Weiskel, P.K., S.L. Brandt, L.A. DeSimone, L.J. Ostiguy, and S.A. Archfield. “Indicators of Streamflow Alteration, Habitat Fragmentation, Impervious Cover, and Water Quality for Massachusetts Stream Basins: U.S. Geological Survey Scientific Investigations Report 2009–5272.” 2010. 70p.**
   A copy of this report, commonly referred to as the “USGS Water Indicators Report” was downloaded from the USGS website. This report is the basis for the development of Biological Categories and Flow Levels for 1400 sub-basins in Massachusetts.

5. **Archfield, S.A., R.M. Vogel, P.A. Steeves, S.L. Brandt, P.K. Weiskel, and S.P. Garabedian. “The Massachusetts Sustainable-Yield Estimator: A decision-support tool to assess water availability at ungagged stream locations in Massachusetts, Scientific Investigations Report 2009-5227.” 2010. 41p.**
   A copy of this report, commonly referred to as the “USGS SYE Report” was downloaded from the USGS website. This report is the basis for the development of Safe Yield for the major basins in Massachusetts and includes information on wastewater discharges.

6. **Armstrong, D.S., T.A. Richards, and S.B. Levin. “Factors influencing riverine fish assemblages in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2011–5193.” 2011. 58p.**
   A copy of this report, commonly referred to as the “USGS Fish and Flow Study” was downloaded from the USGS website. This report establishes a relationship between August flow alteration and biological integrity.

7. **Levin, S.B., Archfield, S.A., and Massey, A.J. “Refinement and Evaluation of the Massachusetts Firm Yield Estimator Model Version 2.0: U.S. Geological Survey Scientific Investigation Report 2011-5125.” 2011. 62p.**
   This report presents data on reservoir characteristics and firm yield for several additional public water supply systems in MA.

8. **MassDEP. “Massachusetts Sustainable Water Management Initiative Framework Summary.” Draft. February 3, 2012. 55p.**
   This document describes the concepts and framework for MassDEP’s proposed Sustainable Water Management Initiative and how it will affect WMA permit reviews and is the basis for this pilot project.

9. **Sutherland, Roger C., P.E. “Methods for Estimating the Effective Impervious Area of Urban Watersheds.” Watershed Protection Techniques. 2(1): 282-284.**

AMHERST

Water Supply Documents:

1. **Skiba, Catherine. Tighe & Bond, Inc. "Work Plan for Proposed Well No. 6, Lawrence Swamp, Amherst, Massachusetts." 8-1A. August 1989. 94p.**
   This report documents the site evaluation, pump test, well installation, groundwater sampling, and Zone II definition for a new well located in Lawrence Swamp. The report was provided by Tighe & Bond, Inc.

2. **Tighe & Bond, Inc. "New Source Approval – BRP WS 19 Amherst Well No. 6 and Belchertown Well P.S. #1. Department of Public Works. Amherst, Massachusetts. Volume I." October 1992. 93p.**
   New Source Approval Application for Amherst Well #6 and Belchertown Well PS #1 for pumping rates of 900 gpm each. Application includes aquifer pumping test data and analysis, Zone II and III delineations, groundwater monitoring program, and wellhead protection through zoning and non-zoning controls.

3. **Tighe & Bond, Inc. "New Source Approval – BRP WS 19 Amherst Well No. 6 and Belchertown Well P.S. #1. Department of Public Works. Amherst, Massachusetts. Volume II." October 1992. 369p.**
   Volume II includes Appendices a through E for the New Source Approval Application for Amherst Well #6 and Belchertown Well PS #1. These Appendices include well logs, analytical methods for determining aquifer parameters, aquifer performance test drawdown and recovery data, test data curves and analytical results, and water quality data.

4. **MassDEP. "Water Demand Projections from Amherst's 1993 WMA Permit for years 1993-2012." 1993. 4p.**
   Calculations used for projections were provided by Kim Longridge of DEP WERO for the Pilot Project.

5. **Couture, Thomas. Tighe & Bond, Inc. Letter regarding "Supplemental Information Pumping Test Report >70 gpm, PWS ID#1008000 Amherst & PWS ID# 1024000 Belchertown." 8-1E. February 23, 1993. 5p.**

6. **Couture, Thomas. Tighe & Bond, Inc. Supplemental Submission to MassDEP regarding "Amherst Well #6 Zone II Delineation PWS ID#1008000 Response to MassDEP Zone II." 8-1G. May 5, 1994. 47p.**

7. **Couture, Thomas. Tighe & Bond, Inc. Submittal to MassDEP regarding "Zone II Approval, Amherst Wells #1 through #6, PWS ID#1008000." 8-1F. June 29, 1994. 16 p.**

8. **MassDEP. "Zone II for Amherst 1008000 Well #1, 3, 4, 5, 6, Replacement Well #2, Daigle Well. Amherst/Belchertown Water Department 1008000-01G, 02G, 05G, 06G, 07G, 08G, 1024000-05G." July 29, 1994. 1p.**
   Map showing the Zone II boundary and public water supply sources that are associated with it at the date of printing.

9. **Couture, Thomas. Tighe & Bond, Inc. Letter regarding "Pumping Test Report, Increased Safe Yields, Amherst Wells #3 and #4, Revised Zone II, PWS-ID# 1008000 GW03, 04." 8-1H. May 31, 1995. 82p.**

10. **Skeels, Jason. Survey Map "Atkins Reservoir, Amherst, Massachusetts." Map is based on surveying performed by Stephen Salvini and Jason Skeels in June of 1996. Scale 1" = 100'. January 9, 1997. 1p.**

11. **Skeels, Jason. Survey Map "Hills Reservoir, Pelham, Massachusetts." Map is based on surveying performed by Arthur Usher and Jason Skeels in July of 1995. Scale 1" = 40'. January 14, 1997. 1p.**

12. **Skeels, Jason. Survey Map "Hawley Reservoir, Pelham, Massachusetts." Map is based on surveying performed by Arthur Usher and Jason Skeels in August of 1995. Scale 1" = 40'. January 15, 1997. 1p.**

13. **Skeels, Jason. Survey Map "Intake Reservoir, Pelham, Massachusetts." Map is based on surveying performed by Stephen Salvini and Jason Skeels in June of 1996. Scale 1" = 20'. January 21, 1997. 1p.**

14. **Amherst DPW Water Division. "Public Water Supply Annual Statistical Report" Reporting Years 2000-2011. PWS ID 1008000.**

15. **MassDEP. "Source Water Assessment and Protection (SWAP) Report for Amherst DPW Water Division." April 3, 2002. 11p.**

16. **Town of Amherst. "Handbook for Water Supply Emergencies for Atkins Reservoir." September 2002. 43p.**
This handbook serves as the emergency response contingency plan and outlines the actions to take in an event of a water emergency, either short-term or long-term at the Atkins Reservoir in order to provide potable water in sufficient quantity to water users. The handbook covers routine problems, minor emergencies, major emergencies, natural disasters, and nuclear disasters/terrorist acts.

17. **Tighe & Bond, Inc. "Town of Amherst Surface Water Supply Protection Plan for Atkins Reservoir." Prepared for MassDEP Bureau of Resource Protection and U.S. EPA Region I. March 2003. 165p.**
The purpose of this report was to improve protection efforts within the Atkins Reservoir watershed, which is located primarily in the Town of Shutesbury, with small portions also located in the Towns of Amherst, Leverett, and Pelham. The report includes five maps and seven written summaries related to surface water protection and education.

18. **Dumais, Omer. Tighe & Bond, Inc. Letter to Amherst DPW regarding "Well #5 Pump Replacement Recommendation." April 11, 2005. 5p.**
The letter presents recommendations for the pump replacement at Well #5 due to an air entrainment problem.

19. **Haas, Glenn. MassDEP. "Water Management Act Registration for Amherst DPW Water Division." Registration #10600802 for 2008-2017. December 31, 2007. 8p.**

20. **Chelminski, Michael, R. Stantec Consulting Services. "Site Reconnaissance, Preliminary Evaluation, and Cost Estimates for Dam Removal: Bartlett Fish Rod Co. Dam Pelham, Massachusetts." June 2009. 19 p.**
This report was prepared for MassDER to document the dam's condition, a proposed removal approach, and an evaluation of and process for restoration.

21. **Cabral, Deirdre. MassDEP. "Sanitary Survey Report and Notice of Non-Compliance for Amherst DPW Water Division." NON-WE-10-5D003. January 5, 2010. 27p.**
This report includes the system description, findings and compliance plan based on a September 15, 2009 Sanitary Survey. It is also a Notice of Noncompliance for violations identified during the Sanitary Survey.

22. **Cabral, Deirdre. MassDEP. "Water Management Act Permit Amendment for Amherst DPW Water Division." Permit #9P-1-06-008.01 for 1994-2013. October 15, 2010. 20p.**

23. **Town of Amherst DPW Water Division. "Status of Water Saving Devices in Municipally-Owned Public Buildings." October 2010. 1p.**

24. **Amherst Board of Health. "Regulations for Private Wells." Adoption Date October 20, 2008. Amended Date February 22, 2011. Effective Date March 15, 2011. 11p.**
These regulations were obtained by the Amherst Board of Health. The regulations govern permits, well location and use, water quantity, water quality, well construction, and decommissioning requirements for private drinking water wells.

25. **Belchertown Water District. "Public Water Supply Annual Statistical Report Reporting Year 2011." PWS ID 1024000. 2011. 39p.**

26. **Hadley Highway and Water Department. "Public Water Supply Annual Statistical Report Reporting Year 2011." PWS ID 1117002. 2011. 38p.**

27. **Amherst DPW Water Division. "Metered Finished Water Use for Calendar Year 2011." 2011.**
This is an excel file provided by the DPW that shows the water usage calculation and number of accounts for 2011 as reported in their ASR.

28. **Amherst DPW Water Division. "Emergency Response Plan." 254p.**

29. **Amherst Water Distribution Map. Amherst GIS. May 2012.**
    Map of the water distribution system including raw and finished water lines, service lines, gates, blowoffs, hydrants, meter pits, supply wells, and storage tanks.

30. **McClellan, John. Tighe & Bond, Inc. Memorandum to Amy Lane/Town of Amherst regarding Nielsen Property Well Development Timeline and Costs." May 8, 2012. 12p.**
    This memorandum summarizes previous well exploration results and provides a list of permits and an Opinion of Probable Costs relative to well development.

31. **Amherst Utility System Viewer. Amherst GIS. May 11, 2012. 2p.**
    This was a print-out from Amherst GIS system that a portion of the Town's water distribution system. The print-out was marked up to depict the location of two existing interconnections to the Town of Hadley.

32. **Lane, Amy. Amherst DPW Water Division. Email correspondence from Amy Lane to Tracy Adamski of Tighe & Bond regarding UMASS Conservation Efforts. May 16, 2012. 3p.**

33. **Amherst Watershed Properties Map. Amherst GIS. May 18, 2012.**
    Map of the watershed properties.

34. **Town of Amherst DPW Water Division. "Summary of Watershed Land Acquisitions by the Town of Amherst, 2003 to present." 1p.**

35. **Osborne, Jeffrey. "Town of Amherst Water Division General Operating Procedures." 1p.**
    Memo from the Water Division Director with brief descriptions sources, treatment, and tanks.

36. **Small, Ezra. UMass Amherst. "Showerhead Proposed Savings." Received June 4, 2012. 3p.**
    This excel spreadsheet provides calculations used in a proposal made to the UMass Director of Residence Life to replace existing 2.5 gpm showerheads in all residence halls with 1.5 gpm showerheads.

Wastewater Documents:

1. **Town of Amherst. "Sewer Regulations of the Town of Amherst, Massachusetts, Volume VII." Rules and Regulations Governing the Use of Common Sewers. Effective July 1, 1973. 8p.**

2. **Town of Amherst DPW Sewer Division. "Table 2 1999 Orchard Valley I/I." January 6, 2000. 1p.**
   This table provides a list of houses in the Orchard Valley subdivision with suspected drains or sump pumps tied into the sanitary sewer system.

3. **CDM. "Town of Amherst, Massachusetts Sewer Extension Master Plan Final Report." October 2005. 86p.**
   This report identifies areas in need of centralized wastewater collection, prioritizes areas for implementation, and identifies solutions for wastewater handling.

4. **CDM. "Town of Amherst, Massachusetts Sewer Extension Master Plan Draft Report." August 2011. 112p.**
   This draft report is intended to update and revise the recommendations from the October 2005 Sewer Extension Master Plan.

5. **Harrington, Brian D. MassDEP WERO. "Individual Reclaimed Water Use Permit. Class C Water Use. Permit No. #914-0. October 23, 2011 – October 23, 2016." September 23, 2011. 10p.**
   MassDEP permit to UMass-Amherst, Central Heating Plant for the use of reclaimed water originating from the Amherst WWTP and then further treated at UMass Reclaimed Water Intake/Treatment System for the purpose of boiler make up water.

6. **CDM Smith. "Draft Report: Wastewater Reuse Feasibility Study." Prepared for Town of Amherst, Massachusetts. January 2012. 182p.**
   This draft report evaluates wastewater reuse options related to the existing reverse osmosis (RO) system operated by Siemens Water Technologies Corporation at the University of Massachusetts (UMass) campus. Report states that relocation of the RO system to the wastewater treatment plant may not be the most viable alternative to meet Town and UMass needs.

7. **Amherst Sewer Distribution System Map. Amherst GIS. May 2012.**
   Map of the sewer distribution system including force main sewer lines, active sewer lines, missing and abandoned lines, sewer line cleanouts, pump stations, and residential and commercial pumps.

8. **Town of Amherst DPW Sewer Division. Unnamed table. June 1, 2012. 1p.**
   This table summarized sewer system projects, estimated I/I removal and project costs undertaken by the DPW Sewer Division from 2003 to 2012.

9. **Town of Amherst DPW Sewer Division. "Slip Line Projects." June 4, 2012. 1p.**
   This table provides a list of Amherst DPW priority areas for slip lining sewer lines to address infiltration.

Stormwater Documents:

1. **Maps of "Town of Amherst Drainage System." March 2011. 80p.**
   The maps depict locations of catch basins, drain manholes, stormwater outfalls, culverts, drain lines, dams, retention ponds, water bodies, and wetlands.

General Town of Amherst Documents:

1. **Town of Amherst Board of Health. "Aquifer Protection Floor Drain & Manure Regulations in the Aquifer Recharge Area (Zone II)." Public Health Regulations. Revised and Adopted April 11, 2000. 4p.**
   These regulations are intended to protect aquifer recharge areas (those areas identified in the Amherst Zoning Bylaw and Official Zoning Map as the Aquifer Protection zoning district) from leaching of stored animal manure.

2. **Town of Belchertown Board of Health. "Groundwater and Recharge Protection Regulation." May 30, 2002. 6p.**
   Regulation includes land use prohibitions within Zone IIs and/or Interim Wellhead Protection Areas, and all designated wetland buffer zones.

3. **Town of Amherst. "Open Space and Recreation Plan 2009 Update." 2009. 105p.**
   This plan provides an assessment of existing conditions and trends in Amherst, identifies the community's current open space and recreation goals, conservation and recreation needs, and objectives.

4. **Town of Amherst Planning Department. "Town of Amherst Centers & Outlying Zoning Map." October 2010.**

5. **Town of Amherst. "General Bylaws of the Town of Amherst, Massachusetts." May 2011. 96p.**
   Bylaws governing all general aspects of the Town, including wetlands protection.

6. **Town of Amherst Planning Department. "Town of Amherst Zoning Map." June 2011. 1p.**

7. **Town of Amherst. Section 3.25 of the Amherst Zoning Bylaw regarding "Aquifer Recharge Protection District." Amended through November 2011. 7p.**
   This section of the bylaw establishes an Aquifer Recharge Protection (ARP) District and designates prohibited and restricted uses within the district for the purpose of preventing contamination of ground and surface waters flowing into the aquifer of Lawrence Swamp.

8. **Amherst Conservation Commission. "Town of Amherst Wetland Protection Bylaw." 8p.**
   Bylaws governing stormwater management and land development within the Town to help safeguard environmental resources.

9. **Amherst Conservation Commission. "Town of Amherst Wetland Protection Bylaw Regulations." Amended January 17, 2012. 36p.**
   Regulations to back the Wetlands Protection Bylaw governing protection of environmental resources within the Town.

<u>DANVERS</u>

Water Supply Documents:

1. **Chiang, T.T. and P.C. Bucknam. Whitman & Howard, Inc. "Report on Size and Capacity of Reservoir No. 12 for the Town of Danvers, Massachusetts." October 1981. 33p.**
   This report provides the results of a feasibility study of Reservoir No. 12 (Emerson Brook Reservoir).The report indicates the reservoir will provide an additional yield of about 1.2 mgd to the existing yield of surface water supplies in Middleton and Danvers.

2. **Stone & Webster Civil and Transportation Services, Inc. "Massachusetts Water Resources Authority Study of Local Sources of Water Supply in Non-MWRA Supplied Communities: Community Report for the Towns of Danvers and Middleton." MWRA Contract #5006. March 16, 1992. 57p.**
   The MWRA supported this study of the water supply system for the Towns of Danvers and Middleton because of their spatial proximity to the MWRA distribution system and the possibility that they might request water from MWRA in the future. The study was intended to assess the short and long term water supply condition of these towns, identify possible contamination threats, and possibly help them reduce or eliminate these threats.

3. **Whitman & Howard. "Town of Danvers Water Supply Alternatives." July 7, 1992. 100p.**
   This report includes discussions on supply conservation, demand conservation, alternate groundwater sources, additional withdrawals from existing wells, feasibility and costs of pumping wells to treatment plant, additional surface water withdrawals, interconnections with Beverly and Peabody, and establishing an interconnection with MWRA.

4. **Yarsites, Robert A. and J. M. Beekman. Whitman & Howard. Letter to Danvers Director of Public Works regarding "Boston Brook." October 17, 1995. 6p.**
   This letter summarizes findings of an investigation into whether or not the Town-owned land along Boston Brook at Curtis Pond should continue to be held by the Town as a potential water supply resource. The final recommendation was to release the property based mostly on the cost to develop the site and repair/rebuild the dam.

5. **DeNatale, Douglas and R. A. Yarsites. Whitman & Howard. Letter to Danvers Director of Public Works regarding "Fracture Trace Analysis." February 28, 1996. 4p.**
   This letter summarizes findings of the fracture-trace analysis completed in the Towns of Danvers and Middleton to identify areas that might be favorable for developing municipal, bedrock water supply wells. Ten areas were identified as being favorable for bedrock test well exploration.

6. **Town of Danvers and Town of Middleton. "Danvers/Middleton Water Contract." August 4, 1997. 15p.**
   This document is the contract between the Town of Danvers and the Town of Middleton stipulating how the Town of Danvers sells water and services to the Town of Middleton for sale to Middleton customers and is compensated by the Town of Middleton.

7. **Town of Danvers. "Rules & Regulations Water Division." Revised February 27, 1998. 9p.**
   Rules and regulations pertaining to service connections, water meters, service renewal, home pools, billing and rates, emergencies, water shut-off, and others.

8. **S E A Consultants, Inc. "Town of Danvers, Massachusetts Drought Management Plan." June 29, 2000. 37p.**
   A 1999 settlement agreement with MassDEP required Danvers complete this Drought Management Plan which includes discussions on: water sources, system demand history, history associated with drought issues; data monitoring; drought stage triggers, communication; and mitigation.

9. **Danvers Water Department. "Public Water Supply Annual Statistical Report" Reporting Years 2000-2011. PWS ID 3071000.**

10. **DeNatale, Douglas. Earth Tech, Inc. "New Source Final Report Gravel-Packed Replacement Wells for Well No. 1, Danvers Water Department, Middleton, Massachusetts." February 2002. 345p.**
    This report documents the results of two prolonged pumping tests to evaluate the suitability of two new replacement wells at Well #1. The report indicates the replacement wells can yield a combined 675 gpm.

11. **S E A Consultants, Inc. "Water Supply Operations Plan for Danvers, Massachusetts." March 2002. 68p.**
This report reviews the existing operational approach for utilization of the available water sources, demonstrates the adequacy or shortfalls of that operational approach, and presents an updated operational strategy to optimize the water supplied while balancing environmental impacts.

12. **Carnevale, Richard M. City of Peabody Department of Public Services. Letter regarding "Water System Interconnections – Mutual Aid." August 1, 2002. 13p.**
This letter was intended to update existing records on the interconnection between Peabody and Danvers. The letter includes attached schematics, photographs, and spreadsheets on the existing interconnections.

13. **Danvers DPW. List of Danvers Tie-Ins (interconnections) with Beverly, Salem, and Peabody. Date Unknown. 1p.**
This list provided by Danvers DPW staff includes the Town, Location, Size, and Pressure of 17 interconnections (4 with Beverly, 6 with Salem, and 7 with Peabody).

14. **Earth Tech, Inc. "Test Well Investigation and Preliminary Prolonged Pumping Tests: Danvers State Hospital, Danvers, MA and Richardson Property, Middleton, MA." October 2002. 131p.**
The report documents the test well program undertaken in 2001 to identify an additional source of water supply for the Town of Danvers. A total of 13 test well sites were tested on the Danvers State Hospital Property in Danvers and the Richardson Property in Middleton.

15. **S E A Consultants, Inc. "Water Distribution Facilities Plan and Capital Improvement Program for Danvers, Massachusetts." December 2003. 116p.**
This report formulates a long-range plan for water supply, storage, distribution, and operations which will correct existing deficiencies and meet requirements for projected water demands into the future. It reviews the existing system, population projections, water requirements, and recommended improvements.

16. **Danvers Water Department. "Community Water System Vulnerability Assessment." June 21, 2004. 23p.**
This is Danvers' Vulnerability Assessment as required by the Public Health and Security and Bioterrorism Act of 2002 which addresses pipes, physical barriers, water collection, treatment, storage, distribution facilities, automated systems, and chemical use, storage, and handling.

17. **S E A Consultants, Inc. "Emerson Brook Reservoir Expansion – Summary for Pre-Filing Meeting." 2004. 4p.**
Summary provided as a brief description of the proposed Emerson Brook Reservoir Expansion project for the pre-filing meeting which was held as an introduction to the project for regulators. The project proposed to increase storage in the reservoir by raising the height of the existing dam by 5 feet.

18. **S E A Consultants, Inc. "Emerson Brook Reservoir Pre-Filing Report for Danvers." November 2004. 65p.**
This report describes the proposed expansion of the Emerson Brook Reservoir including project history and need, project alternatives, conceptual design, ecological characterization and impact, and potential mitigation.

19. **BETA Group, Inc. "Danvers Water Department Emergency Response Plan." December 15, 2004. 64p.**
This emergency response plan is separated into two components: the treatment system and the distribution system. The treatment system consists of operations at the Russell Water Treatment Facility and the Greensand Water Treatment Facility, and the water quality of the surface water supplies. The distribution system consists of the storage tanks, transmission mains, service connections, booster stations, and water quantity of wellheads and surface water supplies.

20. **MassDEP. "Modified Water Management Act Permit for Danvers Water Department." Permit #9P-3-17-071.01 for 1991-2009. March 23, 2006. 18p.**

21. **Lehane, Michael. Murphy, Hesse, Toomey & Lehane, LLP. Letter from Town Counsel to Danvers Town Manager regarding "Final Decision approving Settlement Agreement." March 31, 2006. 28p.**
This letter provides the approved Settlement Agreement between Danvers and Middleton; the Ipswich River Watershed Association, Inc., Essex County Greenbelt Association, and Twelve Citizens; and MassDEP regarding Danvers' Water Management Act Permit. The letter also includes the Modified Water Withdrawal Permit.

22. **Zessoules, Nick and T. Mahin. MassDEP. "Sanitary Survey Report for Middleton Department of Public Works." September 11, 2006. 9p.**
This report includes the system description, findings and compliance plan based on an August 29, 2006 Sanitary Survey.

23. **Haas, Glenn. MassDEP. "Water Management Act Registration for Danvers Water Department." Registration #31707101 for 2008-2017. December 31, 2007. 8p.**

24. **Monnelly, Anne. MassDCR. "Danvers-Middleton Final Water Needs Forecast." June 9, 2009. 5p.**

25. **Jean, Hilary and T. Mahin. MassDEP. "Sanitary Survey Report for Danvers Department of Public Works." September 3, 2010. 11p.**
This report includes the system description, findings and compliance plan based on a Sanitary Survey conducted on July 14 and 15, 2010.

26. **Town of Danvers Water Division. "Annual Water Report – Water Testing Performed in 2010." PWS ID#: 307 1000. 6p.**
This is Danvers' 2010 CCR which includes information on how Danvers provides treatment for their water supply.

27. **Town of Danvers. "Water & Sewer Rates." Effective July 1, 2011. 1p.**

28. **Heidell, Pam. MWRA Policy and Programming Manager. Email correspondence from Pam Heidell to Page Czepiga of Tighe & Bond regarding approximate MWRA Entrance Fees. June 1, 2012. 1p.**
This email includes guidance related to estimating MWRA entrance fee. Approximates entrance fee at $5M/mgd.

29. **Adamski, Tracy; Czepiga, Page. Tighe & Bond, Inc. Memorandum regarding Telephone Interview with Rick Rodgers, Town Engineers. June 14, 2012. 2p.**
This memo summarizes information obtained during a phone interview regarding Danver's water distribution system and the potential for interconnections.

30. **Town of Danvers. "Final Report for the Danvers Water Conservation Grant Project. Project Number 09-04/WCG. April 2, 2010-June 30, 2012." June 15, 2012. 10p.**
This reports documents Danvers' efforts under the MassDEP Water Conservation Grant Program including additional conservation outreach and education, and an updated water conservation rebate program.

Wastewater Documents:

1. **Town of Danvers. "Regulation of Sewer Use Bylaw." Date Unknown. 15p.**
This bylaw regulates the use of public and private sewers and drains, the installation and connection of building sewers, and the discharge of waters and wastes into the public sewer system.

2. **CDM. "Town of Danvers Wastewater Facilities Plan." 1997. 131p.**
This plan evaluates the present and future needs of the wastewater collection system within the Town of Danvers. It addresses two main issues: the capability of the exiting wastewater collection facilities to convey current and future design flows to the SESD interceptor and treatment facility, and the feasibility of sewering unsewered areas which are presently being served by subsurface disposal systems.

3. **CDM. "Town of Danvers, Massachusetts South Essex Sewerage District House to House Inspection Program Report." March 2003. 100p.**
This report presents the findings of the 1998 inspection program and recommends a program for removing identified private inflow sources from the Town of Danvers sanitary sewer system.

4. **CDM. "South Essex Sewerage District, Danvers, Massachusetts, Infiltration/Inflow Investigation." March 2003. 96p.**
This report summarizes the results of a gauging and flow isolation program conducted for the South Essex Sewerage District in Danvers which included flow monitoring, analysis of data, flow isolation, and internal TV inspection.

5. **South Essex Sewerage District. "Sewer Use Regulations." Revision 11.03. Effective Date February 15, 2006. 57p.**
The South Essex Sewerage District sewer use regulations apply to all users of the wastewater treatment plant, whether inside or outside of the district, with a goal of complying with the Federal Water Pollution Control Act, and General Pretreatment Regulations.

6. **Worrall, Eric. MassDEP NERO. "Groundwater Discharge Permit. Permit No. #250-4. June 2, 2009 – June 2, 2014." June 2, 2009. 20p.**
MassDEP permit to Fuller Pond Village Condominium Trust to discharge into the ground a treated effluent from the wastewater treatment facility located at Fuller Pond Condominiums in Middleton, MA.

7. **Worrall, Eric. MassDEP NERO. "Groundwater Discharge Permit. Permit No. #752-1. October 21, 2010 – October 21, 2015." October 21, 2010. 13p.**
MassDEP permit to DSM Realty, Inc., to discharge into the ground a treated effluent from the wastewater treatment facility located at Middleton Market Place in Middleton, MA.

8. **Taubert, Alan. South Essex Sewerage District. "CY 2011 Flows & Loads Final Report." January 25, 2012. 86p.**
This report provides the flows and loads account and entity distribution basis for the annual SESD budget. It includes a schematic of the SESC collection system and other supporting documentation.

9. **Duffield, Martha. Danvers Engineering. Email correspondence from Martha Duffield to Gabrielle Belfit of Tighe & Bond regarding status of I/I reports after 2003. June 6, 2012. 2p.**
Ms. Duffield reported on the status of work completed since 2003, one for cleaning and tving and one for repairs, and that two articles at town meeting have passed for continuation of I/I work.

Danvers Stormwater Documents:

1. **Marquis, Wayne P. Town of Danvers. "NPDES PII Small MS4 General Permit Annual Reports." Nos. 1-9. March 2004 - March 2011.**
Annual reports for Years 1-9, covering March 2004 through March 2012 and documenting progress made by the Town on stormwater BMPs to date.

2. **EPA Region I GIS Center. "Waterbody Assessment and TMDL Status, Danvers MA." EPA. Map Tracker ID 6678. February 25, 2010. 1p.**
Map showing the location and status of 305(b) and 303(d) listed waters within the Town.

3. **EPA Region I GIS Center. "Summary of Waterbody Assessment and TMDL Status in Massachusetts, Danvers MA." EPA. February 25, 2010. 2p.**
Table summarizing the status of 305(b) and 303(d) listed waters within the Town.

4. **EPA Region I GIS Center. "Impervious Cover & Watershed Delineation by Subbasin or GWCA, Danvers MA." EPA. Map Tracker ID 4291. March 3, 2010. 1p.**
Map showing impervious cover and watershed boundaries within the Town.

5. **EPA Region I GIS Center. "Impervious Cover Statistics, Danvers MA." EPA.**
Database providing impervious cover sizes and land use by basin within the Town.

6. **MassDEP, Bureau of Resource Protection – Watershed Management. "BRP WM 08A, NPDES Stormwater General Permit Notice of Intent for Discharges from Small Municipal Separate Storm Sewer Systems (MS4s)." Town of Danvers. July 22, 2003. 7p.**
Notice of Intent for the Town stormwater discharges from its MS4.

7. **EPA New England. "NPDES Phase II Stormwater Program Automatically Designated MS4 Areas, Danvers Massachusetts." September 30, 2002. 1p.**
Map showing the urbanized area and default Phase II coverage within the Town.

8. **CDM. "Town of Danvers Massachusetts, Stormwater Management Plan." July 2003. 34p.**
Stormwater Management Plan (SWMP) outlining a plan for reducing stormwater pollutant discharges from the Town's MS4 as required by the EPA NPDES program.

9. **Town of Danvers. "Proposed Stormwater Management and Land Disturbance Bylaw." Adopted May 16, 2011. 11p.**
Bylaws governing stormwater management and land development within the Town to help safeguard environmental resources.

10. **Town of Danvers. "Regulations Governing Stormwater Management Under the General Bylaws of the Town of Danvers, Chapter XXXIX: Stormwater Management and Land Disturbance Bylaw." Adopted March 29, 2012. 29p.**
Regulations to back the Stormwater Management and Land Disturbance Bylaw governing stormwater management and land development within the Town.

Middleton Stormwater Documents:

1. **Singer, Ira S. Town of Middleton. "NPDES PII Small MS4 General Permit Annual Reports." Nos. 2-9. April 2004-May 2012.**
Annual reports for Years 2 through 9, covering April 2004 through May 2012 and documenting progress made by the Town on stormwater BMPs to date.

2. **EPA Region I GIS Center. "Waterbody Assessment and TMDL Status, Middleton MA." EPA. Map Tracker ID 6678. February 25, 2010.**
Map showing the location and status of 305(b) and 303(d) listed waters within the Town. **1p.**

3. **EPA Region I GIS Center. "Summary of Waterbody Assessment and TMDL Status in Massachusetts, Middleton MA." EPA. February 25, 2010. 2p.**
Table summarizing the status of 305(b) and 303(d) listed waters within the Town.

4. **EPA Region I GIS Center. "Impervious Cover & Watershed Delineation by Subbasin or GWCA, Middleton MA." EPA. Map Tracker ID 4291. March 3, 2010. 1p.**
Map showing impervious cover and watershed boundaries within the Town.

5. **EPA Region I GIS Center. "Impervious Cover Statistics, Middleton MA." EPA.**
Database providing impervious cover sizes and land use by basin within the Town.

6. **MassDEP, Bureau of Resource Protection – Watershed Management. "BRP WM 08A, NPDES Stormwater General Permit Notice of Intent for Discharges from Small Municipal Separate Storm Sewer Systems (MS4s)." Town of Middleton. June 30, 2003. 7p.**
Notice of Intent for the Town stormwater discharges from its MS4.

7. **EPA New England. "NPDES Phase II Stormwater Program Automatically Designated MS4 Areas, Middleton Massachusetts." November 14, 2002. 1p.**
Map showing the urbanized area and default Phase II coverage within the Town.

General Town of Danvers Documents:

1. **Town of Danvers. "Planning Board Rules and Regulations Governing the Subdivision of Land in Danvers, Massachusetts." Adopted September 10, 1979. 116p.**
Bylaws governing construction of subdivisions within the Town.

2. **Town of Danvers Department of Planning and Human Services. "Wetlands Bylaw and Wetlands Bylaw Regulations." March 2003. 41p.**
Bylaws and regulations outlining for protecting wetlands within Town boundaries. Bylaws have been incorporated into the general bylaws while regulations are a stand-alone document.

3. **Town of Danvers. "2009 Open Space and Recreation Plan." 2009. 125p.**
This is Danvers's sixth Open Space and Recreation Plan which focuses the networks of open space including contiguous properties and greenbelts. The plan provides an inventory of existing open space and recreation facilities and recommends strategies for acquisition, use and protection of open space and conservation land.

4. **Town of Danvers. "Zoning Bylaws." January 25, 2010. 162p.**
Bylaws governing zoning restrictions, land use, and structure locations within Town.

5. **Town of Danvers. "By-Laws of the Town of Danvers, Massachusetts, Adopted 1951." Revised through May 17, 2010. 86p.**
Bylaws governing all general aspects of the Town, including wetlands protection and water system connections.

6. **Town of Danvers. "Zoning Map with Groundwater Protection District." Town of Danvers GIS. Revised September 28, 2010. 1p.**
Map showing zoning districts within Town in support of the Zoning Bylaws.

General Town of Middleton Documents:

1. **Town of Middleton. "Chapter 250 Subdivision of Land." Adopted March 25, 1987. 20p.**
Bylaws governing construction of subdivisions within the Town.

2. **Town of Middleton. "Water Use Restriction Bylaw." June 1, 2005. 4p.**
At the May 10, 2005 Annual Town Meeting, the Tow of Middleton adopted this addition to the General By-Laws: "Chapter V – Water Conservation. Section 1: Water Use Restriction." Restrictions are in effect whenever there is in force a State of Water Supply Conservation or State of Water Supply Emergency.

3. **Town of Middleton. "Irrigation/Outside Water Usage Bylaw." June 1, 2005. 2p.**
At the May 10, 2005 Annual Town Meeting, the Tow of Middleton adopted this addition to the General By-Laws: "Chapter V – Water Conservation. Section 2: Irrigation/Outside Water Usage." This By-law is in effect from May 1st to September 30th of each year and makes it unlawful to undertake outside watering of vegetation between the hours of 8:00am to 7:00pm using town water or private well water through a sprinkler or lawn irrigation system. The By-law is superseded in the event of a State of Water Supply Conservation or State of Water Supply Emergency.

4. **Town of Middleton. "Chapter 235 Zoning." Adopted November 29, 2005, amended May 13, 2008. 52p.**
Bylaws governing zoning restrictions, land use, and structure locations within Town.

5. **Town of Middleton. "Private Water Supply Systems." Amendments noted where applicable. Adopted by the Board of Health October 1, 2008. 20p.**

6. **Town of Middleton. "Zoning Map of Middleton Massachusetts." Revised January 1, 2010. 1p.**
Map showing zoning districts within Town in support of the Zoning Bylaws.

7. **Fullerton, Derek. Middleton Board of Health. Email correspondence regarding those sections of the Middleton Irrigation/Outside Water Usage Bylaw that were overturned in 2011. May 7, 2012. 2p.**
At the 2011 Town Meeting those portions of the Middleton Irrigation/Outside Water Usage Bylaw that referred to "private well users" were deleted.

Ipswich River Watershed Association Documents:

1. **Inter-Fluve. "South Middleton Dam, Ipswich River Partial Feasibility Study Phase I Technical Memorandum." 2010. 28p.**
This report discusses the benefits of removing the South Middleton Dam and future studies needed to prepare for its removal. It also identifies the options for managing the impounded sediment at the dam and identifies alternative water supply sources for the fire suppression system of Bostik, Inc.

2. **Mackin, Kerry. IRWA. "Comments on Danvers Pilot Project Meeting." Received June 26, 2012. 3p.**
This document contains comments sent to the Pilot Project Team from Kerry Mackin of the Ipswich River Watershed Association regarding the Danvers Watershed Group Meeting held on June 18, 2012.

DEDHAM-WESTWOOD

Water Supply Documents:

1. **Dedham-Westwood Water District. "White Lodge Water Treatment Plant." 1987. 6p.**
This document provides a summary of the White Lodge Water Treatment Plant including its construction, general operation, visitation areas, and hydraulic profile.

2. **Weston and Sampson. "Rock Meadow Well Water Treatment Feasibility Study Preliminary Draft." October 1989. 30p.**

3. **Anderson-Nichols & Company, Inc. "Report on Extended Pump Test Fowl Meadow Aquifer." April 1990. 364p.**
This report contains findings from the December 1989 extended pump test and recommends that DWWD seek approval for a total yield of 800 gpm or approximately 1.15 mgd.

4. **Anderson-Nichols & Company, Inc. "Zone II Delineation Study Fowl Meadow Aquifer." February 1991. 246p.**
This report contains findings from the Zone II Delineation Study for the Fowl Meadow Well and White Lodge Wellfield.

5. **Weston & Sampson. "Dedham-Westwood Water District Bridge Street Wellfield. Aquifer Pumping Test and Zone II Delineation." April 1991. 169p.**
This report is the final Bridge Street Zone II Delineation Report submitted to MassDEP, which was required in order for DWWD to prepare to complete Well A-2. Well A-2 would be fed into the new Bridge Street Treatment Plant.

6. **Dedham-Westwood Water District "Bridge Street Water Treatment Plant." 1991. 8p.**
This document provides a summary of the Bridge Street Water Treatment Plant including its construction, general operation, visitation areas, and hydraulic profile.

7. **Stone & Webster Civil and Transportation Services, Inc. "Massachusetts Water Resources Authority Study of Local Sources of Water Supply in Non-MWRA Supplied Communities: Community Report for the Towns of Dedham and Westwood." MWRA Contract #5006. February 26, 1992. 58p.**
The MWRA supported this study of the water supply system for the Towns of Dedham and Westwood because of their spatial proximity to the MWRA distribution system and the possibility that they might request water from MWRA in the future. The study was intended to assess the short and long term water supply condition of these towns, identify possible contamination threats, and possibly help them reduce or eliminate these threats.

8. **Massachusetts Water Resources Commission. "Interbasin Transfer Application: Dedham-Westwood Water District Proposed Fowl Meadow Well, WRC Decision." 1992. 15p.**
This documents provides the findings of the July 13, 1992 meeting of the WRC and states that the WRC has approved the interbasin transfer application with conditions concerning water conservation and requirements for streamflow measurements.

9. **Weston & Sampson. "Dedham-Westwood Water District Bridge Street Wellfield. Revised Report on Aquifer Pumping Test and Zone II Delineation." August 31, 1993. 177p.**
This report is the revised final Bridge Street Zone II Delineation Report. It includes findings of the study and recommendation for groundwater protection. The study included data review, observation well installation, a constant-rate pumping test, and computer model simulations.

10. **Gottlieb, Andrew. MassDEP. "Water Management Act Permit for Dedham-Westwood Water District." Permit #9P-3-19-073.01 for 1993-2010. November 2, 1993. 8p.**

11. **Anderson-Nichols & Company, Inc. "Fowl Meadow Public Water Supply Well Site AN-1 Wetland Monitoring Program Water Elevation Readings. #1 – May 1994. #2 – June 1994." July 25, 1994. 60p.**
This report contains the first and second monthly water elevation readings in accordance with Clean Water Act Permit No. 02254-9149 for the filling and replication of wetlands for the development of the new Fowl Meadow Well Site AN-1. The report also contains drilling logs for new piezometers installed.

12. **Anderson-Nichols & Company, Inc. “Report on AN-2A Test Well Exploration Fowl Meadow Aquifer. Dedham, Massachusetts.” February 10, 1995. 147p.**
This report contains findings from the drilling of a 2.5-inch test well designated AN-2A to investigate the feasibility of developing an alternative well site to AN-1. The report recommends development of a final production well at the location of AN-1 in the Fowl Meadow Aquifer based on better aquifer transmissivity.

13. **Dedham-Westwood Water District. “Public Water Supply Annual Statistical Report” Reporting Years 2000-2011. PWS ID 3073000.**

14. **Dedham-Westwood Water District. “Local Water Supply Management Plan.” Date Unknown. 32p.**
This plan was prepared as part of the application process to the MWRA. The plan covers existing and potential water supplies and source water protection, existing regional or watershed plans, analysis of existing zoning and master planning documents, and future water and wastewater needs and alternatives for meeting those needs.

15. **CDM. “Dedham-Westwood Water District Water Conservation Plan Revised Report.” November 16, 2005. 39p.**
This plan contains discussion on the current conservation program including planning; water audits and leak detection; metering; pricing; residential, public sector, agricultural, and industrial, commercial, and institutional water use; lawn and landscape conservations; and education and outreach. It also discusses planned enhancements such as a conservation fund, conservation coordinator, demonstration projects, and rebate programs.

16. **Weston & Sampson. “Dedham-Westwood Water District Water System Study.” April 2007. 98p.**
This report contains the DWWD water system study and capital improvements plan. The report includes updates to the system’s hydraulic model, updates to water system demands and 20-year projections, flow test results from the distribution system, options to eliminate identified deficiencies in the system, and recommended improvements.

17. **Weston & Sampson. “Dedham-Westwood Water District Pressure Zone Mapping.” September 2007. 4p.**
The maps include the Westfield Intermediate Service Area, Sandy Valley High Service Area, High Rock High Service Area, and Burgess Avenue High Service Area.

18. **Haas, Glenn. MassDEP. “Water Management Act Registration for Boston Harbor for the Dedham - Westwood Water District.” Registration #31907301 for 2008-2017. December 31, 2007. 8p.**

19. **Haas, Glenn. MassDEP. “Water Management Act Registration for Charles River for the Dedham-Westwood Water District.” Registration #31707101 for 2008-2017. December 31, 2007. 8p.**

20. **Carroll, Anne. MassDCR. Letter from DCR to DWWD regarding “Temporary Allocation for Water Management Act Withdrawal Permits, 2010-2030.” November 3, 2009. 2p.**
This letter explains that the data currently available do not allow for an estimate of future water needs for the DWWD supply system.

21. **MassDEP. “Wellhead Protection Zones Bridge Street Wells (PWS 3073000-01G, 02G, 03G, 04G, 05G, 14G, 15G, 16G, and 17G).” December 15, 2009. 1p.**
This map shows the Zone II boundary and public water supply sources for Bridge Street.

22. **MassDEP. “Wellhead Protection Zones White Lodge and Fowl Meadow (PWS 3073000-06G, 07G, 08G, 09G, 13G).” December 15, 2009. 1p.**
This map shows the Zone II boundary and public water supply sources for White Lodge and Fowl Meadow.

23. **Dewberry-Goodkind, Inc. “Dedham/Westwood Water District PWS ID# 3073000 Water System Emergency Response Plan.” September 2010. 83p.**

24. **Jean, Hilary and T. Mahin. MassDEP. “Sanitary Survey Report for Dedham-Westwood Water District.” December 17, 2010. 13p.**
This report includes the system description, findings and compliance plan based on a Sanitary Survey conducted on September 29, 2010.

25. **Weston & Sampson. "General Plan Sheet of Distribution System. Dedham/Westwood Water District. Sheet B-2." January 2011.**
The sheet shows the emergency interconnection to Norwood.

26. **Weston & Sampson. "General Plan Sheet of Distribution System. Dedham/Westwood Water District. Sheet C-3." January 2011.**
The sheet shows the regular service connection to MWRA.

27. **Weston & Sampson. "General Plan Sheet of Distribution System. Dedham/Westwood Water District. Sheet F-4." January 2011. 2p.**
The sheet shows the emergency interconnection to MWRA.

28. **Weston & Sampson. "General Plan Sheet of Distribution System. Dedham/Westwood Water District. Sheet G-2." January 2011. 1p.**
The sheet shows the emergency interconnection to Needham.

29. **Commane, Eileen. DWWD. Letter from DWWD to MWRA regarding "Water Supply Continuation Agreement." January 19, 2011. 16p.**
This letter includes a copy of the Water Supply Continuation Agreement between MWRA and the DWWD as well as a copy of the Supplemental Report and Attachments.

30. **Haas, Glenn. MassDEP. Letter regarding "Interim Water Management Act Permit in the Boston Harbor. Permit #I9P31907301." February 22, 2011. 2p.**
This letter explains the Permit Extension Act of 2010 and that the interim permit for DWWD will now expire on February 28, 2013.

31. **Gillen, Michele. MWRA. Letter from MWRA to DWWD regarding "Water Supply Continuation Agreement MWRA Contract No. W289." April 11, 2011. 5p.**
This letter includes a copy of the fully executed Water Supply Continuation Agreement between MWRA and the DWWD.

32. **Hamilton, Catherine. MassDEP. Letter to Dedham-Westwood Water District regarding "Wellhead Protection Best Effort Requirement Compliance, Wells 01G-19G." September 6, 2011. 2p.**
This letter, provided by MassDEP, explains that DWWD satisfies the wellhead protection conditions of its Water Management Act permit because it has met the Best Effort Requirements regarding Zone II protection in Westwood, Norwood, Milton, Dedham, and Canton. This document also contains a copy of the letter sent to the Town of Westwood as part of DWWD's "best efforts."

33. **Dedham-Westwood Water District. "Rules and Regulations." March 27, 2012. 36p.**
These rules and regulations also contain the schedule of water rates in Schedule A which were effective as of February 1, 2011.

34. **Weston & Sampson. "General Plan Sheet of Distribution System. Dedham/Westwood Water District." May 2012. 1p.**

35. **Commane, Eileen. Dedham-Westwood Water District. Email correspondence from Eileen Commane to Jessica Cajigas of CEI regarding "MWRA Water Rates." May 24, 2012.**

36. **Dedham-Westwood Water District. "Pumping History." June 4, 2012.**
DWWD provided this excel sheet with pumping records from the Neponset and Charles from 2003 through 2011.

37. **Dedham-Westwood Water District. "Rebate Program Information through 12/31/2011." June 4, 2012.**
DWWD provided this excel sheet with information on rebates for toilets, washing machines, urinals, rainbarrels, and rain sensors from 2007 through 2011.

38. **Commane, Eileen. Dedham-Westwood Water District. Email correspondence to Peter Galant of Tighe & Bond regarding incremental cost of water production at Fowl Meadow Wellfield, 2012. June 18, 2012.**

39. **Commane, Eileen. Dedham-Westwood Water District. Email correspondence to Peter Galant of Tighe & Bond regarding Fowl Meadow Well Shut-Off Days. June 19, 2012.**

Wastewater Documents:

1. **Town of Dedham. "Sewer Regulations." Updated 2006. 80p.**

2. **Doherty, John. CDM. "Town of Westwood, Massachusetts Wastewater Flows Analysis/Metering Data Review Final Report." June 2009. 87p.**
   This report presents the results of the I/I analysis, identifies sewers subject to higher amounts of I/I, and develops a prioritized plan to pursue I/I reduction where necessary.

3. **Town of Westwood. "Sewer System Map with Street Index." March 2010. 1p.**

4. **Worrall, Eric. MassDEP NERO. "Individual Groundwater Discharge Permit. Permit No. #905-0. October 14, 2010 – October 14, 2015." October 14, 2010. 14p.**
   MassDEP permit to Hale Reservation to discharge into the ground a treated effluent from the wastewater treatment facility located at Hale Reservation in Westwood, MA.

5. **MWRA. "2011 Water & Sewer Retail Rate Survey." Westwood (page 59). 2011. 1p.**
   This pages of the MWRA survey provides residential water and sewer rates for Westwood.

6. **Town of Westwood Department of Public Works Sewer Division. "Sewer System Rules and Regulations and Construction Standards." Draft. March 2011. 65p.**

7. **Weston & Sampson. "Report: Town of Dedham, MA Town-Wide Flow Monitoring Program." October 2011. 15p.**
   This report presents the analysis of flow metering results, provides estimates of peak infiltration/inflow and total inflow volume, and identifies areas that appear to contribute to excessive I/I.

8. **Town of Dedham. "Sewer Map Town of Dedham Norfolk County Massachusetts." May 2012. 1p.**

9. **Hornbrook, Michael. "Attachment 5 to MWRA Annual I/I Reduction Report for FY 11 I/I Reduction Status Update for Member Communities." 2012. 42p.**
   This report was downloaded from the MWRA website **(**http://www.mwra.state.ma.us/harbor/pdf/infinf11_att5.pdf) for the Dedham and Westwood summaries. Dedham summary includes reporting on 2008 contract, 2010 on-call sewer repairs project, and 2011 annual sewer system inspection program. Westwood summary includes report on house-to-house survey and town wide I/I study initiated in CY2010-2011 that included some cleaning and inspection work.

Dedham Stormwater Documents:

1. **Keane, Paul G. and William G. Keegah, Jr. Town of Dedham. "NPDES PII Small MS4 General Permit Annual Reports." Nos. 1-9. March 2003 - March 2012.**
   Annual reports of Years 1 through 9 covering March 2003 through March 2012 and documenting progress made by the Town on stormwater BMPs to date.

2. **EPA Region I GIS Center. "Waterbody Assessment and TMDL Status, Dedham MA." EPA. Map Tracker ID 6678. February 25, 2010. 1p.**
   Map showing the location and status of 305(b) and 303(d) listed waters within the Town.

3. **EPA Region I GIS Center. "Summary of Waterbody Assessment and TMDL Status in Massachusetts, Dedham MA." EPA. February 25, 2010. 2p.**
   Table summarizing the status of 305(b) and 303(d) listed waters within the Town.

4. **EPA Region I GIS Center. "Impervious Cover & Watershed Delineation by Subbasin or GWCA, Dedham MA." EPA. Map Tracker ID 4291. March 3, 2010. 1p.**
   Map showing impervious cover and watershed boundaries within the Town.

5. **EPA Region I GIS Center. "Impervious Cover Statistics, Dedham MA." EPA.**
   Database providing impervious cover sizes and land use by basin within the Town.

6. **MassDEP, Bureau of Resource Protection – Watershed Management. "BRP WM 08A, NPDES Stormwater General Permit Notice of Intent for Discharges from Small Municipal Separate Storm Sewer Systems (MS4s)." Town of Dedham. July 28, 2003. 7p.**
   Notice of Intent for the Town stormwater discharges from its MS4.

7. **EPA New England. "NPDES Phase II Stormwater Program Automatically Designated MS4 Areas, Dedham Massachusetts." October 4, 2002. 1p.**
   Map showing the urbanized area and default Phase II coverage within the Town.

8. **Town of Dedham. "Chapter XXXVI, Stormwater Management By-Law." Adopted April 9, 2001. 8p.**
   Bylaws governing stormwater management within the Town to help safeguard environmental resources.

9. **Town of Dedham. "Town of Dedham Drainage & Stormwater Management Design Standards." Revised July 31, 2002. 43p.**
   A document outlining required design standards for use during stormwater design.

10. **Town of Dedham. "Stormwater Management Rules and Regulations." Adopted May 23, 2002, Amended May 15, 2003. 18p.**
    Regulations to back the Stormwater Management By-Law governing stormwater management and land development within the Town.

Westwood Stormwater Documents:

1. **Walsh, Timothy, Christopher Gallagher, and Vicki Quiram. Town of Westwood. "NPDES PII Small MS4 General Permit Annual Reports." Nos. 1-9. March 2004 - March 2012.**
   Annual reports for Years 2 through 9 covering March 2004 through March 2012 and documenting progress made by the Town on stormwater BMPs to date.

2. **EPA Region I GIS Center. "Waterbody Assessment and TMDL Status, Westwood MA." EPA. Map Tracker ID 6678. February 25, 2010.**
   Map showing the location and status of 305(b) and 303(d) listed waters within the Town.

3. **EPA Region I GIS Center. "Summary of Waterbody Assessment and TMDL Status in Massachusetts, Westwood MA." EPA. February 25, 2010. 3p.**
   Table summarizing the status of 305(b) and 303(d) listed waters within the Town.

4. **EPA Region I GIS Center. "Impervious Cover & Watershed Delineation by Subbasin or GWCA, Westwood MA." EPA. Map Tracker ID 4291. March 3, 2010. 1p.**
   Map showing impervious cover and watershed boundaries within the Town.

5. **EPA Region I GIS Center. "Impervious Cover Statistics, Westwood MA." EPA.**
   Database providing impervious cover sizes and land use by basin within the Town.

6. **MassDEP, Bureau of Resource Protection – Watershed Management. "BRP WM 08A, NPDES Stormwater General Permit Notice of Intent for Discharges from Small Municipal Separate Storm Sewer Systems (MS4s)." Town of Westwood. July 16, 2003. 7p.**
   Notice of Intent for the Town stormwater discharges from its MS4.

7. **EPA New England. "NPDES Phase II Stormwater Program Automatically Designated MS4 Areas, Westwood Massachusetts." November 25, 2002. 1p.**
   Map showing the urbanized area and default Phase II coverage within the Town.

General Town of Dedham Documents:

1. **Town of Dedham. "Town Bylaws: Chapter 28: General Wetlands Protection By-law." Amended April 8, 2002. 5p.**
   Bylaw outlining protection of wetlands within Town boundaries. Bylaws have been incorporated into the general bylaws.

2. **Town of Dedham Board of Health. "Well Regulations: Private Water Supplies/Geo-Thermal Wells." Amended March 6, 2007. 7p.**

3. **Town of Dedham. "Open Space and Recreation Plan." August 2010. 223p.**
   This plan provides an assessment of existing conditions and trends in Dedham, and identifies the community's current open space and recreation goals, conservation and recreation needs, and objectives.

4. **Town of Dedham Department of Infrastructure Engineering. "Zoning Map, Town of Dedham, Norfolk County, Massachusetts." October 2010.**
   Map showing zoning districts within Town in support of the Zoning Bylaws.

5. **Town of Dedham. "Zoning By-Law." Revised November 2011. 106p.**
   Bylaws governing zoning restrictions, land use, and structure locations within Town.

General Town of Westwood Documents:

1. **Town of Westwood. "Westwood Board of Health Private Well Regulations." September 2007. 17p.**

2. **Town of Westwood. "General Bylaws and Charter." Revised October 2009. 81p.**
   Bylaws governing all general aspects of the Town.

3. **Town of Westwood. "Conservation Commission Wetlands Protection Bylaw." January 27, 2010. 19p.**
   Bylaws and regulations outlining for protecting wetlands within Town boundaries.

4. **Town of Westwood. "Zoning Bylaw of the Town of Westwood, Massachusetts." Adopted March 13, 1961, Amended May 2, 2011. 166p.**
   Bylaws governing zoning restrictions, land use, and structure locations within Town.

5. **Town of Westwood Planning Board. "Official Zoning Map with Street Index." May 2011. 1p.**
   Map showing zoning districts within Town in support of the Zoning Bylaws.

Neponset River Watershed Association Documents:

1. **Cooke, Ian (NRWA), L. Larson (MRWA), C. Pawlowski (FRWA), W. Roemer (NRWA), and S. Woods (WRWA). "Boston Harbor Watershed: Water Quality & Hydrologic Investigations." Project Number 2002-02/MWI. June 30, 2003. 377p.**
   This report summarizes the results of water quality and hydrologic investigations in the Boston Harbor Watershed, and recommends actions needed to restore natural resources and achieve water quality standards in the study area.

2. **GeoSyntec Consultants and Neponset River Watershed Association. "Summary of Public Water System Capacities and Issues for the Assessment of Water Sharing Options During Water Supply Emergencies." April 2007. 113p.**
   This report provides a regional assessment of current water supply sources, existing water supply distribution infrastructure, current inter-municipal water supply connections, constraints on water sharing, and existing water sharing agreements within the communities of Dedham, Westwood, Foxborough, Medfield, Norwood, Sharon, and Walpole.

3. **Pearlman, Steven. Neponset River Watershed Association. "Minimizing Municipal Costs for Infiltration & Inflow Remediation: A Handbook for Municipal Officials." June 30, 2007. 51p.**
   This document was designed to provide municipalities with assistance in planning for an effective I/I remediation program and identifying ways to finance I/I programs cost-effectively.

SHREWSBURY

Water Supply Documents:

1. **Shrewsbury Water Department. "Public Water Supply Annual Statistical Report" Reporting Years 2000-2011. PWS ID 2271000.**

2. **Haas, Glenn. MassDEP. "Water Management Act Registration for Shrewsbury Water & Sewer Department." Registration #21227101 for 2008-2017. December 31, 2007. 8p.**

3. **Monnelly, Anne. MassDCR. "Shrewsbury Final Water Needs Forecast." November 20, 2008. 3p.**

4. **Town of Shrewsbury. "Water Department Rules and Regulations for Water Line Installation." Revised February 6, 2009. 9p.**

5. **Town of Shrewsbury. "Shrewsbury Water Conservation Grant Project, Project Number 07-18/WCG." 2009. 28p.**
   This report was a deliverable to MassDEP under the Water Conservation Grant Program. The report documents Shrewsbury's efforts under the grant program to promote water conservation techniques and provide water conservation tools to residents.

6. **Tata & Howard. "Alternate Water Supply Study, Shrewsbury, Massachusetts." January 2010. 57p.**
   This study includes a review of existing and proposed system demands and an evaluation of alternatives for additional supply for the system to meeting projected demands. Alternatives include new sources in Shrewsbury, purchasing raw or finished water from Worcester, and purchasing finished water from Boylston, Northborough, and MWRA.

7. **Stone, Marielle. MassDEP. "Water Management Act Permit for Shrewsbury Water Department." Permit #9P4-2-12-271.01 for 2010-2029. February 26, 2010. 28p.**

8. **Town of Shrewsbury. "Emergency Response Plan for the Shrewsbury Water Department PWS ID 2271000." August 2011. 74p.**

9. **Tata & Howard. Map of "Recommended Improvements, Shrewsbury, Massachusetts." November 2011.**
   This map shows the water system including wells, treatment plants, water mains, tanks, high service areas, low service areas, and reduced high service areas. It also identifies recommended improvements, labeled as "Phase 1" or "Phase 2 Improvements", which came from various studies/reports.

10. **Bostwick, Robert. MassDEP. "Sanitary Survey Report for Shrewsbury Water Department." December 9, 2011. 32p.**
    This report includes the system description, findings and compliance plan based on a Sanitary Survey conducted on October 12, 2011.

11. **Boylston Water District. "Public Water Supply Annual Statistical Report Reporting Year 2011." PWS ID 2039000. 2011. 39p.**

12. **Tata & Howard. "Water Distribution System Study Update, Shrewsbury, MA, T&H No. 2373." April 2012. 103p.**
    This report updates the Town's water distribution system map and computer model and makes recommendations to meet Insurance Service Office fire flow recommendations. It also evaluates the ability of existing sources and storage facilities to meeting existing and future demands.

13. **Tozeski, Robert. Shrewsbury Water & Sewer Department. Memo to SWMI Pilot Project Team regarding "Shrewsbury Water Department and Wastewater Data." Provided on May 3, 2012. 3p.**
    The memo provides information on meter types, source capacities, customers, and septic systems. It also provides sewer and water rates effective April 1, 2011 and rates from 2008.

14. **Shrewsbury Water & Sewer Department. Memo to SWMI Pilot Project Team regarding Number of Water Conservation Devices Provided from 2008-2011. Provided on May 3, 2012. 3p.**
    This hand-written memo provides information on the numbers of low-flow pistol grips, showerheads, and faucet aerators handed out to residents between 2008 and 2011.

Wastewater Documents:

1. **Earth Tech, Inc. "Assabet River Consortium DEP/BRP Project No. CWSRF 424 Planning State Application Comprehensive Wastewater Management Plan/Environmental Impact Report." June 21, 2000. 460p.**
   This is the Assabet River Consortium's SRF Application for the CWMP/EIS for MassDEP and Water Pollution Abatement Trust review and approval.

2. **Earth Tech, Inc. "Comprehensive Wastewater Management Plan and Environmental Impact Report Phase I - Needs Analysis for the Assabet River Consortium." May 2001. 166p.**
   The Towns of Hudson, Maynard, Northborough, Shrewsbury, and Westborough, the City of Marlborough, and the Westborough Treatment Plant Board formed the Assabet River Consortium to address and study issues that affect them relative to wastewater treatment. Each community has wastewater flows to the treatment plant that discharge to the Assabet River. Because of concerns over nutrient discharges to the river, each community must do a CWMP/EIR, and this report serves as part of that requirement providing a summary of existing environmental and wastewater needs of the study area.

3. **Fay, Spofford & Thorndike. "Town of Shrewsbury Comprehensive Wastewater Management Plan/Environmental Impact Report Phase I – Needs Analysis Final." May 2001. 192p.**
   The report focused on wastewater disposal needs, and evaluation of the collection and transmission system, required treatment levels and technologies, effluent disposal options, residual handling and disposal options, and facility siting.

4. **Earth Tech, Inc. "Technical Memorandum to Phase I Needs Survey Assabet Consortium." October 2001. 221p.**
   This Technical Memorandum was written specifically to address comments received on the Phase I Needs Assessment for all Assabet River Consortium communities.

5. **Fay, Spofford & Thorndike. "Town of Shrewsbury Comprehensive Wastewater Management Plan/Environmental Impact Report Phase I – Needs Analysis Technical Memorandum Draft." October 2001. 73p.**
   This memo summarizes the comments made to MEPA as related to the Town of Shrewsbury's Phase I Report, including comments from DEP, community specific comments, and community specific comments from EPA.

6. **Fay, Spofford & Thorndike. "Town of Shrewsbury Comprehensive Wastewater Management Plan/Environmental Impact Report Phase II - Development and Screening of Alternatives." March 2002. 147p.**
   This report provides detail on wastewater minimization issues including infiltration/inflow policy, problems and studies; water reuse guidelines and opportunities; flow and waste reduction including water conservation, and stormwater recharge. The report assessed options for groundwater disposal sites of treated effluent from the Westborough WWTP.

7. **Earth Tech, Inc. "Comprehensive Wastewater Management Plan and Environmental Impact Report Phase II - Development and Screening of Alternatives Assabet Consortium." May 2002. 161p.**
   The Report includes a general discussion of potential technologies as it related to phosphorous removal from discharge to the Assabet River, discharge to groundwater sites, and reuse possibilities. An updated water balance was included in the report.

8. **Fay, Spofford & Thorndike. "Town of Shrewsbury Water and Sewer Commission, Shrewsbury, Massachusetts Wastewater Allocation Study." March 2005. 17p.**
   This report presents the findings of a study to determine the Town's total wastewater flow limit at the Westborough Wastewater Treatment Plant and to recommend allocation of the Town's remaining wastewater flow to the various needs areas in Town.

9. **Gates, Leighton & Associates. "Master Plan with Phasing, Lake Street Recreation." Map. Revised January 14, 2006. 1p.**
This map shows the layout for a proposed recreational master plan for town owned land at the SAC site including a 305,000 gallon per day wastewater treatment facility and disposal fields within the Blackstone River Basin.

10. **Fay, Spofford & Thorndike. "Town of Shrewsbury Comprehensive Wastewater Management Plan/Environmental Impact Report Phase III Alternatives Evaluation and Plan Selection." March 2007. 77p.**
This report provides detail on the evaluation of alternatives and the final recommended plan selection. The main components of the plan are a series of expansions and upgrades to the Towns wastewater collection system, continued use of individual septic systems, and proposed upgrades to the Westborough Wastewater Treatment Plant.

11. **Earth Tech, Inc. "Comprehensive Wastewater Management Plan and Environmental Impact Report Phase III - Draft Recommended Plan and Draft Environmental Impact Report, Program Manager's Report for the Assabet River Consortium." April 2007. 116p.**
This report summarizes the status of the recommended plan, flows, technologies evaluated, and costs for each of the Assabet River Consortium's members.

12. **Fay, Spofford & Thorndike. "Town of Shrewsbury Comprehensive Wastewater Management Plan/Environmental Impact Report Phase IV Final Report." September 2007. 200p.**
This report contains summaries of all previous CWMP phases including the recommended plan focused on the needs of Shrewsbury and the collection system needed to accommodate future flows.

13. **Earth Tech, Inc. "Comprehensive Wastewater Management Plan and Environmental Impact Report Phase IV - Final Recommended Plan and Final Environmental Impact Report for the Assabet River Consortium." October 2007. 202p.**
This report provides the final status of the recommended plan, flows, technologies evaluated, and costs for each of the Assabet River Consortium's members.

14. **Anderson, Paul. MassDEP. Letter to EOEEA Secretary Bowles regarding "Shrewsbury Comprehensive Wastewater Management Plan Phase IV, Final Environmental Impact Report." November 7, 2007. 2p.**
Letter certifies compliance with the Interim NPDES permit, and establishes Shrewsbury's flow limit at the Westborough Wastewater Treatment Facility to 4.39 mgd. The report indicates that by 2030 after I/I removal, the town expects the 4.39 mgd to be 2.47 mgd from residential properties, 1.33 mgd from commercial/industrials and 0.59 from I/I a net reduction of 0.77 mgd from 2007 average I/I flows.

15. **MassEOEEA. "Certificate of the Secretary of Energy and Environmental Affairs on the Special Procedure: Phase IV – Final Recommended Comprehensive Wastewater Management Plan." December 3, 2007. 11p.**
This letter certifies compliance of the Assabet River Consortium Phase IV Plan. EOEA comments on groundwater recharge of wastewater and stormwater as an important component of a watershed-based approach, in order to minimize the existing basin inflow/outflow imbalances affecting the river system.

16. **Weston & Sampson. "Report Town of Shrewsbury, MA Wastewater Capital Improvement Plan." November 2009. 34p.**

17. **Town of Shrewsbury. "Sewer Rates." Effective April 1, 2011. 1p.**

18. **Town of Shrewsbury Board of Sewer Commissioners. "Rules and Regulations for the Installation and Connection of Building Sewers and for the Use of Public Sewers." Revised April 13, 2011. 20p.**

19. **Weston & Sampson. "Final Report Town of Shrewsbury, MA Browning Road and Colton Lane Area Private Inflow Removal Program." July 2011. 44p.**
Report on work for Browning Road, and Colton Lane inflow removal program that included building inspections and smoke and dye testing. The report summarized results of the field work performed to identify sources of inflow to the collection system through sump pumps, floor drains, catchbasins, driveway drains and roof leaders.

20. **Weston & Sampson. "Final Report Town of Shrewsbury, MA Spring 2011 Town-Wide Flow Metering Project." November 2011. 147p.**
This report presents analysis of flow metering results, identifies areas that appear to contribute excessive infiltration and inflow, and provides estimates of peak I/I and total inflow volume.

21. **Weston & Sampson. "Draft Report Town of Shrewsbury, MA 2011 Inflow Investigation." April 2012. 46p.** This report presents findings of the 2011 inflow investigation which included smoke and dye testing and building inspections in the Trowbridge Land and Washington Street area and the Summer Street and Francis Avenue area. The report also presents a cost-effectiveness analysis and preliminary design for rehabilitation of identified inflow sources.

22. **Weston & Sampson. "Town of Shrewsbury, Massachusetts Infiltration and Inflow (I/I) Identification and Rehabilitation Summary." Updated June 2012. 1p.** This is a summary of infiltration and inflow projects proposed and completed from 2010 through 2017.

Stormwater Documents:

1. **Morgado, Daniel, J. and Michael Hale. Town of Shrewsbury. "NPDES PII Small MS4 General Permit Annual Reports." Nos. 1-9. March 2003 - March 2012.** Annual reports for Years 1 through 9, covering March 2003 through March 2012 and documenting progress made by the Town on stormwater BMPs to date.

2. **EPA Region I GIS Center. "Waterbody Assessment and TMDL Status, Shrewsbury MA." EPA. Map Tracker ID 6678. February 25, 2010. 1p.** Map showing the location and status of 305(b) and 303(d) listed waters within the Town.

3. **EPA Region I GIS Center. "Summary of Waterbody Assessment and TMDL Status in Massachusetts, Shrewsbury MA." EPA. February 25, 2010. 2p.** Table summarizing the status of 305(b) and 303(d) listed waters within the Town.

4. **EPA Region I GIS Center. "Impervious Cover & Watershed Delineation by Subbasin or GWCA, Shrewsbury MA." EPA. Map Tracker ID 4291. March 3, 2010. 1p.** Map showing impervious cover and watershed boundaries within the Town.

5. **EPA Region I GIS Center. "Impervious Cover Statistics, Shrewsbury MA." EPA.** Database providing impervious cover sizes and land use by basin within the Town.

6. **MassDEP, Bureau of Resource Protection – Watershed Management. "BRP WM 08A, NPDES Stormwater General Permit Notice of Intent for Discharges from Small Municipal Separate Storm Sewer Systems (MS4s)." Town of Shrewsbury. July 29, 2003. 10p.** Notice of Intent for the Town stormwater discharges from its MS4.

7. **EPA New England. "NPDES Phase II Stormwater Program Automatically Designated MS4 Areas, Shrewsbury Massachusetts." November 20, 2002. 1p.** Map showing the urbanized area and default Phase II coverage within the Town.

8. **Town of Shrewsbury Engineering Department. "Stormwater Infiltration BMPs Approved by the Conservation Commission during Last 5 Years." May 10, 2012. 2p.** Handwritten list of infiltration BMPs installed in Town over the past 5 years.

General Town of Shrewsbury Documents:

1. **Town of Shrewsbury Planning Board. "Inclusionary Housing Submission Requirements, Procedures & Supplemental Regulations." Adopted November 2, 2006. 18p.**

2. **Town of Shrewsbury. "Chapter 43D Rules and Regulations." Revised January 7, 2008. 23p.**

3. **Town of Shrewsbury Planning Board. "Rules and Regulations Governing the Subdivision of Land in Shrewsbury, MA." Revised August 5, 2010. 42p.** Bylaws governing construction of subdivisions within the Town.

4. **Town of Shrewsbury Planning Board. "Rules and Regulations Governing Special Permits & Site Plan Review in Shrewsbury, MA." Adopted April 7, 2011. 25p.** Rules and regulations applying to projects requiring a special permit and/or site plan review by Town departments.

5. **Town of Shrewsbury. "Zoning Map." Revised May 16, 2011.**
Map showing zoning districts within Town in support of the Zoning Bylaws.

6. **Town of Shrewsbury. "Zoning Bylaw." Amendments through September 26, 2011. 150p.**
Bylaws governing zoning restrictions, land use, and structure locations within Town.

7. **Town of Shrewsbury. "General Bylaws of the Town of Shrewsbury Together with Town Meeting Act, Town Manager Act, and Acts of the Legislature Accepted by the Town." October 2011. 85p.**
Article 4-J "Water Department Assessments" provides for special assessments to meet costs related to laying pipes in public and private ways. Article 18 "Water Use Restrictions" allows the Town to regulate water use during a State of Water Supply Conservation and a State of Water Supply Emergency. Private wells are exempt from Article 18. Article 21 "Stormwater Management Bylaw" establishes stormwater management standards for the final conditions that result from development and redevelopment projects.

8. **Town of Shrewsbury Board of Health. "Regulations Regarding the Subsurface Disposal of Sanitary Sewage." Date Unknown. 2p.**

9. **Town of Shrewsbury. "Open Space and Recreation Plan." 2012. 139p.**
This plan provides an assessment of existing conditions and trends in Shrewsbury, and identifies the community's current open space and recreation goals, conservation and recreation needs, and objectives.

Appendix D –

References

Appendix D
References

Section 2

(MWI Report)	Weiskel, P.K., S.L. Brandt, L.A. DeSimone, L.J. Ostiguy, and S.A. Archfield. "Indicators of Streamflow Alteration, Habitat Fragmentation, Impervious Cover, and Water Quality for Massachusetts Stream Basins: U.S. Geological Survey Scientific-Investigations Report 2009–5272." 2010. 70p.
(U.S. Census Website)	U.S. Census. American Fact Finder. Web. Accessed June 8, 2012. http://factfinder2.census.gov/
(UMass Student Life Website)	University of Massachusetts Amherst. Student Life: Living and Learning. Web. Accessed June 19, 2012. http://www.umass.edu/studentlife/living

Section 3

(USGS, SIR 2011-5193)	Armstrong, D.S., T.A. Richards, and S.B. Levin. "Factors influencing riverine fish assemblages in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2011–5193." 2011. 58p.
(EPA WaterSense Website)	EPA WaterSense. Web. Accessed June 20, 2012. http://www.epa.gov/watersense/outdoor/irrigation_professionals.html
(UMass River and Stream Continuity Website)	UMassAmherst. River and Stream Continuity Project. Web. Accessed June 20, 2012. http://www.streamcontinuity.org
(International Rivers Website)	International Rivers. Environmental Impacts of Dams. Web. Accessed June 20, 2012. http://www.internationalrivers.org/environmental-impacts-of-dams

Section 4

(MWI Report)	Weiskel, P.K., S.L. Brandt, L.A. DeSimone, L.J. Ostiguy, and S.A. Archfield. “Indicators of Streamflow Alteration, Habitat Fragmentation, Impervious Cover, and Water Quality for Massachusetts Stream Basins: U.S. Geological Survey Scientific-Investigations Report 2009–5272.” 2010. 70p.
(USGS Concord River Basin Report)	Barlow, L.K., L.A. DeSimone, and L.M. Hutchins. “Water Withdrawals, Use, and Wastewater Return Flows in the Concord River Basin, Eastern Massachusetts, 1996-2000: U.S. Geological Survey Scientific-Investigations Report 2008-5158.” 2009. 134p.
(MassDEP I/I Guidelines)	MassDEP. “Guidelines for Performing Infiltration/Inflow Analyses and Sewer Evaluation Survey.” 1993. 81p.
(USGS SYE Report)	Archfield, S.A., R.M. Vogel, P.A. Steeves, S.L. Brandt, P.K. Weiskel, and S.P. Garabedian. “The Massachusetts Sustainable-Yield Estimator: A decision-support tool to assess water availability at ungaged stream locations in Massachusetts, Scientific Investigations Report 2009-5227.” 2010. 41p.
(Nyman, D.C., 2002)	Nyman, David C. “Estimating Average Annual Recharge: Development of a Methodology for Application in Massachusetts.” Presentation to Storm Water Infiltration and Groundwater Recharge, a Conference on Reducing Runoff while Maintaining Water Quality. Southern New England Chapter of the Soil and Water Conservation Society, Worcester, MA. May 2002.
(AWWA Drinktap Website)	American Water Works Association. Drinktap. Web. Accessed June 11, 2012. http://www.drinktap.org/consumerdnn/default.aspx?tabid=85
(Energy Star Website)	Energy Star. Web. Website accessed June 1, 2012. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

Section 5

(8-1H Pump Test Report)	Couture, Thomas. Tighe & Bond, Inc. Letter regarding “Pumping Test Report, Increased Safe Yields, Amherst Wells #3 and #4, Revised Zone II, PWS-ID# 1008000 GW03, 04.” 8-1H. May 31, 1995. 82p.
(Amherst Interconnections)	Amherst Utility System Viewer. Amherst GIS. May 11, 2012. 2p.
(Amherst WMA Permit)	Cabral, Deirdre. MassDEP. “Water Management Act Permit Amendment for Amherst DPW Water Division.” Permit #9P-1-06-008.01 for 1994-2013. October 15, 2010. 20p.
(Amherst WMA Registration)	Haas, Glenn. MassDEP. “Water Management Act Registration for Amherst DPW Water Division.” Registration #10600802 for 2008-2017. December 31, 2007. 8p.
(Amherst ASRs)	Amherst DPW Water Division. “Public Water Supply Annual Statistical Report” Reporting Years 2000-2011. PWS ID 1008000.
(Amherst 2009 OSRP)	Town of Amherst. “Open Space and Recreation Plan 2009 Update.” 2009. 105p.
(Nielsen Property Memo 2012)	McClellan, John. Tighe & Bond, Inc. Memorandum to Amy Lane/Town of Amherst regarding Nielsen Property Well Development Timeline and Costs.” May 8, 2012. 12p.
(Hadley ASR 2011)	Hadley Highway and Water Department. “Public Water Supply Annual Statistical Report Reporting Year 2011.” PWS ID 1117002. 2011. 38p.
(Belchertown ASR 2011)	Belchertown Water District. “Public Water Supply Annual Statistical Report Reporting Year 2011.” PWS ID 1024000. 2011. 39p.
(S. Hadley MWRA Agreement)	Gillen, Michele. MWRA. Letter from MWRA to DWWD regarding “Water Supply Continuation Agreement MWRA Contract No. W289.” April 11, 2011. 5p.

Section 6

(Danvers 2010 Water Quality Report)	Town of Danvers Water Division. "Annual Water Report – Water Testing Performed in 2010." PWS ID#: 307 1000. 6p.
(Danvers WMA Permit)	MassDEP. "Modified Water Management Act Permit for Danvers Water Department." Permit #9P-3-17-071.01 for 1991-2009. March 23, 2006. 18p.
(Danvers WMA Settlement)	Lehane, Michael. Murphy, Hesse, Toomey & Lehane, LLP. Letter from Town Counsel to Danvers Town Manager regarding "Final Decision approving Settlement Agreement." March 31, 2006. 28p.
(Danvers ASRs)	Danvers Water Department. "Public Water Supply Annual Statistical Report" Reporting Years 2000-2011. PWS ID 3071000.
(Danvers 2009 OSRP)	Town of Danvers. "2009 Open Space and Recreation Plan." 2009. 125p.
(Earth Tech Report 2011)	Earth Tech, Inc. "Test Well Investigation and Preliminary Prolonged Pumping Tests: Danvers State Hospital, Danvers, MA and Richardson Property, Middleton, MA." October 2002. 131p.
(R. Rodgers Interview)	Adamski, Tracy; Czepiga, Page. Tighe & Bond, Inc. Memorandum regarding Telephone Interview with Rick Rodgers, Town Engineers. June 14, 2012. 2p.
(MWRA Email)	Heidell, Pam. MWRA Policy and Programming Manager. Email correspondence from Pam Heidell to Page Czepiga of Tighe & Bond regarding approximate MWRA Entrance Fees. June 1, 2012. 1p.
(MWRA Rate Interview)	Hiedell, Pamela. "MWRA Water Rate." Personal Communication. 25 June 2012.

Section 7

(DWWD IBTA Approval) Massachusetts Water Resources Commission. "Interbasin Transfer Application: Dedham-Westwood Water District Proposed Fowl Meadow Well, WRC Decision." 1992. 15p.

(DWWD WMA Permit) Gottlieb, Andrew. MassDEP. "Water Management Act Permit for Dedham-Westwood Water District." Permit #9P-3-19-073.01 for 1993-2010. November 2, 1993. 8p.

(DWWD MWRA Agreement) Gillen, Michele. MWRA. Letter from MWRA to DWWD regarding "Water Supply Continuation Agreement MWRA Contract No. W289." April 11, 2011. 5p.

(DWWD WMA Neponset) Haas, Glenn. MassDEP. "Water Management Act Registration for Boston Harbor for the Dedham -Westwood Water District." Registration #31907301 for 2008-2017. December 31, 2007. 8p.

(DWWD WMA Charles) Haas, Glenn. MassDEP. "Water Management Act Registration for Charles River for the Dedham-Westwood Water District." Registration #31707101 for 2008-2017. December 31, 2007. 8p.

(DWWD ASRs) Dedham-Westwood Water District. "Public Water Supply Annual Statistical Report" Reporting Years 2000-2011. PWS ID 3073000.

(Dedham OSRP 2010) Town of Dedham. "Open Space and Recreation Plan." August 2010. 223p.

(Dedham I/I Website) Town of Dedham. Infiltration and Inflow. Web. Accessed June 2012. http://www.dedham-ma.gov/index.cfm?pid=15087

Section 8

(Alternate Supply Report 2010)	Tata & Howard. "Alternate Water Supply Study, Shrewsbury, Massachusetts." January 2010. 57p.
(Shrewsbury WMA Permit)	Stone, Marielle. MassDEP. "Water Management Act Permit for Shrewsbury Water Department." Permit #9P4-2-12-271.01 for 2010-2029. February 26, 2010. 28p.
(Shrewsbury ASRs)	Shrewsbury Water Department. "Public Water Supply Annual Statistical Report" Reporting Years 2000-2011. PWS ID 2271000.
(2010 Alternative Supply Report)	Tata & Howard. "Alternate Water Supply Study, Shrewsbury, Massachusetts." January 2010. 57p.

Appendix E –

Qualitative Assessment of Water Offsets

Appendix E
Indirect Offset Volume Calculation Methodology
Qualitative Assessment Approach

Introduction:

The MassDEP Draft SWMI framework requires mitigation of impacts commensurate with the impact from additional withdrawals and proposes a system of offset/mitigation actions. The framework anticipates PWS's will select from a list of offset/mitigation actions to address required Special Conditions for the permitting of withdrawals. Potential mitigation actions include practices for which a PWS can directly estimate a volume or flow that can be used to offset a proposed withdrawal. Potential actions also include measures that do not lend themselves to a direct flow conversion. This Appendix describes a qualitative method for rating this latter set of offset tools, and converting that rating to an allowable offset flow for mitigation credit under the framework. This method is referred to in the accompanying report as the "Indirect Offset Volume Calculation."

Offset /Mitigation Actions Included in this Method

The practices considered for evaluation by this method are listed in Table E-1. These measures are introduced and defined in Section 4 of the report. Specific conditions relative to the evaluation and scoring of these actions are discussed below.

Table E-1. Offset/Mitigation Actions Subject to Indirect Offset Calculation

Category	Offset/Mitigation Action
Stormwater Management	Stormwater Utility Implement MS4 Requirements
Wastewater Improvement	Private inflow removal program Sewer bank (I/I offset) program Wastewater enterprise account
Habitat Improvement	Fish ladder Dam removal Acquire property in Zone II Restore stream buffer Acquire property for other natural resource protection Establish Culvert Rating Stream Teams Culvert replacement to meet stream crossing standards Natural streambank restoration Other habitat restoration project Establish/contribute to aquatic habitat restoration fund Increase watershed tree canopy
Demand Management	Municipal Building Retrofits Pistol grip hose nozzles program Water bank Water supply enterprise account Water conservation rates Monthly billing/remote meters Conservation education/outreach

Evaluation Matrix
The indirect offset volume calculation methodology uses a qualitative assessment scoring system to quantify the relative benefits of a particular offset action. Actions are considered for their potential contribution to augmenting stream flow, augmenting recharge, improving water quality, improving habitat, or other benefit that would allow a withdrawal offset. Tables E-2 and E-3 of this appendix present a scoring matrix and related weighting factors table. The matrix consists of a qualitative scoring of offset actions, and corresponding flow offsets for those actions. The development of the scoring matrix is discussed below. Weighting factors are discussed in the subsequent subsection.

Briefly, the Indirect Offset Volume methodology computes a flow-offset credit based on a qualitative comparison of each management action to a theoretical "Benchmark Measure." In this case, the benchmark is a one-to-one ratio of streamflow augmentation to water withdrawal or a one-to-one ratio of demand reduction to water withdrawal. The assessment uses qualitative rating criteria and a scoring system to assign numerical values to reflect the relative extent to which each action meets those criteria. The final score (expressed as a percentage) is then multiplied by a selected maximum flow-offset allowance, to determine a numerical flow-offset for each action.

The following describes the steps in developing the evaluation, scoring, and conversion to a flow-offset number:

1. A theoretical 1:1 streamflow replacement, or a 1:1 demand reduction, is used as the benchmark for comparison of alternatives, and is assumed to attain a "perfect score," fully meeting all criteria under which the offset/mitigation actions are assessed.

2. For this rating matrix, a perfect score is assigned 50 points.

3. The total points are divided between three categories of criteria[1]:

    a. Flow management (either in-stream flow augmentation or demand reduction): 25 points.

       For evaluation in this matrix a management action can potentially either return flow to the stream, or reduce demand, but not both simultaneously. Each candidate action is therefore scored in only one of the columns in the matrix under this category. Each of the two categories therefore has a potential maximum score of 25 points.

    b. Aquatic habitat improvements (several subcategories): 20 points

[1] The study team has used its professional judgment to allocate points among criteria in the scoring matrix and to set the scoring system within each criterion, and to establish a base flow for allowable maximum offset volume. We anticipate this allocation of values will be reviewed and possibly refined in the course of finalizing the SWMI framework.

Sub-criteria under this category include improvements to in-stream water quality, stream corridor habitat, stream continuity (uninhibited wildlife movement), and coldwater fisheries. Each sub-category has equal weight in the matrix, so each is worth a potential 5 points. A management action can offer benefits in one or more of these categories, so the total potential habitat score is 20 points.

However, note that if the stream under study has no coldwater fishery, all scoring within this subcategory would be set equal to zero. In such a case, the total possible habitat improvement score would be 15 points.

c. Water supply protection: 5 points.

Providing additional water supply protection is accredited a potential total of 5 points, and is included because a number of management actions have potential direct or indirect benefits for protecting the water supply as a sustainable source.

4. For each of the sub-criteria described above, a candidate offset/mitigation action is evaluated for whether it has no benefit for that criterion, has an indirect benefit, or offers a direct benefit. As an example, performing a streambank restoration project results in a direct habitat improvement, while putting money into a restoration fund for some undefined future project is considered an indirect improvement. For the scoring system offered here, an indirect benefit is assigned 40% of the maximum possible score for the category.[2] A direct benefit receives the maximum score. These scoring values assigned to no-benefit/indirect-benefit/direct-benefit allocations are labeled near the top of each column in Table E-2.

   The study team evaluated each management action for each sub-criterion, using the indicated scoring values, to develop a raw score for each potential offset/mitigation action. These are listed in Table E-2. The only values that would change on a case by case basis would be the raw scores in the Coldwater Fishery Resource (CFR) Improvement sub-criterion, which would either be the values shown if the subject stream is a CFR, or be set to zero if it is not a CFR.

5. For each offset/mitigation action, the raw scores for each category are summed, to obtain a subtotal raw score.

6. This raw score is then adjusted by a weighting factor to obtain a final score. Essentially, the weighting factors provide adjustments for the relative quantity of mitigation (for example, total length of streambank restoration, relative to total length of streambank that is currently in need of restoration) and for its location relative to the proposed withdrawal (for example, upstream versus downstream of the withdrawal). The weighting factors are discussed in greater detail below under **Weighting Factors**. The adjusted value, or Final Score, reflects the relative value of each potential offset/mitigation action.

[2] See Footnote 1.

7. The total score, which will always be less than a "perfect" 50 points, is then converted to an Offset Rate. This is simply accomplished by dividing the total (adjusted) score by 50, and expressing the result as a percentage.

8. This Offset Rate is multiplied by a base flow value that represents the Maximum Allowable Offset under this element of the offset credit program. For purposes of this study, the study team has set the maximum allowable offset *for qualitatively assessed mitigation actions only* as 5% of the natural August median flow in the subject streams.[3] Subject streams include the streams located in the same subbasins as the groundwater withdrawals subject to the WMA and SWMI framework. If there is more than one subject stream/subbasin, then the natural August median flow to be used in the spreadsheet shall be calculated as follows:

    - Nested subbasins – If the groundwater withdrawals are located in more than one subbasin and the subbasins are nested (e.g., the median flow in the most downgradient subbasin is a cumulative flow from the upgradient subbasins) then the natural August median flow from the most downgradient subbasin and stream shall be used.

    - Unconnected subbasins – If the groundwater withdrawals are located in more than one subbasin and the subbasins are not connected (e.g., different headwater streams), then the natural August median flows from each subbasin and stream shall be summed for use in the spreadsheet.

    - Combination of nested and unnested basins – If the withdrawals are located in both nested and unnested subbasins, each nested basin natural August median flow is determined from the most downgradient of this set of basins, and that quantity is added to the sum of flows for the unnested basins.

    Once this quantity is determined, to complete the offset calculation, the PWS must enter the total value for the natural August median flow into the spreadsheet, and compute the Maximum Allowable Offset by multiplying that value by 5%.

9. The Maximum Allowable Offset is multiplied by the computed Offset Rate (%) to obtain the Indirect Offset Volume for each offset/mitigation action proposed by the PWS.

10. The Indirect Offset Volumes for all proposed actions are summed to obtain a total computed offset. This computed quantity must be compared to two other metrics to arrive at the offset credit for a particular withdrawal:

    a. The total allowed offset (sum of all potential actions) cannot exceed the maximum base value of 5% of natural August median flow.

[3] See Footnote 1.

b. The total allowed offset for <u>*qualitatively assessed actions*</u> cannot exceed a percentof the requested increase in withdrawal. This maximum percent is to be determined. The remaining percent needs to be addressed through measurable measures to augment streamflow/groundwater recharge or reduce demand.

Table E-2 as presented in this Appendix has been completed assuming coldwater fisheries are present, and with "placeholder" values for natural August median flow and a requested withdrawal increase. These values would need to be replaced with water supply specific figures to determine allowable offsets for a particular withdrawal application. In addition, if any offset action is not considered for a particular application, its corresponding row should be deleted from the worksheet, or the criteria scores set to zero, in order to compute a valid value for total allowed offset (sum of all actions considered).

Weighting Factors

As described above, the raw score developed from assessment of an offset/mitigation action is multiplied by a weighting factor to obtain a final score. Essentially, the weighting factors provide adjustments for the relative quantity of mitigation and for the location of mitigation relative to the proposed withdrawal. The computation of these weighting factors is described below. Table E-3 presents the spreadsheet for computing the weighting factors that are in turn entered on the matrix in Table E-2. Note that for this Appendix, placeholder values of 1.00 are inserted in the rows corresponding to offset/mitigation actions that have variable factors (highlighted cells). These factors will need to be replaced with appropriate numbers at the time of a specific application.

<u>Adjustment for Quantity of Mitigation</u>

A number of the mitigation actions are general in nature, and do not entail physical "on the ground" improvements that contribute to their value as offsets. For these measures, the adjustment factor for "quantity" is set at 1.0. These measures include:

Category	Offset/Mitigation Action
Stormwater Management	Stormwater Utility Implement MS4 Requirements
Wastewater Improvement	Private inflow removal program Wastewater enterprise account
Habitat Improvement	Establish Culvert Rating Stream Teams Establish/contribute to aquatic habitat restoration fund
Demand Management	Water bank Water supply enterprise account Water conservation rates Monthly billing/remote meters Conservation education/outreach

The remaining actions listed in Table E-1 are activities that could be exercised watershed-wide (in which case, maximum credit would be warranted), or that could be implemented in a limited way, warranting only partial credit. For example, if the subject stream associated with a withdrawal request has a total of 6 miles of severely eroded banks, and natural restoration measures are applied to 2 miles of stream, then only 33% of potential mitigation would be implemented. In such a scenario, the study team proposes adjusting the maximum score in proportion to actual results versus potential mitigation. In this case, the adjustment factor would be 0.33. Table E-3 briefly identifies the criteria for adjustment factors for each of the offset/mitigation actions that have a "quantity" component. These factors are discussed further below.

Sewer Bank (I/I offset) Program

Under this program, communities may provide for banking of funds based on differing I/I removal ratios (see discussion in Section 4 of the report). For the scoring methodology, the following adjustment factors are proposed:

Removal Ratio	Adjustment Factor
10:1	1.00
4:1	0.75
2:1	0.50
1:1	0.25

Fish Ladder

The installation of a fish ladder provides access to targeted species to additional habitat range upstream of the structure (usually a dam) surmounted by the ladder. If the subject stream has multiple dams, but the mitigation program does not provide fish ladders at every structure, then a scoring adjustment is warranted. The proposed metric is the total miles of stream made accessible by the mitigation action, divided by the total length of the stream reach.

For this action, and other actions involving stream reach improvements, the "total length of reach" is defined as the length of the stream's main stem upstream of the proposed mitigation action, plus the length of the main stem downstream, to the point of confluence with another stream of the same Strahler Stream Order (that is, the point where stream order increases by one level).

Dam Removal

The removal of a dam provides access to a full range of aquatic wildlife species (and improved access for terrestrial species as well) to the watershed upstream of the dam location. However, if a stream has multiple dams, then removing only a portion of those structures would not accrue the full benefits of a complete stream restoration, and a scoring adjustment is warranted. The proposed metric for this action is the total miles of undammed stream resulting from the action, divided by the total miles of reach. The "total undammed miles" is the length of the stream's main stem upstream of the structure made accessible by dam removal, plus the total length of reach downstream to the nearer of the next dam, or the confluence with a stream of the same Strahler Stream Order. The "total reach" measurement is the same as that for the fish ladder criteria.

Acquisition of Property in a Zone II

If the entire Zone II is not under full control of the water supplier, then acquisition of property is considered for offset credit. As purchase of only part of the unprotected Zone II may be proposed, the proposed adjustment factor is equal to the area of acquisition, divided by the area of the Zone II currently not under direct control of the PWS.

Acquisition of Property for Natural Resource Protection

For this particular action, the value of the offset may depend on the size of the acquisition, the natural resource being protected, and the extent of any associated project activities to protect, restore, or enhance habitat. For this action, the adjustment factor must be negotiated as part of the withdrawal permit review process.

Culvert Replacement to Meet Massachusetts River and Stream Crossing Standards

Culvert replacement improves stream habitat connectivity, and also has benefits relative to long-term channel stability and stream functions related to sediment and debris transport. A particular offset action may propose replacing one or more of a larger number of culverts that are candidates for replacement to correct for moderate to severe barriers in the watershed of a particular stream reach. For this action, the adjustment factor equals the area of watershed made accessible by a culvert replacement, divided by the total area of watershed upstream of the culvert. To determine the area made accessible, the proponent of the action would need to document whether additional barrier culverts are located in the watershed upstream of the proposed replacement. If there are additional barriers, then the corresponding subwatersheds shall not be included in the total area made accessible. "Qualifying culverts" are those rated as moderate to severe barriers under the Massachusetts River and Stream Continuity Project.

Stream Buffer Restoration

The restoration of degraded stream buffer improves stream corridor habitat and qualifies for consideration as an offset. A particular action may involve restoration of only a portion of the stream corridor where buffer has been historically impacted by human activity. To qualify for this credit, the PWS would need to document the extent of degraded buffer at the time of application, and indicate the percentage of this buffer that will be restored in the contemplated mitigation program. That percentage would be used to adjust the scoring in the evaluation matrix. The basis for this metric would be the length of proposed buffer restoration, divided by the length of impacted buffer for the subject stream reach. Reach length is defined the same as for the fish ladder action (main stem length from headwaters to downstream confluence with stream of same Strahler Stream Order). Agency consultation would be required to confirm the PWS assessment of total length of impacted buffer, and the parameters for restoration.

Natural Streambank Restoration

The metric for credit for this action is similar to the Stream Buffer Restoration action. The PWS should document the total length of impacted stream within the subject reach. The adjustment factor would be the total length of bank restored, divided by the total length of bank requiring restoration. Agency consultation would be required to confirm the PWS assessment of total length of impacted streambank, and the parameters for restoration.

Other Aquatic Habitat Restoration Project

For this particular action, the value of the offset may depend on the natural resource being restored, the species that would benefit, the location of the restoration project, and the extent of any associated project activities to protect, restore, or enhance habitat. For this action, the adjustment factor must be negotiated as part of the withdrawal permit review process.

Increase Watershed Tree Canopy

The provision of urban trees and the reforestation of open land may be considered for offset credit. However, this credit should not be applied to a land area already covered by another offset credit; for example, an area where impervious surface is removed and replaced with landscaping receives a direct offset volume credit (see Section 4 of the report) and would not be available for tree canopy credit.

The USGS study, *Factors Influencing Riverine Fish Assemblages* (2011-5193) presents a regression equation that relate relative fish abundance to alterations of natural August median flows through groundwater withdrawal and also to percent forest cover. That equation shows that an increase in withdrawal by 1% is associated with a decrease in relative fish abundance by 0.9% (holding all other parameters constant). The equation also shows that increasing forest cover by 0.75% is associated with an increase in relative fish abundance of approximately 0.9%. Therefore, the evaluation process in the accompanying matrix proposes a metric based on increasing tree canopy in the proportion of 0.75% increase in forest for each 1% increase in withdrawal. If a lesser increase is proposed, then a proportional adjustment is made in the rating. That is, the adjustment factor equals the proposed increase in percent tree cover (including both urban tree planting and reforestation planting) divided by the target percentage. The target percentage is 0.75% for each percentage increase in withdrawal.

Municipal Building Retrofit

Where a community proposes a municipal building retrofit program to replace old water fixtures with low water use fixtures, but cannot readily document the water savings for a Direct Offset Volume, it may compute an Indirect Offset using the evaluation matrix presented in Table E-2. The scoring adjustment for building retrofits is based on the total number of buildings owned or leased by the municipality that are eligible for retrofitting (i.e., not previously retrofitted). The adjustment factor equals the total number of buildings retrofitted, divided by the total number of buildings requiring retrofit. Buildings included in the proposed retrofit program must be fully retrofitted.

Pistol Grip Hose Nozzles Program

The adjustment for the pistol grip program is based on the total number of households in the water supply service area. The adjustment is equal to the number of households provided with pistol grips divided by the total number of households.

<u>Adjustment for Location</u>

The benefits of some of the offset/mitigation measures may vary relative to their location with respect to a proposed withdrawal. The actions are subject to the adjustments as indicated in the notes on Table E-3. The evaluation process proposed in this Appendix uses the same weighting for watershed location as used for Direct Offset Volume measures, described in Section 4 of the report, with one refinement.

A number of the Indirect Offset measures are general programs, are not location specific, or typically do not involve "on the ground" mitigation activities. These activities are assigned a location factor equivalent to the category "within the watershed basin, but outside of the sub-basin" with an adjustment factor of 0.25. These actions include the following:

Category	Offset/Mitigation Action
Stormwater Management	Stormwater Utility Implement MS4 Requirements
Wastewater Improvement	Private inflow removal program Sewer bank (I/I offset) program Wastewater enterprise account
Habitat Improvement	Establish Culvert Rating Stream Teams Establish/contribute to aquatic habitat restoration fund
Demand Management	Municipal building retrofits Pistol grip hose nozzles program Water bank Water supply enterprise account Water conservation rates Monthly billing/remote meters Conservation education/outreach

Table E-2. Indirect Offset Volume Calculation Scoring Matrix

Offset/Mitigation Action	Flow Management (up to 25 points) Action can qualify as instream or demand, but not both: Instream Flow Benefit or	Demand Reduction	Aquatic Habitat Improvements (up to 20 points) Action can qualify in one or more categories: Instream Water Quality Improvement	Stream Corridor Habitat Improvement	Stream Continuity Improvement	Cold Water Fishery Improvement (change all to 0 if no CFR)	Water Supply Protection Benefit (up to 5 points)	Weighting and Total Score: Raw Score Subtotal	Weighting factor from Table E-3	Total Score	Offset Computation: Offset Rate (= total score/50)	August median flow (gpd)	Maximum Allowable Offset for Qualitatively Assessed Actions	Computed Indirect Offset Volume (gpd)
	0 = no increase 10 = indirectly increases 25 = directly increases	0 = no reduction 10 = indirectly reduces 25 = directly reduces	0 = no quality benefit 2 = indirect benefit 5 = directly improves	0 = no improvement 2 = indirect improvement 5 = direct improvement	0 = no improvement 2 = indirect improvement 5 = direct improvement	0 = no improvement 2 = indirect improvement 5 = direct improvement	0 = no increase 2 = indirect protection 5 = direct increase prot.	RS	W	= RS x W	Percentage of "maximum allowable offset"	Enter figure for stream location under study	5% of August median flow	offset = offset rate x maximum allowable offset
BENCHMARK MEASURES														
1:1 streamflow replacement										**50.00**	**100%**			
1:1 demand offset										**50.00**	**100%**			
Stormwater Management														
Stormwater Utility	10	0	2	0	0	0	0	12	0.25	3.00	**6%**	1,000,000	50,000	**3,000**
Implement MS4 Requirements	10	0	2	0	0	0	0	12	0.25	3.00	**6%**	1,000,000	50,000	**3,000**
Wastewater Improvement														
Private inflow removal program	10	0	2	0	0	0	0	12	0.25	3.00	**6%**	1,000,000	50,000	**3,000**
Sewer bank (I/I offset) program	10	0	2	0	0	0	0	12	0.25	3.00	**6%**	1,000,000	50,000	**3,000**
Wastewater enterprise account	0	10	2	0	0	0	0	12	0.25	3.00	**6%**	1,000,000	50,000	**3,000**
Habitat Improvement														
Fish ladder	0	0	0	5	5	0	0	10	1.00	10.00	**20%**	1,000,000	50,000	**10,000**
Dam removal	0	0	5	2	5	5	0	17	1.00	17.00	**34%**	1,000,000	50,000	**17,000**
Acquire property in Zone II	0	0	0	0	0	0	5	5	1.00	5.00	**10%**	1,000,000	50,000	**5,000**
Restore stream buffer	0	0	2	5	2	5	0	14	1.00	14.00	**28%**	1,000,000	50,000	**14,000**
Acquire property for other natural resource protection	0	0	0	2	0	0	0	2	1.00	2.00	**4%**	1,000,000	50,000	**2,000**
Establish Culvert rating Stream Teams	0	0	0	2	2	2	0	6	0.25	1.50	**3%**	1,000,000	50,000	**1,500**
Culvert replacement to meet stream crossing standards	0	0	2	5	5	5	0	17	1.00	17.00	**34%**	1,000,000	50,000	**17,000**
Natural streambank restoration	0	0	2	5	2	5	0	14	1.00	14.00	**28%**	1,000,000	50,000	**14,000**
Other habitat restoration project	0	0	2	5	2	5	0	14	1.00	14.00	**28%**	1,000,000	50,000	**14,000**
Establish/contribute to aquatic habitat restoration fund	0	0	0	2	0	2	0	4	0.25	1.00	**2%**	1,000,000	50,000	**1,000**
Increase watershed tree canopy	0	0	5	0	0	0	0	5	1.00	5.00	**10%**	1,000,000	50,000	**5,000**
Demand Management														
Municipal building retrofits	0	10	0	0	0	0	0	10	0.25	2.50	**5%**	1,000,000	50,000	**2,500**
Pistol grip hose nozzles program	0	10	0	0	0	0	0	10	0.25	2.50	**5%**	1,000,000	50,000	**2,500**
Water bank	0	10	0	0	0	0	2	12	0.25	3.00	**6%**	1,000,000	50,000	**3,000**
Water supply enterprise account	0	10	0	0	0	0	2	12	0.25	3.00	**6%**	1,000,000	50,000	**3,000**
Water conservation rates	0	10	0	0	0	0	0	10	0.25	2.50	**5%**	1,000,000	50,000	**2,500**
Monthly billing/remote meters	0	10	0	0	0	0	0	10	0.25	2.50	**5%**	1,000,000	50,000	**2,500**
Conservation education/outreach	0	10	0	0	0	0	0	10	0.25	2.50	**5%**	1,000,000	50,000	**2,500**

Maximum allowable offset	50,000	A
Sum of all offsets (gpd)	131,000	B
Requested withdrawal increase (gpd)	100,000	
Percent of withdrawal increase (gpd) (to be determined)	TBD	C
Allowed offset = smaller of A, B or C (gpd)	50,000	

Numbers in Black are default values
Numbers in Red must be changed to reflect specific project conditions
Numbers in Blue are computed by spreadsheet

Table E-3. Indirect Offset Volume Calculation Weighting Factors

Mitigation/offset action	Quantity of Mitigation Adjustment Description	Factor Q	Location Adjustment See notes. Factor L	Weighting factor Compute: W = Q x L
Stormwater Management				
Stormwater Utility	N/A	1.00	0.25	0.25
Implement MS4 Requirements	N/A	1.00	0.25	0.25
Wastewater Improvement				
Private inflow removal program	N/A	1.00	0.25	0.25
Sewer bank (I/I offset) program	factor varies with I/I ratio see notes	1.00	0.25	0.25
Wastewater enterprise account	N/A	1.00	0.25	0.25
Habitat Improvement				
Fish ladder	New miles accessible to fish/total miles of reach	1.00	1.00	1.00
Dam removal	New miles undammed/total miles of reach	1.00	1.00	1.00
Acquire property in Zone II	Acreage of purchase/acreage of unprotected Zone II	1.00	1.00	1.00
Restore stream buffer	Linear feet of bank buffered/total linear feet of unbuffered bank on reach	1.00	1.00	1.00
Acquire property for other natural resource protection	Negotiate with agency, based on value of resource being protected and the specific mitigation proposal	1.00	1.00	1.00
Culvert rating stream teams	N/A	1.00	0.25	0.25
Culvert replacement to meet stream crossing standards	Area of watershed made accessible by replacement culvert(s)/area of watershed of the reach	1.00	1.00	1.00
Natural streambank restoration	Linear feet of restoration/linear feet of degraded streambank on reach	1.00	1.00	1.00
Other habitat restoration project	Negotiate with agency, based on value of resource being protected and the specific mitigation proposal	1.00	1.00	1.00
Establish/contribute to aquatic habitat restoration fund	N/A	1.00	0.25	0.25
Increase watershed tree canopy	% of watershed converted to tree canopy/target value: Target value = 0.75% increase in tree canopy cover for each 1% increase in withdrawal	1.00	1.00	1.00
Demand Management				
Municipal building retrofits	Number of municipal buildings retrofitted/number of buildings needing retrofit	1.00	0.25	0.25
Pistol grip hose nozzles program	Number of nozzles issued under program/number of service area households	1.00	0.25	0.25
Water bank	N/A	1.00	0.25	0.25
Water supply enterprise account	N/A	1.00	0.25	0.25
Conservation water rates	N/A	1.00	0.25	0.25
Monthly billing/remote meters	N/A	1.00	0.25	0.25
Water conservation	N/A	1.00	0.25	0.25

Numbers in Black are default values
Numbers in Red must be changed to reflect specific project conditions
Numbers in Blue are computed by spreadsheet

Sewer Bank Factors		
	10:1 I/I removal ratio	1.00
	4:1 I/I removal ratio	0.75
	I/I removal ratio	0.50
	1:1 I/I removal ratio	0.25

"Reach-length" based adjustment factors: Length of main stem above the proposed mitigation, plus length of main stem downstream to confluence that results in next level of Strahler stream order.

Location Adjustment Factors:		
	Upstream of withdrawal or in Zone II	1.00
	Subwatershed basin, downstream	0.75
	Watershed basin	0.25
	Outside watershed basin	0.10
	General measure, with no relation to location	0.25

Appendix F –

Amherst Credit Worksheets

SWMI Decision Support Pilot Tool
Worksheet Summary
Town of Amherst
DRAFT 6/27/2012

	Wastewater Category	Total Number of Projects	Total Wastewater Flow (gpd)	Total Flow Offset Volume (gpd)
1	Septic Systems	10	74,820	18,705
2	Groundwater Discharges	0	0	0
3	Infiltration	2	845,258	105,657
4	Inflow	1	1,927	241
5	Water Reuse - Irrigation	1	120,000	120,000

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Septic Systems
Town of Amherst
DRAFT 6/27/2012

10	Total Number of Projects
18,705	Total Flow Offset Volume (gpd)
74,820	Total Residential WW Flow (gpd)
0	Total Non-Residential WW Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.
If residential water use information is not available, assume 65 gpd per capita.
If non-residential water use information is not available, assume 50% of Title 5 flows.
Use 85% for residental and 90% for non-residential as default recharge factor unless industry specefic data is known.

		Residential Portion					Non-Residential Portion							
Proj. No.	Location	Average Household Occupants	Per capita water use (gpd)	Recharge Factor	No. of Parcels	Subtotal Wastewater Flow (gpd)	Total Water Use (gpd)	Recharge Factor	Subtotal Wastewater Flow (gpd)	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	3.00	65.0	85%	150	24,863	1,250	90%	1,125	25,988	100%	10%	2,599	
														General: Study Areas 1, 11B, and 15 were not included as they are already sewered. Study Areas 2, 6, and 15 were not included as they are proposed to be sewered.
Study Area 3 - Southeast St	Watershed Basin	2.44	65.0	85%	65	8,763		90%	0	8,763	100%	25%	2,191	
Study Area 4 - Bay Road	Watershed Basin	2.44	65.0	85%	25	3,370		90%	0	3,370	100%	25%	843	
Study Area 5 - Hulst Road	Watershed Basin	2.44	65.0	85%	110	14,829		90%	0	14,829	100%	25%	3,707	
Study Area 7 - Shays Street	Watershed Basin	2.44	65.0	85%	20	2,696		90%	0	2,696	100%	25%	674	
Study Area 8 - High Point Drive	Watershed Basin	2.44	65.0	85%	60	8,089		90%	0	8,089	100%	25%	2,022	
Study Area 9 - Market Hill Road	Watershed Basin	2.44	65.0	85%	45	6,066		90%	0	6,066	100%	25%	1,517	
Study Area 10 - Leverett Road	Watershed Basin	2.44	65.0	85%	65	8,763		90%	0	8,763	100%	25%	2,191	
Study Area 11A - Montague Road	Watershed Basin	2.44	65.0	85%	45	6,066		90%	0	6,066	100%	25%	1,517	
Study Area 12 - Meadow Street	Watershed Basin	2.44	65.0	85%	25	3,370		90%	0	3,370	100%	25%	843	
Study Area 13 - Northeast Street	Watershed Basin	2.44	65.0	85%	95	12,807		90%	0	12,807	100%	25%	3,202	
11	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
12	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
13	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
14	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
15	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
16	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
17	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
18	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
19	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
20	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
21	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
22	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
23	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
24	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
25	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Groundwater Discharges
Town of Amherst
DRAFT 6/27/2012

Summary:
0 Total Number of Projects
0 Total Flow Offset Volume (gpd)
0 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	1,000	100%	10%	100	
1	Select Location		100%	Select Location	Select Location	
2	Select Location		100%	Select Location	Select Location	
3	Select Location		100%	Select Location	Select Location	
4	Select Location		100%	Select Location	Select Location	
5	Select Location		100%	Select Location	Select Location	
6	Select Location		100%	Select Location	Select Location	
7	Select Location		100%	Select Location	Select Location	
8	Select Location		100%	Select Location	Select Location	
9	Select Location		100%	Select Location	Select Location	
10	Select Location		100%	Select Location	Select Location	
11	Select Location		100%	Select Location	Select Location	
12	Select Location		100%	Select Location	Select Location	
13	Select Location		100%	Select Location	Select Location	
14	Select Location		100%	Select Location	Select Location	
15	Select Location		100%	Select Location	Select Location	
16	Select Location		100%	Select Location	Select Location	
17	Select Location		100%	Select Location	Select Location	
18	Select Location		100%	Select Location	Select Location	
19	Select Location		100%	Select Location	Select Location	
20	Select Location		100%	Select Location	Select Location	
21	Select Location		100%	Select Location	Select Location	
22	Select Location		100%	Select Location	Select Location	
23	Select Location		100%	Select Location	Select Location	
24	Select Location		100%	Select Location	Select Location	
25	Select Location		100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Infiltration
Town of Amherst
DRAFT 6/27/2012

Summary:
2 Total Number of Projects
105,657 Total Flow Offset Volume (gpd)
845,258 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with P
Select location and project status from the drop-dow
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Source Infiltration Rate (gpd)	Avg Annual WWTF Flow (any units)	Seasonal High GW WWTF Flow (same units as avg)	Average Annual Infiltration Rate (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	10,000	2.5	4.0	6,250	50%	75%	2,344	
Various	Watershed Basin				226,080	50%	25%	28,260	proposed - slip lining wish list provided by Amherst DPW Sewer Division dated June 4, 2012
2003-2011 Projects	Watershed Basin				619,178	50%	25%	77,397	Based on data provided by Amherst DPW Sewer Division dated June 1, 2012
3	Select Location				0	50%	Select Location	Select Location	
4	Select Location				0	50%	Select Location	Select Location	
5	Select Location				0	50%	Select Location	Select Location	
6	Select Location				0	50%	Select Location	Select Location	
7	Select Location				0	50%	Select Location	Select Location	
8	Select Location				0	50%	Select Location	Select Location	
9	Select Location				0	50%	Select Location	Select Location	
10	Select Location				0	50%	Select Location	Select Location	
11	Select Location				0	50%	Select Location	Select Location	
12	Select Location				0	50%	Select Location	Select Location	
13	Select Location				0	50%	Select Location	Select Location	
14	Select Location				0	50%	Select Location	Select Location	
15	Select Location				0	50%	Select Location	Select Location	
16	Select Location				0	50%	Select Location	Select Location	
17	Select Location				0	50%	Select Location	Select Location	
18	Select Location				0	50%	Select Location	Select Location	
19	Select Location				0	50%	Select Location	Select Location	
20	Select Location				0	50%	Select Location	Select Location	
21	Select Location				0	50%	Select Location	Select Location	
22	Select Location				0	50%	Select Location	Select Location	
23	Select Location				0	50%	Select Location	Select Location	
24	Select Location				0	50%	Select Location	Select Location	
25	Select Location				0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Inflow
Town of Amherst
DRAFT 6/27/2012

Summary:
1 Total Number of Projects
241 Total Flow Offset Volume (gpd)
1,927 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Average Annual Rainfall (in)	Design Storm Rainfall (in)	Design Storm Inflow (gal)	Average Annual Inflow Rate(gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	49.0	1.72	2000	156	50%	75%	59	
42 houses - Orchard Valley subdivision	Watershed Basin	48.0	1.72	25200	1,927	50%	25%	241	42 houses were identified as having illegal drains or sump pumps connected to the sewer systems
2	Select Location		1.72		0	50%	Select Location	Select Location	
3	Select Location		1.72		0	50%	Select Location	Select Location	
4	Select Location		1.72		0	50%	Select Location	Select Location	
5	Select Location		1.72		0	50%	Select Location	Select Location	
6	Select Location		1.72		0	50%	Select Location	Select Location	
7	Select Location		1.72		0	50%	Select Location	Select Location	
8	Select Location		1.72		0	50%	Select Location	Select Location	
9	Select Location		1.72		0	50%	Select Location	Select Location	
10	Select Location		1.72		0	50%	Select Location	Select Location	
11	Select Location		1.72		0	50%	Select Location	Select Location	
12	Select Location		1.72		0	50%	Select Location	Select Location	
13	Select Location		1.72		0	50%	Select Location	Select Location	
14	Select Location		1.72		0	50%	Select Location	Select Location	
15	Select Location		1.72		0	50%	Select Location	Select Location	
16	Select Location		1.72		0	50%	Select Location	Select Location	
17	Select Location		1.72		0	50%	Select Location	Select Location	
18	Select Location		1.72		0	50%	Select Location	Select Location	
19	Select Location		1.72		0	50%	Select Location	Select Location	
20	Select Location		1.72		0	50%	Select Location	Select Location	
21	Select Location		1.72		0	50%	Select Location	Select Location	
22	Select Location		1.72		0	50%	Select Location	Select Location	
23	Select Location		1.72		0	50%	Select Location	Select Location	
24	Select Location		1.72		0	50%	Select Location	Select Location	
25	Select Location		1.72		0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Water Reuse - Irrigation
Town of Amherst
DRAFT 6/27/2012

Summary:
1 Total Number of Projects
120,000 Total Flow Offset Volume (gpd)
120,000 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Total Wastewater Flow (gpd)	Allowable Volume Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	1,000	100%	1,000	
UMass _Irrigation	120,000	100%	120,000	Awaiting MassDEP Class A Reuse Permit
2		100%	0	
3		100%	0	
4		100%	0	
5		100%	0	
6		100%	0	
7		100%	0	
8		100%	0	
9		100%	0	
10		100%	0	
11		100%	0	
12		100%	0	
13		100%	0	
14		100%	0	
15		100%	0	
16		100%	0	
17		100%	0	
18		100%	0	
19		100%	0	
20		100%	0	
21		100%	0	
22		100%	0	
23		100%	0	
24		100%	0	
25		100%	0	

Potential Water Savings from Use of Aerator Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	2.2	0.8
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	8.8	3.2
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	7,966	2,897
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$15	
Cost per volume saved	$/gal/year			$ 0.0052
Application				
No. of households supplied with faucet aerators	households			8232
Total annual savings	gal/year			23,845,140
Total daily savings	gal/day			65,329
Total Cost				$ 123,480
Revenue Losses				
Rate	$/gal			$ 0.004
Revenue loss	$/year			$ 95,380.56

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,232 households on the public water supply in 1990 (calculated using same ratio as 2010 = 8,645 households on PWS/9,259 total households x 8,816 households in 1990 (from U.S, Census) = 8,232 households on PWS in 1990.

6. Amherst Water Division's rate as of July 1, 2012 will be $3.35 per 100 cubic feet. This calculates to $0.004 per gallon.

Potential Water Savings from Use of Low Flow Showerheads

	Units	Conventional Showerhead	Low Flow Showerhead	Savings
Assumptions				
Showerhead flow rate	gpm	6	2.5	3.5
Average shower length	min	8	8	
Average water consumption per shower	gal/shower	48	20	28
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual shower consumption per household	gal/household/year	43,450	18,104	25,346
Cost Estimates				
Cost per showerhead	each		$20	
Cost per Volume Saved	$/gal/year			$ 0.0008
Application				
No. of households supplied with low flow showerheads	households			8232
Total annual savings	gal/year			208,644,979
Total daily savings	gal/day			571,630
Total Cost				$ 164,640
Revenue Losses				
Rate	$/gal			$ 0.004
Revenue loss	$/year			$ 834,579.92

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm at 80 psi or 2.2 gpm at 60 psi.

3. Shower length from Aquacraft, 1999. Residential End Uses of Water Study (for American Water Works Association Research Foundation). Found average shower length of 8 minutes and 30 seconds in households with low flow showerheads and 6 minutes and 48 seconds in homes with conventional showerheads. Other sources ranged between 5 and 10 minutes.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,232 households on the public water supply in 1990 (calculated using same ratio as 2010 = 8,645 households on PWS/9,259 total households x 8,816 households in 1990 (from U.S, Census) = 8,232 households on PWS in 1990.

6. Amherst Water Division's rate as of July 1, 2012 will be $3.35 per 100 cubic feet. This calculates to $0.004 per gallon.

Potential Water Savings from Use of HE Toilets

	Units	Conventional Toilet	HE Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.28	2.22
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	6.464	11.211
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	5,851	10,148
Cost Estimates				
Cost per toilet	each		$75	
Cost per volume saved	$/gal/year			$ 0.0074
Application				
No. of households supplied with HE toilets	households			8232
Total annual savings	gal/year			83,539,959
Total daily savings	gal/day			228,877
Total Cost				$ 617,400
Revenue Losses				
Rate	$/gal			$ 0.004
Revenue loss	$/year			$ 334,159.84

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.28 gal/flush for new.

3. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,232 households on the public water supply in 1990 (calculated using same ratio as 2010 = 8,645 households on PWS/9,259 total households x 8,816 households in 1990 (from U.S, Census) = 8,232 households on PWS in 1990.

4. Amherst Water Division's rate as of July 1, 2012 will be $3.35 per 100 cubic feet. This calculates to $0.004 per gallon.

Potential Water Savings from Use of HE Washing Machines

	Units	Conventional Washer	Energy Star Washer	Savings
Assumptions				
Water used per load	gal/load	27	14	13
Average annual loads of laundry per household	loads/household/year	300	300	
Average annual washer water consumption	gal/household/year	8100	4200	3900
Cost Estimates				
Cost per washing machine	$/each		$100	
Cost per volume saved				$ 0.0256
Application				
No. of households supplied with HE washing machines				8232
Total annual savings				32,104,800
Total daily savings				87,958
Total Cost				$ 823,200
Revenue Losses				
Rate	$/gal			$ 0.004
Revenue loss	$/year			$ 128,419.20

Notes:

1. Water use and assumptions obtained from Energy Star, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,232 households on the public water supply in 1990 (calculated using same ratio as 2010 = 8,645 households on PWS/9,259 total households x 8,816 households in 1990 (from U.S, Census) = 8,232 households on PWS in 1990.

3. Amherst Water Division's rate as of July 1, 2012 will be $3.35 per 100 cubic feet. This calculates to $0.004 per gallon.

Potential Water Savings from Use of HE Dishwasher

		Conventional Dishwasher	Energy Star Dishwasher	Savings
Assumptions				
Water used per cycle	gal/cycle	6	4	2
Average annual cycles per household	cycles/household/year	215	215	
Average annual dishwasher water consumption	gal/household/year	1290	860	430
Cost Estimates				
Cost per dishwasher	$/each		$100	
Cost per volume saved	$/gal/year			$ 0.2326
Application				
No. of households supplied with HE dishwasher	households			8232
Total annual savings	gal/year			3,539,760
Total daily savings	gal/day			9,697.97
Total Cost				$ 823,200
Revenue Losses				
Rate	$/gal			$ 0.004
Revenue loss	$/year			$ 14,159.04

Notes:

1. Based on assumptions from Energy Star Dishwasher Calculator.

2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,232 households on the public water supply in 1990 (calculated using same ratio as 2010 = 8,645 households on PWS/9,259 total households x 8,816 households in 1990 (from U.S, Census) = 8,232 households on PWS in 1990.

3. Amherst Water Division's rate as of July 1, 2012 will be $3.35 per 100 cubic feet. This calculates to $0.004 per gallon.

Potential Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households	9259	9259	9259	9259	9259
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks			2		
June	weeks			4		
July	weeks			5		
August	weeks			4		
September	weeks			2		
Total	weeks	0	0	17	0	0
Water savings	gal/year	0	0	106,247,025	0	0
	gal/day	0	0	892,832	0	0
Revenue Losses						
Rate	$/gal	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004
Revenue loss	$/year	$ -	$ -	$ 424,988.10	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.
2. Outdoor watering restrictions would be applied to all households (9,259), whether or not on the public water supply. There were 9,259 households in Amherst in 2010 according to U.S. Census at factfinder2.census.gov. 8,645 households were estimated to be on the public water supply (2010 population served from ASR report divided by average household size from U.S. Census – 21,095/2.44 = 8,645).
3. Amherst Water Division's rate as of July 1, 2012 will be $3.35 per 100 cubic feet. This calculates to $0.004 per gallon.

Potential Residential Rainbarrels

	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			8645
Total annual water savings	gal/year		3,056,352
Total savings	gpd		16,793
Total Cost		$	2,074,800

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Appendix G –

Danvers Credit Worksheets

SWMI Decision Support Pilot Tool
Worksheet Summary
Town of Danvers/Middleton
DRAFT 6/27/2012

Wastewater Category		Total Number of Projects	Total Wastewater Flow (gpd)	Total Flow Offset Volume (gpd)
1	Septic Systems	7	301,322	107,980
2	Groundwater Discharges	2	61,500	46,125
3	Infiltration	4	249,954	14,340
4	Inflow	3	11,159	615
5	Water Reuse - Irrigation	0	0	0

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Septic Systems
Town of Danvers/Middleton
DRAFT 6/27/2012

7	Total Number of Projects
107,980	Total Flow Offset Volume (gpd)
301,322	Total Residential WW Flow (gpd)
0	Total Non-Residential WW Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.
If residential water use information is not available, assume 65 gpd per capita.
If non-residential water use information is not available, assume 50% of Title 5 flows.
Use 85% for residental and 90% for non-residential as default recharge factor unless industry specefic data is known.

		Residential Portion					Non-Residential Portion							
Proj. No.	Location	Average Household Occupants	Per capita water use (gpd)	Recharge Factor	No. of Parcels	Subtotal Wastewater Flow (gpd)	Total Water Use (gpd)	Recharge Factor	Subtotal Wastewater Flow (gpd)	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	3.00	65.0	85%	150	24,863	1,250	90%	1,125	25,988	100%	10%	2,599	
subbasin 14061	Watershed Basin	2.68	65.0	85%	801	118,604		90%	0	118,604	100%	25%	29,651	Middleton lots on septic system determined from MassGIS land use data and town zoning. According to Board of Health, there are approximately 2,155 septic systems in Town.
subbasin 21071	Watershed Basin	2.68	65.0	85%		0		90%	0	0	100%	25%	0	Ferncroft area - primarily sewered, remaining area not served by PWS (~13 lots)
subbasin 21013	Watershed Basin	2.68	65.0	85%	138	20,434		90%	0	20,434	100%	25%	5,108	
subbasin 21018	Watershed Basin	2.68	65.0	85%	191	28,281		90%	0	28,281	100%	25%	7,070	
subbasin 21019	Upstream or in Zone II	2.68	65.0	85%	294	43,533		90%	0	43,533	100%	100%	43,533	Removed multi-family - under GW discharge permit
subbasin 21020	Watershed Basin	2.68	65.0	85%	315	46,642		90%	0	46,642	100%	25%	11,661	
subbasin 21021	Watershed Basin	2.68	65.0	85%	165	24,432		90%	0	24,432	100%	25%	6,108	
subbasin 21069	Watershed Basin	2.68	65.0	85%		0		90%	0	0	100%	25%	0	not served by PWS (~82 lots)
subbasin 21072	Watershed Basin	2.68	65.0	85%	131	19,397		90%	0	19,397	100%	25%	4,849	assume approximatley 25 lots not served by PWS
10	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
11	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
12	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
13	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
14	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
15	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
16	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
17	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
18	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
19	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
20	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
21	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
22	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
23	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
24	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
25	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Groundwater Discharges
Town of Danvers/Middleton
DRAFT 6/27/2012

Summary:
2 Total Number of Projects
46,125 Total Flow Offset Volume (gpd)
61,500 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	1,000	100%	10%	100	
Fuller Pond Village	Sub-Basin Downstream	48,000	100%	75%	36,000	
Middleton Market Place	Sub-Basin Downstream	13,500	100%	75%	10,125	
3	Select Location		100%	Select Location	Select Location	
4	Select Location		100%	Select Location	Select Location	
5	Select Location		100%	Select Location	Select Location	
6	Select Location		100%	Select Location	Select Location	
7	Select Location		100%	Select Location	Select Location	
8	Select Location		100%	Select Location	Select Location	
9	Select Location		100%	Select Location	Select Location	
10	Select Location		100%	Select Location	Select Location	
11	Select Location		100%	Select Location	Select Location	
12	Select Location		100%	Select Location	Select Location	
13	Select Location		100%	Select Location	Select Location	
14	Select Location		100%	Select Location	Select Location	
15	Select Location		100%	Select Location	Select Location	
16	Select Location		100%	Select Location	Select Location	
17	Select Location		100%	Select Location	Select Location	
18	Select Location		100%	Select Location	Select Location	
19	Select Location		100%	Select Location	Select Location	
20	Select Location		100%	Select Location	Select Location	
21	Select Location		100%	Select Location	Select Location	
22	Select Location		100%	Select Location	Select Location	
23	Select Location		100%	Select Location	Select Location	
24	Select Location		100%	Select Location	Select Location	
25	Select Location		100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Infiltration
Town of Danvers/Middleton
DRAFT 6/27/2012

Summary:
4 Total Number of Projects
14,340 Total Flow Offset Volume (gpd)
249,954 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with P
Select location and project status from the drop-dow
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Source Infiltration Rate (gpd)	Avg Annual WWTF Flow (any units)	Seasonal High GW WWTF Flow (same units as avg)	Average Annual Infiltration Rate (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	10,000	2.5	4.0	6,250	50%	75%	2,344	
21019	Sub-Basin Downstream		28.2	41.0	0	50%	75%	0	100% of rates used, per CDM 2003 study.
21071	Watershed Basin	25500.0	28.2	41.0	17,539	50%	25%	2,192	WWTP data from DMR data 9/05 - 12/07 (www.epa.gov/region1/npdes/permits/draft/2008/draftma0100501fs.pdf); infiltration rates from Table 8-1 Manhole Cost Effective Analysis from CDM 2003 I/I Investigation report using total infiltration observed
3	In Town / Different Watershed Basin	229500.0	28.2	41.0	157,851	50%	10%	7,893	
21071	Watershed Basin	10215.0	28.2	41.0	7,026	50%	25%	878	Sewer laterals infiltration removal from Table 8-2 Sewer Lateral Cost Effective Analysis from CDM 2003 I/I Investigation report using total infiltration observed
5	In Town / Different Watershed Basin	98194.0	28.2	41.0	67,538	50%	10%	3,377	
6	Select Location				0	50%	Select Location	Select Location	
7	Select Location				0	50%	Select Location	Select Location	
8	Select Location				0	50%	Select Location	Select Location	
9	Select Location				0	50%	Select Location	Select Location	
10	Select Location				0	50%	Select Location	Select Location	
11	Select Location				0	50%	Select Location	Select Location	
12	Select Location				0	50%	Select Location	Select Location	
13	Select Location				0	50%	Select Location	Select Location	
14	Select Location				0	50%	Select Location	Select Location	
15	Select Location				0	50%	Select Location	Select Location	
16	Select Location				0	50%	Select Location	Select Location	
17	Select Location				0	50%	Select Location	Select Location	
18	Select Location				0	50%	Select Location	Select Location	
19	Select Location				0	50%	Select Location	Select Location	
20	Select Location				0	50%	Select Location	Select Location	
21	Select Location				0	50%	Select Location	Select Location	
22	Select Location				0	50%	Select Location	Select Location	
23	Select Location				0	50%	Select Location	Select Location	
24	Select Location				0	50%	Select Location	Select Location	
25	Select Location				0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Inflow
Town of Danvers/Middleton
DRAFT 6/27/2012

Summary:
3 Total Number of Projects
615 Total Flow Offset Volume (gpd)
11,159 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Average Annual Rainfall (in)	Design Storm Rainfall (in)	Design Storm Inflow (gal)	Average Annual Inflow Rate(gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	49.0	1.72	2000	156	50%	75%	59	
21019	Watershed Basin	42.0	1.72	4800	321	50%	25%	40	from CDM 2003 House to House Inspection Report - 278 sumps total (used 600 gpd inflow/sump) 8 sumps
21071	Watershed Basin	42.0	1.72	6600	442	50%	25%	55	11 sumps
Other	In Town / Different Watershed Basin	42.0	1.72	155400	10,396	50%	10%	520	259 sumps
4	Select Location		1.72		0	50%	Select Location	Select Location	
5	Select Location		1.72		0	50%	Select Location	Select Location	
6	Select Location		1.72		0	50%	Select Location	Select Location	
7	Select Location		1.72		0	50%	Select Location	Select Location	
8	Select Location		1.72		0	50%	Select Location	Select Location	
9	Select Location		1.72		0	50%	Select Location	Select Location	
10	Select Location		1.72		0	50%	Select Location	Select Location	
11	Select Location		1.72		0	50%	Select Location	Select Location	
12	Select Location		1.72		0	50%	Select Location	Select Location	
13	Select Location		1.72		0	50%	Select Location	Select Location	
14	Select Location		1.72		0	50%	Select Location	Select Location	
15	Select Location		1.72		0	50%	Select Location	Select Location	
16	Select Location		1.72		0	50%	Select Location	Select Location	
17	Select Location		1.72		0	50%	Select Location	Select Location	
18	Select Location		1.72		0	50%	Select Location	Select Location	
19	Select Location		1.72		0	50%	Select Location	Select Location	
20	Select Location		1.72		0	50%	Select Location	Select Location	
21	Select Location		1.72		0	50%	Select Location	Select Location	
22	Select Location		1.72		0	50%	Select Location	Select Location	
23	Select Location		1.72		0	50%	Select Location	Select Location	
24	Select Location		1.72		0	50%	Select Location	Select Location	
25	Select Location		1.72		0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Too Summary:
Wastewater Credits Worksheet
Water Reuse - Irrigation
Town of Danvers/Middleton
DRAFT 6/27/2012

0 Total Number of Projects
0 Total Flow Offset Volume (gpd)
0 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	1,000	100%	25%	250	
1		100%	25%	0	
2		100%	25%	0	
3		100%	25%	0	
4		100%	25%	0	
5		100%	25%	0	
6		100%	25%	0	
7		100%	25%	0	
8		100%	25%	0	
9		100%	25%	0	
10		100%	25%	0	
11		100%	25%	0	
12		100%	25%	0	
13		100%	25%	0	
14		100%	25%	0	
15		100%	25%	0	
16		100%	25%	0	
17		100%	25%	0	
18		100%	25%	0	
19		100%	25%	0	
20		100%	25%	0	
21		100%	25%	0	
22		100%	25%	0	
23		100%	25%	0	
24		100%	25%	0	
25		100%	25%	0	

Existing Water Savings from Use of HE Washing Machines

	Units	Conventional Washer	Energy Star Washer	Savings
Assumptions				
Water used per load	gal/load	27	14	13
Average annual loads of laundry per household	loads/household/year	300	300	
Average annual washer water consumption	gal/household/year	8100	4200	3900
Cost Estimates				
Cost per washing machine	$/each		$100	
Cost per volume saved				$ 0.0256
Application				
No. of households supplied with HE washing machines				611
Total annual savings				2,382,900
Total daily savings				6,528
Total Cost				$ 61,100
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 16,680.30

Notes:

1. Water use and assumptions obtained from Energy Star, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.
2. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Existing Water Savings from Use of HE Toilets

	Units	Conventional Toilet	HE Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.28	2.22
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	6.464	11.211
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	5,851	10,148
Cost Estimates				
Cost per toilet	each		$75	
Cost per volume saved	$/gal/year			$ 0.0074
Application				
No. of households supplied with HE toilets	households			80
Total annual savings	gal/year			811,856
Total daily savings	gal/day			2,224
Total Cost				$ 6,000
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 5,682.99

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.28 gal/flush for new.

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Existing Water Savings from Use of Low Flow Toilets

	Units	Conventional Toilet	Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.6	1.9
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	8.08	9.595
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	7,314	8,685
Cost Estimates				
Cost per toilet	each		$50	
Cost per volume saved	$/gal/year			$ 0.0058
Application				
No. of households supplied with low flow toilets	households			96
Total annual savings	gal/year			833,798
Total daily savings	gal/day			2,284
Total Cost				$ 4,800
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 5,836.58

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.6 gal/flush for new (minimum per Mass Plumbing Code).

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Existing Water Savings from Use of Low Flow Showerheads

	Units	Conventional Showerhead	Low Flow Showerhead	Savings
Assumptions				
Showerhead flow rate	gpm	6	2.5	3.5
Average shower length	min	8	8	
Average water consumption per shower	gal/shower	48	20	28
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual shower consumption per household	gal/household/year	43,450	18,104	25,346
Cost Estimates				
Cost per showerhead	each		$20	
Cost per Volume Saved	$/gal/year			$ 0.0008
Application				
No. of households supplied with low flow showerheads	households			21
Total annual savings	gal/year			532,258
Total daily savings	gal/day			1,458
Total Cost				$ 420
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 3,725.80

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm at 80 psi or 2.2 gpm at 60 psi.

3. Shower length from Aquacraft, 1999. Residential End Uses of Water Study (for American Water Works Association Research Foundation). Found average shower length of 8 minutes and 30 seconds in households with low flow showerheads and 6 minutes and 48 seconds in homes with conventional showerheads. Other sources ranged between 5 and 10 minutes.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Existing Water Savings from Use of Low Flow Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	2.2	0.8
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	8.8	3.2
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	7,966	2,897
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$150	
Cost per volume saved	$/gal/year			$ 0.0518
Application				
No. of households supplied with faucets	households			60
Total annual savings	gal/year			173,798
Total daily savings	gal/day			476
Total Cost				$ 9,000
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 1,216.59

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Existing Water Savings from Irrigation Moisture Sensors

	Units		
Assumptions			
Average residential water use	gal/capita/day	65	
Average household size (from U.S. Census)	people/household	2.48	
Average residential water use	gal/household/year	58,838	
Percent reduction from implementation of water audit - use of sensors		13.4%	
Ratio of New England watering season (second half of May through first half of September) to Florida watering season (12 months) (17 weeks /52 weeks)		0.33	
Household Savings			
Annual water savings from use of sensors	gal/household/year	2,578	
Cost Estimates			
Irrigation sensor costs	each	$ 50	
Cost per volume saved	$/gal/year		$ 0.0194
Application			
No. of households with irrigation sensor	households		9
Total annual savings	gal/year		23,198
Total daily savings	gal/day		195
Total Cost			$ 450
Revenue Losses			
Rate	$/gal		$ 0.007
Revenue loss	$/year		$ 162.39

Notes:

1. Percent reduction in water use from implementation of irrigation recommendations based on *Florida Water Resources Journal. "Quantifying Potable Water Savings Derived from a Residential Irrigation Audit Program in Seminole County" by Terrence McCue, James Murin, and Debbie Meinert. August 2007.*

2. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Existing Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households		10615			
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks		2			
June	weeks		4			
July	weeks		5			
August	weeks		4			
September	weeks		2			
Total	weeks	0	17	0	0	0
Water savings	gal/year	0	81204750	0	0	0
	gal/day	0	682,393	0	0	0
Revenue Losses						
Rate	$/gal		$ 0.007			
Revenue loss	$/year	$ -	$ 568,433.25	$ -	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

2. Outdoor watering restrictions would be applied to all households (13,424), whether or not on the public water supply. There were 13,424 households in Shrewsbury in 2010 according to U.S. Census at factfinder2.census.gov, all of which are assumed to be on the public water supply.

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

4. Danvers implements outdoor watering restrictions based on drought triggers as outlined in its Drought Management Plan. Specific water usage restrictions are employed for each drought condition during the months of May through October. At drought condition “Mild,” voluntary 3 day per week outdoor watering is implemented. At drought condition “Moderate,” mandatory 3 day per week watering is enforced. At drought condition “Severe,” there is a total ban on outdoor water use.

Potential Water Savings from Use of HE Washing Machines

	Units	Conventional Washer	Energy Star Washer	Savings
Assumptions				
Water used per load	gal/load	27	14	13
Average annual loads of laundry per household	loads/household/year	300	300	
Average annual washer water consumption	gal/household/year	8100	4200	3900
Cost Estimates				
Cost per washing machine	$/each		$100	
Cost per volume saved				$ 0.0256
Application				
No. of households supplied with HE washing machines				8508
Total annual savings				33,181,200
Total daily savings				90,907
Total Cost				$ 850,800
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 232,268.40

Notes:

1. Water use and assumptions obtained from Energy Star, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of HE Toilets

	Units	Conventional Toilet	HE Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.28	2.22
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	6.464	11.211
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	5,851	10,148
Cost Estimates				
Cost per toilet	each		$75	
Cost per volume saved	$/gal/year			$ 0.0074
Application				
No. of households supplied with HE toilets	households			9039
Total annual savings	gal/year			91,729,554
Total daily savings	gal/day			251,314
Total Cost				$ 677,925
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 642,106.88

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.28 gal/flush for new.

3. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

4. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of Low Flow Showerheads

	Units	Conventional Showerhead	Low Flow Showerhead	Savings
Assumptions				
Showerhead flow rate	gpm	6	2.5	3.5
Average shower length	min	8	8	
Average water consumption per shower	gal/shower	48	20	28
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual shower consumption per household	gal/household/year	43,450	18,104	25,346
Cost Estimates				
Cost per showerhead	each		$20	
Cost per Volume Saved	$/gal/year			$ 0.0008
Application				
No. of households supplied with low flow showerheads	households			9098
Total annual savings	gal/year			230,594,269
Total daily savings	gal/day			631,765
Total Cost				$ 181,960
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 1,614,159.88

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm at 80 psi or 2.2 gpm at 60 psi.

3. Shower length from Aquacraft, 1999. Residential End Uses of Water Study (for American Water Works Association Research Foundation). Found average shower length of 8 minutes and 30 seconds in households with low flow showerheads and 6 minutes and 48 seconds in homes with conventional showerheads. Other sources ranged between 5 and 10 minutes.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flov devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

6. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of Aerator Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	2.2	0.8
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	8.8	3.2
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	7,966	2,897
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$15	
Cost per volume saved	$/gal/year			$ 0.0052
Application				
No. of households supplied with faucet aerators	households			9059
Total annual savings	gal/year			26,240,662
Total daily savings	gal/day			71,892
Total Cost				$ 135,885
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 183,684.63

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

6. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of HE Dishwasher

		Conventional Dishwasher	Energy Star Dishwasher	Savings
Assumptions				
Water used per cycle	gal/cycle	6	4	2
Average annual cycles per household	cycles/household/year	215	215	
Average annual dishwasher water consumption	gal/household/year	1290	860	430
Cost Estimates				
Cost per dishwasher	$/each		$100	
Cost per volume saved	$/gal/year			$ 0.2326
Application				
No. of households supplied with HE dishwasher	households			9119
Total annual savings	gal/year			3,921,170
Total daily savings	gal/day			10,742.93
Total Cost				$ 911,900
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 27,448.19

Notes:

1. Based on assumptions from Energy Star Dishwasher Calculator.
2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.
3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Irrigation Moisture Sensors

	Units		
Assumptions			
Average residential water use	gal/capita/day	65	
Average household size (from U.S. Census)	people/household	2.48	
Average residential water use	gal/household/year	58,838	
Percent reduction from implementation of water audit - use of sensors		13.4%	
Ratio of New England watering season (second half of May through first half of September) to Florida watering season (12 months) (17 weeks /52 weeks)		0.33	
Household Savings			
Annual water savings from use of sensors	gal/household/year	2,578	
Cost Estimates			
Irrigation sensor costs	each	$ 50	
Cost per volume saved	$/gal/year		$ 0.0194
Application			
No. of households with irrigation sensor	households		9110
Total annual savings	gal/year		23,481,544
Total daily savings	gal/day		197,324
Total Cost			$ 455,500
Revenue Losses			
Rate	$/gal		$ 0.01
Revenue loss	$/year		$ 164,370.81

Notes:

1. Percent reduction in water use from implementation of irrigation recommendations based on *Florida Water Resources Journal. "Quantifying Potable Water Savings Derived from a Residential Irrigation Audit Program in Seminole County" by Terrence McCue, James Murin, and Debbie Meinert. August 2007.*

2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households			10615		
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks			2		
June	weeks			4		
July	weeks			5		
August	weeks			4		
September	weeks			2		
Total	weeks	0	0	17	0	0
Water savings	gal/year	0	0	121,807,125	0	0
	gal/day	0	0	1,023,589	0	0
Revenue Losses						
Rate	$/gal			$ 0.007		
Revenue loss	$/year	$ -	$ -	$ 852,649.88	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

2. Outdoor watering restrictions would be applied to all households (13,513), whether or not on the public water supply. There were 10,615 households in Danvers and 2,898 households in Middleton in 2010 according to U.S. Census at factfinder2.census.gov. All 2,898 households in Danvers are assumed to be on the public water supply. 1,885 households in Middleton were estimated to be on the public water supply (2010 population served from ASR report divided by average household size from U.S. Census – 5,052/2.68 = 1,885).

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

4. Danvers implements outdoor watering restrictions based on drought triggers as outlined in its Drought Management Plan. Specific water usage restrictions are employed for each drought condition during the months of May through October. At drought condition “Mild,” voluntary 3 day per week outdoor watering is implemented. At drought condition “Moderate,” mandatory 3 day per week watering is enforced. At drought condition “Severe,” there is a total ban on outdoor water use.

Potential Danvers Residential Rainbarrels

	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			10615
Total annual water savings	gal/year		3,752,826
Total savings	gpd		20,620
Total Cost		$	2,547,600

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Potential Danvers Recharge Offset from Stormwater Bylaw

Ipswich Subwatershed

	Units	Hydrologic Soil Group A	B	C	D	Total
Average annual precipitation	inches	44	44	44	44	
Predevelopment Recharge - minimum						
Predevelopment recharge factor (Mass SW Handbook)	inches	0.6	0.35	0.25	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft. impervious surface	15.9	9.6	6.5	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft. impervious surface	9.9	6.0	4.1	0.9	
Postdevelopment Recharge - enhanced						
Postdevelopment recharge factor (Mass SW Handbook)	inches	1.25	1	0.5	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft./year	24.5	22.6	13.6	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Credited Recharge						
Credited recharge	gal/sq.ft./year	5.4	8.1	4.4	0.0	
Application						
Total impervious area recharged	sq.ft.	365,625	1,371,151	3,049,430	469,075	
Total additional annual recharge	million gal/year	2	11	13	0	26

North Coast Subwatershed

	Units	Hydrologic Soil Group A	B	C	D	Total
Average annual precipitation	inches	44	44	44	44	
Predevelopment Recharge - minimum						
Predevelopment recharge factor (Mass SW Handbook)	inches	0.6	0.35	0.25	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft. impervious surface	15.9	9.6	6.5	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft. impervious surface	9.9	6.0	4.1	0.9	
Postdevelopment Recharge - enhanced						
Postdevelopment recharge factor (Mass SW Handbook)	inches	1.25	1	0.5	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft./year	24.5	22.6	13.6	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Credited Recharge						
Credited recharge	gal/sq.ft./year	5.4	8.1	4.4	0.0	
Application						
Total impervious area recharged	sq.ft.	2,512,381	2,684,910	9,082,930	1,995,139	
Total additional annual recharge	million gal/year	14	22	40	0	75

Total

	Units	Hydrologic Soil Group A	B	C	D	Total
Average annual precipitation	inches	44	44	44	44	
Predevelopment Recharge - minimum						
Predevelopment recharge factor (Mass SW Handbook)	inches	0.6	0.35	0.25	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft. impervious surface	15.9	9.6	6.5	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft. impervious surface	9.9	6.0	4.1	0.9	
Postdevelopment Recharge - enhanced						
Postdevelopment recharge factor (Mass SW Handbook)	inches	1.25	1	0.5	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft./year	24.5	22.6	13.6	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Credited Recharge						
Credited recharge	gal/sq.ft./year	5.4	8.1	4.4	0.0	
Application						
Total impervious area recharged	sq.ft.	2,878,006	4,056,061	12,132,361	2,464,215	
Total additional annual recharge	million gal/year	15	33	53	0	102

Existing Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households		2,898			
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks	2	2	2	2	2
June	weeks	4	4	4	4	4
July	weeks	5	5	5	5	5
August	weeks	4	4	4	4	4
September	weeks	2	2	2	2	2
Total	weeks	17	17	17	17	17
Water savings	gal/year	0	22,169,700	0	0	0
	gal/day	0	186,300	0	0	0
Revenue Losses						
Rate	$/gal	$ 0.007	$ 0.007	$ 0.007	$ 0.007	$ 0.007
Revenue loss	$/year	$ -	$ 155,187.90	$ -	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

2. Outdoor watering restrictions would be applied to all households (13,513), whether or not on the public water supply. There were 10,615 households in Danvers and 2,898 households in Middleton in 2010 according to U.S. Census at factfinder2.census.gov. All 2,898 households in Danvers are assumed to be on the public water supply. 1,885 households in Middleton were estimated to be on the public water supply (2010 population served from ASR report divided by average household size from U.S. Census – 5,052/2.68 = 1,885).

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of HE Washing Machines				
	Units	Conventional Washer	Energy Star Washer	Savings
Assumptions				
Water used per load	gal/load	27	14	13
Average annual loads of laundry per household	loads/household/year	300	300	
Average annual washer water consumption	gal/household/year	8100	4200	3900
Cost Estimates				
Cost per washing machine	$/each		$100	
Cost per volume saved				$ 0.0256
Application				
No. of households supplied with HE washing machines				1240
Total annual savings				4,836,000
Total daily savings				13,249
Total Cost				$ 124,000
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 33,852.00

Notes:

1. Water use and assumptions obtained from Energy Star, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of HE Toilets

	Units	Conventional Toilet	HE Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.28	2.22
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	6.464	11.211
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	5,851	10,148
Cost Estimates				
Cost per toilet	each		$75	
Cost per volume saved	$/gal/year			$ 0.0074
Application				
No. of households supplied with HE toilets	households			1240
Total annual savings	gal/year			12,583,765
Total daily savings	gal/day			34,476
Total Cost				$ 93,000
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 88,086.35

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.28 gal/flush for new.

3. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

4. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of Low Flow Showerheads

	Units	Conventional Showerhead	Low Flow Showerhead	Savings
Assumptions				
Showerhead flow rate	gpm	6	2.5	3.5
Average shower length	min	8	8	
Average water consumption per shower	gal/shower	48	20	28
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual shower consumption per household	gal/household/year	43,450	18,104	25,346
Cost Estimates				
Cost per showerhead	each		$20	
Cost per Volume Saved	$/gal/year			$ 0.0008
Application				
No. of households supplied with low flow showerheads	households			1240
Total annual savings	gal/year			31,428,544
Total daily savings	gal/day			86,106
Total Cost				$ 24,800
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 219,999.81

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm at 80 psi or 2.2 gpm at 60 psi.

3. Shower length from Aquacraft, 1999. Residential End Uses of Water Study (for American Water Works Association Research Foundation). Found average shower length of 8 minutes and 30 seconds in households with low flow showerheads and 6 minutes and 48 seconds in homes with conventional showerheads. Other sources ranged between 5 and 10 minutes.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flov devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

6. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of Aerator Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	2.2	0.8
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	8.8	3.2
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	7,966	2,897
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$15	
Cost per volume saved	$/gal/year			$ 0.0052
Application				
No. of households supplied with faucet aerators	households			1240
Total annual savings	gal/year			3,591,834
Total daily savings	gal/day			9,841
Total Cost				$ 18,600
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 25,142.84

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.

6. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Use of HE Dishwasher

		Conventional Dishwasher	Energy Star Dishwasher	Savings
Assumptions				
Water used per cycle	gal/cycle	6	4	2
Average annual cycles per household	cycles/household/year	215	215	
Average annual dishwasher water consumption	gal/household/year	1290	860	430
Cost Estimates				
Cost per dishwasher	$/each		$100	
Cost per volume saved	$/gal/year			$ 0.2326
Application				
No. of households supplied with HE dishwasher	households			1240
Total annual savings	gal/year			533,200
Total daily savings	gal/day			1,460.82
Total Cost				$ 124,000
Revenue Losses				
Rate	$/gal			$ 0.007
Revenue loss	$/year			$ 3,732.40

Notes:

1. Based on assumptions from Energy Star Dishwasher Calculator.
2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 9,119 households in Danvers assumed to be on the public water supply in 1990. 1,240 households in Middleton were estimated to be on the public water suupply in 1990, (calculated using same ratio as 2010 = 1,885 households on PWS/2,898 total households x 1,907 households in 1990 (from U.S, Census) = 1,240 households on PWS in 1990.
3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households			2,898		
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks			2		
June	weeks			4		
July	weeks			5		
August	weeks			4		
September	weeks			2		
Total	weeks	0	0	17	0	0
Water savings	gal/year	0	0	33,254,550	0	0
	gal/day	0	0	279,450	0	0
Revenue Losses						
Rate	$/gal			$ 0.007		
Revenue loss	$/year	$ -	$ -	$ 232,781.85	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.
2. Outdoor watering restrictions would be applied to all households (13,513), whether or not on the public water supply. There were 10,615 households in Danvers and 2,898 households in Middleton in 2010 according to U.S. Census at factfinder2.census.gov. All 2,898 households in Danvers are assumed to be on the public water supply. 1,885 households in Middleton were estimated to be on the public water supply (2010 population served from ASR report divided by average household size from U.S. Census – 5,052/2.68 = 1,885).
3. Danvers Water Division's FY 2012 rates use a 3 step increasing block rate for residential customers. The charge of $5.35 per 100 cubic feet was used to calculate a per gallon rate of $.007.

Potential Middleton Residential Rainbarrels

	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			1,885
Total annual water savings	gal/year		666,423
Total savings	gpd		3,662
Total Cost		$	452,400

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Potential Middleton Recharge Offset from Stormwater Bylaw

Ipswich Subwatershed (Total)

	Units	Hydrologic Soil Group A	B	C	D	Total
Average annual precipitation	inches	44	44	44	44	
Existing Bylaw Recharge						
Predevelopment recharge factor (Mass SW Handbook)	inches	0	0	0	0	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Enhanced Recharge						
Postdevelopment recharge factor (Mass SW Handbook)	inches	1.25	1	0.5	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft./year	24.5	22.6	13.6	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Credited Recharge						
Credited recharge	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Application						
Total impervious area recharged	sq.ft.	6,920,682	40,399,678	19,106,919	6,368,363	
Total additional annual recharge	million gal/year	106	569	162	6	842

Appendix H –

Dedham-Westwood Credit Worksheets

SWMI Decision Support Pilot Tool
Worksheet Summary
Town of Dedham / Westwood
DRAFT 6 / 27 / 2012

	Wastewater Category	Total Number of Projects	Total Wastewater Flow (gpd)	Total Flow Offset Volume (gpd)
1	Septic Systems	4	76,798	8,094
2	Groundwater Discharges	1	28,000	2,800
3	Infiltration	5	5,626,581	510,504
4	Inflow	3	900,124	89,883
5	Water Reuse - Irrigation	0	0	0

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Septic Systems
Town of Dedham/Westwood
DRAFT 6/27/2012

4 Total Number of Projects
8,094 Total Flow Offset Volume (gpd)
76,798 Total Residential WW Flow (gpd)
0 Total Non-Residential WW Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.
If residential water use information is not available, assume 65 gpd per capita.
If non-residential water use information is not available, assume 50% of Title 5 flows.
Use 85% for residental and 90% for non-residential as default recharge factor unless industry specefic data is known.

		Residential Portion					Non-Residential Portion								
Proj. No.	Location	Average Household Occupants	Per capita water use (gpd)	Recharge Factor	No. of Parcels	Subtotal Wastewater Flow (gpd)	Total Water Use (gpd)	Recharge Factor	Subtotal Wastewater Flow (gpd)	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	3.00	65.0	85%	150	24,863	1,250	90%	1,125	25,988	100%	10%	2,599	
Subbasin 21035	In Town / Different Watershed Basin	2.78	65.0	85%	6	922		90%	0	922	100%	10%	92	
Subbasin 21036	In Town / Different Watershed Basin	2.78	65.0	85%	18	2,765		90%	0	2,765	100%	10%	276	
Subbasin 21126	Watershed Basin	2.78	65.0	85%	18	2,765		90%	0	2,765	100%	25%	691	
Unknown	In Town / Different Watershed Basin	2.78	65.0	85%	458	70,347		90%	0	70,347	100%	10%	7,035	
5	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
6	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
7	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
8	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
9	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
10	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
11	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
12	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
13	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
14	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
15	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
16	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
17	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
18	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
19	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
20	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
21	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
22	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
23	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
24	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
25	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Groundwater Discharges
Town of Dedham/Westwood
DRAFT 6/27/2012

Summary:
1 Total Number of Projects
2,800 Total Flow Offset Volume (gpd)
28,000 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	1,000	100%	10%	100	
Hale Reservation	In Town / Different Watershed Basin	28,000	100%	10%	2,800	
2	Select Location		100%	Select Location	Select Location	
3	Select Location		100%	Select Location	Select Location	
4	Select Location		100%	Select Location	Select Location	
5	Select Location		100%	Select Location	Select Location	
6	Select Location		100%	Select Location	Select Location	
7	Select Location		100%	Select Location	Select Location	
8	Select Location		100%	Select Location	Select Location	
9	Select Location		100%	Select Location	Select Location	
10	Select Location		100%	Select Location	Select Location	
11	Select Location		100%	Select Location	Select Location	
12	Select Location		100%	Select Location	Select Location	
13	Select Location		100%	Select Location	Select Location	
14	Select Location		100%	Select Location	Select Location	
15	Select Location		100%	Select Location	Select Location	
16	Select Location		100%	Select Location	Select Location	
17	Select Location		100%	Select Location	Select Location	
18	Select Location		100%	Select Location	Select Location	
19	Select Location		100%	Select Location	Select Location	
20	Select Location		100%	Select Location	Select Location	
21	Select Location		100%	Select Location	Select Location	
22	Select Location		100%	Select Location	Select Location	
23	Select Location		100%	Select Location	Select Location	
24	Select Location		100%	Select Location	Select Location	
25	Select Location		100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Infiltration
Town of Dedham/Westwood
DRAFT 6/27/2012

Summary:
5 Total Number of Projects
510,504 Total Flow Offset Volume (gpd)
5,626,581 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with P
Select location and project status from the drop-dow
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Source Infiltration Rate (gpd)	Avg Annual WWTF Flow (any units)	Seasonal High GW WWTF Flow (same units as avg)	Average Annual Infiltration Rate (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	10,000	2.5	4.0	6,250	50%	75%	2,344	
Westwood	Watershed Basin	801,263	1.2	2.0	480,758	50%	25%	60,095	WW-NO-1C Charles River Basin per 2009 WW Flow Analysis/Metering
Dedham	Watershed Basin	1,553,821	4.0	7.4	839,903	50%	25%	104,988	According to peak infiltration of 3,107,641 gpd from W&S Town-Wide Flow Monitoring Program October 2011 report - assumed half in Charles River Basin and half in Neponset River Basin
Dedham	In Town / Different Watershed Basin	1,553,821	4.0	7.4	835,921	50%	10%	41,796	According to peak infiltration of 3,107,641 gpd from W&S Town-Wide Flow Monitoring Program October 2011 report - assumed half in Charles River Basin and half in Neponset River Basin
Dedham 2007-2012	Watershed Basin				1,735,000	50%	25%	216,875	According to estimated I/I removal of 3,470,000 gpd from Dedham's I/I website - assumed half in Charles River Basin and half in Neponset River Basin
Dedham 2007-2012	In Town / Different Watershed Basin				1,735,000	50%	10%	86,750	According to estimated I/I removal of 3,470,000 gpd from Dedham's I/I website - assumed half in Charles River Basin and half in Neponset River Basin
6	Select Location				0	50%	Select Location	Select Location	
7	Select Location				0	50%	Select Location	Select Location	
8	Select Location				0	50%	Select Location	Select Location	
9	Select Location				0	50%	Select Location	Select Location	
10	Select Location				0	50%	Select Location	Select Location	
11	Select Location				0	50%	Select Location	Select Location	
12	Select Location				0	50%	Select Location	Select Location	
13	Select Location				0	50%	Select Location	Select Location	
14	Select Location				0	50%	Select Location	Select Location	
15	Select Location				0	50%	Select Location	Select Location	
16	Select Location				0	50%	Select Location	Select Location	
17	Select Location				0	50%	Select Location	Select Location	
18	Select Location				0	50%	Select Location	Select Location	
19	Select Location				0	50%	Select Location	Select Location	
20	Select Location				0	50%	Select Location	Select Location	
21	Select Location				0	50%	Select Location	Select Location	
22	Select Location				0	50%	Select Location	Select Location	
23	Select Location				0	50%	Select Location	Select Location	
24	Select Location				0	50%	Select Location	Select Location	
25	Select Location				0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Inflow
Town of Dedham/Westwood
DRAFT 6/27/2012

Summary:
3 Total Number of Projects
89,883 Total Flow Offset Volume (gpd)
900,124 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Average Annual Rainfall (in)	Design Storm Rainfall (in)	Design Storm Inflow (gal)	Average Annual Inflow Rate(gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	49.0	1.72	2,000	156	50%	75%	59	
dedham	Watershed Basin	49.0	1.72	3,866,303	301,766	50%	25%	37,721	According to peak inflow of 7,732,605 gpd from W&S Town-Wide Flow Monitoring Program October 2011 report - assumed half in Charles Rier Basin and half in Neponset River Basin
dedham	In Town / Different Watershed Basin	49.0	1.72	3,866,303	301,766	50%	10%	15,088	According to peak inflow of 7,732,605 gpd from W&S Town-Wide Flow Monitoring Program October 2011 report - assumed half in Charles Rier Basin and half in Neponset River Basin
westood	Watershed Basin	49.0	1.72	3,800,000	296,591	50%	25%	37,074	Design storm inflow = average of inflow from storms in Westwood I/I study for WW-NO-1C Charles River Basin per 2009 WW Flow Analysis/Metering
4	Select Location		1.72		0	50%	Select Location	Select Location	
5	Select Location		1.72		0	50%	Select Location	Select Location	
6	Select Location		1.72		0	50%	Select Location	Select Location	
7	Select Location		1.72		0	50%	Select Location	Select Location	
8	Select Location		1.72		0	50%	Select Location	Select Location	
9	Select Location		1.72		0	50%	Select Location	Select Location	
10	Select Location		1.72		0	50%	Select Location	Select Location	
11	Select Location		1.72		0	50%	Select Location	Select Location	
12	Select Location		1.72		0	50%	Select Location	Select Location	
13	Select Location		1.72		0	50%	Select Location	Select Location	
14	Select Location		1.72		0	50%	Select Location	Select Location	
15	Select Location		1.72		0	50%	Select Location	Select Location	
16	Select Location		1.72		0	50%	Select Location	Select Location	
17	Select Location		1.72		0	50%	Select Location	Select Location	
18	Select Location		1.72		0	50%	Select Location	Select Location	
19	Select Location		1.72		0	50%	Select Location	Select Location	
20	Select Location		1.72		0	50%	Select Location	Select Location	
21	Select Location		1.72		0	50%	Select Location	Select Location	
22	Select Location		1.72		0	50%	Select Location	Select Location	
23	Select Location		1.72		0	50%	Select Location	Select Location	
24	Select Location		1.72		0	50%	Select Location	Select Location	
25	Select Location		1.72		0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Too Summary:
Wastewater Credits Worksheet
Water Reuse - Irrigation
Town of Dedham/Westwood
DRAFT 6/27/2012

0 Total Number of Projects
0 Total Flow Offset Volume (gpd)
0 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	1,000	100%	25%	250	
1		100%	25%	0	
2		100%	25%	0	
3		100%	25%	0	
4		100%	25%	0	
5		100%	25%	0	
6		100%	25%	0	
7		100%	25%	0	
8		100%	25%	0	
9		100%	25%	0	
10		100%	25%	0	
11		100%	25%	0	
12		100%	25%	0	
13		100%	25%	0	
14		100%	25%	0	
15		100%	25%	0	
16		100%	25%	0	
17		100%	25%	0	
18		100%	25%	0	
19		100%	25%	0	
20		100%	25%	0	
21		100%	25%	0	
22		100%	25%	0	
23		100%	25%	0	
24		100%	25%	0	
25		100%	25%	0	

Existing Water Savings from Use of Low Flow Toilets				
	Units	Conventional Toilet	Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.6	1.9
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	8.08	9.595
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	7,314	8,685
Cost Estimates				
Cost per toilet	each		$50	
Cost per volume saved	$/gal/year			$ 0.0058
Application				
No. of households supplied with low flow toilets	households			748
Total annual savings	gal/year			6,496,675
Total daily savings	gal/day			17,799
Total Cost				$ 37,400
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 58,470.07

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.6 gal/flush for new (minimum per Mass Plumbing Code).

3. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Existing Water Savings from Use of HE Toilets

	Units	Conventional Toilet	HE Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.28	2.22
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	6.464	11.211
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	5,851	10,148
Cost Estimates				
Cost per toilet	each		$75	
Cost per volume saved	$/gal/year			$ 0.0074
Application				
No. of households supplied with HE toilets	households			141
Total annual savings	gal/year			1,430,896
Total daily savings	gal/day			3,920
Total Cost				$ 10,575
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 12,878.06

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.28 gal/flush for new.

3. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Existing Water Savings from Use of HE Washing Machines				
	Units	Conventional Washer	Energy Star Washer	Savings
Assumptions				
Water used per load	gal/load	27	14	13
Average annual loads of laundry per household	loads/household/year	300	300	
Average annual washer water consumption	gal/household/year	8100	4200	3900
Cost Estimates				
Cost per washing machine	$/each		$100	
Cost per volume saved				$ 0.0256
Application				
No. of households supplied with HE washing machines				1051
Total annual savings				4,098,900
Total daily savings				11,230
Total Cost				$ 105,100
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 36,890.10

Notes:

1. Water use and assumptions obtained from Energy Star, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

2. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Existing Water Savings from Irrigation Moisture Sensors

	Units		
Assumptions			
Average residential water use	gal/capita/day	65	
Average household size (from U.S. Census)	people/household	2.48	
Average residential water use	gal/household/year	58,838	
Percent reduction from implementation of water audit - use of sensors		13.4%	
Ratio of New England watering season (second half of May through first half of September) to Florida watering season (12 months) (17 weeks /52 weeks)		0.33	
Household Savings			
Annual water savings from use of sensors	gal/household/year	2,578	
Cost Estimates			
Irrigation sensor costs	each	$ 50	
Cost per volume saved	$/gal/year		$ 0.0194
Application			
No. of households with irrigation sensor	households		278
Total annual savings	gal/year		716,561
Total daily savings	gal/day		6,022
Total Cost			$ 13,900
Revenue Losses			
Rate	$/gal		$ 0.009
Revenue loss	$/year		$ 6,449.05

Notes:

1. Percent reduction in water use from implementation of irrigation recommendations based on *Florida Water Resources Journal. "Quantifying Potable Water Savings Derived from a Residential Irrigation Audit Program in Seminole County" by Terrence McCue, James Murin, and Debbie Meinert. August 2007.*

2. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Existing Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households		14900			
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks		2			
June	weeks		4			
July	weeks		5			
August	weeks		4			
September	weeks		2			
Total	weeks	0	17	0	0	0
Water savings	gal/year	0	113,985,000	0	0	0
	gal/day	0	957,857	0	0	0
Revenue Losses						
Rate	$/gal		$ 0.009			
Revenue loss	$/year	$ -	$ 1,025,865.00	$ -	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

2. outdoor watering restrictions would be applied to all households (14,900), whether or not on the public water supply. There were 9,651 households in Dedham and 5,249 households in Westwood in 2010 according to U.S. Census at factfinder2.census.gov, all of which are assumed to be on the public water supply.

3. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Potential Water Savings from Use of HE Toilets

	Units	Conventional Toilet	HE Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.28	2.22
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	6.464	11.211
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	5,851	10,148
Cost Estimates				
Cost per toilet	each		$75	
Cost per volume saved	$/gal/year			$ 0.0074
Application				
No. of households supplied with HE toilets	households			12412
Total annual savings	gal/year			125,959,424
Total daily savings	gal/day			345,094
Total Cost				$ 930,900
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 1,133,634.81

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.28 gal/flush for new.

3. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,750 households in Dedham and 4,551 households in Westwood (13,301 total) in 1990, all of which are assumed to be on the public water supply.

4. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Potential Water Savings from Use of HE Washing Machines

	Units	Conventional Washer	Energy Star Washer	Savings
Assumptions				
Water used per load	gal/load	27	14	13
Average annual loads of laundry per household	loads/household/year	300	300	
Average annual washer water consumption	gal/household/year	8100	4200	3900
Cost Estimates				
Cost per washing machine	$/each		$100	
Cost per volume saved				$ 0.0256
Application				
No. of households supplied with HE washing machines				12250
Total annual savings				47,775,000
Total daily savings				130,890
Total Cost				$ 1,225,000
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 429,975.00

Notes:

1. Water use and assumptions obtained from Energy Star, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,750 households in Dedham and 4,551 households in Westwood (13,301 total) in 1990, all of which are assumed to be on the public water supply.

3. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Potential Water Savings from Use of Aerator Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	2.2	0.8
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	8.8	3.2
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	7,966	2,897
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$15	
Cost per volume saved	$/gal/year			$ 0.0052
Application				
No. of households supplied with faucet aerators	households			13301
Total annual savings	gal/year			38,528,209
Total daily savings	gal/day			105,557
Total Cost				$ 199,515
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 346,753.88

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,750 households in Dedham and 4,551 households in Westwood (13,301 total) in 1990, all of which are assumed to be on the public water supply.

6. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Potential Water Savings from Use of Low Flow Showerheads

	Units	Conventional Showerhead	Low Flow Showerhead	Savings
Assumptions				
Showerhead flow rate	gpm	6	2.5	3.5
Average shower length	min	8	8	
Average water consumption per shower	gal/shower	48	20	28
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual shower consumption per household	gal/household/year	43,450	18,104	25,346
Cost Estimates				
Cost per showerhead	each		$20	
Cost per Volume Saved	$/gal/year			$ 0.0008
Application				
No. of households supplied with low flow showerheads	households			13301
Total annual savings	gal/year			337,121,826
Total daily savings	gal/day			923,621
Total Cost				$ 266,020
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 3,034,096.43

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm at 80 psi or 2.2 gpm at 60 psi.

3. Shower length from Aquacraft, 1999. Residential End Uses of Water Study (for American Water Works Association Research Foundation). Found average shower length of 8 minutes and 30 seconds in households with low flow showerheads and 6 minutes and 48 seconds in homes with conventional showerheads. Other sources ranged between 5 and 10 minutes.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,750 households in Dedham and 4,551 households in Westwood (13,301 total) in 1990, all of which are assumed to be on the public water supply.

6. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Potential Water Savings from Use of HE Dishwasher

		Conventional Dishwasher	Energy Star Dishwasher	Savings
Assumptions				
Water used per cycle	gal/cycle	6	4	2
Average annual cycles per household	cycles/household/year	215	215	
Average annual dishwasher water consumption	gal/household/year	1290	860	430
Cost Estimates				
Cost per dishwasher	$/each		$100	
Cost per volume saved	$/gal/year			$ 0.2326
Application				
No. of households supplied with HE dishwasher	households			13301
Total annual savings	gal/year			5,719,430
Total daily savings	gal/day			15,669.67
Total Cost				$ 1,330,100
Revenue Losses				
Rate	$/gal			$ 0.009
Revenue loss	$/year			$ 51,474.87

Notes:

1. Based on assumptions from Energy Star Dishwasher Calculator.
2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,750 households in Dedham and 4,551 households in Westwood (13,301 total) in 1990, all of which are assumed to be on the public water supply.
3. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Potential Water Savings from Irrigation Moisture Sensors

	Units		
Assumptions			
Average residential water use	gal/capita/day	65	
Average household size (from U.S. Census)	people/household	2.48	
Average residential water use	gal/household/year	58,838	
Percent reduction from implementation of water audit - use of sensors		13.4%	
Ratio of New England watering season (second half of May through first half of September) to Florida watering season (12 months) (17 weeks /52 weeks)		0.33	
Household Savings			
Annual water savings from use of sensors	gal/household/year	2,578	
Cost Estimates			
Irrigation sensor costs	each	$ 50	
Cost per volume saved	$/gal/year		$ 0.0194
Application			
No. of households with irrigation sensor	households		13023
Total annual savings	gal/year		33,567,525
Total daily savings	gal/day		282,080
Total Cost			$ 651,150
Revenue Losses			
Rate	$/gal		$ 0.01
Revenue loss	$/year		$ 302,107.72

Notes:

1. Percent reduction in water use from implementation of irrigation recommendations based on *Florida Water Resources Journal. "Quantifying Potable Water Savings Derived from a Residential Irrigation Audit Program in Seminole County" by Terrence McCue, James Murin, and Debbie Meinert. August 2007.*

2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 8,750 households in Dedham and 4,551 households in Westwood (13,301 total) in 1990, all of which are assumed to be on the public water supply.

3. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Potential Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households			14,900		
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks			2		
June	weeks			4		
July	weeks			5		
August	weeks			4		
September	weeks			2		
Total	weeks	0	0	17	0	0
Water savings	gal/year	0	0	170,977,500	0	0
	gal/day	0	0	1,436,786	0	0
Revenue Losses						
Rate	$/gal			$ 0.009		
Revenue loss	$/year	$ -	$ -	$ 1,538,797.50	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

2. outdoor watering restrictions would be applied to all households (14,900), whether or not on the public water supply. There were 9,651 households in Dedham and 5,249 households in Westwood in 2010 according to U.S. Census at factfinder2.census.gov, all of which are assumed to be on the public water supply.

3. DWWD's rates use a 3 step increasing block rate for residential customers. The charge of $6.77 per 100 cubic feet was used to calculate a per gallon rate of $.009.

Existing Dedham Residential Rainbarrels

	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			169
Total annual water savings	gal/year		59,748
Total savings	gpd		328
Total Cost		$	40,560

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Potential Dedham Residential Rainbarrels

	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			9482
Total annual water savings	gal/year		3,352,265
Total savings	gpd		18,419
Total Cost		$	2,275,680

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Existing Westwood Residential Rainbarrels			
	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			169
Total annual water savings	gal/year		59,748
Total savings	gpd		328
Total Cost		$	40,560

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Potential Westwood Residential Rainbarrels

	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			4913
Total annual water savings	gal/year		1,736,941
Total savings	gpd		9,544
Total Cost		$	1,179,120

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Appendix I –

Shrewsbury Credit Worksheets

SWMI Decision Support Pilot Tool
Worksheet Summary
Town of Shrewsbury
DRAFT 6/27/2012

	Wastewater Category	Total Number of Projects	Total Wastewater Flow (gpd)	Total Flow Offset Volume (gpd)
1	Septic Systems	8	246,084	55,014
2	Groundwater Discharges	1	300,000	75,000
3	Infiltration	3	836,560	57,149
4	Inflow	5	45,515	3,312
5	Water Reuse - Irrigation	0	0	0

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Septic Systems
Town of Shrewsbury
DRAFT 6/27/2012

8 Total Number of Projects
55,014 Total Flow Offset Volume (gpd)
246,084 Total Residential WW Flow (gpd)
0 Total Non-Residential WW Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.
If residential water use information is not available, assume 65 gpd per capita.
If non-residential water use information is not available, assume 50% of Title 5 flows.
Use 85% for residental and 90% for non-residential as default recharge factor unless industry specefic data is known.

		Residential Portion					Non-Residential Portion							
Proj. No.	Location	Average Household Occupants	Per capita water use (gpd)	Recharge Factor	No. of Parcels	Subtotal Wastewater Flow (gpd)	Total Water Use (gpd)	Recharge Factor	Subtotal Wastewater Flow (gpd)	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	3.00	65.0	85%	150	24,863	1,250	90%	1,125	25,988	100%	10%	2,599	
1A1	Upstream or in Zone II	2.62	65.0	85%	79	11,436		90%	0	11,436	100%	100%	11,436	
1A2	Upstream or in Zone II	2.62	65.0	85%		0		90%	0	0	100%	100%	0	
1B1	Upstream or in Zone II	2.62	65.0	85%	230	33,294		90%	0	33,294	100%	100%	33,294	
1B2	Watershed Basin	2.62	65.0	85%	20	2,895		90%	0	2,895	100%	25%	724	
1B3	Watershed Basin	2.62	65.0	85%		0		90%	0	0	100%	25%	0	commercial - expect to be sewered
10A	Watershed Basin	2.62	65.0	85%	130	18,818		90%	0	18,818	100%	25%	4,705	
10B	In Town / Different Watershed Basin	2.62	65.0	85%	72	10,422		90%	0	10,422	100%	10%	1,042	commercial - expect to be sewered
11	In Town / Different Watershed Basin	2.62	65.0	85%	70	10,133		90%	0	10,133	100%	10%	1,013	commercial - expect to be sewered
12	In Town / Different Watershed Basin	2.62	65.0	85%	156	22,582		90%	0	22,582	100%	10%	2,258	
G	In Town / Different Watershed Basin	2.62	65.0	85%		0		90%	0	0	100%	10%	0	commercial - expect to be sewered
1C	Watershed Basin	2.62	65.0	85%	15	2,171		90%	0	2,171	100%	25%	543	
Other	Select Location	2.62	65.0	85%	928	134,333		90%	0	134,333	100%	Select Location	Select Location	remaining septic systems identified by town (1700 total)
13	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
14	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
15	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
16	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
17	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
18	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
19	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
20	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
21	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
22	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
23	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
24	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	
25	Select Location		65.0	85%		0		90%	0	0	100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Groundwater Discharges
Town of Shrewsbury
DRAFT 6/27/2012

Summary:
1 Total Number of Projects
75,000 Total Flow Offset Volume (gpd)
300,000 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	In Town / Different Watershed Basin	1,000	100%	10%	100	
SAC Site	Watershed Basin	300,000	100%	25%	75,000	Potential future credit for groundwater treatment/disposal facility
2	Select Location		100%	Select Location	Select Location	
3	Select Location		100%	Select Location	Select Location	
4	Select Location		100%	Select Location	Select Location	
5	Select Location		100%	Select Location	Select Location	
6	Select Location		100%	Select Location	Select Location	
7	Select Location		100%	Select Location	Select Location	
8	Select Location		100%	Select Location	Select Location	
9	Select Location		100%	Select Location	Select Location	
10	Select Location		100%	Select Location	Select Location	
11	Select Location		100%	Select Location	Select Location	
12	Select Location		100%	Select Location	Select Location	
13	Select Location		100%	Select Location	Select Location	
14	Select Location		100%	Select Location	Select Location	
15	Select Location		100%	Select Location	Select Location	
16	Select Location		100%	Select Location	Select Location	
17	Select Location		100%	Select Location	Select Location	
18	Select Location		100%	Select Location	Select Location	
19	Select Location		100%	Select Location	Select Location	
20	Select Location		100%	Select Location	Select Location	
21	Select Location		100%	Select Location	Select Location	
22	Select Location		100%	Select Location	Select Location	
23	Select Location		100%	Select Location	Select Location	
24	Select Location		100%	Select Location	Select Location	
25	Select Location		100%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Infiltration
Town of Shrewsbury
DRAFT 6/27/2012

Summary:
3 Total Number of Projects
57,149 Total Flow Offset Volume (gpd)
836,560 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with F
Select location and project status from the drop-dow
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Source Infiltration Rate (gpd)	Avg Annual WWTF Flow (any units)	Seasonal High GW WWTF Flow (same units as avg)	Average Annual Infiltration Rate (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	10,000	2.5	4.0	6,250	50%	75%	2,344	
M9A-47 Greenwood Ave	In Town / Different Watershed Basin		3.8	5.9	19,440	50%	10%	972	Based on W&S I/I Identification and Rehabilitation Summary Updated June 2012 - volume is for infiltration from 9 manholes
9A-81/82 Main Blvd Easement	In Town / Different Watershed Basin		3.8	5.9	0	50%	10%	0	
2C-1 Ladyslipper Dr	In Town / Different Watershed Basin		3.8	5.9	0	50%	10%	0	
2A-27 South st easement	In Town / Different Watershed Basin		3.8	5.9	0	50%	10%	0	
9C-285 Francis Ave easement	In Town / Different Watershed Basin		3.8	5.9	0	50%	10%	0	
3B-1 Hill Street	In Town / Different Watershed Basin		3.8	5.9	0	50%	10%	0	
4B-3 Walnut St easement	In Town / Different Watershed Basin		3.8	5.9	0	50%	10%	0	
Proposed infiltration removal	In Town / Different Watershed Basin		3.8	5.9	612,840	50%	10%	30,642	Based on W&S I/I Identification and Rehabilitation Summary Updated June 2012 - volume is for total removable infiltration identified x 2, minus removable infiltration from manhole projects conducted x 0.75 as focus is in Concord Basin
Proposed infiltration removal	Watershed Basin		3.8	5.9	204,280	50%	25%	25,535	Based on W&S I/I Identification and Rehabilitation Summary Updated June 2012 - volume is for total removable infiltration identified x 2, minus removable infiltration from manhole projects conducted x 0.25 as focus is in Concord Basin
10	Select Location				0	50%	Select Location	Select Location	
11	Select Location				0	50%	Select Location	Select Location	
12	Select Location				0	50%	Select Location	Select Location	
13	Select Location				0	50%	Select Location	Select Location	
14	Select Location				0	50%	Select Location	Select Location	
15	Select Location				0	50%	Select Location	Select Location	
16	Select Location				0	50%	Select Location	Select Location	
17	Select Location				0	50%	Select Location	Select Location	
18	Select Location				0	50%	Select Location	Select Location	
19	Select Location				0	50%	Select Location	Select Location	
20	Select Location				0	50%	Select Location	Select Location	
21	Select Location				0	50%	Select Location	Select Location	
22	Select Location				0	50%	Select Location	Select Location	
23	Select Location				0	50%	Select Location	Select Location	
24	Select Location				0	50%	Select Location	Select Location	
25	Select Location				0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Tool
Wastewater Credits Worksheet
Inflow
Town of Shrewsbury
DRAFT 6/27/2012

Summary:
5 Total Number of Projects
3,312 Total Flow Offset Volume (gpd)
45,515 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Location	Average Annual Rainfall (in)	Design Storm Rainfall (in)	Design Storm Inflow (gal)	Average Annual Inflow Rate(gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	Sub-Basin Downstream	49.0	1.72	2000	156	50%	75%	59	
7 Hillside Dr driveway redirect	In Town / Different Watershed Basin	48.0	1.72		45	50%	10%	2	Based on W&S I/I Identification and Rehabilitation Summary Updated June 2012
9D-285/9D-20 South of Maple Ave Easement	In Town / Different Watershed Basin	48.0	1.72		124	50%	10%	6	Based on W&S I/I Identification and Rehabilitation Summary Updated June 2012
3C - Browning Road/Colton Ave	Watershed Basin	48.0	1.72	43200	3,303	50%	25%	413	Based on July 2011 Browning Road and Colton Lane Area Private Inflow Removal Program Report
Proposed inflow removal	In Town / Different Watershed Basin	48.0	1.72		31,532	50%	10%	1,577	Based on W&S I/I Identification and Rehabilitation Summary Updated June 2012 - volume is for total removable inflow identified minus removable inflow from projects conducted x 0.75 as focus is in Concord Basin
Proposed inflow removal	Watershed Basin	48.0	1.72		10,511	50%	25%	1,314	Based on W&S I/I Identification and Rehabilitation Summary Updated June 2012 - volume is for total removable inflow identified minus removable inflow from projects conducted x 0.25 as focus is in Concord Basin
6	Select Location		1.72		0	50%	Select Location	Select Location	
7	Select Location		1.72		0	50%	Select Location	Select Location	
8	Select Location		1.72		0	50%	Select Location	Select Location	
9	Select Location		1.72		0	50%	Select Location	Select Location	
10	Select Location		1.72		0	50%	Select Location	Select Location	
11	Select Location		1.72		0	50%	Select Location	Select Location	
12	Select Location		1.72		0	50%	Select Location	Select Location	
13	Select Location		1.72		0	50%	Select Location	Select Location	
14	Select Location		1.72		0	50%	Select Location	Select Location	
15	Select Location		1.72		0	50%	Select Location	Select Location	
16	Select Location		1.72		0	50%	Select Location	Select Location	
17	Select Location		1.72		0	50%	Select Location	Select Location	
18	Select Location		1.72		0	50%	Select Location	Select Location	
19	Select Location		1.72		0	50%	Select Location	Select Location	
20	Select Location		1.72		0	50%	Select Location	Select Location	
21	Select Location		1.72		0	50%	Select Location	Select Location	
22	Select Location		1.72		0	50%	Select Location	Select Location	
23	Select Location		1.72		0	50%	Select Location	Select Location	
24	Select Location		1.72		0	50%	Select Location	Select Location	
25	Select Location		1.72		0	50%	Select Location	Select Location	

SWMI Decision Support Pilot Too Summary:
Wastewater Credits Worksheet
Water Reuse - Irrigation
Town of Shrewsbury
DRAFT 6/27/2012

0 Total Number of Projects
0 Total Flow Offset Volume (gpd)
0 Total Wastewater Flow (gpd)

Instructions:
Complete one row for each project, beginning with Project No. 1
Select location and project status from the drop-down list.
Fill in blue cells; grey cells will fill in automatically.

Proj. No.	Total Wastewater Flow (gpd)	Allowable Volume Factor	Location Factor	Project Flow Offset Volume (gpd)	User Notes
SAMPLE	1,000	100%	25%	250	
1		100%	25%	0	
2		100%	25%	0	
3		100%	25%	0	
4		100%	25%	0	
5		100%	25%	0	
6		100%	25%	0	
7		100%	25%	0	
8		100%	25%	0	
9		100%	25%	0	
10		100%	25%	0	
11		100%	25%	0	
12		100%	25%	0	
13		100%	25%	0	
14		100%	25%	0	
15		100%	25%	0	
16		100%	25%	0	
17		100%	25%	0	
18		100%	25%	0	
19		100%	25%	0	
20		100%	25%	0	
21		100%	25%	0	
22		100%	25%	0	
23		100%	25%	0	
24		100%	25%	0	
25		100%	25%	0	

Existing Water Savings from Use of Aerator Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	2.2	0.8
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	8.8	3.2
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	7,966	2,897
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$15	
Cost per volume saved	$/gal/year			$ 0.0052
Application				
No. of households supplied with faucet aerators	households			750
Total annual savings	gal/year			2,172,480
Total daily savings	gal/day			5,952
Total Cost				$ 11,250
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 13,034.88

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Existing Water Savings from Use of Low Flow Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	1.5	1.5
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	6	6
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	5,431	5,431
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$150	
Cost per volume saved	$/gal/year			$ 0.0276
Application				
No. of households supplied with faucets	households			150
Total annual savings	gal/year			814,680
Total daily savings	gal/day			2,232
Total Cost				$ 22,500
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 4,888.08

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Existing Water Savings from Use of Low Flow Showerheads

	Units	Conventional Showerhead	Low Flow Showerhead	Savings
Assumptions				
Showerhead flow rate	gpm	6	2.5	3.5
Average shower length	min	8	8	
Average water consumption per shower	gal/shower	48	20	28
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual shower consumption per household	gal/household/year	43,450	18,104	25,346
Cost Estimates				
Cost per showerhead	each		$20	
Cost per Volume Saved	$/gal/year			$ 0.0008
Application				
No. of households supplied with low flow showerheads	households			550
Total annual savings	gal/year			13,940,080
Total daily savings	gal/day			38,192
Total Cost				$ 11,000
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 83,640.48

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm at 80 psi or 2.2 gpm at 60 psi.

3. Shower length from Aquacraft, 1999. Residential End Uses of Water Study (for American Water Works Association Research Foundation). Found average shower length of 8 minutes and 30 seconds in households with low flow showerheads and 6 minutes and 48 seconds in homes with conventional showerheads. Other sources ranged between 5 and 10 minutes.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Existing Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households		13424			
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks	2	2	2	2	2
June	weeks	4	4	4	4	4
July	weeks	5	5	5	5	5
August	weeks	4	4	4	4	4
September	weeks	2	2	2	2	2
Total	weeks	17	17	17	17	17
Water savings	gal/year	0	102,693,600	0	0	0
	gal/day	0	862,971	0	0	0
Revenue Losses						
Rate	$/gal	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006
Revenue loss	$/year	$ -	$ 616,161.60	$ -	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

2. Outdoor watering restrictions would be applied to all households (13,424), whether or not on the public water supply. There were 13,424 households in Shrewsbury in 2010 according to U.S. Census at factfinder2.census.gov, all of which are assumed to be on the public water supply.

3. From May 1st to Sept 30th of each year Shrewsbury implements 3 day/week watering for all residences (even #s T, Th, Sa, and odd #s W, F, and Su. No Mondays).

4. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Potential Water Savings from Use of Aerator Faucets

	Units	Conventional Faucet	Aerator Faucet	Savings
Assumptions				
Faucet flow rate	gpm	3	2.2	0.8
Average faucet use	min/person/day	4	4	
Average daily faucet water consumption per household	gal/person/day	12	8.8	3.2
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual water consumption per household	gal/household/year	10,862	7,966	2,897
Cost Estimates				
Cost per household (assumes 3 faucets)	$/per household		$15	
Cost per volume saved	$/gal/year			$ 0.0052
Application				
No. of households supplied with faucet aerators	households			9305
Total annual savings	gal/year			26,953,235
Total daily savings	gal/day			73,844
Total Cost				$ 139,575
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 161,719.41

Notes:

1. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures installed after 1995 to have a peak flow rate of no more than 2.2 gpm.

2. Pre-1995 faucets have peak flow rates ranging from 2.75 to 7.0 gpm, depending on the age & location of faucet. Low flow kitchen aerators designed to flow between 1.5 and 2.2 gpm, bathroom faucet aerators between 1.0 and 1.5 gpm.

3. Average faucet use assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map

5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 10,055 households in Shrewsbury in 1990, all of which are assumed to be on the public water supply.

6. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Potential Water Savings from Use of Low Flow Showerheads

	Units	Conventional Showerhead	Low Flow Showerhead	Savings
Assumptions				
Showerhead flow rate	gpm	6	2.5	3.5
Average shower length	min	8	8	
Average water consumption per shower	gal/shower	48	20	28
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual shower consumption per household	gal/household/year	43,450	18,104	25,346
Cost Estimates				
Cost per showerhead	each		$20	
Cost per Volume Saved	$/gal/year			$ 0.0008
Application				
No. of households supplied with low flow showerheads	households			9505
Total annual savings	gal/year			240,909,928
Total daily savings	gal/day			660,027
Total Cost				$ 190,100
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 1,445,459.57

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of low flow showerheads meeting 2.5 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.
2. The Federal Energy Policy Act of 1992, effective 1994, requires all faucet fixtures manufactured in the United States restrict maximum water flow at or below 2.5 gpm at 80 psi or 2.2 gpm at 60 psi.
3. Shower length from Aquacraft, 1999. Residential End Uses of Water Study (for American Water Works Association Research Foundation). Found average shower length of 8 minutes and 30 seconds in households with low flow showerheads and 6 minutes and 48 seconds in homes with conventional showerheads. Other sources ranged between 5 and 10 minutes.
4. http://www.indexmundi.com/facts/united-states/quick-facts/massachusetts/average-household-size#map
5. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 10,055 households in Shrewsbury in 1990, all of which are assumed to be on the public water supply.
6. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Potential Water Savings from Use of HE Toilets

	Units	Conventional Toilet	HE Low Flow Toilet	Savings
Assumptions				
Water used per flush	gal/flush	3.5	1.28	2.22
Daily flushes per person	flushes/person	5.05	5.05	
Average daily toilet water consumption	gal/person/day	17.675	6.464	11.211
Household Savings				
Average household size (from U.S. Census)	people/household	2.48	2.48	
Annual toilet water consumption per household	gal/household/year	15,999	5,851	10,148
Cost Estimates				
Cost per toilet	each		$75	
Cost per volume saved	$/gal/year			$ 0.0074
Application				
No. of households supplied with HE toilets	households			10055
Total annual savings	gal/year			102,040,123
Total daily savings	gal/day			279,562
Total Cost				$ 754,125
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 612,240.74

Notes:

1. The 1989 Massachusetts Plumbing Code required installation of Ultra Low Flush Toilets meeting 1.6 gpm flowrate and other water efficient plumbing figures for all new construction, remodeling and replacement projects.

2. Calculations are based on assumptions from EPA WaterSense (http://www.epa.gov/watersense/our_water/how_works.html). Assumptions include 5.05 flushes/person/day, 3.5 gal/flush for older toilets vs. 1.28 gal/flush for new.

3. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 10,055 households in Shrewsbury in 1990, all of which are assumed to be on the public water supply.

4. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Potential Water Savings from Use of HE Dishwasher

		Conventional Dishwasher	Energy Star Dishwasher	Savings
Assumptions				
Water used per cycle	gal/cycle	6	4	2
Average annual cycles per household	cycles/household/year	215	215	
Average annual dishwasher water consumption	gal/household/year	1290	860	430
Cost Estimates				
Cost per dishwasher	$/each		$100	
Cost per volume saved	$/gal/year			$ 0.2326
Application				
No. of households supplied with HE dishwasher	households			10055
Total annual savings	gal/year			4,323,650
Total daily savings	gal/day			11,845.62
Total Cost				$ 1,005,500
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 25,941.90

Notes:

1. Based on assumptions from Energy Star Dishwasher Calculator.
2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 10,055 households in Shrewsbury in 1990, all of which are assumed to be on the public water supply.
3. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Potential Water Savings from Use of HE Washing Machines

	Units	Conventional Washer	Energy Star Washer	Savings
Assumptions				
Water used per load	gal/load	27	14	13
Average annual loads of laundry per household	loads/household/year	300	300	
Average annual washer water consumption	gal/household/year	8100	4200	3900
Cost Estimates				
Cost per washing machine	$/each		$100	
Cost per volume saved				$ 0.0256
Application				
No. of households supplied with HE washing machines				10055
Total annual savings				39,214,500
Total daily savings				107,437
Total Cost				$ 1,005,500
Revenue Losses				
Rate	$/gal			$ 0.006
Revenue loss	$/year			$ 235,287.00

Notes:

1. Water use and assumptions obtained from Energy Star, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.
2. Water saving devices would be provided to all households on the PWS, constructed before 1990 (before plumbing code changes required low flow devices), minus those that have already received them. There were an estimated 10,055 households in Shrewsbury in 1990, all of which are assumed to be on the public water supply.
3. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Potential Water Savings from Water Use Restrictions

	Units	No Restrictions	3 Days/Week	2 Days/Week	1 Day/Week	0 Days/Week
Assumptions						
No. of days per week of lawn watering	days/week	5	3	2	1	0
Average watering flowrate	gpm	5	5	5	5	5
Average watering run time	min/day	45	45	45	45	45
Weekly water consumption	gal/week	1125	675	450	225	0
Application						
No. of households	households			13424		
Total weekly savings over no restrictions	gal/week	0	450	675	900	1125
Primary watering weeks restricted (17 week season)						
May	weeks			2		
June	weeks			4		
July	weeks			5		
August	weeks			4		
September	weeks			2		
Total	weeks	0	0	17	0	0
Water savings	gal/year	0	0	154,040,400	0	0
	gal/day	0	0	1,294,457	0	0
Revenue Losses						
Rate	$/gal			$ 0.006		
Revenue loss	$/year	$ -	$ -	$ 924,242.40	$ -	$ -

Notes:

1. Assumptions are based on a representative cross section of consulted references, including federal, state, and commercial sources and professional judgment.

2. Outdoor watering restrictions would be applied to all households (13,424), whether or not on the public water supply. There were 13,424 households in Shrewsbury in 2010 according to U.S. Census at factfinder2.census.gov, all of which are assumed to be on the public water supply.

3. Currently from May 1st to Sept 30th of each year Shrewsbury implements 3 day/week watering for all residences (even #s T, Th, Sa, and odd #s W, F, and Su. No Mondays).

4. Shrewsbury uses a 3 step increasing block rate for its residential water rates. The charge of $6/1,000 gallons was used to calculate a per gallon rate of $.006.

Existing Residential Roof Leader Disconnection Program

	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average residential roof area	sq.ft.		1000
Target recharge per household	inch/storm		1.79
Total annual recharge per household	inches/year		23.0
Total annual recharge per household	gal/house/year		14,353
Cost Estimates			
Cost per drywell	/drywell		$ 5,000
Drywells per household	(front and back)		2
Cost per household			$ 10,000
Cost per Volume Recharged	/gal/year		$ 0.70
Application		Adj. Factor	
No. of homes disconnected, upstream of withdrawal or in Zone II		1	0
No. of homes disconnected, subwatershed basin, downstream		0.75	23
No. of homes disconnected, watershed basin		0.25	17
No. of homes disconnected, outside watershed basin		0.1	9
Total number of homes			49
Total weighted number of homes			22
Total annual recharge	gal/year		321,515
Total recharge	gpd		881
Total Cost			$ 490,000

Assumes two drywells, each 2'dia x 2'deep surrounded by 2' of stone (sides and underneath). This allows for 558 gal of storage.

Potential Residential Rainbarrels			
	Units		
Unit Recharge			
Average annual precipitation	inches		44
Average precipitation (May through October)			24
Average residential roof area	sq.ft.		1000
Rainbarrel storage	inch/storm		0.18
Total annual storage per household	inches/year		2.3
Percent time rainbarrel storage available			25%
Total annual storage per household	gal/house/year		354
Cost Estimates			
Cost per rainbarrel	/rainbarrel	$	120
Rainbarrels per household	(front and back)		2
Cost per household		$	240
Cost per volume stored/reduced	/gal/year	$	0.68
Application			
No. of households			13424
Total annual water savings	gal/year		4,745,919
Total savings	gpd		26,076
Total Cost		$	3,221,760

Assumes 55 gallon capacity rainbarrel with rainwater used after each rainfall.

Shrewsbury Recharge Offset from Stormwater Bylaw

Blackstone Subwatershed

	Units	A	B	C	D	Total
		Hydrologic Soil Group				
Average annual precipitation	inches	44	44	44	44	
Existing Bylaw Recharge						
Predevelopment recharge factor (Mass SW Handbook)	inches	0	0	0	0	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Enhanced Recharge						
Postdevelopment recharge factor (Mass SW Handbook)	inches	1.25	1	0.5	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft./year	24.5	22.6	13.6	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Credited Recharge						
Credited recharge	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Application						
Total impervious area recharged	sq.ft.	8,012,475	19,130,698	17,368,672	2,518,606	
Total additional annual recharge	million gal/year	123	269	147	2	541

SuAsCo Subwatershed

	Units	A	B	C	D	Total
		Hydrologic Soil Group				
Average annual precipitation	inches	44	44	44	44	
Existing Bylaw Recharge						
Predevelopment recharge factor (Mass SW Handbook)	inches	0	0	0	0	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Enhanced Recharge						
Postdevelopment recharge factor (Mass SW Handbook)	inches	1.25	1	0.5	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft./year	24.5	22.6	13.6	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Credited Recharge						
Credited recharge	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Application						
Total impervious area recharged	sq.ft.	2,380,026	6,386,725	22,444,376	2,474,143	
Total additional annual recharge	million gal/year	36	90	190	2	319

Total

	Units	A	B	C	D	Total
		Hydrologic Soil Group				
Average annual precipitation	inches	44	44	44	44	
Existing Bylaw Recharge						
Predevelopment recharge factor (Mass SW Handbook)	inches	0	0	0	0	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft. impervious surface	0.0	0.0	0.0	0.0	
Enhanced Recharge						
Postdevelopment recharge factor (Mass SW Handbook)	inches	1.25	1	0.5	0.1	
Total annual recharge per sq.ft. impervious surface	inches/sq.ft./year	24.5	22.6	13.6	1.5	
Total annual recharge per sq.ft. impervious surface	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Credited Recharge						
Credited recharge	gal/sq.ft./year	15.3	14.1	8.5	0.9	
Application						
Total impervious area recharged	sq.ft.	10,392,501	25,517,423	39,813,048	4,992,749	
Total additional annual recharge	million gal/year	159	359	337	5	860