Final Report: Data and Assessment (Full Report)

Horsley Witten Group, Inc.

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A Steering Committee provided the overall guidance on technical aspects of the project. The Committee members included:

Edward Minnock, Ph.D - Bridgewater State College, Office of External Affairs  
Dr. Kevin Curry - Bridgewater State College, Watershed Access Laboratory  
Alison Bowden - The Nature Conservancy  
Sara Cohen - MA Department of Conservation and Recreation  
Pamela Truesdale - MA Department of Environmental Protection Southeast Region  
John Clarkeson - MA Executive Office of Energy and Environmental Affairs  
Bill Napolitano - Southeastern Regional Planning and Economic Development District  
Jim Watson - Old Colony Planning Council

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Our subcontractors included Weston & Sampson, who provided data collection and compilation assistance, and Geosyntec Consultants, who provided a habitat analysis of stream buffers throughout the watershed. Both firms also participated in several public workshops and Steering Committee meetings, and provided valuable advice throughout the project.

Several environmental organizations also assisted with the project. They include:

Members of the Taunton River Watershed Campaign  
The Environmental League of Massachusetts  
Manomet Center for Conservation Sciences  
Mass Audubon  
The Nature Conservancy  
Save the Bay-Narragansett Bay  
Southeastern Regional Planning & Economic Development District  
Taunton River Watershed Alliance  
The Trust for Public Land  
The Trustees of Reservations  
Wildlands Trust of Southeastern MA
EXECUTIVE SUMMARY

This Taunton River Watershed Management Plan is intended to be a comprehensive long-term roadmap to protect and restore the sensitive natural resources of the Taunton watershed while enhancing the quality of life and vitality of the residents who live, work, and play in the watershed. The planning effort has been divided into three phases consisting of:

- Phase I – data collection, initial watershed assessment, long-term visioning and scoping for subsequent phases;
- Phase II – implementation of targeted pilot projects to highlight and demonstrate specific management measures; and
- Phase III – widespread implementation of management measures and plan adaptations as necessary to reflect changing conditions.

This report is the culmination of Phase I which included the following important accomplishments:

- The collection of detailed baseline data related to water use and water transfer throughout the watershed;
- Development of a planning-level water balance tool to evaluate human impacts to the natural water balance in the watershed;
- Performance of a planning level assessment of hydrologic conditions and ecological indicator conditions in the over 100 subbasins of the watershed to prioritize the subbasins for future management efforts;
- Evaluation of local codes and practices in a case study community (Town of Easton) to highlight potential smart growth, low impact design (LID), innovative wastewater management and other practices to improve management of and limit impacts to water resources and habitat areas;
- Development of a broad set of conclusions from which to build upon in subsequent phases of the planning effort; and
- Development of a detailed scope of work for Phase II of this planning effort.

Section 1 of this report provides a brief introduction. Section 2 describes the significant data collection effort required for the development of the water balance tool and for the general understanding of the conditions and methods of water management in the watershed. Section 3 of this report describes the significant public outreach and public participation component of this project. Section 4 describes the water balance tool, including the methodology, assumptions and results. Section 5 describes the analysis of riparian buffers and land conservation, and Section 6 presents the case study of the Town of Easton. Section 7 presents general conclusions for Phase I of the project, and Section 8 presents the scope of work for Phase II of the project to develop the Taunton River Watershed Management Plan.
The Taunton River Watershed

The Taunton River is the longest coastal river in New England that remains unimpaired by dams. It has a significant watershed encompassing approximately 562 square miles (see Figure ES-1). The basin contains 108 sub-watersheds\(^1\) and full or partial land area of 43 municipalities. It is the second largest watershed in Massachusetts and also one of the flattest, with only a twenty-foot elevation drop along its forty-mile main stem length. This unique topography makes the wetlands within the watershed somewhat vulnerable to dewatering as a consequence of unbalanced consumptive uses of water throughout the watershed. Saltwater intrusion in some wells already occurs as far as twelve miles upstream with tidal influences and as far as eighteen miles upstream from the mouth of the river. The relatively flat topography may also make this watershed and its riverine ecosystem particularly vulnerable to the effects of global warming and sea level rise.

The watershed is generally characterized by low-permeability (glacial till) soils with more limited sand and gravel (outwash) soils, shallow depths to groundwater and numerous wetlands. While these features represent significant constraints to (conventional) wastewater disposal and exacerbate stormwater runoff issues, they also afford unique habitats for both aquatic and terrestrial wildlife.

The watershed supports 45 species of fish (including the very rare, native sturgeon) and many species of shellfish, including seven types of freshwater mussels. The watershed provides a habitat for 154 species of birds, including 12 considered rare or threatened/endangered. The watershed is also home to the river otter, mink, and gray fox. It is home to deer and often more common wildlife. The 16,950-acre Hockomock Swamp is one of the largest wetlands in New England and a habitat for numerous, common uncommon and rare species. Additionally, the watershed’s archaeological treasures date back 10,000 years.

\(^1\) Sub-watersheds: Typically considered the drainage area upstream from the confluence of 2 second-order streams, ranging in size from 5 to 10 square miles.
Importance of a Long-Term Watershed Management Plan

The Taunton River and its watershed provides important functions and values to both humans and its diverse ecosystems. The watershed is the source for nearly all drinking water for the communities, either through public water supply systems or through an array of individual private wells. It is the source for water for irrigation of golf courses, lawns, and agriculture. The cranberry industry, still active in the Taunton watershed is heavily dependent on the availability of water for growing and harvesting its crop. In addition to water supply, the Taunton watershed also serves as a receiving area for wastewater from these same communities, both through centralized wastewater collection and treatment facilities and through individual on-site septic systems. The watershed also provides a vast area for development such as housing, businesses, schools, shopping areas, and industry; however, traditional development of land renders large areas of the land surface impervious, reducing the ability of the watershed to soak up rainwater and increasing the demand for drinking water supply and wastewater management.

The Taunton River Watershed area is poised to experience significant growth as commuter rail service expands through this area and the Boston metropolitan area continues to expand to include communities further and further from the city. These seemingly competing uses of the finite water resources in the watershed create an unmistakable need for long-term innovative and pragmatic planning to ensure the long-term availability of clean water to meet both human and ecological needs. Watershed planning provides a framework to protect, preserve, and restore the water resources and related ecosystems that communities depend on for so many reasons.

Data Collection

An important part of the Phase I effort consisted of developing a high-quality database of key information. This data collection effort was focused primarily on compiling water use and wastewater information that is relevant to understanding the current hydrologic exchange in the watershed. This information is not generally readily available in the same way that other relevant information, such as impervious cover data, land use data, wetlands and waterways coverage data, and surface geology data, is available.

Specifically, the categories of data that were collected and processed include:

- Service area maps for public water distribution systems and public wastewater collection systems. Water and sewer line locations were mapped using a geographic information system (GIS) and cross-referenced against parcel maps to create estimated service areas for each community. The inverse of these maps indicates areas that use private water wells and on-site septic systems.
- Estimates of inflow and infiltration into the public wastewater collection systems. The length of sewer infrastructure in each subbasin was used to estimate the volume of water that is lost annually to inflow and infiltration into the sewer lines.
- Groundwater and surface water withdrawals permitted and registered through the Massachusetts Water Management Act (WMA). The existence, location,
permitted or registered withdrawal volumes and actual reported annual withdrawal volumes were compiled for facilities in the Taunton Watershed. These represent large withdrawals generally over 100,000 gallons per day.

- Watewater discharges permitted through the Massachusetts Groundwater Discharge Permit (GWDP) program. The existence, location, permitted or discharge volumes and actual reported discharge volumes were compiled for facilities in the Taunton Watershed. These represent large discharges generally over 10,000 gallons per day.

- Surface water discharges permitted through the National Pollutant Discharge and Elimination System (NPDES). The location, permitted and reported discharges for the individual NPDES permits in the watershed were compiled. These generally represent large surface water discharges, primarily from wastewater treatment facilities, in the watershed.

Data and information were collected and verified through a combination of sources, including websites from regulatory agencies, water and wastewater planning reports, regulatory reporting forms, databases from MA Department of Environmental Protection (DEP), personal communication with and mapping provided by municipal public works, water and sewer departments, and personal communication with MA DEP staff. Summary tables of the collected data as well as a detailed description of the data collection and processing methods are provided in Section 2 of this report, and the full data tables are provided in electronic format in the attached data CD.

Public Outreach

The public outreach and public participation component of this project included a range of public meetings, an outdoor watershed appreciation day, and a project website. The goal of this component was to bring the public into this watershed planning process, educate the public about the data collection and assessment effort, educate the public about a number of smart growth, LID and other land use planning and engineering concepts that may be utilized in the watershed plan, solicit input on plan priorities from different interest groups, and develop a network of interested participants for future planning efforts. Public outreach and public participation will continue to be an integral part of the Taunton River Watershed planning effort. The project website will continue to be a public resource for information about this project: www.horsleywitten.com/tauntonwatershed.

Water Balance Tool

The water balance in a watershed describes the natural equilibrium of inputs and exports of water from the watershed when there is no human alteration of the watershed system. Alterations to this natural water cycle are registered when human development occurs in the watershed. These alterations occur primarily as a result of the human necessities of water supply withdrawals, wastewater discharges and stormwater runoff associated with land uses. This development changes the volumes and rates of water exchange between precipitation, surface water, groundwater and the atmosphere, and can be observed
through changes in the base flow of streams, changes in the extent of wetlands, changes in the combination of plants and animals that inhabit wetland and riparian areas, and even potentially changes in the microclimates that occur in the watershed.

For the purposes of this study, base flow in streams was used as the primary indicator for understanding impacts to the water balance. Base flow is the flow that sustains a stream between precipitation and runoff events. It is derived from groundwater discharge into the stream and from surface water storage released from wetlands and impoundments. A planning-level tool was developed as part of this study to evaluate the hydrologic impacts associated with water supply withdrawals, wastewater discharges and stormwater runoff associated with land uses. The method uses a mass balance approach that accounts for net changes in groundwater recharge as it relates to base flow to streams and wetlands on an annual basis. It estimates stream base flow changes resulting from water withdrawal, water transfer, wastewater discharges and stormwater runoff associated with different land uses.

Specifically, the water balance tool evaluated the fate of water in 108 individual subbasins within the Taunton watershed for variables associated with precipitation, natural recharge, water supply, wastewater management, and stormwater runoff. The tool was employed under two different scenarios: the first looks at only water withdrawals and discharges that affect groundwater levels, and the second incorporates large, regular surface water withdrawals and discharges as well. The water balance tool revealed that many sub-watersheds in the upper Taunton Watershed are highly out of balance compared to natural conditions as a result of water transfers. Most of the imbalances are negative, meaning that water is being lost from the watershed. Figures ES-2 and ES-3 present the results of the water balance analysis under the two scenarios. These results will help to prioritize implementation measures in Phase II of the planning effort. The tool itself can also be used to evaluate alternative management scenarios such as changes in wastewater collection systems, water conservation measures to reduce water withdrawal volumes and improved stormwater management.
Figure ES.2
Taunton Water Budget - Excluding Surface Water Withdrawals and NPDES Effluent

Legend

- Taunton River Watershed
- Town Boundaries
- Sub-basins
- Taunton River
- Rivers, Streams
- Surface Water

Water Balance

- < -10% (withdrawals > recharge)
- -10% to -5%
- -5% to 0%
- 0% to 5%
- > 5% (recharge > withdrawals)
Legend

- Taunton River Watershed
- Town Boundaries
- Sub-basins
- Taunton River
- Rivers, Streams
- Surface Water

Water Balance

- °<10\% (withdrawals > recharge)
- °10\% to -5\%
- °-5\% to 0\%
- °0\% to 5\%
- °5\% (recharge > withdrawals)
Figures ES-4 and ES-5 present the watershed-wide water balance results. When anthropogenic groundwater withdrawals and discharges are accounted for across the watershed, as a whole, the analysis shows that urbanization has resulted in net losses in groundwater recharge (-6.2%). Figure ES-4 is a graphical representation of the various water withdrawal and recharge categories and quantities, excluding surface water withdrawals and discharges, for the Taunton watershed as a whole.

![Figure ES-4 - Taunton Watershed Balance, Excluding Surface Water Withdrawals and NPDES (Natural Recharge = 131 Billion Gallons per Year)](image)

A significant portion of the recharge deficit is, however, returned to streams via surface discharges of wastewater regulated by NPDES permit program. When accounting for NPDES discharges as well as surface water withdrawals (usually from larger water systems, such as the Attleboro system withdrawing from the Wading River and the Brockton System withdrawing from Brockton Reservoir and Monponsett Pond), the watershed-wide analysis shows a net increase in total watershed baseflow of approximately 2%. In other words, at the full watershed scale, anthropogenic losses of natural baseflow that had previously been provided by precipitation-derived recharge have been compensated for the discharge of treated wastewater from sources located outside the watershed. This is presented in Figure ES-5.
Analysis of Riparian Buffers and Land Conservation

The study included an assessment of the condition of ecological buffers to surface water resources, as well as the level of land conservation in the watershed. As with the water balance assessment, this was performed at the subbasin scale and will help to prioritize subbasins for future management efforts to protect existing open space and vegetated buffers. This assessment helps to illustrate that there are significant areas of ecological importance that remain in relatively healthy condition and warrant future protection.

Watershed Case Study: Town of Easton

The Town of Easton was selected as a case-study community to help illustrate how some of the issues related to the watershed plan apply on the ground. Participants from the town of Easton showed particular interest in this study and provided more detailed information related to conditions and regulatory structure in Easton, and hosted a workshop in their community. Within Easton, we evaluated the Coweeset subbasin using the water balance model and the natural buffer assessment. A review of the local code was conducted, including the Zoning Bylaw, the Subdivision Rules and Regulations and the Wetlands Protection Bylaw as well as other local planning documents. The purpose of this review was to evaluate the existing mechanisms and techniques being used in Easton to manage water resources, wastewater, land use and growth, and then to recommend improvements to the local code. This case study can serve as an example for other communities and as a guide for future work under Phase II.
Major Study Conclusions

Several key findings from this Phase I study are as follows:

1. Despite extensive data collection efforts, information remains partially incomplete for some communities’ water infrastructure, withdrawal rates, and source locations; as well as sewer infrastructure, and discharge rates and locations.
2. The water balance analysis shows that urbanization and related water usage have resulted in hydrologic shifts throughout the Taunton watershed.
3. The implications of water balance shifts can be significant ecologically, and can affect sensitive wetland systems that are highly dependent on certain hydrologic flow regimes.
4. Progressive amendments to local land use codes, particularly Subdivision Rules and Regulations, but also potentially wetlands protection and stormwater management codes, are needed to expand these stormwater controls throughout the watershed.
5. Public education training of local government officials was deemed to be the highest priority for the management of the watershed, according to participants at Phase I public participation meetings.
6. A comprehensive wastewater management approach is needed throughout the watershed.
7. There is a need to re-think development patterns, particularly sprawl-type patterns, that are largely controlled by the local land use codes of the 43 member communities.

Recommendations for Phase II

The final product of Phase I was to develop a scope of work for the next phase of the Taunton River Watershed Management Plan. Phase II will build on the data collection and assessment work performed in Phase I, and will provide a more targeted watershed management approach, which includes more detailed recommendations and demonstration projects throughout the watershed. Public outreach and public participation will continue throughout Phase II, with the goal of building on the existing network of interested stakeholders and working directly with more municipal volunteers and decision-makers as well. A set of demonstration projects will be implemented throughout the watershed to illustrate management practices in three main subject areas: 1) Stormwater/ LID retrofits; 2) Wastewater management solutions; and 3) Habitat restoration. Phase II will also include an in-depth code analysis and reform project for two local watershed communities to illustrate the potential for code reforms to address issues of water imbalance, water quality problems, and/or preserving or restoring habitat areas. In addition, there will be six public workshops throughout the watershed to educate stakeholders about smart growth and LID techniques, using the Phase I data and assessment as a basis for discussion. Phase II of the Taunton River Watershed Management Plan will be documented in a final report that describes the targeted implementation measures demonstrated in Phase II and how to apply them more broadly.
across the watershed. Phase II is expected to be completed in a timeframe of approximately 18 months, beginning in earnest in January 2009.
# Taunton River Watershed Management Plan
## Phase I: Data and Assessment

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Appendix A: Water Balance Analysis Assumptions

CD Pocket: Full Report (.pdf) and Watershed Database

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SECTION 1
INTRODUCTION

The goal of this project was to gather information and data to begin the development of a long-term vision and strategy for the sustainable management of the Taunton River Watershed and its ecological resources in support of the hydrologic, environmental, and economic sustainability of the region.

At the July 20, 2006 Massachusetts Water Resources Commission meeting, Massachusetts Executive Office of Environmental Affairs (now Energy and Environmental Affairs, EEA) Secretary Pritchard introduced the concept of a Sustainable Water Policy for the Commonwealth, one which would truly balance all of the diverse uses of water resources in a manner to maintain healthy ecosystems. At first glance, this might appear unattainable when one considers land development and population growth rates that demand seemingly unending increases in water supply and resource depletion. This is particularly timely in the Taunton River Watershed when considering the area’s relatively affordable housing and access to major job centers.

Integrated water management and smart growth provide two important frameworks upon which a sustainable water policy can be built. Integrated water management is a planning process that jointly considers water supply, wastewater and stormwater as one resource: water. Smart growth principles provide effective tools that protect critical areas, guide growth to areas that can sustainably support it, and design development projects in a manner that have either lower impact than traditional recent development or, in some cases, can result in a positive impact (i.e. restoration).

Water resources and how we affect them are at the very core of community needs and community development in the Taunton Watershed communities. The ability of a community to manage its growth is heavily impacted by the ability of the community to provide drinking water for future development, to manage wastewater produced by future development and to maintain the community and environmental character that draws new development to the area. As the population in southeastern Massachusetts continues to grow, and the rate at which land is developed continues to grow, it is more and more economically prudent for communities to manage their water resources as a single finite renewable system. This system includes groundwater, surface water, stormwater, and wetlands, and is dependent on forest and other natural areas that capture water and allow water it to infiltrate into the ground. Without a sustainable source of clean water, the cost of local services increases. As water becomes more scarce from growth and over-consumption, and sources of water become threatened by pollution from development, the municipal costs to provide water increase significantly. Likewise, as development strains municipal wastewater systems and uses up land with prime soils for wastewater disposal locations, the municipal costs of wastewater management increase significantly. However, with a comprehensive approach to water resource management, and an understanding that water is a finite resource, the communities in the Taunton Watershed...
can help limit their exposure to these increasing public service costs. Watershed-based management can increase the ability of communities in the Taunton Watershed to realize their potential for positive economic development. Making decisions about land use management, planning for future development and protecting key ecological resources are integral components in maintaining the health of Taunton Watershed communities.

1.0 BACKGROUND

The Taunton River is the longest coastal river in New England unimpaired by dams, and has a significant watershed encompassing approximately 562 square miles (see Figure 1). The basin contains 108 sub-watersheds \(^1\) (based on Mass GIS “drainage sub basins” data layer). It is also one of the flattest watersheds with only a twenty-foot elevation drop along its forty-mile length along the main stem. This unique topography makes the river system vulnerable to dewatering as a consequence from unbalanced consumptive uses of water throughout its watershed. Saltwater intrusion in some wells already occurs as far as twelve miles upstream with tidal influences as far as eighteen miles upstream, from its source. The effects of global warming and sea level rise may also have a significant impact on this riverine ecosystem.

The watershed is generally characterized by low-permeability (glacial till) soils with more limited sand and gravel (outwash) soils, shallow depths to groundwater and numerous wetlands (see Figure 2). While these features represent significant constraints to (conventional) wastewater disposal and exacerbate stormwater runoff issues, they also afford unique habitats for both aquatic and terrestrial wildlife.

The watershed supports 45 species of fish (including the very rare, native sturgeon) and many species of shellfish, including seven types of freshwater mussels. The watershed provides a habitat for 154 species of birds, including 12 considered rare or threatened/endangered. A small sample of the ecological resources is provided in Figure 3. The watershed is also home to the river otter, mink, and gray fox. It is home to deer and often more common wildlife. The 16,950-acre Hockomock Swamp is one of the largest wetlands in New England and a habitat for numerous, common uncommon and rare species (see Figure 4). Additionally, the watershed’s archaeological treasures date back 10,000 years.

While much of the watershed and streams are relatively healthy, a number of water quality impairments were identified in the Massachusetts Department of Environmental Protection (DEP) Taunton River Watershed 2001 Water Quality Assessment Report. These included algal blooms, dissolved oxygen, sediments/siltation and pathogens (fecal coliform). The most common pollutant pathway noted in the report is stormwater runoff from roadways. A Total Maximum Daily Load (TMDL) report has also been prepared for the Taunton River that addresses pathogenic pollutants in the river. The report identifies 15 pathogen-impaired segments of the Taunton River and cites a wide variety

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\(^1\) Sub-watersheds: Typically considered the drainage area upstream from the confluence of 2 second-order streams, ranging in size from 5 to 10 square miles.
of pollutant sources, although it states, “most of the bacteria sources are believed to be stormwater related.”

The Taunton River Watershed includes 43 municipalities, many of which can be considered rural towns located among three urban centers: Fall River/New Bedford, Taunton, and Brockton. Over the last 20 to 30 years, many of these rural communities have become more concentrated, as residential and commercial development expanded dramatically along the I-495 and commuter rail corridors. The amount of developed land within the watershed has gone from 56,800 acres in 1971 to 92,340 acres in 1999, a 62% increase in a span of 28 years. With increased development came increased concerns regarding water quality, water supply, wastewater, and stormwater management. In an effort to address development-related impacts, many municipalities have undertaken comprehensive municipal water or wastewater resource planning projects, focusing on problems and solutions within the boundaries of individual towns. The focus of this project is to expand the analyses of these issues beyond municipal boundaries to the watershed scale to consider an array of possible regional solutions and to provide a comprehensive evaluation of problems and solutions to balance the ecological health of the watershed with the development needs of the watershed communities.

This project is considered Phase I of a longer-term effort. This Phase I has focused on the collection of data, establishment of public participation process, habitat and hydrology data collection and assessment, and preliminary analysis. Future phases of the project will be to complete the data gathering and analysis, develop comprehensive watershed management strategies, and then implement and update those strategies over the long term.

2.0 A PHILOSOPHY OF WATERSHED PLANNING AND MANAGEMENT

Watershed planning provides a framework to protect, preserve, and restore the water resources and related ecosystems that communities depend on for so many reasons. Healthy water resources benefit local communities by providing drinking water, active and passive recreation, habitat for fish and shellfish, attractive landscapes, transportation, tourism destinations, and flood mitigation, among many others. Management of these resources on a watershed scale provides a comprehensive and integrated approach.

With an increasing appreciation of the basic ecosystem functions provided by healthy watersheds, communities are increasingly undertaking initiatives to restore impaired waters or protect remaining water resources from land use impacts. They are also discovering that a watershed-based approach can be an effective method of protecting local water resources. Watershed planning also provides local governments with a framework to prioritize valuable and sometimes scarce resources by integrating natural resource protection with other community planning initiatives. Watershed planning is a cooperative effort and is performed in conjunction with other ongoing programs and initiatives throughout the watershed and/or region.
Watershed plans must recognize the relationships between social and natural processes and provide a roadmap for integrating water resources protection and restoration with growth management at the local level. Effective watershed plans provide specific recommendations and implementation schedules that identify who, what, when, and how actions will be undertaken. While the process for generating a local watershed plan may vary, the plan itself should include these key elements:

- Rationale for why watershed plan is required;
- Process for involving key partners (stakeholders);
- Evaluation of historic (natural), current and future watershed conditions;
- On-the-ground investigation of key areas within water resource corridors and uplands;
- Procedure for setting watershed goals and identifying actions to protect existing resources and/or restoring previously degraded resources;
- Implementation measures to achieve measurable outcomes; and
- Strategies for long-term monitoring, progress tracking, and plan revision.

This document, which captures Phase I of the Taunton River watershed planning effort, lays the groundwork for the plan through data collection and assessment, and preliminary data analysis and general recommendations. The subsequent Phases of this planning effort will flesh out the comprehensive watershed plan with more detailed analysis and implementation measures.

Several key organizations are involved in watershed planning efforts in the Taunton watershed. In addition to the federal, state, regional, and local government organizations, a number of private non-profit organizations are key contributors, and are identified as follows:

**The Taunton River Watershed Alliance**

The Taunton River Watershed Alliance (TRWA) is a non-profit alliance of individual businesses and organizations united to restore and properly manage water related natural resources within the Taunton River Watershed. The TRWA is focused on protecting and restoring the Taunton River Watershed, its tributaries, wetland floodplains, river corridors and wildlife. More information on the TRWA can be found on their website at: [http://savethetaunton.org](http://savethetaunton.org).

**Taunton River Watershed Campaign**

The Taunton River Watershed Campaign (TRWC) is a partnership of ten organizations working to protect natural communities, the landscape, and the quality of life in the Taunton River Watershed. The TRWC’s goals include: protecting critical land and water resources; linking environmental groups and municipalities working to protect natural resources; and identifying environmental priorities to help ensure growth happens in a manner that supports biodiversity and water quality while preserving community character. More information on the TRWC can be found at: [http://savethetaunton.org](http://savethetaunton.org)
Taunton River Stewardship Council

The Taunton River Stewardship Council (TRSC) serves as the coordinating/facilitating body for the implementation of the Taunton River Stewardship Plan, developed as part of the Taunton Wild & Scenic River Study. The purpose of the TRSC is to promote long term protection of the river by bringing together and coordinating between various groups working on river management and by discussing and making recommendations regarding issues of concern and implementing the Stewardship Plan. The council is currently seeking official designation of the Taunton River as a Wild & Scenic River. More information can be found at [www.tauntonriver.org](http://www.tauntonriver.org). Members of the Taunton River Watershed Campaign include:

- The Environmental League of Massachusetts
- Manomet Center for Conservation Sciences
- Mass Audubon
- The Nature Conservancy
- Save the Bay-Narragansett Bay
- Southeastern Regional Planning & Economic Development District
- Taunton River Watershed Alliance
- The Trust for Public Land
- The Trustees of Reservations
- Wildlands Trust of Southeastern MA

There are several other projects related to this one. First, a Five Year Plan was recently completed for the Taunton River basin by Geosyntec Consultants, and provides a comprehensive overview of issues and management options. A Water Assets study recently completed by MA EEA provides an analysis of water supply sources and water use figures in the basin. Another project being considered by the University of Massachusetts and The Nature Conservancy is examining fish population data along the Taunton River. A TMDL study is being undertaken by MA DEP examining water quality conditions and probable sources of pathogen pollution in the river. It suggests that stormwater is the primary source of pathogens. More recently MA DEP and the Old Colony Planning Commission, with support from several watershed communities, have commissioned CDM to begin the Upper Taunton Wastewater Study to examine possible regional wastewater solutions among the more northern municipalities in the basin. During Phase I of the Taunton River Watershed Management Plan project, HW worked with CDM by presenting relevant materials at three public participation workshops.
SECTION 2

DETAILED DATA COLLECTION AND VERIFICATION PROCESS

An important part of the Phase I effort consisted of developing a high-quality database of key information to further the planning process of the overall Taunton watershed. The data collection and compilation efforts described in this Section were undertaken by Weston & Sampson as a sub-consultant to the Horsley Witten Group, Inc., in support of the Taunton River Watershed Plan. Additional verification and information gathering was completed by the Horsley Witten Group, Inc., particularly for Water Management Act Permit information.

The purpose of this data collection effort was focused on compiling water use and wastewater information relevant to understanding water balance issues as they relate to ecosystem health and sustainability. Tables and summaries of the collected data and their corresponding sources are provided in electronic format for reference. The very large size of the datasets (e.g., detailed data across 108 sub-watersheds) makes it such that the printed versions are of limited use. Summaries of these data are provided within this Section, when relevant.

1.0 WATER AND WASTEWATER SYSTEM MAPPING

1.1. Introduction

Developing an accurate hydrologic balance within the Taunton River Watershed requires the definition and mapping of municipal water and wastewater supply and distribution systems. Data relevant to this task include: water extraction and wastewater discharge volumes and locations, and community water and wastewater infrastructure plans.

Location and extent of community sewer lines are relevant because these lines collect wastewater flow from various users and transfer it to a treatment facility. After treatment, this facility will discharge the wastewater flow into the watershed at a specific location, a receiving area. This receiving area may be a surface water body (e.g., stream, river) or underground (e.g., infiltration). These positive flows into a watershed can account for an important amount of that watershed’s recharge. Conveyance of wastewater from one watershed to another may also be substantial, leading to positive or negative water balances in neighboring watersheds. In the water balance tool, an accurate mapping of this wastewater infrastructure is therefore essential.

Conversely, water infrastructure allows the transfer of flow from a source (e.g., well, river) to the end user. This infrastructure represents a negative recharge, as water is taken out of the watershed from either surface water or groundwater bodies and conveyed to residential, commercial, or industrial customers. Individual sources service a variety of customers and water needs, and an accurate mapping of the water infrastructure is therefore essential to the understanding of the water balance. In addition, individuals and
businesses that are not serviced by the water infrastructure are most likely supplied by private wells, which need to be accounted for in the water balance model.

Water and sewer infrastructure is recorded with varying degrees of accuracy in different communities. For example, some communities only have paper maps of their systems, showing a schematic representation of the infrastructure. The maps for these systems are likely not as accurate as other systems that may be electronically mapped using Computer Aided Drafting (CAD) software or other similar engineering programs. However, CAD maps only represent the infrastructure accurately when based on field survey or other verification techniques. They may be schematic only and may not be accurately geo-coded or referenced to known markers. The greatest degree of accuracy in mapping of municipal infrastructure can be provided by properly georeferenced electronic Geographic Information Systems (GIS) mapping. When infrastructure in these GIS maps is geo-referenced to known markers, their representation of a community system can reliably represent the location of piping and system components. These geo-referenced GIS maps may also contain inaccuracies due to the age of a map (e.g., may not account for recent development) or the assumptions made while creating the map (e.g., an entire street segment is serviced by water or sewer).

The following sub-sections describe how water and sewer infrastructure data were obtained and verified, and present the results.

1.2. Methods

In 2002, the Bureau of Resource Protection (BRP) of DEP’s Southeast Regional Office (SERO) gathered water and sewer data for most of the communities in the Taunton River Watershed and created a water and sewer map in GIS for planning purposes. This GIS dataset showing municipal water and sewer systems was obtained from DEP and the MA Executive Office of Environmental Affairs (EEA) for use with the understanding that actual water and sewer lines would not be presented in this report or any public forums. In 2002, not all communities had GIS capabilities or wanted to share their infrastructure mapping with the State. They are therefore not all represented in the GIS dataset obtained from DEP. Table 2.1 summarizes the communities for which no data was obtained, either due to a lack of infrastructure in the community, or to a lack of mapping information. A list of all communities with service area maps is provided in electronic format.
Table 2.1. Water and Sewer Line Data not Provided by DEP

<table>
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<tr>
<th>Reason for lack of data</th>
<th>Water Service</th>
<th>Sewer Service</th>
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</thead>
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<tr>
<td>No infrastructure in community</td>
<td>Rehoboth and Rochester</td>
<td>Berkley, East Bridgewater, Halifax, Hanson, Lakeville, Norfolk, Pembroke, Plympton, Rehoboth, Rochester, Swansea, and West Bridgewater</td>
</tr>
<tr>
<td>No data obtained from DEP for community</td>
<td>Dartmouth, Holbrook, Norfolk, and Walpole</td>
<td>Attleborough, Dartmouth, Easton, Freetown, Holbrook, Kingston, Plymouth, Walpole, and Wrentham</td>
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</table>

The dataset includes line work for water and sewer mains, which was superimposed to a base map. The MassHighway road layer from MassGIS served as a base map, and road segments were coded as having either water service, sewer service, or both. If a water or sewer main extended only part-way along a road segment, a decision was made, based on density of housing, to represent the main as either running along the complete extent of the road segment, or not at all. This modified DEP sewer and water GIS data is referred to as State data.

In addition, sewer and/or water line information was obtained from certain communities. A complete list of communities in the Taunton River Watershed having provided water and/or sewer line data is available in electronic format. This dataset is referred to as Actual data and was compared to State data for six communities: Abington, Mansfield, Middleborough, Sharon, Stoughton, and Taunton. These six communities represent various stages of development. Middleborough and Sharon are rural communities; Abington, Mansfield, and Stoughton are suburban communities; and Taunton is an urban community. State and Actual data for these six communities were overlaid in GIS, and differences in total linear feet of water and / or sewer between the two maps were calculated. A detail of the calculations is provided in electronic format. As a result of the comparison, it was determined that State data could be improved by obtaining the most current actual datasets where available and updating the infrastructure line work.

Two general differences were noted in the line work from each dataset. First, the State datasets show infrastructure or line work in areas beyond the water and sewer mains represented in the Actual datasets, essentially overestimating the length or amount of infrastructure. As a percentage of total linear feet, the difference ranged between 2 and 30 percent. Secondly, the Actual datasets revealed infrastructure or line work in areas where the State datasets did not depict the presence of water or sewer infrastructure. This was generally in areas of newer development or system expansion. In these areas, the State dataset essentially underestimates the amount of infrastructure. As a percentage of the total linear feet, this percent difference ranges between 8 and 25 percent.

Therefore, each community in the Taunton River Watershed was contacted to obtain more recent and accurate water and sewer main mapping, preferably in GIS or CAD.
format. In certain instances, communities only had small amount of either water or sewer main infrastructure within the watershed, and/or electronic mapping was not available. In these instances, paper copy maps or verbal descriptions from local officials were used to create a GIS version of the infrastructure map.

Following exhaustive efforts to contact and request available CAD or GIS mapping from individual municipal systems, Actual water/sewer data of the infrastructure location and extent was received from 17 communities. In communities for which no Actual electronic data was available, State data was used, when available. State and Actual water and sewer infrastructure data were not available for three communities: Dartmouth, Norfolk, and Walpole, but these communities do not have significant area (and therefore infrastructure) within the Taunton River Watershed. In addition, no Actual or State sewer infrastructure data was available in electronic format for three other communities: Easton, Freetown, and Wrentham. For these communities, sewer line information was determined using a combination of verbal descriptions, and hard copy sewer maps.

1.3. Verification Process

DEP was contacted to identify the assumptions used in the mapping process and evaluate the accuracy of the State dataset. DEP confirmed that the State dataset was developed based on the criteria that if more than 50% of a road segment was serviced by water or sewer, then the entire road segment was mapped as having water or sewer infrastructure. In addition, the data represented in the DEP maps reflect a number of years prior to 2002, rather than a single point in time.

Sewer and water maps created from a combination of State and Actual data were distributed to water and/or wastewater superintendents in the pertinent communities to improve mapping accuracy, and incorporate distribution system updates. Comments were received from 28 of the 38 recipients either in verbal or hard copy format. This revised information was incorporated in the infrastructure datasets used for this final report.

1.4. Results

As a result of collecting sewer and water infrastructure data from the State and/or local communities, data for 38 of the 41 communities that have infrastructure were obtained (Rehoboth and Rochester have neither water or sewer infrastructure). Certain communities, such as Dartmouth, Norfolk and Walpole were not pursued for infrastructure data because a very small area of the community is located within the boundaries of the Taunton River Watershed, and therefore provide insignificant infrastructure area as a whole. After excluding the two communities without infrastructure and the three communities with minimal area in the watershed, water and sewer infrastructure data were obtained for all of the remaining 38 communities.
2.0 PARCEL DATA

Digital parcel maps were collected from as many watershed communities as possible to generate water and sewer service area maps, which are described in Sub-Section 3.0. This Sub-Section describes the collection effort for parcel data.

Similar to water and sewer infrastructure data, parcel data for communities in the Taunton River Watershed initially came from through MassGIS. MassGIS obtained consolidated parcel data for numerous Massachusetts communities through an agreement with Banker and Tradesman. These data are therefore considered for internal project use only. The dataset is also referred to as State data in this report. In addition, nine communities within the watershed provided digital parcel data, referred to as Actual parcel data. Similar to water and sewer data, when both State and Actual parcel data were available for a community, the more recent Actual data were used.

Digital parcel maps were collected for 35 of the 43 Taunton River Watershed communities. Nine of these maps were provided by individual communities or their consultants, and State parcel data were used for 26 communities. Parcel mapping was not pursued for Norfolk because a very small section of the community is located within the boundaries of the Taunton River Watershed. Parcel data were not available for seven communities: Brockton, Foxborough, Freetown, Pembroke, Plainville, Plympton, and Rockland. A summary of parcel data source (i.e., State of Actual) for each community within the Taunton River Watershed is provided in electronic format.

3.0 SERVICE AREA MAPS

3.1. Introduction

Water and sewer lines along streets are assumed to service parcels with frontage on that street segment. Service area maps were therefore developed in GIS by creating a buffer around the water and sewer lines, and selecting all parcels intersecting the buffer. The method used to determine the most appropriate buffer width for this mapping exercise is described below.

3.2. Methods

Service area results for varying buffer widths (25 feet, 50 feet and 200 feet) were compared to known service areas in towns for which these were available. Initially, the comparison was undertaken for sewer systems. In the towns of Mansfield, Middleborough and Taunton, the number of parcels being serviced for each different buffer width was calculated. The estimated number of serviced parcels was then compared to the known number of parcels being serviced for Mansfield (Mansfield, 2004), Middleborough (Amory Engineers, 2003) and Taunton (EPAa1). The number of parcels calculated using the 50 foot buffer compared most favorably to the actual number

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1 DEP and EPA followed by a lower case letter is a DEP or EPA reference listed at the end of this Section.
for each town. Thus, the 50 foot buffer was used to most accurately represent serviced areas.

To see the difference in estimated and actual parcels being served by water, the 50 foot buffer analysis was also conducted for the water service maps in Mansfield and Middleborough. These values were then compared to the 2006 Annual Statistical Reports which give the number of service connections known to exist for these towns. Table 2.2 shows the results of the buffer analysis in estimating water and sewer connections for Middleborough, Mansfield and Taunton. The best correlation for each community is highlighted in bold.

Table 2.2. Comparison of Actual and Estimated Sewer Service Areas for Different Buffer Widths

<table>
<thead>
<tr>
<th>State Sewer data</th>
<th>Middleboro¹</th>
<th>Mansfield²</th>
<th>Taunton³</th>
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<tr>
<td>using 25' buffer</td>
<td>-22 %</td>
<td>-44 %</td>
<td>-30.3 %</td>
</tr>
<tr>
<td>using 50' buffer</td>
<td>13 %</td>
<td>-22 %</td>
<td>-4 %</td>
</tr>
<tr>
<td>using 200' buffer</td>
<td>32 %</td>
<td>-8 %</td>
<td>8 %</td>
</tr>
<tr>
<td>Actual Sewer data</td>
<td>Middleboro¹</td>
<td>Mansfield²</td>
<td>Taunton³</td>
</tr>
<tr>
<td>using 25' buffer</td>
<td>-17 %</td>
<td>-19 %</td>
<td>-33 %</td>
</tr>
<tr>
<td>using 50' buffer</td>
<td>9 %</td>
<td>-5 %</td>
<td>-18 %</td>
</tr>
<tr>
<td>using 200' buffer</td>
<td>27 %</td>
<td>8 %</td>
<td>-2 %</td>
</tr>
</tbody>
</table>

1. Calculation based on GIS analysis of parcels served vs. total number of parcels given in WSE "Program Evaluation Report - 2004"
2. Calculation based on GIS analysis of parcels served vs. total number of parcels given in Mansfield’s 2004 "Inflow and Infiltration Overview and Summary"
3. Calculation based on GIS analysis of parcels served vs. total number of parcels given in Taunton WWTP 2007 NPDES permit.

The 50 foot buffer is the best approximation for both and Actual and State data for Mansfield, Middleborough and Taunton. Actual datasets were better approximated by the 50 foot buffer than State datasets, most likely because the State datasets are older and may be missing newer developments that are included in the Actual datasets.

Service area maps were then created for each community using the most current infrastructure and parcel data and a 50 foot buffer around the infrastructure line work. If parcel data were not available for a community, developed parcels were estimated based on 2005 aerial photographs available from MassGIS. Developed parcels were overlaid on water and sewer maps to estimate service areas. In certain cases when only a small area of the town within the Taunton River Watershed was serviced by water and/or sewer and electronic information for these areas was not available, service area maps were created based on hard copy maps or verbal descriptions of the service areas by local officials. Data sources used in creating the estimated service area maps are listed in electronic format.
3.3. Verification Process

Additional comparison of the 50 foot buffer analysis was undertaken based on water and sewer data for three communities: Middleboro, Mansfield, and Taunton. For each community, the estimated number of parcels serviced by water and/or sewer lines was compared to the known number of water and/or sewer service connections. Table 2 summarizes the comparison results for each of the three communities.

Table 2.3. Comparison of Actual and Estimated Water and Sewer Service Connection for a 50 Foot Buffer

<table>
<thead>
<tr>
<th>Data</th>
<th>Middleboro</th>
<th>Mansfield</th>
<th>Taunton</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Sewer</td>
<td>13(1)%</td>
<td>-22(2)%</td>
<td>-4(3)%</td>
</tr>
<tr>
<td>State Water</td>
<td>-20(4)%</td>
<td>-21(4)%</td>
<td></td>
</tr>
<tr>
<td>Actual Sewer</td>
<td>9(1)%</td>
<td>-5(2)%</td>
<td>-18(3)%</td>
</tr>
<tr>
<td>Actual Water</td>
<td>1(4)%</td>
<td>-4(4)%</td>
<td></td>
</tr>
</tbody>
</table>

1. Percentage calculation is based on GIS analysis of parcels served vs. total number of parcels from WSE "Program Evaluation Report - 2004"
2. Mansfield calculation is based on GIS analysis of parcels served vs. total number of parcels from Mansfield's 2004 "Inflow and Infiltration Overview and Summary"
3. Taunton calculation is based on GIS analysis of parcels served vs. total number of parcels from Taunton WWTP 2007 NPDES permit.
4. Based on 2006 Annual Statistical Report

3.4. Results

Service area maps were created for a total of 38 out of the 43 communities in the Taunton River Watershed. Of the remaining five communities, Rehoboth and Rochester were not mapped because these communities have neither public sewer nor public water service. Maps were not created for the three other communities (Dartmouth, Norfolk and Walpole) because these communities each have insignificant areas within the Taunton River Watershed. These maps are provided in electronic format.

4.0 INFILTRATION AND INFLOW

Inflow and infiltration (I&I) describes the ways that groundwater and stormwater enter into dedicated wastewater or sanitary sewer systems. These sewer pipes are designed strictly to transport wastewater from the various users to the treatment plant. I&I flows can contribute significant amounts of additional effluent, and should be included in the water balance. This flow represents a negative recharge for a watershed as the water flows from the ground to a wastewater system.

An additional analysis of I&I was therefore required for the water balance model to estimate how much groundwater may be transported within the sewer mains due to inflow and infiltration. The length of sewer main for each sub-watershed was calculated using the available sewer mapping. An I&I value for each sub-watershed was estimated using an average I&I rate of one gallon per day per linear foot of sewer main as a
representative value (NEIWPC, 1998). However, I&I values may vary from town to town based on the age of sewer infrastructure and the level of I&I remediation undertaken to date. Lengths of sewer pipe and estimated I&I for each sub-watershed are provided in electronic format.

5.0 WATER WITHDRAWALS AND DISCHARGES

5.1 Introduction

Water withdrawals and discharges were identified through permits that regulate large water and wastewater flows. These permits include the MA Water Management Act (WMA) Withdrawal Permits, the MA Ground Water Discharge Permits (GWDP) and the National Pollutant Discharge Elimination System (NPDES) Permits. For the purposes of the water balance model, both the location of the discharge / withdrawal and the annual flow volumes were identified for these facilities.

5.2 Water Management Act Withdrawals

5.2.1 Introduction

The WMA regulates large water withdrawals from surface or groundwater sources in Massachusetts. WMA permits are generally required for withdrawals greater than 100,000 gallons per day. Locations that were withdrawing significant volumes of water prior to the registration date of 1988 may have a WMA registration to withdraw a certain volume of water annually, often in addition to a permitted volume. This Sub-Section describes the methods used to obtain WMA permit and registration data, the verification process, and the data collection results.

5.2.2 Methods

A comprehensive list of WMA facilities in the Taunton River Watershed was obtained from the State (DEPc) in July 2007. This list includes facility name, mailing address and permit / registration number. It was enhanced by including the sources for the WMA facilities provided in different documents by the State (DEPd, DEPe) as well as registered / permitted values for each facility. Where facilities had more than one source, the permitted / registered values for each source were estimated by evenly dividing the registered / permitted values among the sources. These sources were precisely located through data received by the State (DEPd, DEPe) and MassGIS.

These facilities were then categorized by “type” with input from State data sources (DEPb, DEPd). Facility type categories include public water supply (PWS), agriculture (AGRI), golf courses (GOLF), cranberry operations (CRAN) and waste management facilities (WMF). These types were used to assist with assigning actual flow values for these facilities.
Reported flows for WMA facilities categorized as PWS facilities were taken from the 2006 Annual Statistical Reports (ASRs) provided by the State (DEPh). Reported flows for the other categories of WMA facilities were also provided by the State in a separate listing (DEPb). Cranberry facilities were not assigned reported flow numbers for purposes of the water balance model since losses due to water use in cranberry bogs are addressed through the use of a negative recharge value on an acre by acre basis, as described in the water budget methodology.

5.2.3. Verification Process

An examination of the permitted / registered values against the reported flow values was conducted to verify accuracy. A reported flow that was less than 5% of the permitted and registered flows was considered to be a suspect value. Likewise, a reported flow that was greater than 100% of the permitted and registered flows was considered to be a suspect value. In five instances, reported flows were either significantly higher or lower than the permitted and registered flows. Verification for both permitted and registered flows and reported flow was requested from the State (DEPj). In two instances, the data originally obtained was in error. For one of these two instances, the water supplier’s ASR was incorrectly providing a supply. For the other instance, the water sources for the City of Brockton, we worked with DEP to clarify which sources were physically located within the Taunton River Basin and which were not, and then gathered the pertinent Taunton River Basin withdrawal information. After confirming the correct reported flow values, the database was updated with the correct information. The three other registered users had accurately recorded values when the DEP databases were checked against the reported flows as provided in the ASRs.

5.2.4. Results

The location, permitted / regulated flow values and reported flow information for the WMA facilities and individual sources for these facilities are provided in electronic format. A total of 355 Water Management Act (WMA) permitted and registered sources were identified within the Taunton River Watershed, including 195 cranberry facilities. The WMA water withdrawal information for cranberry facilities was not necessary for the water balance tool since water use for these facilities was estimated as a function of cranberry bog area. We were unable to obtain the location for two non-cranberry facilities, so these were excluded from the water balance. One of these sources, Aquaria Water, was listed as being located in Brockton. This appears to be incorrect and it is believed to be located outside the study area. The other non-located source is a golf course well. Withdrawal volumes for three sources could not be obtained. These included a golf course, a sand and gravel well and a water supply well. However, there is some question as to whether the water supply well may actually be a cranberry operation well. Despite these minimal omissions, we are confident that the water budget analysis results are still representative of the watershed. The full dataset of WMA data collected for this report is provided in electronic format.
5.3. **Groundwater Discharge Permits**

5.3.1. **Introduction**

Facilities with these types of permits discharge at least 10,000 gallons per day (gpd) through on-site disposal systems. These discharges are included in the water balance model as positive recharge as the facilities are providing direct sub-surface recharge. This Sub-Section describes the methods used to obtain GWDP data, the data verification process, and results.

5.3.2. **Methods**

The latest and most up-to-date list of GWDP facilities and associated permitted flows were obtained through the DEP website in August 2007, and are provided for reference in electronic format. Accurate locations (latitude/longitude coordinates) were obtained either through the MassGIS GWDP data layer, or geo-referenced in GIS using the location address noted for the facility on the DEP website. Reported flow values for these facilities were obtained from the 2006 / 2007 Discharge Monitoring Reports (DMRs) from the State (DEPk) for all facilities except one. For the facility with no DMR, a ratio of 0.48 was used between actual flow volumes and permitted flow volumes. This ratio is based on data from facilities in the watershed for which both permitted and actual flows were available.

5.3.3. **Verification Process**

The MassGIS GWDP data layer was used to verify the GWDP facility list obtained through the DEP website for the Taunton River Watershed facilities. In cases where facilities were noted in the MassGIS database but not in the list taken from the DEP website, the State (DEPi) was contacted for an explanation. The State clarified that the additional GWDP facilities in the MassGIS database were inactive facilities. As such, these were not included in the data collection effort and are not used for the water balance analysis.

5.3.4. **Results**

The data collection effort for the GWDP facilities resulted in a complete list of GWDP facilities in the Taunton River Watershed that can be accurately mapped. Reported discharge flows associated with all facilities were also compiled. A spreadsheet of these facilities and their associated flows and locations is provided in electronic format.

5.4. **Individual NPDES Discharge Permits**

5.4.1. **Introduction**

Facilities with individual NPDES discharge permits include industrial, municipal or other facilities discharging directly into the waters of the United States. These facilities are
considered to be adding flow to a given stream reach since they are discharging water to surface water bodies at a specific location. This Sub-Section describes the methods used to obtain NPDES data, the data verification process, and results.

5.4.2. **Methods**

A comprehensive list of NPDES facilities, permitted flow values and facility locations was created using information from two different EPA websites, the general EPA website and the Region I EPA website (USEPAb, USEPAd). Accurate locations (latitude / longitude coordinates) for these facilities were obtained from the NPDES permits available online through the EPA website.

Reported flow values for the NPDES facilities were obtained through a Freedom of Information Act (FOIA) request to the US EPA. Reported discharge flow data was requested for the identified individual NPDES permitted facilities within the Taunton River Watershed for all available years. However, data was not received for all years at all facilities. The data gathered from the FOIA request (USEPAe) includes all available historic monthly 12-month average flows for each facility in the Taunton River Watershed.

5.4.3. **Verification Process**

Facilities were verified visually using 2005 aerial photography obtained through MassGIS. This process showed that the coordinates for one NPDES facility (Inima Water Desalination Plant, under construction) were inaccurately reflected in the DEP website. The correct coordinates were verified for this facility both online with the NPDES permit number and through MassGIS.

5.4.4. **Results**

A list of all of the NPDES permits and associated discharge locations in the Taunton River Watershed was assembled. Reported flows were obtained for 14 or the 20 NPDES facilities through the FOIA request. The two facilities in West Bridgewater are not located within the boundaries of the Taunton River Watershed, and were not included in the water balance analysis, such that actual flows were available for 13 of the 18 NPDES facilities. A summary spreadsheet of the average monthly flow data from 2001 - 2006 is provided in electronic format.

6.0 **REFERENCES**


MA Department of Environmental Protection (DEPa) “State” water, sewer and parcel layers. Compiled 2002.

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MA Department of Environmental Protection (DEPj), personal communications (email) with Pamela Truesdale DEP 2/25/08.

MA Department of Environmental Protection (DEPk), 2006/2007 Discharge Monitoring Reports (DMRs) provided by Pamela Truesdale DEP.


Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs, various data layers.

Mansfield, Town of, “Inflow and Infiltration Overview and Summary,” 2004


US Environmental Protection Agency (EPAe), Freedom of Information Act (FOIA) request, Request 01-RIN-00029-08, data received December 4, 2007.
1.0 INTRODUCTION

The Taunton River Watershed Study included a significant public education and outreach component to build a greater understanding about the project within the watershed and to solicit input. This component included presentations at 10 public meetings, an outdoor watershed awareness and education day, development and maintenance of a project website and coordination with Bridgewater State College student projects on stream flow and land use development issues.

The project was initiated with the establishment of a website at the following location: www.horsleywitten.com/tauntonwatershed. The website contains an overview of the project and provides information on upcoming events. It also provides an opportunity to make comments and suggestions.

A project kick-off meeting was held on June 13, 2007 at Bridgewater State College at which the project was introduced and comments were received. A public Watershed Day was held on September 15, 2007 featuring a presentation by State Senator Mark Pacheco. Field trips were conducted, despite inclement (rainy) weather.

During the month of November, four public meetings were held throughout the watershed to present preliminary findings and to identify and prioritize key watershed issues. The highest priority issues included:

- public education;
- training of local government officials;
- the amount of habitat, wetlands, and open space being protected;
- the extent of inappropriate development; and
- water quantity, flow and quality in the rivers, lakes and streams in the Taunton watershed.

In the spring of 2008 HW organized and ran a workshop to explore smart growth issues in the Town of Easton. Easton was selected as representative of the many issues facing communities in the watershed and had expressed interest in working with the project. A planning meeting was held with Easton town officials prior to the actual workshop at which the scope of the meeting was focused to low impact development (LID) and transfer of development rights (TDR). HW presented the preliminary results of the water balance work (described in Section 4 of this report) and provided introductions to the two selected smart growth techniques. Exercises were conducted by break out groups to explore the potential applications of these techniques, and additional time allocations are recommended for future workshops. However, insufficient time was provided for discussions and comments at the end of the meeting.
During the month of June, HW participated in three public meetings organized by the Upper Taunton Wastewater Project. The water budget model results were presented and discussed. A range of wastewater management alternatives were presented by the project contractor, CDM. The workshops included discussions as to how creative wastewater solutions could lead to “keeping water local” and in some instances may assist in restoring natural hydrologic conditions in those sub-watersheds identified as out of balance.

Overall, the public participation process was successful in explaining the project and obtaining input about priority issues. However, the attendance at the workshop was relatively low. Perhaps this reflects the public’s focus on other important issues such as the economy. We will seek to improve public participation in the future through the establishment of local stakeholder groups and other techniques.

2.0 PUBLIC MEETING AND EVENT SUMMARIES

Summaries of the public meetings and outreach events that took place as part of Phase I of the Taunton River Watershed Management Plan project are provided on the following pages. These include:

<table>
<thead>
<tr>
<th>Meeting/Event</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Forum (June 13, 2007)</td>
<td>3-3</td>
</tr>
<tr>
<td>Taunton River Watershed Day (September 15, 2007)</td>
<td>3-6</td>
</tr>
<tr>
<td>Public Meetings (November, 2007)</td>
<td>3-7</td>
</tr>
<tr>
<td>Public Workshop in Easton (April 20, 2007)</td>
<td>3-10</td>
</tr>
</tbody>
</table>
Attendees:
Attendees were asked to sign in and pick up a “Watershed Perceptions and Practices” survey for completion during the event. We had 28 members of the public attend the meeting, plus several Steering Committee members and several of the interns that will be supporting the project and their advisors. Representatives from the consultant team of Horsley Witten Group, Inc. (HW), Geosyntec and Weston & Sampson were also present. The public was represented by a combination of non-profit organizations, town staff in the water, sewer and other departments, representatives of local boards and commissions (Conservation, Health, Water Supply, Wastewater), residents and a local reporter. (Contacts have been added to the project master contact list, and surveys are being tallied for future reference. A copy of the survey is also being made available on the project website.)

Introduction:
The meeting was opened by Ed Minnock, Vice President for External Affairs, Bridgewater State College and primary contact for the Steering Committee. Mr. Minnock introduced the project, the consultant team led by Horsley Witten Group, Inc., and Scott Horsley.

Presentation:
Scott Horsley presented a slideshow that included an overview of the Steering Committee, the project scope of work, the draft outline for Phase II of the project, and a general overview of watershed statistics and concerns. Bob Hartzel, from Geosyntec, presented an overview of the previous EOEEA 5-year Action Plan, describing how that was different and will contribute to this study. Mr. Horsley then described the water budget methodology, including the use of a trial sub-watershed to test the methodology before applying it throughout the Taunton watershed. Potential watershed restoration and protection tools were introduced, such as LID, integrated water resource management techniques, smart growth and village style development, and trading of development rights. Ellie Baker of HW then reviewed some statistics of homeowner practices that can affect the watershed, and solicited feedback on a watershed perceptions and practices survey.

A copy of the presentation is available to download from our project website, under ‘Public Workshops’.

Discussion/Question and Answer:
The last hour of the meeting entailed discussion and questions from the attendees about the project and the major issues in the watershed. Below is a summary of the comments that were voiced:
• Commercial-Industrial properties in our trial sub-watershed, Coweeset Brook, are located in both Brockton and Easton and discharge to the Brockton treatment plant. Industrial discharges from Brockton require pretreatment while those from Easton do not require the same pretreatment.

• Comment that local changes (zoning, ordinances/bylaws, regulation, and enforcement) can begin now, and do not need to wait until this study is completed.

• Question was raised about whether building inspections enforce or can enforce stormwater management on sites.

• Easton DPW discussed the benefits and successes in Easton from public education/ watershed education. He noted that the Wastewater Department has $20,000 in its annual budget to fund household hazardous waste.

• Concerns were voiced about the water quality to the Salisbury Plain River from the Brockton wastewater treatment plant.

• A large wetlands replication project being considered for Burridge Pond was mentioned.

• A suggestion was made for a survey to be given to local town boards in the watershed to gather information about needs, problems and areas to highlight for Phase II of the project.

• It was noted that there appear to be missing groundwater discharge permits in the data from MassGIS.

• It was stated that there are problems in Taunton with untreated wastewater discharges to the river during large storm events due to overflows. Many sump pumps are hooked directly to the system (stormwater or wastewater?) and contribute to overflows. These overflows create fines for the city to DEP, and this person questioned whether that money was used by the state to help solve the problem. A large study on sump pump locations was done in Brockton to begin to address this problem.

• A question was asked about whether the project would include any watershed education outreach to young school children. Kevin Curry commented that Bridgewater State College was working on that down the road.

• Wetland restoration to address historic wetland loss was requested to be included in the recommendations from the project. Another noted that wetland loss seems to be an even growing problem, despite regulations.
• It was noted that the local elderly services agencies were urging elderly residents to throw away all old medicines by flushing them down the toilet, and commented that we contact them with alternative approaches for water quality purposes.

• Several people commented that local enforcement of wetland regulations and other local building regulations was inadequate and needs improvement.

• A concern was raised regarding aerial mosquito spraying, a large concern in southeastern MA, and asked how that should be addressed. Is it a water quality and habitat concern, and can it be done differently with less impact? Similarly, is cranberry bog aerial spraying a concern and will it be addressed?

• A suggestion was made that we compare and contrast our pilot watershed, Coweeset Brook, with the Salisbury/Matfield Rivers sub-watershed due to differences in the amount of protected area and the existence of an Enterprise Zone for Commercial development in one watershed.

• A question was asked about the recently released DEP RFP for a wastewater study in the northern Taunton communities, and questioned whether that study should wait to start until after this study is completed.

• A Bridgewater State College professor noted that BSC has an Institute of Regional Development that is adept at carrying out surveys. He suggested that they may help in gathering watershed survey information, such as the survey distributed at the meeting.
Taunton River Watershed Day
September 15, 2007

Taunton River Watershed Day was held at Watson Pond State Park in Taunton on September 15, 2007. We had a great group of people in attendance, and we managed to fit in some great informational walking tours and a nice barbecue lunch before the wind and rain took over. Three tours were offered:

- Local development and stormwater management tour, led by Rich Claytor, PE, Principal at HW;
- Hydrology and water quality tour, including a stint on the water in some rented kayaks, led by Neal Price, Senior Hydrogeologist at HW; and
- Wetland and shoreline ecology tour, led by Alison Bowden, Freshwater Programs Director for The Nature Conservancy Massachusetts Chapter.

MassAudubon’s Sarah Slack, Director of the Oak Knoll Sanctuary in Attleboro, offered a hands-on investigations table for children. They sampled water from the pond’s edge and investigated the plants and critters that they found. A table-top watershed model was also a big hit.

Senator Pacheco (D – First Plymouth and Bristol Districts) gave lunch time remarks in support of the watershed study, and we offered a free barbecue lunch, using donations from local vendors.

Many thanks to:

The MA Department of Conservation and Recreation
The Nature Conservancy
The Taunton River Watershed Campaign
The Taunton River Watershed Alliance
Atlantic Pest Control: Project PEST
Joe Noberini - Noberweenies
Canoe Passages
Hannaford’s of Taunton
Trader Joe’s
Waste Management
The Taunton River Watershed Study Steering Committee
Four public meetings were held in November to engage the public and discuss watershed issues that the residents, businesses and municipalities think are most pressing in the Taunton watershed. Attendance at these meetings by the general public (i.e., non-Steering Committee or Project staff) ranged from six to thirteen people, with a total of 36 people participating in the meetings. We engaged a sub-consultant (with funds donated by Horsley Witten Group) to assist in promoting these meetings by making personal invitations to town offices and community groups, and making brief presentations at local Selectmen’s and other municipal board and commission meetings. We also issued two press releases and received front page coverage in the Brockton Enterprise (11/9/07) (text attached).

Meetings were held on:

- November 5 (Bridgewater State College);
- November 8 (Southeastern Regional High School, S. Easton); and
- November 13 (two meetings, Bristol County Agricultural High School, Dighton).

The November 5 and November 13 afternoon meetings were recorded by local cable access shows, and copies will be distributed to other cable stations in the watershed.

At each meeting, HW presented a Powerpoint presentation, which you can download from the project website (www.horsleywitten.com/tauntonwatershed) and clicking on the Public Meetings tab. We also provided several handouts to guide the discussion, which are also available for download on the website. Participants were asked to join in small group discussions to identify the most important issues facing the watershed, ranging from wastewater to low flow issues in the Taunton River tributaries to education of the municipal boards and staff. The full list of issues identified by the groups in the four meetings is attached, along with the ranking that resulted from an individual voting process. The issues that rose to the top in these discussions were:

- The level of public education and training for municipal boards, commission and commissions;
- The level of general public education and outreach on environmental issues;
- The amount of habitat, wetlands, and open space being protected;
- The extent of inappropriate development; and
- Water quantity, flow and quality in the rivers, lakes and streams in the Taunton watershed.

The need for education of both the general public and municipal officials on these issues was the overwhelming priority concern at these meetings. Even if this was not identified by a discussion group as the top priority, it came up in discussions as a problem area, and a potential solution for other priority concerns.
Once the full list of issues was identified, attendees discussed potential solutions to address those issues. Solutions included:

**Education:**
- Mandatory training for local officials
- Outreach efforts using PSAs on radio and town websites
- Use a positive message
- Use good science as a basis for education and awareness
- Reach kids in high school and younger: science fairs, scouting troops
- Organize an umbrella educational organization, similar to DEP Wetlands Circuit Rider program, to reach all communities
- Get people out to experience the river, solicit corporate sponsors and adopt a wetland program

**Extent of Inappropriate Development and Habitat Protection:**
- Improve local regulations
- Improve local enforcement
- Improve education and training for officials

**Water quality and flow in rivers, streams and lakes:**
- Improve aquifer recharge using LID and Smart Growth techniques
- LID retrofits
- Find illicit connections in the stormwater system
- Limit “effective imperviousness” into the NPDES Phase II permits
- Improve Water Management Act permitting process
- Provide education and outreach about outdoor water use

We would like to thank everyone who participated in these meetings, and provided valuable insight and feedback for our study as we move forward. We will cover these key topics in more detail in our April 2008 public workshops (exact times and locations to be determined).

Looking ahead to the spring workshops, we propose that we coordinate these with other, on-going projects, specifically the Upper Taunton Wastewater Study and the MBTA Expansion project. We would focus on wastewater and smart growth issues respectively. We believe that this would ensure better attendance and participation and would serve to provide interaction and coordination with these two other important studies.
<table>
<thead>
<tr>
<th>RANK</th>
<th>ISSUE</th>
<th>Nov 5</th>
<th>Nov 8</th>
<th>Nov 13 afternoon</th>
<th>Nov 13 evening</th>
<th>Total</th>
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</thead>
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<tr>
<td>1</td>
<td>The amount of public education (training) for municipal staff, boards, commissions</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>The amount of public education and outreach about environmental issues</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>The amount of habitat, wetlands and open space being protected</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>The extent of inappropriate development</td>
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<td>3</td>
<td>1</td>
<td>3</td>
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<td>5</td>
<td>Quantity of flow and availability of critical habitat in rivers, stream and lakes</td>
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<td></td>
<td></td>
<td></td>
<td>9</td>
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<tr>
<td>6</td>
<td>The quality of water in the rivers, streams and lakes</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>8</td>
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<tr>
<td>7</td>
<td>The problems with local permitting, compliance and enforcement</td>
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<td>3</td>
<td>1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>The quality of my drinking water</td>
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<td>1</td>
<td>2</td>
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<td>The way stormwater is being managed</td>
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<tr>
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<td>The way wastewater is being managed</td>
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<td>3</td>
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<td>14</td>
<td>Science should drive priorities</td>
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<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Ecological health/biodiversity should be maintained/restored</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Laws</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Public water supply withdrawal impacts on rivers</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>Dams and obstructions</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Contamination hot spots</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Desalination impacts on rivers</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Aquifer recharge</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
The meeting was coordinated with NRT of Easton, Town of Easton, Canoe River Aquifer Advisory Committee, Brockton Conservation, and TRWA.

There were 34 attendees, including:
- General public
- Boards/commissioners/selectmen
- Environmental groups
- Engineering firms
- Representatives of the Upper Taunton Wastewater Study

During the meeting, HW presented an overview of the study, the water budget tool and preliminary results, and the preliminary buffer and conservation land analysis. Then we presented three Smart Growth tools: LID, Traditional Village Districts, and Transfer of Development Rights. Attendees then split into three groups to do smart growth exercises. Everyone seemed to really understand the LID concept and were already familiar with the topic. The traditional village district concept was complex and people voiced concern about density, growth and wastewater needs. While people were very interested in the concept of transfer of development rights, this tool was very complex and was probably the least understood and embraced of the tools presented. There were questions about how the property rights banking works and concern about the fact that conservation was not guaranteed in the sending areas because owners are not required to use the overlay district.

Feedback received since the meeting:
- Excited about tying this in with Upper Taunton Wastewater Study, in terms of identifying potential wastewater locations;
- Thank you from RI Audubon, who was pleased with our work here and in RI;
- Call from Sharon resident thanking us for materials since he could not attend.

A follow up press release is under development. An HW Press Release and Easton press release prior to the meeting generated interest in a follow up to the meeting.
SECTION 4

SUB-WATERSHED ANALYSIS-WATER BALANCE

1.0 INTRODUCTION

The water balance tool developed for the Taunton River Watershed Study is a planning level assessment designed to evaluate the hydrologic impacts associated with water supply withdrawals, wastewater discharges and stormwater runoff associated with land uses. The method uses a mass balance approach that accounts for net changes in groundwater recharge as it relates to base flow to streams and wetlands on an annual basis. It estimates stream base flow changes resulting from water withdrawal, water transfer, wastewater discharges and stormwater runoff associated with different land uses. Base flow is the flow that sustains the stream between precipitation and runoff events. It is derived from discharge from groundwater and from surface water storage released from wetlands and impoundments. Base flow is the stream flow that continues after runoff from precipitation has ceased for several days.

The tool is intended primarily for comparative purposes between and among sub-watersheds. Different sub-watersheds of the Taunton River watershed can be compared against each other in terms of their relative degree of water balance impairment. This information will serve as a means to target sub-watersheds in greatest need of remedial activities and to evaluate the water balance impacts of potential land use management options. This water balance tool calculates both pre-development (natural), and post-development recharge. It also provides a tool to evaluate future land use scenarios and the associated water, sewer and stormwater infrastructure impacts.

Massachusetts DEP and EOEEA have developed policies to “keep water local” by maintaining a balance between water withdrawal and discharges (http://mass.gov/dep/water/local.htm). The DEP website provides an excellent overview of this policy as follows.

Massachusetts is considered “water rich” in comparison to other regions of the country. However, Massachusetts’ water is not always located in the areas where it is most needed. In many areas of the state, the natural water cycle has been disrupted by the demands for clean water for consumptive use and the need to dispose of wastewater in an environmentally responsible manner. Clean drinking water is often obtained from groundwater wells located in the headwaters of our streams. The water is used by residences and businesses, and then in many cases discharged to a sewer system that delivers the wastewater to a centralized treatment facility that discharges the treated wastewater some distance away to a mainstem of the river or to the ocean. The naturally occurring phenomenon of groundwater serving as base flow to the smaller streams as they progress to larger streams and then to rivers has been short circuited, at least in part, by water supply systems and wastewater collection systems. This effect is further compounded in developed areas as the
amount of impervious surface area increases. Rainfall that normally recharges groundwater to serve as future base flow may be diverted off impermeable surfaces of developed areas and captured by storm drains that discharge directly to streams.

This type of water balance approach is presented in a recent publication by the USGS that describes a “two dimensional” analysis that depicts “human withdrawals” and “human return flows” as a valid method to evaluate the “sustainability of human water use practices” (Weiskel et al., 2006). Another study by the US Geological Survey (USGS) of the Ipswich, Blackstone and SuAsCo basins (and their sub-watersheds) also examines water balance (withdrawals versus return flows) and their impact on fisheries (Armstrong et al., 2008).

2.0 WATER BALANCE METHODOLOGY

Water balance calculations were conducted on the Hydrologic Unit Code (HUC) 14 sub-watershed scale, referring to the 14 digits in the code name for each sub-watershed. The more digits in the HUC code, the smaller the sub-watersheds. These sub-watersheds are the smallest sub-watersheds delineated in MassGIS and there are 108 in the Taunton River Watershed. It is understood that these sub-watershed delineations are based on surface water drainage areas and may not always exactly coincide with groundwater contributing areas. In early discussions with the Steering Committee for this project it was decided to use the HUC-14 sub-watersheds as the best available, published data to subdivide the project, despite any limitations of those delineations. The HUC-14 sub-watershed water balance results can be grouped together to look at water balance issues for HUC-12 or HUC-10 sub-watersheds, or for specific resource areas of interest.

A central assumption behind the water balance tool is that groundwater recharge is the primary source of base flow to streams and that declines in recharge will result in diminished base flow and potential ecological impacts including habitat loss. This relationship between groundwater discharge and base flow is an accepted principal in hydrology, as cited in Hansen & Lapham (1992) “stream base flow during periods of average groundwater storage can be used to estimate recharge.” The groundwater recharge we refer to here that sustains base flow to streams is sometimes referred to as “effective” or “net” groundwater recharge to distinguish it from the shallow groundwater recharge that may be intercepted and evapotranspired by plants before it reaches streams or rivers. For simplicity, we simply use the term “recharge” here but “effective” or “net” recharge is implied. In addition, some portion of the groundwater recharge in a sub-watershed may exit the sub-watershed as underflow beneath the streams. That underflow component is likely negligible in the sub-watersheds of the Taunton River watershed and is not considered here.

Groundwater recharge rates were selected based upon literature values from representative USGS studies, and by comparing them to actual measured flow at a USGS gage station at Rattlesnake Creek in the Taunton River Watershed. The resulting recharge rates were then applied to each sub-watershed along with the permitted water
withdrawals, discharges and the existing land uses in order to estimate the resultant base
flow for each stream draining a given sub-watershed. These estimates for the developed
conditions were then compared to pre-development streamflow estimates for each sub-
watershed. These comparisons give a planner a measure of the relative impacts that
development has had on the water balance in each sub-watershed in order to help
prioritize actions to address these development impacts. Additionally, this planning tool
can be used to estimate future relative impacts of proposed alternative development
plans. It can also be used to evaluate impacts across groups of sub-watersheds
contributing to key resources, such as the Hockomock Swamp or certain tributaries of the
Taunton River.

One key characteristic of this water balance planning tool is that it focuses on average
annual conditions as a planning level assessment of the overall hydrologic balance of
subject watersheds. Because water discharged to a gaining stream from groundwater is
the primary source of the base flow that occurs between precipitation-runoff events,
average annual groundwater recharge within a watershed can be considered as a proxy
for average annual base flow discharge. That is, provided that there is no long-term
change in storage volume within the watershed and there is no significant component of
groundwater underflow, net groundwater recharge within a basin must approximate net
stream base flow gain within the basin on a long-term average basis.

By focusing on groundwater recharge as a proxy for average annual base flow in a
stream, we can ignore many of the temporal fluctuations that complicate streamflow
evaluations while still allowing us to effectively evaluate the overall long-term
hydrologic health of a watershed. Given the difficulty of obtaining the time-dependent
data necessary to accurately evaluate surface water flow conditions, this groundwater
recharge approach is considered a pragmatic and effective planning level tool.

Although the water balance tool focuses on groundwater as the dominant source
sustaining base flow to streams, please note that the tool also incorporates significant
surface water withdrawals and surface water discharges. Infrequent or “flashy” surface
water components such as stormwater discharges to surface waters are not evaluated in
the tool because they do not effectively support the long term stream base flow that is so
important for ecological and habitat concerns. However, major permitted surface water
withdrawals, such as public water supplies, are included because they occur regularly and
steadily in a manner that is likely to reduce base flow. Similarly major surface water
discharges, such as wastewater treatment plants, permitted under the NPDES are included
because they occur with sufficient regularity to support stream base flow.

The water balance tool is run under separate scenarios including and excluding major
surface water components. This separation allows for an evaluation of the surface water
component to the water balance of any specific sub-watershed. This is particularly
significant for small sub-watersheds that may happen to have a major wastewater NPDES
discharge that can potentially constitute a large proportion of the base flow during
naturally dry periods.
This water balance tool evaluates conditions over an average annual period for the purposes of planning level decision making and understanding. Therefore, the tool does not incorporate drought conditions that may occur in certain years and which can affect the water balance in a given period. Within the Taunton watershed, climate conditions can be such that certain areas of the watershed may experience drought conditions while others may not. These types of anomalies are not captured in this tool.

3.0 STRUCTURE OF THE WATER BALANCE TOOL

Mathematically, the groundwater recharge-based water balance approach is expressed as follows:

\[ BF = (GW_{nat} + WW_{GWDP} + WW_{septic}) - (WS_{WMA} + WS_{prvt} + SW_{EIA}) \]

Where:
- \( BF \) = Average annual base flow in a stream;
- \( GW_{nat} \) = Natural groundwater recharge;
- \( WW_{GWDP} \) = Groundwater Discharge Permit inflows;
- \( WW_{septic} \) = Private septic system inflows;
- \( WS_{WMA} \) = Water Management Act permitted groundwater withdrawals;
- \( WS_{prvt} \) = Private groundwater withdrawals; and
- \( SW_{EIA} \) = Stormwater runoff from effective impervious areas.

Note: Units for all data inputs must be consistent and are either in gallons per year (GPY) or cubic feet per second (cfs).

In addition, surface water withdrawals (with Water Management Act permits) and inputs (with NPDES permits) were taken into account for comparison purposes. Comparative results are described in Section 7.0 of this report.

Figure 4.1 illustrates the various inputs and outputs of the water balance methodology in graphical format. One of the primary considerations is how drinking water and wastewater services are supplied to given land areas. A land area may receive public water supply or be served by private wells. Similarly, it may be served by public wastewater or have private septic systems. Alternatively, either water supply or wastewater can be served publicly while the other is served privately. Other examples include withdrawals for golf course irrigation, industrial uses, or agriculture, among others. Other groundwater discharges may be associated with industrial wastewater or wastewater from large private facilities. Discharges flowing directly to surface waters, such as those permitted through the NPDES program do not provide groundwater recharge to the watershed.
Four Main Water Use Development Scenarios:
1. Public Water Supply & Public Wastewater
2. Public Water Supply & Private Wastewater (septic)
3. Private Water Supply & Private Wastewater (septic)
4. Private Water Supply & Public Wastewater

Notes:
- GWDP - Ground Water Discharge Permit (Public Wastewater)
- PWS - Public Water Supply
- Water Budget Inputs are (+) and Outputs are (-)
4.0 WATER BALANCE INPUTS

This Section describes all inputs to the water balance model. In addition, a summary of all assumptions used in the model is provided in Appendix A. This Appendix also provides information on the sources for these assumptions.

4.1. Natural Recharge

Natural recharge is the amount of average annual precipitation infiltrating pervious ground cover to recharge the underlying groundwater aquifer and support base flow to streams. Natural recharge is distinct from wastewater discharges and other anthropogenic sources that infiltrate to groundwater. As described in Section 4, Subsection 2.0, groundwater recharge for this report is equivalent to the terms “effective” or “net” recharge sometimes used to specify that is the amount of groundwater recharge available to support stream base flow after all losses to evapotranspiration or runoff have been accounted for, and assuming that underflow out of the basin is negligible.

Long term average natural recharge in the Taunton River sub-watershed varies spatially depending upon the presence of permeable or impermeable land use coverage and the underlying surficial geology. Land areas for each surficial geological formation were calculated in GIS. Initial recharge rates based on available USGS information and best professional judgment were evaluated for each surficial geological area. Important USGS sources used include Hansen and Lapham (1992), Mullaney (2004), Bent (1995), Morrisey (1983) and Melvin et al (1992). These were refined and adjusted to match actual base flow measurements within the Taunton River Watershed. The potential range of recharge rates from the literature is as follows in Table 4.1.

<table>
<thead>
<tr>
<th>Surficial Geology Type</th>
<th>Recharge Rate (inches/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand and gravel deposits</td>
<td>8-26</td>
</tr>
<tr>
<td>Till or bedrock</td>
<td>1-23</td>
</tr>
<tr>
<td>Fine-grained deposits and floodplain alluvium</td>
<td>5-10</td>
</tr>
</tbody>
</table>

To better refine the potential range of recharge rates and to select representative recharge rates for the Taunton River Watershed, an analysis of stream base flow measurements from Rattlesnake Creek was undertaken. The Rattlesnake sub-watershed was selected because it is largely undeveloped, and daily flow data was available from a USGS gage station. It was important to select an undeveloped sub-watershed to remove the impacts of water withdrawals and return flows, thereby focusing the analysis on natural recharge. As shown in Figure 4.2, the Rattlesnake sub-watershed is located in Freetown and Fall River and covers an area of approximately 2,700 acres, most of which is undeveloped and only 2% of which is impervious. Rattlesnake Brook flows generally from south to north through the watershed. Wetlands cover approximately 315 acres, or 12% of the sub-watershed. Impervious areas and wetlands are shown in Figure 4.3.
Figure 4.2
Taunton Watershed and Rattlesnake Sub-watershed

Legend

- Taunton River Watershed
- Rattlesnake Sub-watershed
- Sub-watersheds

±4.5 Miles
Figure 4.3
Wetlands and Impervious Surfaces in Rattlesnake Sub-watershed
According to MassGIS (see Figure 4.4), surficial geology in the sub-watershed is divided into the following three categories:

- Sand and gravel: 31%;
- Till or bedrock: 64%; and
- Floodplain alluvium: 5%.

Approximately 2,600 acres of the sub-watershed (97%) are forested area, only 9 acres (0.3%) are residential; and none of the watershed is commercial or industrial land. The impact of development on recharge and the overall water balance is therefore assumed to be negligible.
Figure 4.4
Surficial Geology in Rattlesnake Sub-watershed
The USGS started collecting real-time stream flow data for the Rattlesnake Brook near Assonet (USGS station 01109090) in January 2007. As a result, a full year of daily mean flow January 1, 2007 - December 31, 2007 was reviewed for the USGS gauge station. The stream and gauge location are provided in Figure 4.5. Given that only one full year of data have been collected, statistical flows are not available for the stream. An average annual base flow for Rattlesnake was estimated by comparing its measured flows to long term data obtained for another Massachusetts reference stream that is geographically close to Rattlesnake, and has similar watershed characteristics.

Watershed characteristics such as drainage area, mean basin slope, and stratified drift area per stream length were obtained from the USGS StreamStats web-based tool for the Rattlesnake sub-watershed. These characteristics were then compared to those of the Index Streams identified in the 2007 Index Streamflows for Massachusetts Draft Report (DCR, October 2007) to identify Candidate Index Streams for comparison to Rattlesnake Brook. The characteristics of these Index Streams in relation to Rattlesnake Brook are illustrated in Table 4.2. Old Swamp River in Weymouth, Massachusetts was selected as the most appropriate Index Stream for comparison.

<table>
<thead>
<tr>
<th>USGS Gage #</th>
<th>Gage Name</th>
<th>Drainage Area (square mile)</th>
<th>Mean Basin Slope (%)</th>
<th>Stratified Drift per Stream Length (square mile/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01109090</td>
<td>Rattlesnake Brook Freetown, MA</td>
<td>4.22</td>
<td>1.84</td>
<td>0.19</td>
</tr>
<tr>
<td>01118300</td>
<td>Pendleton Hill Brook Clarks Falls, CT</td>
<td>4.02</td>
<td>6.47</td>
<td>0.065</td>
</tr>
<tr>
<td>01105600</td>
<td>Old Swamp River Weymouth, MA</td>
<td>4.39</td>
<td>3.11</td>
<td>0.142</td>
</tr>
<tr>
<td>01115098</td>
<td>Peeptoad Brook Westerly, MA</td>
<td>4.96</td>
<td>6.94</td>
<td>0.231</td>
</tr>
</tbody>
</table>

* Selected stream characteristic in bold

To further illustrate the similarity between the Old Swamp River index stream and Rattlesnake Brook, Figure 4.6 displays the 2007 hydrographs for both streams, in cubic feet per second per square mile of drainage area (cfsm). As can be seen in that figure, the flow characteristics are generally similar between the two streams. Owing to its higher percentage of impervious surfaces and increased stormwater runoff, the Old Swamp River index stream is a little more flashy in its flow record, exhibiting higher short duration peak flows and generally slightly lower base flows.
Figure 4.5
USGS Stream Gauge Station
Rattlesnake Sub-watershed

Legend

- Town Line
- Rattlesnake Brook Subwatershed
- Taunton River Watershed
- Streams
- Major River, Streams
- Surface Water

USGS Stream Gauge Station

Horsley Witten Group
phone: 508-833-6600
www.horsleywitten.com
Figure 4.6. 2007 Hydrographs for Rattlesnake Brook - Freetown, MA (USGS Gage 01109090) and Old Swamp River - Weymouth, MA (USGS Gage 01105600)
The USGS period of record for discharge of the Old Swamp River covers the period between May 1966 and the current year. Mean daily flows and daily statistical flows are available for that river. Those statistical data were used to calculate the mean of the minimum flows in order to approximate an average annual base flow for Old Swamp River. Essentially, the minimum daily January flow was identified for each year of the twenty years between 1987 and 2006 and then all of the January minimum flows from all of the years were averaged together to provide an average January minimum daily flow. That same process was repeated for each of the other months over the same period of 20 years. Finally, all twelve average monthly minimum flows were averaged together to provide a long term average mean of the minimum monthly flows, which is considered a representative estimate of average annual base flow. That value for Old Swamp River is 2.93 cubic feet per second (cfs). The monthly ratios of the 2007 minimum monthly flows to the long term average mean of the minimum monthly flows for Old Swamp River were then calculated and applied to the 2007 minimum monthly flows for Rattlesnake Brook to produce a long term average mean of the minimum monthly flows; which is considered a representative estimate of average annual base flow for Rattlesnake Brook. The estimated, representative, average annual base flow for Rattlesnake Brook, calculated by this technique is 4.8 cfs.

For comparison purposes, the online hydrograph separation program WHAT (Purdue University) was used on the 2007 Rattlesnake Brook data and a baseflow of 5.1 cfs was estimated. However, 2007 appeared to be a relatively dry year for Old Swamp River so the overall baseflow is likely higher than that estimated for 2007. The hydrograph separation technique for Old Swamp River showed that the 2007 estimated baseflow was approximately 75% of that estimated for the last 20 years. Applying that same ratio to Rattlesnake Brook would result in an overall estimated baseflow of 6.4 cfs, a number that would require recharge rates at or above the maximum range support by literature.

The estimated Rattlesnake Brook representative base flow of 4.8 cfs was then used to refine the selection of the most representative recharge rates for each category of surficial geology, for use throughout the Taunton River Watershed. Annual recharge rates for the various types of surficial geology were within the ranges shown in Table 4.1, and the calculated recharge flow was compared to the estimated representative stream base flow of 4.8 cfs.

Table 4.3 shows the base flows generated by the water balance tool under a subset of recharge rate assumptions. The base flow closest to the estimated value of 4.8 cfs was obtained for recharge rates of 25 inches per year (in/yr) for sand and gravel, and 14 in/yr for till or bedrock. Variation in the recharge rates for floodplain alluvium/fine grained deposits had no observable effect on the base flow calculated by the water balance tool since the area of fine grained deposits in the Rattlesnake Brook sub-watershed is minimal. A recharge rate of 5 in/yr was estimated for Floodplain Alluvium or other fine-grained deposits. Floodplain Alluvium or other fine-grained deposits are relatively rare throughout the entire Taunton River Watershed. In most cases, much of the fine grained deposits and floodplain alluvium is overlain by wetlands, which, as discussed further below, supersedes the recharge rate of these types of geology.
Table 4.3. Base flow in Rattlesnake Brook Generated by Water Balance Tool using Varying Recharge Rate Assumptions

<table>
<thead>
<tr>
<th>Sand / Gravel Recharge Rate (in/yr)</th>
<th>22</th>
<th>22</th>
<th>24</th>
<th>24</th>
<th>25</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Till / Bedrock Recharge Rate (in/yr)</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Calculated Base Flow (cfs)</td>
<td>3.8</td>
<td>4.2</td>
<td>4.4</td>
<td>4.7</td>
<td>4.8</td>
<td>4.9</td>
</tr>
</tbody>
</table>

* Selected values highlighted

Wetland areas have unique recharge characteristics with evaporation (ET) rates that approach precipitation rates leaving little or no available water for recharge to the underlying soils. In fact, most wetlands are considered to be groundwater discharge areas. Therefore, we have used a zero recharge rate for wetlands. This is consistent with USGS modeling assumptions in the Plymouth-Carver Aquifer (Hansen and Lapham, 1992). The presence of wetlands supersedes the underlying surficial geology such that all wetland areas have a simulated recharge rate of zero in/yr, regardless of the underlying surficial geology. Because of the consumptive water demands of Cranberry Cultivation for irrigation, frost protection and harvesting exceed the natural precipitation rate, cranberry bogs have a net negative impact on recharge from a water balance standpoint. Consistent with prior hydrologic modeling done by the USGS in the nearby Plymouth-Carver Aquifer, cranberry bogs were assigned a negative net recharge rate of -17 in/yr (Hansen and Lapham, 1992). This negative recharge rates includes all water use for the bogs (irrigation, flooding, etc.).

Characteristics of sub-watersheds of the Taunton River Watershed vary in terms of size, surficial geology cover distribution, basin slope, land use characteristics, and, to a lesser extent, climate. The Rattlesnake Brook sub-watershed is among the lesser developed sub-watersheds in the watershed but its natural characteristics are well within the range of variability exhibited among the 108 sub-watersheds of the Taunton River Watershed.

Please be aware that the recharge rates estimated here for the Taunton River Watershed are simply representative estimates developed using the best data available at the time of this study. In all likelihood, recharge rates may vary from location to location at a scale smaller than mapped surficial geology coverage. It is notable that recharge rate estimates in southern New England have been climbing in recent decades with new research. Future research may well better refine recharge rates for the Taunton River Watershed. For the purposes of this study, however, the estimated representative recharge rates are more than adequate for the goals of this water balance planning tool. Water balance discrepancies between sub-watersheds can be effectively compared and evaluated.

4.2. Impervious Surfaces

Impervious and pervious surfaces were identified throughout the watershed using a MassGIS image shapefile produced in 2007 that displays all of the impervious areas throughout the state. Impervious surfaces include rooftops, roads, parking lots, and incidental impermeable surfaces such as sidewalks, patios, pools, etc. This is known as
the total impervious area (TIA). However, some of the TIA is small and disconnected from other impervious areas, such that it drains to grassed or vegetated areas and is able to infiltrate into the ground before it is channelized and reaches the stormwater system. The subset of the TIA that is directly connected to centralized stormwater systems that directly discharge to surface waters is commonly called effective impervious area (EIA). It is this EIA that results in higher runoff volumes and peak flow rates as well as reduced recharge or base flow. Runoff from small fragmented impervious areas that is not connected into organized drainage systems does not appreciably change the recharge versus runoff characteristics of the underlying surficial geology. The recharge loss from EIA in the water balance tool was calculated using an equation used by the Charles River Watershed Association (CRWA) for a water balance analysis conducted in 2007 (EEA Water balances Analysis, under development). The relationship between EIA and TIA was developed from ten calibrated EIA values in two local USGS studies (Zarriello and Ries, 2000; Zarriello and Barlow, 2002).

The equation is:

\[
\text{Effectiveness (\%)} = -22.6 + 1.774 \times \text{TIA (\%)} , \quad \text{min} = 0\%
\]

\[
\text{EIA (\%)} = \frac{\text{Effectiveness (\%)} \times \text{TIA (\%)}}{100}
\]

The percent EIA was determined from the percentage of total impervious area within each surficial geological category and subtracted from the total area in each surficial geological category.

4.3. Land Use Analysis

GIS was used to estimate areas serviced by public wastewater and water systems. Sewer and water line data provided by DEP and communities in the watershed was used as a basis for estimating the service areas (Section 2). In separate processes, a 50-foot buffer was applied to the sewer and water lines in GIS, and then merged with parcel data to capture all parcels that intersected the buffers. These areas were considered to be serviced by a public wastewater or water system, respectively. The remaining parcels within the watershed were assumed to be serviced by private septic systems and private water wells, respectively. In towns where parcel boundaries were not available in GIS, aerial photographs were examined in combination with the sewer line and water line buffers to estimate areas that were serviced by public sewer or water. More specific information about the data collection effort, data sources and buffer width is provided in Section 2 of this report and in the project database, provided in electronic format.

Using GIS, MassGIS land use data (1999) was applied to the areas served by private wastewater (septic systems) and private water wells within each sub-watershed. The land use categories that were included in these calculations include:

- Residential – Multi-family
- Residential – Smaller than 0.25 acre lots
The remaining MassGIS land use categories were either not located within the watershed or were assumed to have no significant septic flow or water withdrawal contribution.

4.3.1 Residential

The four residential land use categories include: “Multi-family”; “Smaller than 0.25 acre lots”; “0.25 - 0.5 acre lots”; and “Larger than 0.5 acre lots”. The acreage associated with each residential land use was first divided by the average lot size for each category: 0.125 for “Multi-family”; 0.16 for “Smaller than 0.25 acre lots”; 0.38 for “0.25 – 0.5 acre lots”; and 1 for “Larger than 0.5 acre lots”. This provides the estimated number of lots for each residential area. Next, the average occupancy rate for the watershed (2.6 people per household) was applied to each number of lots to determine the number of people per residential area (Census, 2000).

Finally, an average wastewater flow and/or water use, expressed in gallons per capita per day (gpcd), was applied to each category. These calculations are described in the following sections. The average wastewater flow (gpcd) was calculated as the 64 gpcd average per capita water use in the watershed (EOEEA, 2006), reduced by 15 percent. On average, fifteen percent of household water use is estimated to be lost via outdoor water use (e.g., lawn watering) and therefore would not contribute to the wastewater effluent (USGS, 1982). The resulting wastewater flow per person is 53 gpcd.

4.3.2 Commercial

Within the MassGIS land use definitions, commercial areas are defined as “general urban; shopping center.” For the purposes of the study these areas were divided into three components, office, retail, and restaurant, based on US Census data as follows (Census, 2005):

- Office space: 50%
- Retail space: 40%
- Restaurant space: 10%

An estimate of gross square footage for each of these categories was calculated for the entire commercial area within the sub-watershed, for use in both the water use and wastewater discharge calculations. Twenty percent of the total commercial area was assumed to be rooftop. Based on visual observation within the watershed, it was assumed that the average number of floors per commercial building is 1.5. The total building footprint was therefore multiplied by 1.5 floors to provide the total gross square footage.
The percentage of each commercial component (office, retail and restaurant) was then applied to the resulting commercial gross square footage to estimate a total gross square footage for office space, retail space, and restaurant space.

According to Title 5, restaurant wastewater flow is based on number of seats. This relationship was also used to estimate the water use from restaurants on private wells. An average of 29 seats per 1,000 gross square feet of restaurant space was used for the calculation (NRBL, 2008).

4.3.3 Industrial

Industrial land uses were analyzed in a similar fashion to commercial land uses. First, gross square footage was calculated for the entire industrial area within the sub-watershed. Similar to the commercial area gross square footage, twenty percent of the total industrial area was assumed to be occupied by buildings. Based on a general understanding of the watershed, it was assumed that the average number of floors per industrial building is the same as commercial buildings (1.5). The total building footprint was then multiplied by 1.5 floors to provide the total gross square footage.

4.3.4 Participation Recreation

Massachusetts GIS data has a land use category for participation recreation that includes things like golf, tennis, playgrounds and skiing. Because there was no simple way to divide up the land use category and because golf is assumed to be the dominant land use in this category, we used certain assumptions upon which we could estimate water use and wastewater flows. We assumed the average nine-hole golf course was approximately 100 acres in area. According to Title V, wastewater flows are basically estimated based on the number of lockers in the clubhouse and the number of seat in the club restaurant. We assumed that there are 40 lockers and seats in the average clubhouse, and that the course is in operation for 184 days (May – October).

4.4 Septic System Inputs

Septic system inputs were estimated for both on-site septic systems and on-site/small decentralized wastewater treatment plants for all areas that were not determined to be connected to public sewer systems.

4.4.1 Residential

The average wastewater flow (gpcd) was calculated as the 64 gpcd average per capita water use in the watershed (EOEEA, 2006), reduced by 15 percent. On average, fifteen percent of household water use is estimated to be lost via outdoor water use (e.g., lawn watering) and therefore would not contribute to the wastewater effluent (USGS, 1982). The resulting wastewater flow per person is 53 gpcd.
4.4.2 Commercial

According to 310 CMR 15.203 (Title V), the wastewater design flows for each of the commercial land-use categories is as follows:

- Office building: 75 gpd per 1,000 gross square feet
- Retail store: 50 gpd per 1,000 gross square feet
- Restaurant: 35 gpd per seat

These design flows were then divided in half, since Title V design flow calculations represent peak design flow conditions and are generally about double the actual average flows (310 CMR § 15.203 (6)). The gross square footage for office space and retail space were each divided by 1,000 square feet (Title V) and then multiplied by 50% of the wastewater design flow (37.5 gpd and 25 gpd respectively) to determine a total wastewater flow for each component. The restaurant space gross square footage was multiplied by 0.029 (29 seats per 1,000 square feet) and multiplied by 50% of the wastewater design flow (17.5 gpd).

4.4.3 Industrial

The area of industrial space was then divided by 1,000 square feet (Title V) and multiplied by 50% of the wastewater design flow (37.5 gpd) to determine a total industrial wastewater flow.

4.4.4 Participation Recreation

An assumption of 30 gpd per golfer was used based on Title V (10 gpd per locker and 20 gpd per seat). It was estimated that there are 40 lockers and seats in the average clubhouse, and that the course is in operation for 184 days (May – October). The estimated flow per golf course, divided by 100 acres for the average nine-hole golf course, provides a value of 2,208 gallons per year/acre of golf course, or approximately six gallons per acre per day.

4.5. Groundwater Discharge Permit Inputs

Groundwater Discharge Permits are generally required by DEP for all groundwater discharges that are greater than 10,000 gallons per day. A set of Groundwater Discharge Permit (GWDP) data collected from DEP was utilized to determine the wastewater flow associated with all of these discharges. This compiled data set included the total annual discharge from these facilities for a given year, based on Daily Monitoring Reports provided by DEP. This data set was used in GIS to determine the discharge flow associated with GWDPs in each sub-watershed. In some cases, a sub-watershed may include a portion of a wastewater service area, but the discharge from that wastewater service area may be located in an adjacent sub-watershed. More specific information about the data collection effort and data sources is provided in Section 2 and in the project database provided in electronic format.
4.6. **Private Drinking Water Well Withdrawals**

4.6.1 **Residential**

An average water use estimate for the watershed (64 gpcd) was applied to the number of people within each residential area to determine the total estimated private drinking water withdrawal volume (EOEEA, 2006).

4.6.2 **Commercial**

Each wastewater design flow for office space, retail and restaurant was multiplied by a factor of 60% to determine an estimated water use, since indoor water use is approximately 50% of the Title V design flow (310 CMR § 15.203 (6)) and water lost via outdoor use is approximately 15% of total use (USGS, 1982). The gross square footage for office space and retail space were each divided by 1,000 square feet (Title V) and then multiplied by 60% of the wastewater design flow (45 gpd and 30 gpd respectively) to determine a total drinking water use volume for each component. The restaurant space gross square footage was multiplied by 0.029 (29 seats per 1,000 square feet) and multiplied by 60% of the wastewater design flow (21 gpd) to estimate a total drinking water use for restaurants.

4.6.3 **Industrial**

The total gross square footage for industrial space was divided by 1,000 square feet (Title V) and multiplied by 60% of the wastewater design flow (45 gpd) to estimate a total industrial private drinking water withdrawal volume.

4.6.4 **Participation Recreation**

The estimated water flow per golf course, divided by 100 acres for the average nine-hole golf course, provides a water use value of 2,208 gallons per year / acre of golf course, or approximately six gallons per acre per day. A ratio of water use per capita to wastewater flow per capita (62 gpd / 53 gpd or 117%) was then used to determine the total private drinking water well withdrawals associated with golf courses. It should be noted that this estimate does not include any use of water withdrawals for irrigation purposes. Water withdrawals from irrigation wells with Water Management Act permits or registrations are addressed under the following section.

4.7. **Water Management Act Withdrawals**

Water withdrawals generally above 100,000 gpd require a Permit under the MA WMA. In addition, large withdrawals in existence prior to the 1988 registration date may be Registered withdrawals. In some cases, a single entity or municipal water system may have both Registered and Permitted withdrawals. WMA permit and registration data collected provided by DEP, in combination with the MassGIS Public Water Supply data.
layer, were utilized to determine the existence of and location of major water withdrawals associated with public and non-public (such as industrial withdrawals and golf irrigation well withdrawals) water supply withdrawals within each sub-watershed, as well as the annual maximum allowable withdrawals (permitted and or registered volumes). The Annual Statistical Reports required under the WMA were provided by DEP in a combination of tabular form and hard copy, and were used to determine the 2006 actual withdrawal volumes for WMA permitted and registered withdrawals. In some cases, additional investigative research was conducted to clarify or fill in certain data that was either not provided in one of the data sources, or in some cases, conflicted with other information. This included research such as re-examining a map, speaking with the water department official, or discussing the matter with DEP for clarification. More specific information about the data collection effort and data sources is provided in Section 2 and in the project database provided in electronic format.

4.8. Inflow and Infiltration

Stormwater and groundwater can enter a sewer system through holes, breaks, joint failures, connection failures, and from cross-connections with storm sewers. This phenomenon is called inflow and infiltration (I&I) and is described in Section 2 as well, where most inflow comes from stormwater and most infiltration comes from groundwater. High groundwater levels and storm events can contribute to excessive sewer flows, and therefore to losses in groundwater recharge. To account for recharge losses to I&I, this tool assumes losses in each sub-watershed are equivalent to one (1) gpd of I&I for every linear foot (lf) of sewer pipe (NEIWPCC, 1998).

5.0 CASE STUDY: WATER BALANCE FOR COWEESET SUB-WATERSHED

To illustrate the use of the water balance tool, an analysis of the Coweeset sub-watershed was undertaken. As shown in Figure 4.7, the Coweeset sub-watershed, located in Easton, West Bridgewater and Brockton, and covers 5,314 acres, of which 1,194 (or 22%) are impervious. Approximately 215 acres (18%) of the total impervious area were calculated as effective impervious area, per the methodology discussed in Section 4.2, and constitute a net loss of stormwater recharge. The watershed is moderately developed with mixed land uses including residential, commercial, and industrial. Wetlands cover approximately 890 acres, or 17% of the sub-watershed. Impervious areas and wetlands are shown in Figure 4.8.

According to MassGIS (see Figure 4.9), surficial geology in the sub-watershed is divided into the following four categories:

- Sand and gravel: 50%;
- Till or bedrock: 41%;
- Fine grained deposits and Floodplain alluvium: 9%.
Areas without water and/or sewer service are assumed to use private wells and/or septic systems, respectively. Water and sewer service information is based on data collected from DEP and individual communities, groundwater discharge permit information from DEP and MassGIS, and WMA information obtained from DEP (see in Section 2 and the project database, provided in electronic format, for more information about data collection). Water use in the sub-watershed can be summarized as follows (Figure 4.10):

- One groundwater discharge permit for 23,500 gpd, with actual flow of 1.2 mgy;
- Five operational public wells with total actual withdrawals of 613 mgy in 2006;
- Areas on septic systems: 74% of the sub-watershed (i.e., 26% of the sub-watershed is sewered);
- Areas on private wells: 21% of the sub-watershed;
- Areas on both septic systems and private wells: 20% of the sub-watershed; and
- Areas with public water supply and sewer: 17% of the sub-watershed.

To account for recharge losses to I&I, this tool assumes losses in each sub-watershed are equivalent to one (1) gpd of I&I for every lf of sewer pipe (NEIWPCC, 1998). There are an estimated 57,836 lf of sewer pipes in the Coweeset sub-watershed, accounting for approximately 21 million gallons per year of I&I losses.
Figure 4.7
Taunton Watershed and Coweeset Sub-watershed
Figure 4.8
Wetlands and Impervious Surfaces in Coweeset Sub-watershed
Figure 4.9
Surficial Geology in Coweeset Sub-watershed

Legend
- Town Line
- Coweeset Sub-Watershed
- Sub-watersheds
- Sand Gravel
- Till Bedrock
- Fine Grained Deposits
- Floodplain Alluvium

Horsley Witten Group
Phone: 508-833-8600
www.horsleywitten.com
Legend

- Town Line
- Coweeset Sub-Watershed
- Sub-watersheds
- Both Water & Sewer Service
- Water Service Only

Figure 4.10
Water and Wastewater Service Areas in Coweeset Sub-watershed
5.1. **Coweeset Brook Case Study Results**

Table 4.4 shows a summary of relevant outputs from the water balance method applied to the Coweeset sub-watershed. According to the water balance, existing net recharge (base flow) is estimated to be 7.3 cfs. As compared to an estimated natural (pre-development) flow of the 9.6 cfs. This represents an estimated net loss to base flow of approximately 24%.

<table>
<thead>
<tr>
<th>Total Area (acres)</th>
<th>5,314</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Inputs (MGY)</strong></td>
<td></td>
</tr>
<tr>
<td>Estimated effluent from Groundwater Discharge Permit data</td>
<td>1</td>
</tr>
<tr>
<td>Estimated effluent from septic systems</td>
<td>276</td>
</tr>
<tr>
<td>Estimated natural recharge (adjusted for EIA)</td>
<td>2,141</td>
</tr>
<tr>
<td><strong>Water Outputs (MGY)</strong></td>
<td></td>
</tr>
<tr>
<td>Estimated withdrawal volume from private wells</td>
<td>61</td>
</tr>
<tr>
<td>Estimated withdrawal volume from WMA Permit data</td>
<td>613</td>
</tr>
<tr>
<td>Estimated Losses to I&amp;I</td>
<td>21</td>
</tr>
<tr>
<td><strong>Existing Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Existing Base flow Estimate (MGY)</td>
<td>1,722</td>
</tr>
<tr>
<td>Existing Base flow Estimate (cfs)</td>
<td>7.3</td>
</tr>
<tr>
<td><strong>Natural Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Natural Conditions Base flow Estimate (MGY)</td>
<td>2,316</td>
</tr>
<tr>
<td>Natural Conditions Base flow Estimate (cfs)</td>
<td>9.6</td>
</tr>
<tr>
<td><strong>Percent Change in Net Recharge</strong></td>
<td>-24%</td>
</tr>
</tbody>
</table>

5.2. **Water Balance Sensitivity Analysis**

A sensitivity analysis was conducted for the Coweeset Brook sub-watershed to evaluate the significance of certain assumptions in the water balance. This analysis was conducted to better understand the importance to the overall water balance output of some of the input factors whose quantitative values are less well defined than other input factors. Within this analysis, for each change in the assumptions, the aquifer recharge (base flow) is calculated by the water balance tool to determine how sensitive the method is to each assumption. The results of the sensitivity analysis are as follows:

- Increasing the average “greater than 0.5 acre" residential lot size by 25% resulted in less than a 0.1% decrease in recharge. Increasing other average residential lot sizes resulted in a similar small reduction in the calculated total aquifer recharge.

- Increasing the assumed percentage of commercial space composed of rooftop by 25% resulted in a 1.4% increase in aquifer recharge in this sub-watershed. This
occurs because an increase of roof area results in a 1.5 times increase in square footage and a corresponding increase of septic system inputs.

- Aquifer recharge is also sensitive to the assumption about the average number of floors for commercial and industrial buildings because the larger the number of floors, the larger the square footage, the greater the septic system inputs, and the greater the resulting recharge. A 33% change in the number of commercial floors per building resulted in a 1.8% change in aquifer recharge. This is consistent with the previous sensitivity (i.e., rooftop area), and indicates that the more dense the industrial / commercial use, the greater the aquifer recharge (for areas sewered with public water supply and septic system wastewater disposal).

- Commercial areas are assumed to be divided at the sub-watershed level between office, retail, and restaurant activities (50%, 40%, and 10%, respectively, of the overall commercial area for each activity). The sensitivity analysis for the Coweeset sub-watershed showed that the tool was much more sensitive to the share of restaurant space than to office or retail space. This can be explained by the fact that water use per square foot is two orders of magnitude larger for restaurant space than for the other two activities. Changing the restaurant activity to 20% of the commercial area, and equally dividing the change between retail (45%) and office (35%), results in a 1.5% increase in aquifer recharge.

Overall, significant changes to these anthropogenic assumptions have a small impact (<5%) on the calculated recharge within the Coweeset Brook sub-watershed under developed conditions.

The water balance tool relies on a number of anthropogenic factors for which certain assumptions were made. The process of refining the tool, as described above, indicates that streamflow estimated by the tool is of the appropriate order of magnitude. For example, the distribution of commercial space between office, retail, and restaurant areas, the average number of floors for commercial and industrial buildings, as well as the average footprint of these buildings may vary from one sub-watershed to another, but the overall effect on the recharge of each assumption is not very significant.

5.3. **Flow Data for Coweeset Brook Sub-watershed**

Because the Coweeset Brook sub-watershed is one of the initial case study sub-watersheds for this water balance tool but long term stream gage records do not exist, the Massachusetts Riverways Program and Bridgewater State College have been collecting flow data to help ground-truth the calculations of the water balance tool. Beginning in the summer of 2007 and continuing at least for the near future (no termination date as of yet), the collected flow data currently allow for a rough estimation of base flow conditions in the watershed, and the accuracy of the estimate will improve as the total number of flow measurements increase. It is intended that sufficient flow data will be available by the end of Phase II of this project to allow for a more accurate estimate of
base flow conditions and, therefore, a more thorough evaluation of the water balance tool and its input factors.

Two streams flow into this sub-watershed: Coweeset and Queset Brooks. Below their confluence, the Hockomock River discharges from the sub-watershed. Flow attributed to the net recharge within the sub-watershed is assumed to be equal to the difference between flow out of the watershed in the Hockomock River and the cumulative flow into the watershed from the two brooks. Flow measurements were made at the locations where the respective streams entered or exited the sub-watershed. Flow data for Coweeset Brook, Queset Brook, and Hockomock River were collected on seven days over the past year by Bridgewater State College Watershed Access Laboratory staff and students and the Massachusetts Riverways Program. These data are presented in Table 4.5.

Table 4.5. Stream Gage Flow Measurements in Coweeset Sub-watershed (cfs)

<table>
<thead>
<tr>
<th>Date</th>
<th>Queset</th>
<th>Coweeset</th>
<th>Hockomock</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/19/2007</td>
<td>3.55</td>
<td>1.47</td>
<td>7.66</td>
</tr>
<tr>
<td>7/10/2007</td>
<td>3.41</td>
<td>1.27</td>
<td>7.65</td>
</tr>
<tr>
<td>7/17/2007</td>
<td>1.13</td>
<td>0.51</td>
<td>2.65</td>
</tr>
<tr>
<td>7/24/2007</td>
<td>0.9</td>
<td>0.42</td>
<td>3.14</td>
</tr>
<tr>
<td>11/9/2007</td>
<td>2.35</td>
<td>0.67</td>
<td>4.12</td>
</tr>
<tr>
<td>2/1/2008</td>
<td>13.15</td>
<td>1.19</td>
<td>26.44</td>
</tr>
<tr>
<td>4/3/2008</td>
<td>16.73</td>
<td>2.15</td>
<td>40.62</td>
</tr>
</tbody>
</table>

Precipitation information in the days preceding the measurements are reported in Table 4.6. These data were summarized from the National Weather Service (NWS), for Taunton, MA. Of the seven measurement days, two of the measurements occurred within two days of a rainfall event greater than 0.25 inches and are, therefore, not good indicators of base flow conditions (July 10 and February 1). The other five measurement dates are considered good indicators of base flow conditions.

Table 4.6. Precipitation at NWS Taunton Stations

<table>
<thead>
<tr>
<th>Precipitation (inches)</th>
<th>6/19/07</th>
<th>7/10/07</th>
<th>7/17/07</th>
<th>7/24/07</th>
<th>11/9/07</th>
<th>2/1/08</th>
<th>4/3/08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day of Measurement</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>T</td>
<td>1.15</td>
<td>0</td>
</tr>
<tr>
<td>Previous day</td>
<td>0.01</td>
<td>0.01</td>
<td>T</td>
<td>0.04</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Two days before</td>
<td>0.19</td>
<td>0.42</td>
<td>0.16</td>
<td>0</td>
<td>0</td>
<td>0.14</td>
<td>N/A</td>
</tr>
</tbody>
</table>

T = Traces
N/A: no data was available for that day on the NOAA website.
To normalize the limited base flow measurements for the Coweeset sub-watershed to a longer term record that can be considered more indicative of long term average conditions, the USGS streamflow statistics for the long term record (from 1966 to the present) of the Old Swamp River in Weymouth, MA (USGS gage 01105600) were reviewed and analyzed. This river is the same as the one used to analyze the Rattlesnake data. In this case, the average of monthly minimum flows was used as a base flow condition in the Old Swamp River. Accordingly, adjustments were made to the five recorded base flow measurements from the Queset, Coweeset and Hockomock to estimate base flows, based on comparisons to actual recorded flow at the Old Swamp River gage station on those same dates and the computed average monthly minimums (see Table 4.7). The two Coweeset measurement dates that are not considered representative of base flow conditions were left out of this analysis because the precipitation – runoff response in a developed watershed like Coweeset Brook is likely different from that of a relatively undeveloped watershed like Old Swamp River.

<table>
<thead>
<tr>
<th>Date</th>
<th>Old Swamp River</th>
<th>Old Swamp River Mean of Minimums</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/19/2007</td>
<td>1.4</td>
<td>1.5</td>
<td>0.93</td>
</tr>
<tr>
<td>7/17/2007</td>
<td>0.41</td>
<td>0.62</td>
<td>0.66</td>
</tr>
<tr>
<td>7/24/2007</td>
<td>0.47</td>
<td>0.62</td>
<td>0.76</td>
</tr>
<tr>
<td>11/9/2007</td>
<td>2.1</td>
<td>3.5</td>
<td>0.60</td>
</tr>
<tr>
<td>4/3/2008</td>
<td>5.4</td>
<td>5.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The three June/July flows were then averaged to determine a summer flow which was in turn averaged with the two remaining November and April measurements to estimate a preliminary, average annual baseflow for the three streams (see Table 4.8). This analysis suggests that the total cumulative inflow to the Coweeset sub-watershed from the Queset and Coweeset Brooks is approximately 9 cfs and that the average annual outflow through the Hockomock River as it leaves the Coweeset sub-watershed is 17.6 cfs, indicating a net gain in base flow of 8.6 cfs from aquifer recharge within the watershed.

Our preliminary estimate of base flow gain in the watershed is, therefore, approximately 8.6 cfs. This compares favorably to the estimate from our case study water balance tool of approximately 7.3 cfs of average annual aquifer recharge occurring under existing conditions. As more flow data is collected, a more accurate comparison of the water balance results to field-generated base flow estimates can be obtained.
6.0 GIS BASED WATER BALANCE METHOD

In order to streamline and automate the water balance calculations, apply the water balance methodology to all 108 sub-watersheds, and have the ability to simulate alternative water management or development scenarios, the water balance method was converted to a two-step GIS-based tool. This tool uses the same assumptions as the spreadsheet version developed for the Coweeset and Rattlesnake sub-watersheds. The outputs for the Coweeset and Rattlesnake sub-watersheds using the GIS-based tool were compared against the outputs of the spreadsheet-based tool in order to ensure that the GIS-based tool was developed properly.

The GIS-based tool was created in two steps. The first step automates the geo-processing of information layers such as geology, land use, impervious areas, or wetlands through the use of an ArcGIS tool called ModelBuilder. Instead of performing individual geo-processing steps within ArcGIS by hand, which can be very time-consuming, ModelBuilder allows the ArcGIS user to automate the process by creating a flow-chart of individual geo-processes that can all be run at once, creating all relevant output information layers in a single run. Information layers utilized in this first step include the following:

- sub-watershed boundaries;
- land use;
- wetlands;
- geology;
- impervious areas;
- water service areas;
- sewer service areas;
- sewer pipe lengths;
- permitted groundwater discharges; and
- permitted groundwater withdrawals.

A second step uses a script to automate the water balance calculations based on the assumptions described earlier, and on the information layers generated from the first step. This step allows the user of the planning tool to avoid the creation of individual spreadsheets for each of the 108 sub-watersheds in the Taunton watershed. This second step:
• accesses data behind the information layers generated by the first step (e.g., sewered industrial areas);
• calculates the water balance components (e.g., public well withdrawals, groundwater recharge);
• compares natural recharge to recharge under developed conditions; and
• exports the information to a GIS layer so that the water balance for each sub-watershed can be mapped.

7.0 SUMMARY OF WATER BALANCE RESULTS

7.1 Water Balance Results

Figure 4.11 shows the results of the water balance analysis by sub-watersheds, excluding surface water withdrawals and NPDES permit information. This analysis shows that of the 108 sub-watersheds, 29 (27%) have surplus water compared to natural conditions and 79 (73%) show water deficits. They range from a high surplus of 9% in one sub-watershed to a net reduction of 231% in a small sub-watershed with several significant major water withdrawals. These surpluses and reductions are placed into 5 categories for the purposes of comparing the relative impact of development on these watersheds over time. As this water balance method is a planning level tool, it is these categories that are most relevant to the decision-maker rather than actual water balance numbers themselves.

Overall, the analysis shows a total existing net recharge of 122,900 mgy compared to an estimated natural recharge rate of 131,000 mgy. This represents a 6.2% water deficit throughout the entire Taunton watershed.

It should be recognized that each of the computed water balances is specifically for that sub-watershed. With the exception of headwater sub-watersheds (those that are located at the top of the Taunton watershed and have no inflow), the majority of sub-watersheds receive inflow from other upstream sub-watersheds and observable streamflow is therefore also impacted by upgradient sub-watersheds. Cumulative analyses of sub-watersheds will be required in these cases to evaluate impacts on ecosystems.

For example, we have completed a cumulative analysis of the sub-watersheds that flow into and include the Hockomock Swamp (Figure 4.12) whose drainage area includes 19 sub-watersheds. The total existing recharge of this drainage area is 24,206 mgy and the natural recharge rate is 23,741 mgy. This represents a 4.5% deficit in recharge to the Hockomock Swamp.

Figure 4.13 shows the results of the water balance analysis by sub-watersheds, including surface water withdrawals and NPDES permit information. This analysis shows that of the 108 sub-watersheds, 34 (31%) have surplus water compared to natural conditions and 74 (69%) show water deficits. They range from a high surplus of 259% in one sub-watershed to a net reduction of 1225% in a small sub-watershed with several significant major water withdrawals. These surpluses and reductions are placed into 5 categories for
the purposes of comparing the relative impact of development on these watersheds over time. As this water balance method is a planning level tool, it is these categories that are most relevant to the decision-maker rather than actual water balance numbers themselves.

Overall, the analysis shows a total existing net recharge of 132,983 mgy compared to an estimated natural recharge rate of 130,962 mgy. This represents a 1.5% water surplus throughout the entire Taunton watershed. The sample cumulative analysis of the Hockomock swamp sub-watersheds including surface water withdrawals and NPDES permit information results in a total existing recharge of this drainage area is 24,206 mgy and the natural recharge rate is 23,741 mgy. This represents a 2.0% surplus in recharge to the Hockomock Swamp.

Based upon the results of these analyses, there is a need to balance the hydrologic budgets in the Taunton River Watershed. The historic development of land and the related water, sewer and stormwater infrastructure has resulted in many shifts from one sub-watershed to another leaving many areas with water deficits and some with surpluses. The water policy of “keeping water local” encouraged by DEP and EEA should direct future land use planning and infrastructure projects to, at a minimum, not exacerbate hydrologic imbalances and ideally to restore natural balances to the extent possible. As it is refined with future work, the water balance method presented here may be one tool to help evaluate the hydrologic impacts of potential future policies, development scenarios, or other water resource related questions.

7.2 Water Balance Methodology Limitations

As described earlier, this water balance tool is a planning-level tool to assist in the watershed planning decision making process across the Taunton watershed. The purpose of this model is to provide a better understanding of the relative impacts on the natural hydrologic budget in different regions of the watershed. This tool provides a useful and manageable strategy for breaking down the watershed into smaller sections for closer evaluation, and provides a mechanism for prioritizing these areas for future action (remediation, protection, etc.). While the actual numeric results of the water balance tool are interesting, it is the comparison between watersheds that is most useful. For this reason, we have presented the results using a color coding for ranges of water balance deficit or surplus. Following is a summary of certain limitations that should be considered when using this tool:

- It is reflective of conditions over an annual timeframe in order to show long term impacts to the natural water balance budget from human uses in the watershed. Therefore, the tool does not capture drought or wet conditions, and does not reflect conditions that occur over short time periods of less than a year.
- The data collection effort undertaken for this phase of the project was rigorous, but in certain cases, as described in Section 2, data were unavailable or thought to be potentially inaccurate. Reasonable assumptions were incorporated when necessary, as described in Appendix A.
- The model reflects data for the time period of approximately 2005 and 2006.
Figure 4-11
Taunton Water Budget - Excluding Surface Water Withdrawals and NPDES Effluent

Legend
- Taunton River Watershed
- Town Boundaries
- Sub-basins
- Taunton River
- Rivers, Streams
- Surface Water

Water Balance
- < -10% (withdrawals > recharge)
- -10% to -5%
- -5% to 0%
- 0% to 5%
- > 5% (recharge > withdrawals)

± 3.25 Miles
Figure 4-12
Hockomock Swamp Water Budget - Excluding Surface Water Withdrawals and NPDES Effluent

Hockomock Swamp Watershed
Total Natural Recharge: 23,741 MGY
Existing (Current / Developed) Recharge: 22,661 MGY
Water Balance: -4.5%

Legend
- Taunton River Watershed
- Town Boundaries
- Sub-basins
- Rivers, Streams
- Surface Water
- Wetlands

Water Balance
- <-10% (withdrawals > recharge)
- -10% to -5%
- -5% to 0%
- 0% to 5%
- > 5% (recharge > withdrawals)

1.25 Miles

Horsley Witten Group
Phone: 508-505-8460
www.horsleywitten.com
Legend

Taunton River Watershed
Town Boundaries
Sub-basins
Taunton River
Rivers, Streams
Surface Water

Water Balance

-10% to -5%
-5% to 0%
0% to 5%
> 5% (recharge > withdrawals)
<-10% (withdrawals > recharge)
8.0 REFERENCES


Morrisey, 1983. Hydrology of Little Androscoggin River Valley Aquifer, Oxford County, Maine. USGS WRI 83-4018


US Census Bureau. Census 2000 Summary File 1 (SF 1), Table P17. Average Household Size (for Bristol County, Plymouth County, and Norfolk County, MA).


SECTION 5
STREAM BUFFER AND HABITAT ANALYSIS

1.0 INTRODUCTION

This Section of the report was prepared by Geosyntec Consultants as a subcontractor to Horsley Witten Group to analyze stream buffers and high priority habitat areas within the watershed using Geographic Information System (GIS) data and tools. This Section provides a GIS-based overview of land development and land protection patterns in the watershed. This is important because stream buffers are known to provide important water quality and habitat functions, and to contribute significantly and directly to the overall health of the watershed. Naturally-vegetative buffers provide for the interception and “filtering” of surface runoff as it flows from upland areas in the watershed and the tributary or stream. This filtering includes: (i) physical trapping of sediment particles; (ii) uptake of nutrients and other pollutants into the vegetative mass; and (iii) biochemical processing of pollutants in the root zone where microbes breakdown hydrocarbons and transform nitrogen to atmospheric nitrogen. Trees within the buffer zone provide shading of the water that helps maintain healthy temperature conditions for aquatic organisms. In addition, vegetated buffers function as important habitats to a wide range of species, and are hydrologically important as they provide for the maintenance of natural soils where infiltration and recharge can occur. This information and additional GIS maps and analysis are used to help answer the following two questions:

1. How well protected are stream buffers throughout the Taunton River Watershed?
   Section 3.0 of this analysis provides a map-based analysis of the level of protection of stream buffers throughout the Watershed, including:
   a. Assessment of the 200-foot buffer to streams throughout the watershed;
   b. Assessment of stream buffers at a sub-watershed level, to allow for comparison and relative ranking of sub-watersheds with regard to the condition of stream buffers.

2. How well protected are the most ecologically critical areas of the watershed?
   Section 3.0 of this analysis provides a map-based analysis of the following:
   a. Tier 1 and Tier 2 “Priority Habitat Areas”, as defined by The Nature Conservancy (TNC);
   b. Protected land and unprotected lands within TNC Priority Habitat Areas;
   c. The current percentage of impervious surfaces within each sub-watershed and within TNC Priority Habitat Areas.
2.0 OVERVIEW OF WATERSHED LAND PROTECTION AND LAND DEVELOPMENT PATTERNS

Geosyntec prepared a series of GIS maps to illustrate key land protection and land development patterns for the Taunton River Watershed. These maps were created to support the assessment of stream buffers and priority habitat areas presented in Sections 3.0 and 4.0 of this analysis. Information on each data source and on the geoprocessing techniques used to analyze the geographic data is provided below. All GIS analysis was conducted using ArcGIS.

2.1 Watershed and Subbasin Boundaries

The MassGIS “Drainage Subbasins” layer dated December 2007 was overlaid with the “Major Drainage Basins” layer (also from MassGIS) to determine the subbasins within the Taunton River Watershed. In several areas along the periphery of the Watershed, the “Major Drainage Basins” layer does not align exactly with the boundaries in the “Drainage Subbasins” layer. In these areas, Geosyntec assessed the subbasins according to the “Major Drainage Basins” boundary. The Taunton River subbasins are shown and labeled according to the MassGIS subbasin ID in Figure 5.1.

2.2 Conservation Lands and Protected Open Space

The MassGIS Protected and Recreational Open Space layer was used to determine existing conservation lands and open space. Facility-based recreational sites (e.g. ice skating rinks, baseball fields) and agricultural lands, while included in the Protected and Recreational Open Space layer, were excluded from consideration as conservation lands or open space. Agricultural lands converted via conservation easements were classified as conservation lands. The MassGIS Protected and Recreational Open Space layer was last updated on January 22, 2007. As such, conservation lands and protected open space parcels are somewhat under estimated because lands that have acquired “protected” status since the January 2007 update are not reflected in this report.

Figure 5.2 shows the areas classified as conservation lands or protected open space in the Taunton River Watershed. Figure 5.3 allows for a comparison of the percentage of each subbasin classified as conservation lands or open space.

Overall, conservation lands and protected open space comprise 12.5% of the Taunton River Watershed. As shown in Figure 5.4, 56% (59 subbasins out of 105) of all subbasins are comprised of less than 10% conservation lands or open space. Only 23% of subbasins in the Watershed are composed of greater than 20% conservation lands or protected open space. This indicates that the majority of the remaining land in each subbasin is either already developed or vulnerable to future development.
Conservation Lands and Protected Open Space
Taunton River Watershed, Massachusetts

Legend
- Taunton Watershed
- Town Boundary
- Subbasin Boundaries
- Surface Water

Open Space - Primary Purpose
- Conservation
- Recreation
- Conservation & Recreation
- Agriculture
- Habitat
- Historical/Cultural
- Scenic
- Water Supply
- Road Control
- Underwater
- Other
- Unknown

Notes
- Subbasin boundaries from MassGIS (2005)
- Conservation lands and protected open space classification from MassGIS (2007)
- Hydrography from MassGIS (2000)

Conservation Lands and Protected Open Space
Taunton River Watershed, Massachusetts

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Conservation Lands and Protected Open Space (in each subbasin)

Taunton River Watershed, Massachusetts

Legend
Percent of Conservation/Protected Open Space Land

Notes
Subbasin boundaries from MassGIS (2005)
Open space classification from MassGIS (2007)
1:100,000 Hydrography from MassGIS (2000)
2.3 **Protected and Unprotected Lands**

The Conservation and Protected Open Space layer (generated from the MassGIS Protected and Recreational Open Space datalayer) was combined with the MassGIS wetlands and Areas of Critical Environmental Concern (ACEC) datalayers to determine protected and unprotected lands. Wetland areas and ACEC lands were included in this category due to existing regulatory restrictions on future development of these lands. Figure 5.5 shows the areas classified as “protected” for the purposes of this study.

2.4 **Developed and Undeveloped Areas**

The MassGIS land use datalayer (LU37_1999 field) was used as a proxy for determining developed and undeveloped lands within the Taunton River Watershed. Areas with land use codes 3 (forest), 4 (wetlands), and 20 (water) were all considered to be undeveloped. The MassGIS land use data layer was last updated in 1999. Figure 5.6 provides an overview of developed and undeveloped land within the Taunton River Watershed.

2.5 **Impervious Cover**

Impervious surfaces (e.g. roads, rooftops and parking lots) impact the quality of streams and surface waters by reducing infiltration and natural pollutant attenuation, increasing
peak storm flows, increasing stream temperature, and increasing pollutant loads associated with land uses. As shown in Figure 5.7, the Impervious Cover Model developed by the Center for Watershed Protection indicates that (1) sensitive stream elements tend to be lost from stream system systems at about 10% watershed impervious cover, and (2) stream quality tends to shift to a poor condition (e.g., diminished aquatic diversity, water quality, and habitat scores) at about 25% watershed impervious cover. The MassGIS Impervious Surface layer dated February 2007 was used to determine impervious cover as a percentage of total area per subbasin within the Taunton River Watershed (Figure 5.8).

3.0 200-FOOT STREAM BUFFER ASSESSMENT

Vegetated stream buffers can play an important role protecting in-stream water quality. Buffer zones attenuate storm water pollutant loads by allowing for vegetative uptake, reducing runoff velocity and thus allowing for increased infiltration and settling of suspended particulate matter in runoff. To assess the condition of stream buffers throughout the Taunton River Watershed, Geosyntec assessed the following conditions for each subbasin:

- Percent of 200-foot stream buffer currently undeveloped (forested, wetland, etc.);
- Percent of 200-foot stream buffer that is currently impervious; and
- Percent of 200-foot stream buffer protected from future development, either through protected conservation lands or significant regulatory protection (e.g. MA Wetlands Protection Act, ACEC)

Stream buffer areas in the Taunton River Watershed were determined based on the MassGIS 1:100,000 hydrography layer. The buffer tool in ArcGIS was used to create a 200-foot buffer around each of the stream lines mapped in the hydrography layer. Overall, Geosyntec’s GIS analysis estimated that approximately 10.9% of the Taunton River Watershed is located within 200 feet to a stream, lake or pond.
Taunton River Watershed, Massachusetts

Legend
- Taunton Watershed
- Town Boundary
- Subbasin Boundaries
- Areas of Critical Environmental Concern
- Surface Water
- Wetlands
- Protected Lands
  - Conservation
  - Recreation
  - Conservation & Recreation
  - Habitat
  - Historical/Cultural
  - Scenic
  - Water Supply
  - Flood Control
  - Underwater

Notes
- Subbasin boundaries from MassGIS (2005)
- Protected land classification from MassGIS (2007)
- Hydrography from MassGIS (2000)

Protected and Unprotected Land
Taunton River Watershed, Massachusetts
Undeveloped Land
Taunton River Watershed, Massachusetts

Legend
- Taunton Watershed
- Subbasin Boundaries
- Town Boundary
- Surface Water
- Land Cover
- Forest
- Water

Notes
Subbasin boundaries from MassGIS (2005)
Land Cover from MassGIS (2002)
Hydrography from MassGIS (2000)

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Figure 5.6

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Figure 5.7: The Impervious Cover Model

(Source: Center for Watershed Protection, Impacts of Impervious Cover on Aquatic Systems, 2003.)
3.1 Developed/Undeveloped Land Within 200-foot Stream Buffers

As shown below in Figure 5.9, the 200-foot buffer is less than 50 percent developed in the vast majority (91%) of subbasins in the Watershed. In general, the subbasins with the most developed land in the 200-foot buffer are those with the highest percentage of impervious cover. Subbasin #25165 in Taunton and Dighton was estimated to have the highest level of development within 200-foot stream buffers (68% developed).

Figure 5.10 allows for a watershed-wide comparison of subbasins with regard to the level of development existing within 200-foot stream buffers. Throughout the Taunton River Watershed, approximately 26% of lands within a 200-foot stream buffer are developed. Figure 5.11 shows a closer view of developed and undeveloped land within 200-foot stream buffers in the Coweeset Brook subbasin (33.1% developed).
Figure 5.9: Undeveloped land in 200-foot buffer (aggregated by subbasin)
Legend
- Taunton Watershed
- Subbasin Boundary
- Town Boundary
- Surface Water
- Percent Undeveloped (in 200-foot Stream Buffer)
  - 25-35%
  - 35-50%
  - 50-65%
  - 65-80%
  - 80-100%

Notes
- Subbasin boundaries from MassGIS (2005)
- Land Cover from MassGIS (2002)
- Hydrography from MassGIS (2000)
- 200-foot buffer created from MassGIS 1:100,000 Hydrography

Percent of Undeveloped Land Within 200-foot Stream Buffer
Taunton River Watershed, Massachusetts
Figure 5.11

Legend
- Surface Water
- Subbasin Boundaries
- Town Boundary
- Developed Land
- Undeveloped Land

Notes
- Subbasin boundaries from MassGIS (2005)
- Land Cover from MassGIS (2002)
- Hydrography from MassGIS (2000)
- 200 foot buffer created from MassGIS 1:100,000 Hydrography

Undeveloped Land Within 200-foot Stream Buffer
Coweeset Brook
Taunton River Watershed, Massachusetts

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Figure 5.11
3.2 Impervious Cover Within 200-foot Stream Buffers

On average, the 200-foot stream buffers within the Taunton River Watershed contain approximately 6.3% impervious cover. As shown in Figure 5.12, the 200-foot stream buffers in 82% of the subbasins contain 10% or less impervious cover. The subbasins with the highest percentage of impervious cover are located in Brockton, Avon, Mansfield and Foxborough.

Figure 5.12: Subbasin Impervious Cover Within 200-foot Stream Buffers

Figure 5.13 allows for a watershed-wide comparison of subbasins with regard to the level of impervious cover existing within 200-foot stream buffers. Figure 5.14 shows a view of impervious cover within the Coweeset Brook subbasin and its associated 200-foot stream buffers.
Impervious Cover Within 200-foot Stream Buffer

Taunton, Massachusetts

Legend
- Taunton Watershed
- Subbasin Boundary
- Town Boundary
- Surface Water
- Rivers and Streams

Percent Impervious Cover (in stream buffer)
- 0-5%
- 5-10%
- 10-15%
- 15-20%
- 20-30%

Notes
Subbasin boundaries from MassGIS (2005)
Impervious cover from MassGIS (2005)
Impervious Cover Within 200-foot Stream Buffer
Coweeset Brook
Taunton River Watershed, Massachusetts

Legend
- Taunton Watershed
- Impervious Cover
- Subbasin Boundaries
- Surface Water
- 200-foot Buffer

Notes
- Subbasin boundaries from MassGIS (2005)
- Impervious cover from MassGIS (2007)
- Hydrography from MassGIS (2000)
- 200-foot stream buffer created from MassGIS 1:100,000 Hydrography

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Figure 5.14
3.3 **Protected Land within 200-foot Stream Buffers**

As shown below in Figure 5.15, 43 percent of all subbasins (45 subbasins) in the Watershed have between 0-10% protected land within the 200-foot stream buffer. In the remaining subbasins, the percent of the stream buffer ranges from 10 to 100 percent and demonstrates a relatively even distribution of subbasins within each category. As defined in Subsection 1.1, protected land is defined for the purposes of this study as conservation lands, protected open space, wetlands, and Areas of Critical Environmental Concern.

**Figure 5.15: Subbasin Percent Protected Land in 200-foot Stream Buffer**

- 45 subbasins with 0-10% protected land.
- 10 subbasins with 10-20% protected land.
- 11 subbasins with 20-30% protected land.
- 5 subbasins with 30-40% protected land.
- 9 subbasins with 40-50% protected land.
- 7 subbasins with 50-60% protected land.
- 8 subbasins with 60-70% protected land.
- 4 subbasins with 70-80% protected land.
- 2 subbasins with 80-90% protected land.
- 3 subbasins with 90-100% protected land.

Figure 5.16 allows for a watershed-wide comparison of subbasins with regard to the percent of protected land within 200-foot stream buffers. Figure 5.17 shows a view of protected and unprotected stream buffer within the Coweeset Brook subbasin and its associated 200-foot stream buffers.
Figure 5.16

Percent of Land Protected Within 200-foot Stream Buffer (by subbasin)
Taunton River Watershed, Massachusetts

Legend
- Taunton Watershed
- Town Boundary
- Surface Water
- Subbasin Boundary
- Percent of Land Protected Within 200-foot Stream Buffer
  - < 10%
  - 10-25%
  - 25-50%
  - 50-75%
  - 75-100%
  - No 100k hydrography layer buffer

Notes
- Subbasin boundaries from MassGIS (2005)
- Land Cover from MassGIS (2002)
- 200-foot stream buffer created from MassGIS 1:100,000 Hydrography
  - Two subbasins do not contain 100k hydrography layer stream lines
4.0 PRIORITY HABITAT AREA ASSESSMENT

“Priority habitat areas” within the Taunton River Watershed were determined based on the areas delineated by TNC as either Tier One or Tier Two Priority Habitat. The TNC Priority Habitat data was provided to Geosyntec by the TNC in October 2007. Tier One Priority Habitats include the following:

- Riparian zone of the Taunton River and its largest tributaries;
- Areas surrounding smaller “coldwater streams”;
- Important habitat areas for species identified by TNC as the most imperiled;
- Important habitat areas for species identified by the Massachusetts Natural Heritage and Endangered Species Program (NHESP); and
- “Natural communities” identified as rare, endangered, or of special conservation concern by the NHESP.

Tier Two Priority Habitat Areas include important habitat areas mapped by NHESP which TNC identified as second-tier priorities for species protection and lands located within the region’s least fragmented areas.

Figure 5.18 shows the areas classified as priority habitats by TNC. Overall, approximately 31.7% of the Taunton River Watershed is classified as either Tier One or Tier Two Priority Habitat.

Figure 5.19 allows for a relative comparison of the percentage of Priority Habitat Areas within the Watershed’s subbasins. Figure 5.20 shows the percentage unprotected Priority Habitat Area within the subbasins.
Figure 5.19

Legend
- Taunton Watershed
- Subbasin Boundaries
- No Priority Area
- Percent TNC Priority Habitat Area

Notes
- Subbasin boundaries from MassGIS (2005)
- Priority Habitat Areas from The Nature Conservancy (TNC, 2007)
- Hydrography from MassGIS (2000)

Percentage of TNC Priority Habitat Area within Subbasins
Taunton River Watershed, Massachusetts

Acton, MA 19-JUNE-2008
Figure 5.20

Percentage of TNC Priority Habitat Area which is Unprotected (by subwatershed)
Taunton River Watershed, Massachusetts

Legend
- Taunton Watershed
- Subbasin Boundaries
- No Priority Habitat Area
- Percent of TNC Priority Habitat Area Unprotected
  - 0-10
  - 10-20
  - 20-30
  - 30-40
  - 40-50
  - 50-60
  - 60-70
  - 70-80
  - 80-90
  - 90-100

Notes
- Subbasin boundaries from MassGIS (2005)
- Priority Habitat Areas from The Nature Conservancy (TNC, 2007)
- Hydrography from MassGIS (2000)
5.0 SUMMARY

Conservation lands and protected open space comprise 12.5% of the Taunton River Watershed. Fifty six (56) percent of all subbasins are comprised of less than 10% conservation lands or open space. Only 23% of subbasins in the Watershed are composed of greater than 20% conservation lands or protected open space. This indicates that the majority of the remaining land in each subbasin is either already developed or vulnerable to future development.

Vegetated stream buffers can play an important role protecting in-stream water quality. Buffer zones attenuate stormwater pollutant loads by allowing for vegetative uptake, reducing runoff velocity and thus allowing for increased infiltration and settling of suspended particulate matter in runoff. Approximately 10.9% of the Taunton River Watershed is located within 200 feet to a stream, lake or pond. Approximately 26% of these lands within a 200-foot stream buffer are developed.

Impervious surfaces (e.g. roads, rooftops and parking lots) impact the quality of streams and surface waters by reducing infiltration and natural pollutant attenuation, increasing peak storm flows, increasing stream temperature, and increasing pollutant loads associated with land uses. On average, the 200-foot stream buffers within the Taunton River Watershed contain approximately 6.3% impervious cover. The 200-foot stream buffers in 18% of the subbasins contain 10% or more impervious cover. Opportunities to improve and restore stream buffers (e.g. through re-vegetation projects, LID retrofits, land acquisition, conservation easements, etc.) should be prioritized for these subbasins. The subbasins with the highest percentage of impervious cover include portions of Brockton, Avon, Mansfield and Foxborough.

Approximately 40 percent of all subbasins in the Watershed have between 0-10% protected land within the 200-foot stream buffer. In the remaining subbasins, the amount of protected stream buffer ranges with a relatively even distribution from 10 to 100 percent. “Protected land” was defined for the purposes of this study as conservation lands, protected open space, wetlands, and Areas of Critical Environmental Concern.

“Priority habitat areas” within the Taunton River Watershed were determined based on the areas delineated by TNC as either Tier One or Tier Two Priority Habitat. These areas include:

- Riparian zone of the Taunton River and its largest tributaries;
- Areas surrounding smaller “coldwater streams”;
- Important habitat areas for species identified by TNC as the most imperiled;
- Important habitat areas for species identified by the NHESP;
- “Natural communities” identified as rare, endangered, or of special conservation concern by the NHESP; and
- Important habitat areas mapped by NHESP which TNC identified as second-tier priorities for species protection and lands located within the region’s least
fragmented areas.

Overall, approximately one third of the Taunton River Watershed is classified as either Tier One or Tier Two Priority Habitat.

The degree of protection from future development impacts that is provided to TNC Priority Habitat Areas varies widely across the watershed;

- In general, sub-watersheds in the south-central portion of the watershed have the highest percentage of unprotected Priority Habitat Area. This area, which includes significant portions of Dighton Taunton, Raynham, Berkeley, Bridgewater, Lakeville and Middleborough, is characterized by having between 70-100% of TNC Priority Habitat Area unprotected.

- Sub-watersheds in the north-central portion of the watershed has the highest level of protection for Priority Habitat Areas, including significant portions of Easton, West Bridgewater, Mansfield, Norton, and the northern portions of Bridgewater, Raynham and Taunton. This area is characterized by having 0-30% unprotected Priority Habitat Area.
SECTION 6

SMART GROWTH CASE STUDY: EASTON

1.0 INTRODUCTION

The Taunton River Watershed Study included a smart growth case study of one community in the watershed, as an example, to highlight existing smart growth opportunities and to recommend additional smart growth tools that can help that community address some of the ecological and water resources issues identified in this phase of the study. While the breadth and depth of this study does not allow for an in-depth analysis of each community in the watershed, a case study approach can at least provide an example for other communities and may lay the groundwork for future work addressing each community. With the help of the Steering Committee and representatives from the community, the Town of Easton was selected as the focus for this case study. The specific objective of this case study is described below.

Objective: To encourage the progress of the watershed communities’ adoption of smart growth techniques, identify areas suitable for smart growth applications, and ensure compatibility with current local bylaws and ordinances.

2.0 OVERVIEW OF EASTON

2.1 Location

Easton is located in the upper northwest section of the Taunton River Watershed boundary, approximately 25 miles southwest of Boston. It is surrounded by the towns of Sharon and Stoughton to the north, Brockton and West Bridgewater to the east, Norton, Taunton and Raynham to the south, and Mansfield to the west.

2.2 Natural Resources

There are three main watershed sub-basins that are located within the Town boundary: the Queset Brook, Black Brook, and Mulberry Brook subwaterheds. The town’s flat terrain leads to extensive Flood Hazard areas mapped by the Federal Emergency Management Agency. These areas run north and south along the Town’s major streams and spread out in low-lying areas, particularly the Hockomock Swamp area. Hockomock Swamp is one of two Areas of Critical Environmental Concern located within the Town, along with the Canoe River Aquifer Area in the southwest portion of the Town. These areas provide critical habitat to a diversity of wildlife: deer, foxes, beavers, moles, etc; a variety of warm and cold-water fish and amphibians; and permanent and migrating water birds. According to the NHESP, there are approximately twenty-four endangered, rare or threatened species located in Town, and there are thirty-six certified vernal pools.
Easton’s extensive wetlands provide wildlife habitat, flood storage areas, pollution abatement, flood control and groundwater recharge (2007 Open Space Plan). They are located principally within the flood plain. A town-wide wetlands inventory, completed by William MacConnell, lists eleven types of open fresh water wetlands, flats, bog, shrub swamp, meadow, shallow marshes, deep marsh, open water, and beaver ponds, but leaves wooded swamp included within the forest land category. Although there are scattered areas of wet meadow, open marsh and a few cranberry bogs in the southeastern portion of the Town, Easton’s undeveloped land is primarily woodland and wooded swamp.

2.3 Population/Development Potential

The U.S. Census reported the Town’s population at 22,299 in 2000 and estimated its increase to 23,031 in 2006. Recent population projections by the Old Colony Planning Council suggest growth to 29,903 by 2025. At present, the average household size is 2.974 people. According to the 2007 Open space Plan, this growth would require 2,355 acres of land if accommodated in new single-family detached houses, under current zoning. A buildout analysis was completed for the Town in 2000 by the Massachusetts Executive Office of Energy and Environmental Affairs. This analysis projected the default scenario for growth by graphically illustrating what the community may look like if all remaining developable lands were developed, to their maximum potential, based on existing zoning. The results of the analysis reported a net buildable area of 4,897.2 acres that could accommodate 16,211 new residents. If this figure was added to the year 2000 population of 22,299, a total population at full build-out would be approximately 38,510, at an unknown date.

2.4 Transportation Infrastructure

The state highways and major town streets are generally in good condition affording easy access to most parts of Town. However, a number of local streets, collector streets and minor arterials are extremely narrow and are in poor condition. These could be inadequate for significant new subdivisions, but such limitations will not necessarily prevent development.

Sidewalks exist in major business areas and in newer neighborhoods but not along the older, narrower roads. There are few pedestrian/bikeways connecting subdivisions to other neighborhoods, schools, parks, stores or other destinations.

The Massachusetts Bay Transportation Authority (MBTA) provides commuter rail service the nearby towns of Brockton, Mansfield, Sharon and Stoughton. The MBTA is planning to extend commuter rail service from Metro Boston to the cities of Fall River and New Bedford. Planning included an alternative extension plan (“Stoughton Alternative”) that would bring commuter service to Easton. According to the Southeastern Massachusetts Commuter Rail Task Force, there are three possible station locations in Easton: 1) Route 138 at the Stoughton Line; 2) the North Easton Station at Oliver Street and Sullivan Avenue; and 3) off of Route 123 at Church Street. Each
alternative will undergo extensive environmental review and the favored route will be selected in 2010.

2.5 Water Service

Easton draws on seven gravel packed wells for its primary public water supply; three in the Queset Brook Aquifer, three in the Canoe River Aquifer and one in the Mulberry Brook Aquifer. A daily average of 2.1 million gallons of water is pumped to residents and businesses/public institutions (approximately 7,134 active services) through 161 miles of water mains. Growth has strained the system on peak days or during droughts. There are also approximately 135 private wells serving residential properties.

2.6 Wastewater Management

Easton primarily relies on on-site subsurface disposal systems for wastewater treatment. There are also three large conventional Title 5 systems (between 2,000 and 10,000 gallon per day (gpd)) in Town and three very large conventional Title 5 systems (>10,000 gpd) systems, which serve condominium complexes. Four small (<40,000 gpd) wastewater treatment plants with on-site subsurface disposal serve three condominium complexes and the Easton School complex. Soil in the western portion of the Town between Eastman St. and Rockland St., and in the southern portion of the Town south of Depot St. and Purchase Street west of Bay Road limit the use of on-site systems. Specifically, the 1992 Undeveloped Land Inventory reported that of 5,795 acres of vacant land, 1,225.5 acres were in flood plain and 1,344.64 acres were severely restricted for septic systems. However, many of these areas are developed since the large lots required by the Zoning bylaw often have some usable soil.

3.0 RELATED PLANNING INITIATIVES IN EASTON

3.1 Comprehensive Wastewater Management Plan

In 2003, the Town of Easton hired a consulting firm (Camp Dresser & McKee, Inc.) to work with their Wastewater Management Study Committee to refine the Town’s existing Draft Comprehensive Wastewater Management Plan. The purpose of this revision was to establish long-term wastewater needs for the community, prioritize wastewater needs areas, and develop and screen viable alternatives for wastewater management. The Town’s goals for developing this plan were to attenuate the impacts of on-site, subsurface disposal systems, maintain high water quality, and protect the community’s natural resources including areas of critical environmental concern (ACEC). The results of the study are listed below.

- Two-thirds of the Town’s land area is considered severely limited for septic systems, based on subsurface conditions in the Town.
- Seventeen areas of Town were evaluated based on proximity to environmental resources, zoning, lot size and density of the built environment, suitability of soils for septic systems, and land use characteristics.
• Five studied areas were identified as having the greatest and most immediate need for an off-site wastewater management solution. These areas are generally the central village areas with the most density and/or with the highest percentage of commercially and industrially zoned land.
• Three other study areas were considered to have a need for off-site wastewater management, but the need was not immediate.
• Two alternative approaches were recommended:
  1. Preferred Approach - Regional Treatment. This approach would direct approximately 1.2 mgd to existing wastewater treatment facilities in adjacent towns. This approach would attempt to eliminate failing septic systems.
  2. Alternate Approach - In-Town Treatment and Disposal. This approach would direct approximately 1.2 mgd to 2 proposed new wastewater treatment facilities Town. This approach would attempt to eliminate failing septic systems and would recharge to groundwater. It would require the construction of treatment and disposal systems and a subsurface effluent disposal area(s).
• It was determined that in the nine remaining study areas an on-site solution is feasible.

3.2 Easton Open Space Plan (Dec 2007 Draft update)

In general, the Open Space Plan goals are to extend greenbelt corridors within the Town: north-south Poquanticut Brook/Mulberry Brook corridor, Wheaton Farm to Borderland State Park, Wheaton Farm to Hockomock Swamp, Flyaway Pond to Hockomock Swamp; acquire open space areas to give each developed or developing section of Easton an “open space setting”; protection of existing open space resources; and the creation of additional team sports fields. Although these goals do not contradict those of the Easton Housing Authority, consideration of how to accommodate housing needs while protecting/acquiring open space must be continually discussed.

3.3 Easton Housing Authority Goals

The following Easton Housing Authority goals relate to smart growth planning:

• Develop a Housing Plan that would address the needs and requirements for affordable housing for individuals, family housing, elderly housing and housing for special populations;
• Establish criteria or standards by which Town boards and commissions might use to evaluate proposals for affordable housing under the Comprehensive Permit Law (Ch40B);
• Work with private and/or non-profit developers to facilitate the construction and/or preservation of affordable housing units to meet Easton's fair share, provided that said housing meets the criteria and/or standards established by the housing partnership;
• Encourage the development of a wide variety of housing choices by adopting zoning by-laws and other development regulations that allow alternatives to the single-family home on one acre of land; and
• Develop a system of regular monitoring and enforcement of the requirements of deed restrictions and/or orders of conditions for affordable housing projects in order to maintain its affordable housing inventory.

3.4 Stormwater/Low Impact Development Working Group

A Stormwater and Low Impact Development (LID) Working Group was established to encourage development practices and the use of stormwater treatment methods that provide the greatest benefit and least negative impact to the Town’s natural resources, landscape and character. The Group plans to undergo a regulatory review of existing policies, by-laws and processes and make recommendations for changes to meet the new Massachusetts Stormwater Management Standards. In addition, they intend to provide guidance to developers regarding Best Management Practices through the development of design standards that facilitate ease of maintenance and are consistent with the above goal.

3.5 2008 Departmental Goals and Objectives

Department staff was asked to draft goals and objectives for their perspective roles. Goals and objectives established by the Department: Planning and Community Development, which directly relate to smart growth planning, are listed below.

1. Goal: Improve the Quality of Life for Easton Residents.
   Objectives:
   • Prepare conceptual plan for the potential redevelopment of Route 138 from Belmont Street to Depot Street;
   • Prepare report relating to business/mixed use zoning on Route 138 (Main Street to the Stoughton town line).

   Objectives:
   • Propose amendments incorporating Low Impact Development;
   • Propose private road standards for residential compounds; and
   • Propose standards for open space planning.

4.0 Watershed Study Results in Easton Area

4.1 Taunton River Watershed Study – Easton Sub-watersheds

The water budget study conducted for the entire Taunton River Watershed included four sub-watersheds that are located mainly within the Town boundary. Collectively, there is a surplus of water within these sub-watersheds (approximately 26 cfs). This can be attributed to water recharge from on-site subsurface wastewater treatment versus online...
sewer treatment. In addition, this portion of the Town primarily includes forest, croplands, recreation, or low to medium-density residential development. Development that is typically associated with higher water withdrawals or large-scaled stormwater management is (i.e., commercial development) is extremely limited within these watersheds. These sub-watersheds differ from the Coweeset Brook sub-watershed described below.

4.2 Coweeset Brook Sub-watershed Pilot Study

The Coweeset sub-watershed was chosen as a pilot study area as it is septic sensitive of significantly developed areas that includes an unsewered suburban community (Easton) and a portion of a sewered urban center (Brockton). The sub-watershed where water transfers are known to occur. Two streams flow into this sub-watershed: Coweeset and Queset Brooks. The Hockomock River discharges from the sub-watershed below their confluence. The Coweeset is more developed than the sub-watersheds described above with mixed land uses including medium to high-density residential, commercial, and industrial development. One of the most prominent land uses within this sub-watershed is Stonehill College, which is connected to Brockton’s sewer system.

The sub-watershed covers 5,314 acres, of which 1,194 (or 22%) are impervious. Approximately 215 acres (18%) of the total impervious area were calculated as “effective impervious area” (i.e., a subset of an area’s total impervious area that is directly connected to centralized stormwater systems that discharge to surface waters), and constitutes a net loss of stormwater recharge. Wetlands cover approximately 890 acres, or 17% of the sub-watershed. According to the pilot water budget, existing net recharge (base flow) is estimated to be 5.3 cfs, as compared to an estimated natural (pre-development) flow of the 7.5 cfs. This represents an estimated net loss to base flow of approximately 30%. However, there is a NPDES surface water discharge in this sub-watershed that compensates for this deficit. For the purposes of this case-study, challenges and supporting recommendations will predominantly focus on this sub-watershed and other developed areas in Town with similar issues.

5.0 RECOMMENDATIONS FOR SMART GROWTH TECHNIQUES

Recommendations for how the Town could ensure that development that protects natural resources, enhances quality of life, offers housing choices, reduces energy consumption, and improves municipal finances (Smart Growth) are discussed below. Recommendations for Smart Growth include: mixing land uses; increasing the availability of a range of housing types in neighborhoods; taking advantage of compact design; preserving open space, farmland, and critical environmental areas; providing a variety of transportation choices; and encouraging community and stakeholder collaboration in development decisions. These recommendations are based on the existing Town plans and studies, existing conditions of the Town (environmental and human-altered) and the results of the watershed study.
5.1 Proposed Regulatory Revisions

Based on a review of the existing planning and regulatory framework within the Town of Easton, a set of regulatory changes is recommended to incorporate smart growth techniques and assist the Town in addressing the water resources challenges and ecological conservation issue identified in this study. For each recommendation listed below, we have provided a brief overview; described the objective of the regulatory change; provided recommended regulatory language, in some cases; provided a reference to the enabling legal authority for the recommended change, if applicable; and identified the responsible agency or department.

5.1.1 General Recommendations

Within all areas, Low Impact Development (LID) techniques should be incorporated into the subdivision, wetlands, and zoning regulations to obtain the long-term environmental benefits of these techniques. Wherever possible, the Town of Easton should request that LID techniques are used. The following language should be considered for inclusion within the Town’s Zoning Bylaw (Site Plan Review), and/or the Subdivision Regulations.

\textit{LID is a more sustainable land development pattern than the conventional method currently used in most areas. LID incorporates a suite of landscaping and design techniques that attempt to maintain the natural, pre-development hydrology of a site and the surrounding watershed. The goals of LID include:}

\begin{itemize}
  \item Prevent environmental impacts rather than having to mitigate for them.
  \item Manage water (quantity and quality) as close to the source as possible and minimize the use of large or regional collection and conveyance.
  \item Preserve natural areas and native vegetation, and reduce the impact on watershed hydrology.
  \item Use natural drainage pathways as a framework for site design.
  \item Create a multifunctional landscape.
  \item Utilize a natural system approach and methods for stormwater management.
\end{itemize}

An important LID principle is the idea that stormwater is not merely a waste product to be disposed of, but rather that rainwater is a resource. LID also integrates a range of structural best management practices (BMPs) for road design and stormwater and wastewater management systems that minimize environmental impacts. The matrix below provides guidance regarding specific stormwater practices to use for different land uses.
### Table X: Selecting Appropriate Practices for Different Land Use Types

<table>
<thead>
<tr>
<th>LID Practices</th>
<th>Single Family Residential Lot</th>
<th>Small Commercial/Multifamily Lot</th>
<th>Existing Development</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Underdrain Soil Filters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioretention System</td>
<td>O</td>
<td>●</td>
<td>O</td>
</tr>
<tr>
<td>Rain Garden</td>
<td>●</td>
<td>O</td>
<td>●</td>
</tr>
<tr>
<td>Swale</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>Vegetated Buffer</strong></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>Infiltration Practices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry well</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Infiltration Trench</td>
<td>O</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Pervious Pavement</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Rain Barrel/Cistern</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Green Roof</td>
<td>O</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Stormwater Planter</td>
<td>O</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Micro-bio Inlet</td>
<td>O</td>
<td>O</td>
<td>●</td>
</tr>
</tbody>
</table>

Key: ● = suitable, ○ = sometimes suitable with careful design, O = rarely suitable

1. Infiltration practices are not appropriate in wellhead protection zones without pretreatment to remove pollutants that contribute to groundwater contamination. In addition, infiltration practices are prohibited for land uses with higher potential pollutant loads (Hotspots), as specified in the Massachusetts Stormwater Management Policy.

#### 5.1.2 Zoning

**General.** General requirements that should be considered for inclusion within the Zoning Bylaw are as follows:

- Permit the use of common driveways to serve up to four houses, rather than three (Section 8-11), including OSRD lots that do not meet standard dimensional requirements.
- Consider including the following parking requirements:
  - Permit use of permeable paving for parking stalls and spillover parking areas.
  - Do not require more than 3 off-street parking spaces per 1000 square feet of gross floor area in professional office buildings.
  - Do not require more than 4.5 off-street parking spaces per 1000 square feet gross floor area of shopping centers.
Establish formulas for the utilization of shared parking for uses with different peak demand periods (e.g., office peak demand period 9am – 5pm; housing peak demand period 6pm – 8am.) Allow reduction of parking requirements if shared parking is proposed. Provide model shared parking agreements that can be included as deed restrictions or permit requirements.

- Allow reduced parking for homes and businesses near major transit stops.
- Permit stall width of 9 feet or less for a standard parking space.
- Permit stall length of 18 feet or less for a standard parking space.
- Recommend or require smaller stalls for compact cars, up to 30% of total number of parking spaces.
- Establish landscaping requirements for parking areas that include vegetated islands with bioretention functions.

**Special Permit.** The bylaw permits two-family, multi-family and apartment uses by special permit. Similarly, two-family conversions are only permitted by special permit. The Town may wish to consider adoption of specific development standards for two-family, multi-family and apartment uses in order to encourage a more compact development pattern within the village center and surrounding neighborhoods. Additionally, mixed-use buildings with ground-floor commercial and upper floor office and residential units would promote economic activity within the village center.

**Dimensional and Density Regulations.** Compared to the average lot size of 11,000 SF within the village center, the existing zoning regulations require 40,000 SF lots and at least 150 feet of frontage for each lot. These standards, although originally adopted to control unplanned growth and development within the Town, promote a land consumptive land use pattern that significantly increases housing costs and promotes building placement and streetscape patterns that are inconsistent with the traditional village character. Consideration should be given to reduce dimensional standards within the village center. Permitting new or replacement structures to be located within the historic or established front yard setback would significantly improve the streetscape of existing neighborhoods and prevent the gap-tooth affect of newer buildings being setback according to modern zoning requirements that do not reflect the design character of the neighborhood. Other dimensional requirements that should be considered are as follows:

- Establish limits on impervious lot coverage (e.g., 15 %.) in rural, low-density areas (Note: This strategy is not appropriate for town centers, transit-oriented districts, and moderate density neighborhoods, where compact development should be encouraged.)
- Permit the location of bioretention areas, rain gardens, filter strips, swales, and constructed wetlands in required setback areas and in buffer strips.
- Establish limits on the extent of lawn area on residential lots, either area or percentage of lot.

**Off-Street Parking Requirements.** The current requirements for residential apartments is two spaces per unit. Compared to other bylaws this requirement appears unreasonably high for all apartment buildings. Consideration should be given to lowering the allowed
residential parking figure for mixed-use buildings or base the requirements on the location, size, style and number of bedrooms rather than a blanket requirement for two spaces.

**Site Plan Review.** Smart Growth provisions exist for Estate Lots, Residential Compounds, Planned Business Districts, Planned Industrial Developments, Home Occupations, Adult Retirement Communities and Open Space Residential Developments. Other than potentially reducing the tract size for some of these special permits, they all represent sound growth management strategies for encouraging compact development patterns.

The Town has created Site Plan Guidelines to ensure that development does not cause detrimental consequences to the environment. Although this is a very comprehensive document, we recommend the following additions/changes for smart growth planning and permitting purposes:

- Allow LID techniques (e.g., bioretention areas, filter strips, swales, and constructed wetlands) to count towards fulfillment of site landscaping/open space requirements; and
- Require that driveway widths are no more than 9 feet. In addition, the requirement for bituminous concrete berming of perimeter of the parking area and driveway perimeters should be changed since this requirement may inhibit the use of LID techniques. The use of pervious material for single family driveways (e.g., porous pavers, paving stones, pervious asphalt or concrete), and/or use of ‘two-track’ design for residential driveways should also be considered.

**Overlay Districts.** The Town has two existing overlay districts that help to encourage smart growth: the Aquifer Protection District and the Queset Smart Growth Overlay District. The Aquifer Protection District functions as an overlay district and no density bonuses are permitted within the district for any permitted uses. The Queset Smart Growth Overlay District is a 70-acre district, located partially within Zone II, which would include mixed uses. The Development proposal that stimulated the establishment of this district proposes conventional Title V leaching system and Zenon membrane treatment system with some treated effluent being pumped back to existing facilities (the assisted living and Stone Forge complex). An obstacle to accepting this proposal is the stipulations in Section C.4 of Title V that prohibits package treatment plants within the Zone II Aquifer Protection District.

Understanding the significant water and wastewater infrastructure issues in Easton, the Town would likely benefit from using targeted development districts (overlays), in addition to the above-mentioned districts, to direct new growth and development to existing service areas. Additional 40R Smart Growth Overlay Districts and Transit Oriented Development (TOD) districts could be used within Transfer of Development Rights (TDR) “receiving” areas or growth centers. In addition, these techniques would help the Town promote new housing and economic development goals, higher density...
mixed-use developments should be considered within the village center and along transportation hubs like the MBTA commuter rail system.

TOD creates mixed-use, higher density communities that encourage people to live, work and shop near transit services and decrease their dependence on driving. TOD reduces auto usage; results in efficient use of existing land, infrastructure, and services; supports the revitalization of community centers and neighborhoods; and fosters a sense of place through the creation of mixed-use centers that combine residential uses with economic activity. TODs that combine a variety of housing alternatives with diverse economic activity provide both employment and living options for a wide range of people, and create a dynamic 24 hour environment. In suburban areas, such as Easton, TOD often takes the form of new development clustered around a rail station on underutilized or vacant sites, which should be considered when discussing the potential MBTA extension through Easton. TOD can be encouraged and/or mandated in the following ways:

- Development of station area plans that include some or all of the following elements: a market study; a physical plan for infrastructure and utility needs; a land use plan; a phasing plan; redevelopment strategies; and recommendations for regulatory changes and incentives to encourage TOD.
- Zoning changes may take the form of modifications to the underlying zoning, interim zoning while plans are prepared for the station areas, or zoning overlay districts. Components of the zoning often include providing for mixed uses, density bonuses, parking restrictions, reduced setbacks, and pedestrian amenities.
- Station area design guidelines can help ensure that new development of redevelopment of existing sites and buildings is pedestrian-friendly, attractive, and connects the neighborhood to the transit station. Design guidelines often address the design of parking (including berms and landscaping around lots), pedestrian furniture, signage, street lighting, sidewalk width and materials, ground level building façade design and materials and respect for neighborhood spaces.
- Siting public facilities near transit stations can act as a catalyst for attracting private investment. Incentives exist for encouraging development and redevelopment near transit, including: sharing infrastructure development costs, providing for brownfield remediation, streamlining the development process, and adopting District Improvement Financing (DIF) and Tax Incentive Financing (TIF) districts.

A nearby example of TOD is Canton, where a Canton Center Economic Opportunity District Bylaw was created that directly encourages TOD and better connect the MBTA Canton Station to the downtown area (http://www.mass.gov/envir/smart_growth_toolkit/pages/SG-CS-tod.html).

In order to support other land conservation programs to protect the outlying open space areas, the Town should consider adopting a TDR program. TDR provides an opportunity to transfer development rights from sensitive (sending districts) to areas that can more easily support additional growth (receiving districts). The TDR program would designate the rural “sending” areas for preservation and the village center and other existing activity centers could be considered for “receiving” areas for medium to high-density
mixed-use development. Developers within the receiving areas would be required to
donate to a land mitigation fund that the Town would use to purchase development rights
within the sending areas. Please refer to the Massachusetts Smart Growth Toolkit
website for specific information regarding the implementation of TDR

Open Space Residential Development Bylaw. The goal of the bylaw is to preserve open
space, natural and historical resources, and rural and scenic character. Developments are
approved through a special permit process. Minimum Tract Size is five acres, and it must
have at least forty feet of frontage on a public way. At least sixty percent of the total tract
area shall be set aside as “Common Land” to be used for natural resource protection,
recreation, park purposes, outdoor education, agriculture, horticulture, or forestry. A
portion of the Common Land may be also be used for pedestrian walks, bicycle paths,
emergency access, and the construction of leaching areas associated with supply wells or
septic disposal systems serving the development. Consideration should be given for
permitting Open Space Residential Developments (OSRD) as a “by right” form of
development (no special permit required). In addition, OSRD should be considered
within the Aquifer Protection District at higher densities than the underlying zoning. A
more restrictive set of permitted uses could also be considered and adding LID standards
for building and site design would support the purpose and intent of this overlay district.

Authority/Responsible Party. Authority is granted to the Town to make changes to its
Zoning Bylaw under Chapter 40A, Section 5 of the General Laws of the Commonwealth
of Massachusetts and amendments thereto, herein called the "Zoning Act" and the powers
granted to the Town under the Home Rule amendment to the Massachusetts Constitution.
The responsible party would be the Easton Planning and Zoning Board.

5.1.3 Subdivision Regulations

General. Non-specific revisions that should be considered within the subdivision rules
and regulations are as follows:

- Provision to minimize the number of cul-de-sacs and dead-end streets permitted. If
  presented for permitting, cul-de-sacs should include landscaped areas to reduce their
  impervious cover.
- Language regarding landscaping that encourages the use of drought-tolerant plant
  materials and plants that uptake pollutant (if necessary). Also the reduction of
  clearing of natural vegetation should be mandated. The Town should also consider
  adding language to ensure that heartier trees remain onsite and/or are replaced with
  equal caliper trees.
- Standard regarding the use of fertilizers, such as: 0.9 lbs of nitrogen per 1,000 square
  feet of lawn and garden.
- Requirement that invasive species should not be utilized for landscaping purposes
  should be considered.
- Permit the use of permeable paving for road shoulders/parking lanes in residential
  neighborhoods, with use of conventional paving for travel lanes only. Also,
sidewalks should be designed so that the runoff is disconnected from the stormwater system. e.g., place a green strip.

**Design and Construction Standards.** The design and construction standards require closed drainage, traditional sidewalks, and excessive pavement widths. Additional changes to the preservation of natural areas and open space would provide better protection of groundwater resources.

The drainage design requirements are somewhat outdated, particularly Section 5.10, that mandates a closed drainage system, which may lead to the use of conventional drainage that does not allow for recharge. The Massachusetts Stormwater Manual was recently updated and should be referenced in this section for a more comprehensive approach to stormwater management. LID stormwater management techniques outlined above, such as bio-retention, water quality swales and rain gardens, should be considered as an alternative to the required closed drainage system. This approach not only improves water quality treatment on the site but also should decrease capital expenditure on road and drainage infrastructure. In addition, it is recommended that language be inserted into the regulations discussing how the roadway, drainage design and building construction in all subdivisions shall be designed to reduce, to the greatest extent possible:

- Volume of cut and fill.
- Area over which existing vegetation will be disturbed, especially if within 200 feet of a water body, wetlands resource area, or a slope of more than 15%;
- Number of mature trees removed;
- Extent of waterways altered or relocated;
- Visual impact of man-made elements not necessary for safety;
- Erosion or siltation;
- Alteration of natural flood storage areas;
- Disturbance of important wildlife habitats, outstanding ecological or botanical features, scenic views or historic resources; and
- Detrimental impacts to water quality.

Street width requirements within the regulations are as follows: Residential Minor Street: 24', Residential Major Street: 28', Residential Collector Street: 32'. This provision does not allow for smaller street widths used in LID practices. It is recommended that the Town require a minimum pavement width of 18-22 feet on low-traffic local streets in residential neighborhoods. In addition, the Town should allow narrower pavement widths along sections of roadway where there are no houses, buildings, or intersections, and where on-street parking is not anticipated. It is especially important to involve public works officials and emergency response officials in this discussion.

There is no mention of the use of conservation restrictions to ensure that open space areas and groundwater resources are permanently protected. Example language that can be used in this section is as follows: “Open space land must remain as open space via a conservation restriction or easement to the Town.”
**Authority/Responsible Party.** Authority is granted to the Town to make changes to its Subdivision Regulations under Chapter 41, Sections 81Q of the General Laws of the Commonwealth of Massachusetts and the powers granted to the Town under the Home Rule amendment to the Massachusetts Constitution. The responsible party would be the Easton Planning and Zoning Board.

5.1.4 **Wetlands Protection (bylaw and regulations)**

The Town of Easton’s Wetlands Protection Bylaw and Regulations are quite sophisticated in comparison to other Massachusetts communities. It protects Massachusetts Wetlands Protection Act resources as well as intermittent streams, vernal pools and ponds of any size. However, in order to ensure that recharge to groundwater occurs, LID techniques (such as bioretention areas, infiltration trenches, or grass swales) should be permitted within the buffer zone of state or local jurisdictional wetland resource areas, provided the location of these structures is not in conflict with any other setback criteria required by Massachusetts Wetland Protection Act regulations or the Stormwater Management Policy and Standards. In addition, the Town should consider providing opportunities for staff and Commission members to participate in LID workshops or conferences.

5.2 **Proposed Planning Changes**

5.2.1 **Wastewater Management**

The Alternate Approach described above should be considered by the Town in order to keep water local and recharge to groundwater, particularly in the Coweeset sub-watershed and any other sub-watersheds where a water deficit has been calculated.

There are other areas of Town where sewering was not proposed. The Town may want to consider using/mandating shared septic systems on sites with shallow depths to groundwater, in areas with poor soils, and in higher density areas where the location of individual leaching areas is impractical. A shared system is a traditional septic system that is used by two or more adjacent properties. Recent changes to the State Environmental Code, Title 5 (310 CMR 15.000) encourage shared septic systems in cluster developments, promoting conservation design and smart growth principles. A shared system can be approved if a proposed cluster development complies with Easton’s Open Space Residential Development Bylaw, or provides 50% of the site as permanent open space. With the exception of cluster developments, applicants proposing a shared system for new construction must prove that each lot connecting to the system can support a complying Title 5 system of their own. The minimum lot size for a property in a cluster development using a shared system does not have to be controlled by the septic system design because the system can be located on its own separate lot, and therefore density is controlled by the local zoning and subdivision codes.
5.3 **Stormwater Management Bylaw (proposed)**

In developing the Town’s proposed stormwater bylaw, careful consideration should be made to ensuring that annual groundwater recharge rates are maintained, wherever possible, by promoting infiltration through the use of structural and non-structural methods. At a minimum, annual recharge from the post development site should mimic the annual recharge from pre-development site conditions. The stormwater runoff volume to be recharged to groundwater should be determined using the methods prescribed in the 2008 version of the Massachusetts Stormwater Management Standards (or an equivalent local manual).

6.0 **CONCLUSION**

As discussed, the buildout analysis conducted for the Town shows the substantial growth potential that Easton could undergo over the next few years to upcoming decades. Easton is rich in natural resources that must be protected in order to help replenish the Town’s groundwater resources. A noted in the Watershed Study, although there is a surplus of water in a number of sub-watershed areas within Town, this is due to water recharge from on-site wastewater treatment. The Town is currently planning for growth and considering alternative wastewater treatment options that would discharge treated water away from these sub-watersheds, as is done in the Coweeset sub-watershed. Alternative wastewater options should be considered in order to maintain, and in some areas, increase water recharge. In addition, the increase in impervious surfaces due to development decreases water recharge in the sub-watersheds. We have discusses various options for maintaining the hydrologic balance of a development site, as well as methods for preserving open space where natural recharge can occur.

The Town of Easton is well poised for making the proposed regulatory and non-regulatory changes for smart growth planning due to its current level of cross-board coordination (e.g., stormwater working group) and recent planning projects (housing and open space planning).
SECTION 7

CONCLUSIONS AND ADDITIONAL COMMENTS

The results of the Phase I efforts include significant data collection, habitat and hydrologic analyses, a public outreach program, a smart growth case study and the development of recommendations for future phases of the Watershed Plan. As a product of this work, a number of conclusions were developed and are summarized and discussed below.

1.0 CONCLUSIONS

1. Water Balance (Entire Watershed)

Based on the data collected to date (see Section 2), and on a number of modeling assumptions (see Section 4 and Appendix A), the water balance analysis shows that urbanization had resulted in hydrologic shifts throughout the Taunton watershed. Specific conclusions and illustrations of some of these shifts at the sub-watershed scale are provided in Section 4 of this report. Groundwater recharge provides the primary source of baseflow to streams and wetland systems and replenishes aquifers. When anthropogenic groundwater withdrawals and discharges are accounted for across the watershed, and the effects of impervious surfaces are accounted for, the analysis shows that urbanization and water transfers have resulted in net losses in groundwater recharge of – 7.97 billion gallons per year (-6.2%). A graphical representation of the various water withdrawal and recharge categories and quantities, excluding surface water withdrawals and discharges, is provided for the Taunton watershed in Figure 7.1.
These findings are consistent with a report issued in 2001 by the Massachusetts Water Resources Commission that indicates that 50% of the Taunton River Watershed is classified as “medium-stressed” (flow deficit), 10% of the basin as “highly-stressed” and the remainder of the basin is designated as “unassessed” due to lack of data.

A significant portion of the recharge deficit is, however, returned to streams via surface discharges of wastewater regulated by NPDES permit program. When accounting for NPDES discharges as well as surface water withdrawals (usually from larger water systems, such as the Attleboro system withdrawing from the Wading River and the Brockton System withdrawing from Brockton Reservoir and Monponsett Pond), the watershed-wide analysis shows a net increase in total watershed baseflow of approximately 2%. In other words, at the full watershed scale, anthropogenic losses of natural baseflow that had previously been provided by precipitation-derived recharge have been compensated for the discharge of treated wastewater from sources located outside the watershed. Our work suggests that approximately 19 billion gallons per year (GPY) of wastewater discharges now comprise almost 15% of the total estimated baseflow (131 billion GPY) throughout the Taunton River Watershed. A graphical representation of the various recharge categories and quantities, including surface water withdrawals and discharges, is provided for the Taunton Watershed in Figure 7.2.
2. Water Balance (Sub-Watersheds)

While the watershed as a whole is in relative balance, the picture is often very different when looking at the sub-watershed scale. The water balance analysis excluding surface water withdrawals and NPDES discharges shows that of the 108 sub-watersheds, 27% (29) have surplus water and 73% (79) have water deficits under current conditions compared to natural conditions. They range from a surplus of 9% in one sub-watershed to a deficit of 231% in a small sub-watershed with several significant major water withdrawals. A total of 25 sub-watersheds have a water deficit of greater than 10%, and eight (8) sub-watersheds have a surplus of greater than 5%. As discussed earlier, across the entire Taunton Watershed, the water balance tool indicates a total net recharge of 122,900 mgy under existing conditions compared to an estimated natural recharge rate of 131,000 mgy. This represents a 6.2% water deficit throughout the entire Taunton watershed. In other words, the volume of water in the ground within the watershed is 6.2% less than it would be under natural conditions.

When the same analysis was performed incorporating surface water withdrawals and NPDES discharges, 31% (34) of the 108 sub-watersheds have surplus water compared to natural conditions and 69% (74) have water deficits. They range from a surplus of 259% in one sub-watershed to a deficit of 1,225% in a small sub-watershed with several significant major water withdrawals. A total of 29 sub-watersheds have a water deficit of greater than 10%, and 15 sub-watersheds have a surplus of greater than 5 percent. Overall for the entire Taunton Watershed, the analysis shows a total existing net recharge of 132,983 mgy compared to an estimated natural recharge rate of 130,962 mgy. This represents a 1.5% water surplus throughout the entire Taunton watershed. In other...
words, when surface withdrawals and discharges are included in the analysis, the overall volume of water in the Taunton Watershed is greater now than under natural conditions. However, when these results are compared to the analysis that looks at recharge only, the extent to which individual sub-watersheds differ from natural conditions (both surpluses and deficits) is amplified significantly.

However, when these two analyses are compared side by side (with and without surface water withdrawals and discharges), it is clear that the surface water withdrawals and discharges shift water more significantly between sub-watersheds than the groundwater withdrawals and discharges alone. The range of deficits and surpluses among sub-watersheds is significantly increased when surface water is considered in the analysis. In general, groundwater effects are felt over the long term, as groundwater moves relatively slowly through the watershed, and surface water impacts are felt over the shorter term, as surface waters generally flow more rapidly through the streams and rivers of the watershed. Therefore, while groundwater withdrawals and discharges are clearly impacting the Taunton Watershed over the long term (groundwater moves relatively slowly), the surface water withdrawals and discharges are likely affecting different sub-watersheds of the watershed over the short term.

Clearly, this shows that the use and movement of water in the watershed is altering the natural hydrology of the watershed on a macro and a micro scale. At the sub-watershed scale, where the small headwater streams occur, and where critical aquatic and riparian habitats exist, the effects of urbanization on the water balance have significant and measurable impacts. Subsequent phases of this watershed plan must focus on reversing this trend at the sub-watershed scale. The sub-watershed analysis is an important tool in such a large watershed because it helps to break down the big picture into smaller areas that can be addressed through individual management techniques. Evaluation of groundwater impacts alone versus surface and groundwater impacts is helpful to direct the recommended management tools in Phase II of this watershed plan.

3. Stream Buffer and Habitat Analysis

A GIS-based analysis was performed to begin to understand the current land development and land protection patterns in the watershed, as an indicator of watershed health. This analysis, like the water balance analysis, was performed at the sub-watershed scale in order to help prioritize future watershed management actions. Specifically, the following two questions were posed:

1. How well protected are stream buffers throughout the Taunton River Watershed?
2. How well protected are the most ecologically critical areas of the watershed?

The key results of the analysis are summarized as follows:

**Stream Buffer Protection**
- Approximately 10.9% of the Taunton River Watershed is located within 200 feet to a stream, lake or pond, and approximately 26% of lands within a 200-foot stream buffer are developed.
• The 200-foot buffer is less than 50 percent developed in the vast majority (91%) of sub-watersheds in the Watershed. In general, the sub-watersheds with the most developed land in the 200-foot buffer are those with the highest percentage of impervious cover.

• On average, the 200-foot stream buffers within the Taunton River Watershed contain approximately 6.3% impervious cover. As shown in Figure 5.12, the 200-foot stream buffers in 82% of the sub-watersheds contain 10% or less impervious cover. The sub-watersheds with the highest percentage of impervious cover are located in Brockton, Avon, Mansfield and Foxborough.

• Forty three (43) percent of all sub-watersheds (45 sub-watersheds) in the Watershed have between 0-10% protected land within the 200-foot stream buffer.

Protection of Ecologically-Critical Areas

• Conservation lands and protected open space comprise 12.5% of the Taunton River Watershed. Fifty six (56) percent of all sub-watersheds are comprised of less than 10% conservation lands or open space. Only 23% of sub-watersheds in the Watershed are composed of greater than 20% conservation lands or protected open space. This indicates that the majority of the remaining land in each sub-watersheds is either already developed or vulnerable to future development.

• In general, sub-watersheds in the south-central portion of the watershed have the highest percentage of unprotected Priority Habitat Area. This area, which includes significant portions of Dighton Taunton, Raynham, Berkeley, Bridgewater, Lakeville and Middleborough, is characterized by having between 70-100% of TNC Priority Habitat Area unprotected.

4. Public Outreach and Participation

According to participants at four public workshops held throughout the watershed, public education training of local government officials was deemed to be of the highest priority. An estimated 300 new local officials are elected or appointed each year in the watershed. These volunteer officials assume major responsibilities for making decisions that have long-term impacts on the sustainability of natural resources in their communities. These individuals could better fulfill their responsibilities with additional training in land use, smart growth, habitat, water conservation, and related topics. An organized training program is needed for local officials on these topics.

Another issue that was raised at the public workshops and observed throughout the watershed during our study is the presence of “sprawl”-type growth, characterized by relatively low density, high imperviousness and segregated uses (residential separated from commercial shopping and job centers). This land use pattern results in large expanses of land used at a relatively low density, loss of naturally-vegetated open space, expensive wastewater solutions and the heavy reliance on the automobile with the subsequent generation of auto-related stormwater pollution. There is a need to re-think development patterns that are largely controlled by the local land use codes of the 43 member communities. Smart growth techniques provide a viable option for the future and need to be fully executed in future phases of this project.
The buffer zone analysis suggests that this sprawl-type development is encroaching on the Riverfront Area, a 200-foot buffer zone to the Taunton River and its tributaries. This encroachment compromises the inherent values of the riparian buffers that include attenuation of pollutants, and maintenance of the natural hydrologic regime and habitat. In addition to Riverfront Areas, future land protection efforts should prioritize acquisition and conservation easements to preserve a contiguous mosaic of protected priority habitat areas throughout the watershed. Such efforts will be particularly critical in the south-central portion of the watershed, where critical habitat areas have the highest overall threat of future development impacts.

5. Data Collection
It is increasingly important that watershed data is collected and maintained in an organized and readily available format. Effective planning depends on an accurate understanding of baseline (current) conditions, historical trends and a mechanism for monitoring future changes. While the data collection and verification effort during Phase I was very thorough, some data gaps remain. Based on the level of effort required to compile this information, it is clear that a better electronic data management system would facilitate better decision making and planning on the part of permitting agencies, municipalities and other interested parties to make informed decisions. A summary of the Phase I data collection effort is provided below.

- Water and sewer service area maps were created for all communities in the Taunton River Watershed except for the two communities without any water or sewer infrastructure (Rehoboth and Rochester), as well as the three communities with minimal areas within the boundaries of the Taunton River Watershed (Dartmouth, Norfolk, and Walpole).
- A total of 355 Water Management Act (WMA) permitted and registered sources were identified within the Taunton River Watershed, including 195 cranberry facilities.
- Average daily flow and exact geographical coordinates were obtained for all 22 groundwater discharge permits within the Taunton River Watershed.
- Latitude and longitude information was obtained for all 18 NPDES discharge locations within the Taunton River Watershed. Reported average monthly discharge volumes were available for 13 of the 18 facilities, and volumes were approximated for the remaining five facilities based on permitted volumes.

2.0 ADDITIONAL COMMENTS

The implications of water balance shifts can be significant ecologically. As less water enters the subsurface as recharge, groundwater levels decline, thus reducing the aquifer storage volumes. Declining groundwater levels also affect surface water features. In the very flat terrain of the Taunton basin even minor declines in water table can represent significant horizontal shifts in wetland systems that are highly-dependent upon shallow water tables within the root zone. Decreases in recharge-derived baseflow can also affect aquatic ecosystems, and can result in shifts in species composition. This is illustrated in
the preliminary results of a recent study by the US Geological Survey (USGS) of the Ipswich, Blackstone and SuAsCo basins, which examined the water balance (withdrawals versus return flows) and its impact on fisheries (Armstrong et al., 2008). This study examined four classifications of sub-watersheds (natural, depleted, surcharged, and churned). Depleted sub-watersheds are those where water withdrawals exceed return flows. Surcharged sub-watersheds are those where return flows exceed withdrawals. Churned sub-watersheds refer to those where both withdrawals and return flows occur and are balanced. This study indicates that in some cases, even very mild shifts in the water balance can have a measurable effect on the species composition.

Other related ecological impacts associated with changes in the streamflow regime can include wetlands losses and/or modifications and the associated effects on ecosystem composition including species diversity. Such impacts are caused by lowered water table elevations and/or modified flood durations during and following storm events.

The effects of climate change are also important to be considered in a long-term watershed management strategy. Higher intensity rainfall events coupled with lengthier drought periods will affect the hydrologic regime of the watershed. Rising temperatures and sea levels will result in ecological impacts.

A comprehensive wastewater management approach is needed throughout the watershed. The Upper Taunton Wastewater Study currently underway will examine some potential regional solutions, largely related to the urban centers and the existing wastewater treatment facilities of Brockton, Mansfield and Taunton in the northern part of the watershed. As presented in the water and sewer service area mapping produced in Phase I, the vast majority of the watershed is currently served by on-site septic systems, and many of these are located in soils that have “severe limitations” for sewage disposal (according to the USDA Natural Resources Conservation Service Soil Surveys). Low-density land use patterns (sometimes described as sprawl) result in the consumption of large land areas for relatively little housing and job production. This results in the loss or under-utilization of limited “good soils” for sewage disposal and high costs associated with extending and connecting sewers to this widely dispersed development. Innovative and alternative sewage treatment technologies are available on both an individual home and village-scale basis, and, in conjunction with smart growth land use codes, will offer more effective and affordable wastewater solutions. A comprehensive analysis of viable recharge areas, future land use planning, project permitting, and open space acquisition programs can preserve natural areas, and good soil locations.

Stormwater management is an important piece of the water balance and watershed health puzzle in the Taunton Watershed. A water quality evaluation known as a Total Maximum Daily Load (TMDL) analysis for the Taunton River suggests that pathogens (bacteria, viruses, and other microorganisms) are the primary water quality impact and that the primary source of these pollutants is stormwater runoff. In addition, as shown in Section 5 of this report, there are significant areas of the watershed that are impervious, particularly within the 200–foot buffer to surface waters. Application of the 2008 Massachusetts Department of Environmental Protection Stormwater Standards and DEP’s
pending Stormwater General Permit will help in minimizing additional future stormwater impacts for new developments within the 100-foot jurisdictional buffer zone to wetlands and large impervious areas beyond the jurisdiction of the Wetlands Protection Act. However, progressive amendments to local land use codes, particularly Subdivision Rules and Regulations and wetlands protection and stormwater management codes, are needed to expand and strengthen these stormwater controls throughout the watershed. Stormwater retrofit projects are also needed to address the many existing untreated stormwater discharges.

3.0 REFERENCES

SECTION 8

PHASE II SCOPE OF SERVICES

1. GOALS

The principal goal of this management plan is to restore and maintain a hydrologically, and biologically connected and integrated watershed system that will sustain human and ecological health. The results of Phase I indicate that historic land development practices and associated water withdrawals and discharges have resulted in shifts in the hydrologic balances in many of the Taunton sub-watersheds. These hydrologic shifts cause habitat and wetlands losses, magnify the impacts of pollutants and limit water supplies. Phase II is designed to supplement these analyses and to provide a comprehensive management approach to preserve and where necessary restore the Taunton River.

2. OBJECTIVES

The more specific objectives in the development of a comprehensive watershed management plan are to:

- preserver valuable habitats in the Taunton River Watershed;
- manage additional wastewater needs within the watershed;
- develop innovative stormwater management and LID techniques;
- sustain river flow regime and associated natural habitats;
- protect water supplies; and
- develop and implement smart growth initiatives for the watershed communities.

Based upon our data collection, preliminary analyses of water budgets and habitat protection, and our public outreach workshops we recommend the following scope of services.

3. PHASE II SCOPE OF SERVICES

Task 1: Development of Comprehensive Management Plan Introductory Text

A comprehensive management approach is needed to provide the long-term framework for implementation of the watershed plan. This task will develop a clear articulation of why a comprehensive plan for the watershed is useful and necessary, and link it’s importance to the interests of town officials, local citizens, and environmental/stewardship groups.

It will build on Phase I results and examples from other watersheds as applicable, and will provide context for the difference between a targeted approach and a comprehensive watershed planning approach. The reality is that Phase II will represent a targeted approach for implementation of specific projects but these will be accomplished within the context of a larger long-term comprehensive management strategy being used here in
Taunton and being espoused by other regulatory agencies (EPA, DEP), planning agencies (OCPC, SRPEDD, MAPC) and leading environmental proponents (Center for Watershed Protection, CRWA, NRDC, TNC) as the most effective long-term water resources planning approach. The text developed under this task will serve as the Introduction to the Taunton River Watershed Management Plan and will be a key tool in drawing support and attention to this issue for public education and outreach efforts.

HW will provide a preliminary draft of the Management Plan Introduction to the Steering Committee for review. Comments will be incorporated into a final draft for submittal to the Steering Committee.

_Anticipated Timetable: Month 1_

_Deliverables:_
- Preliminary Draft Introductory Text for review and comment by the Steering Committee
- Final Draft Introductory Text
- Discussion at Steering Committee Meeting #1

**Task 2: Detailed Presentation of Phase I Results**

Under this task, HW will further analyze data collected in Phase I of this study to help describe the water budget results and will present this at two public workshops. The Phase I water budget results will be presented in context within the comprehensive watershed management approach. We will answer questions about how the sub-watershed scale, water budget and buffer analyses relate to the watershed as a whole. For instance, how do the water budget results relate to known flow problems in the watershed, or to known habitat loss or habitat protection needs in the watershed?

**Task 2a: Water Budget Analysis:** This task will involve further analysis of the input variables of the water budget model. The water budget model will be amended to produce intermediate results to present a more detailed description of the water budget analysis and the specific quantification of the different sources contributing to the water budget. First we will produce summaries of the relative sources within each delineated subwatershed. The relative sources will show which factors are contributing the water budget. We will “scale up” the water budget analysis to evaluate the water budget at the HUC 10 level and at the full watershed level.

HW will also compare the water budget results with the stream buffer and habitat analysis presented in Phase I to identify subwatersheds threatened by both a severe water imbalance and a loss of stream buffer and important habitat areas. This will help to prioritize areas in need for future expanded habitat protection efforts.

_Anticipated Timetable: Month 1_
Deliverables:
- Detailed water budgets showing relative components.
- Presentation and discussion at Steering Committee Meeting #2.

Task 2b. Presentation of Phase I Results and Identification of Priorities: Two stakeholder meetings/workshops are proposed to present the Phase I results, to discuss the implications and to solicit their interest in developing solutions. The workshops will also be used to identify and address related issues such as water balance deficits, identified water quality issues, NPDES permits, Priority Development/Priority Conservation Area Plans, wastewater studies, hydropower proposals and others.

These workshops will be used to develop a short-list of communities that are interested in and committed to working with us during Phase II in developing and implementing town-specific solutions including demonstration projects (Task 3), and/or code reform (Task 4). Identified communities should be willing to appoint committees and to provide in-kind services that might include additional data gathering, public participation, and assistance with the implementation of recommendations developed during this phase of the project.

Two workshops will be scheduled and will be advertised by a letter to each of the 43 Taunton Watershed Communities inviting them to participate. Assistance from the two regional planning agencies (SRPEDD an OCP) will be sought. The letter will offer the consulting services to those communities which show interest by attending the meeting and are willing to form an advisory committee to implement the recommendations.

Anticipated Timetable: Months 2 - 3

Deliverables:
- Letter to towns
- Two public workshops to identify demonstration projects (Task 3) and identify code reform projects (Task 4).

Task 3: Demonstration Projects

HW will prepare plans for six demonstration projects to illustrate the process of implementing physical watershed management recommendations on the ground. Projects will be selected based upon discussions with the Steering Committee. These will serve as examples for other communities in terms of understanding the required planning and site selection, design, permitting and implementation costs. These projects are a key to the implementation of the targeted approach within the context of a comprehensive watershed management plan in that it is the cumulative benefit of replicating these types of projects throughout the watershed that will be the key to measurable success. Ultimately, improvement of the watershed will depend on both large scale thinking and small scale actions; many of these small-scale projects will need to be implemented.
throughout the watershed to achieve the preservation of present healthy conditions and move toward remediation of impaired conditions in the watershed.

The six demonstration projects will include the following three subject areas: 1) Stormwater/LID Retrofits; 2) Wastewater Solutions; and 3) Habitat Restoration. To the extent possible, HW will attempt to identify demonstration projects that address multiple subject areas.

Task 3a – Project Planning: Meet with project stakeholders (including DPW directors, Conservation Commissions and other local/state officials) to review project goals, review alternative methods to measure effectiveness, and agree on project timeline. A discussion of impaired waters as they relate to specific stream reaches will be considered.

Anticipated Timetable: Month 4

Task 3b - Inventory and Assessment of Existing Information: Review existing data, reports, maps, and other relevant information related to study area collected during Phase I of this project. Collect supplementary data of existing infrastructure (stormwater, water sewer, etc.) and utilities within stream corridors.

Anticipated Timetable: Months 5 - 6

Task 3c - Watershed Delineation and Stormwater Retrofit Inventory: Use the above information coupled with a field reconnaissance to develop a watershed characterization matrix and summary. The characterization will include GIS-derived maps of watershed boundaries, land use, water resources, habitat, and any identified site-specific sources of impairment to summarize the character and severity of the stormwater issues. Utilize the basic methodology outlined in the publication “Urban Stormwater Retrofit Practices” (Schueler, et al., 2007) to locate and identify practices. Identify stormwater practices and strategies that have the best reported pollutant removal capability for the pollutants of concern and ability to mitigate for altered hydrology, such as: bioretention, water quality swales, infiltration, permeable pavements, filter strips and constructed wetlands. For potential wastewater design sites, identify possible wastewater strategies such as shared systems, village scale wastewater treating systems and innovative and alternative technologies. HW will also identify potential stream corridor areas where habitat restoration and/or buffer enhancement is possible. HW will seek projects that offer the opportunity to demonstrate projects that address at least two subject areas.

Anticipated Timetable: Months 6 - 7

Task 3d – Assessment and Ranking: Use the Phase I water budget method to quantify potential recharge benefits of candidate retrofit and/or restoration projects. Rank sites based on recharge potential, other environmental benefits and impacts such as ability
to protect habitat, educational opportunity, and cost. For wastewater sites use DEP-NO3 model to assess water quality benefits.

**Anticipated Timetable: Months 8 - 9**

**Task 3e - Schematic Designs and Cost Estimates:** Develop schematic designs for up to six demonstration projects (to the 25% design level), and prepare preliminary construction cost estimates for each project. Provide a draft copy of the schematic designs and cost estimates. Meet with stakeholders to discuss the concepts to incorporate any changes that might be desired prior to commencement of final design.

**Anticipated Timetable: Months 10 - 11**

**Interim Deliverables:**
- **Watershed assessment report, containing stormwater, wastewater and habitat restoration project reviews identifying potential schematic designs, environmental benefits, site photos, maps, preliminary construction cost estimates and narrative.**

**Task 3f - Field Survey of Existing Conditions:** Conduct a field-run topographic survey for the immediate area of each of the six selected project locations. The topographic survey will be developed for a 2-foot contour interval (unless additional detail is needed) and will locate all existing infrastructure (physical structures, paving, etc.); existing utilities; trees greater than 12” DBH (where applicable and within 50 feet of the project limits); test pit locations (see Task 7); and other data as necessary to provide adequate base information for each site. All topographic data will be collected using Total Station field instrumentation and data collectors in digital format.

**Anticipated Timetable: Months 11 - 12**

**Task 3g - Soil Test Pits:** Arrange for and conduct up to 6 deep-hole test pits to assess soil characteristics and depth to groundwater at selected locations of proposed facilities. The test pit locations will be coordinated with Town/University staff as necessary. Prepare test pit logs documenting subsurface conditions at the site. To the extent possible, Town DPW will provide back hoe/excavation services on an in-kind basis so that the allocated budget can be re-assigned to other tasks on an as-needed basis.

**Anticipated Timetable: Month 12**

**Task 3h - Resource Area Delineation:** Identify and delineate jurisdictional wetlands and other resource areas within the vicinity of the project sites. Flag all resource areas and complete wetland data sheets as necessary.

**Anticipated Timetable: Month 12**
Task 3i - Base Maps: Compile all existing condition information into a set of base maps depicting existing conditions at the proposed project sites. Base mapping will be presented in digital format and paper format for project stakeholders, upon request.

**Anticipated Timetable:** Month 13

Task 3j – Design Plans (75% Completion Stage): HW will prepare a set of “permit-ready” or “grant-ready” engineering plans for each of the demonstration projects. These plans will be developed to a sufficient level of detail to be able to submit for applicable permits and to funding organizations for possible grants.

These plans will include:

- Engineering design plans, profiles and details;
- Erosion and sediment control plan and details; and
- A recommended general construction sequence.

**Anticipated Timetable:** Months 13 - 14

**Deliverables:**
- Meetings with six communities to discuss projects.
- Engineering design plans (75%) and digital plans (in AutoCAD v. 2006) for up to six demonstration/restoration projects.

**Task 4: Local Code Reform Projects**

HW will select and work with two case study communities to assist them with code reform that will encourage smart growth, LID, innovative wastewater solutions and habitat preservation/restoration.

HW will work with two communities to assist them in reforming a portion of their land use codes to better facilitate Smart Growth development that reduces the impact of new development on the watershed’s water resources and habitat areas in comparison to traditional development under the current codes. Communities will be selected by HW with assistance from the Steering Committee based on demonstrated interest in implementing such code reforms.

An implementation project will be designed for each community. Generally, these projects will be oriented at resolving identified water balance issues, preventing/remediating water quality problems and/or preserving/restoring habitats. Each project will be tailored to meet that individual community’s identified priorities and needs. A series of three meetings will be organized with each community as follows:

a.) Kickoff Meeting – Identification/discussion of issues, needs and priorities.

**Anticipated Timetable:** Months 4 - 5
b.) Analysis/Recommendations – Analysis of issues and possible solutions and discussion and presentation and discussion of recommendations and options.

Anticipated Timetable: Months 6 - 8

c.) Implementation – Public hearing to adopt recommendations. This may include a formal resolution, a regulation, or nomination of a town meeting article.

Anticipated Timetable: Months 9 - 11

Deliverables:
- 6 meetings with selected communities (3 meetings in each community)
- Development of two implementation strategies that will include recommendations for code changes

Task 5: Phase II Education and Outreach

The public workshops conducted during Phase I identified education of local government officials as the number one issue throughout the watershed. During Phase II a training program will be developed and implemented that provides training courses to local officials. Six workshops will be organized (with 3 – 5 communities targeted at each) on smart growth/smart energy techniques invited to each workshop. The communities will be organized based upon proximity to each other and like issues. The workshops will include: 1) a summary of the Phase I results including the water budget analysis, 2) introduction to smart growth/LID techniques and 3) recommendations for improvement (specific to those communities in attendance). This training program will be coordinated with numerous organizations including BSC, SERPED, OCP, MACC, APA, the Taunton River Watershed Alliance and others. They would be conducted at host town halls or other suitable public facilities with the neighboring towns invited. Local regulatory boards will be targeted. Specific code amendment recommendations will be provided to each community in attendance.

Anticipated Timetable: Months 4 – 6 and Months 15 - 16

Deliverables:
- Six sub-regional workshops

Task 6: Preparation of Taunton River Watershed Management Plan (Phase II Final Report)

This task involves the compilation of all of the work performed under the previous tasks into a final report. The report will provide recommendations for the synthesis of the results of this targeted project into the larger context of the longer term comprehensive watershed planning approach. This task will include recommendations to monitor success of the six demonstration projects, plan a program for widespread implementation,
and plan for code reform in other communities. HW will prepare a preliminary draft and
final draft to the Steering Committee for review and comment, and will then prepare a
final report entitled, “Taunton River Watershed Management Plan (Phase II Final
Report).”

Anticipated Timetable: Months 17 - 18

Deliverables:
• Preliminary Draft and Final Draft for review and comment by the Steering
  Committee
• Final Report entitled, “Taunton River Watershed Management Plan (Phase II
  Final Report)”

Task 7: Progress Meetings

HW will attend and participate in four progress meetings to coordinate with the steering
committee regarding the progress of the project.

Anticipated Timetable: 1st, 6th, 12th, and 18th month from start date.

Deliverables:
• Four progress meetings with steering committee
Appendix A - Water Balance Model Assumptions

- Private wastewater flows were estimated for all areas determined not to be within public sewer system service areas.

- Areas serviced by private drinking water withdrawals were estimated for those areas determined not to be within public drinking water service areas.

- Private septic discharge volumes and private drinking water withdrawal volumes were calculated using the MacConnell Land Use data 21-category classification system provided by MassGIS land use data layer (1999) and unit area flow assumptions based on land use.

- Those MacConnell land uses that are assumed to contribute a private septic discharge volume and private water well withdrawal in the Taunton watershed include:

<table>
<thead>
<tr>
<th>Land Use code</th>
<th>Abbrev.</th>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>7*</td>
<td>RP</td>
<td>Participation Recreation</td>
<td>Golf; tennis; Playgrounds; skiing</td>
</tr>
<tr>
<td>10</td>
<td>R0</td>
<td>Residential</td>
<td>Multi-family</td>
</tr>
<tr>
<td>11</td>
<td>R1</td>
<td>Residential</td>
<td>Smaller than 1/4 acre lots</td>
</tr>
<tr>
<td>12</td>
<td>R2</td>
<td>Residential</td>
<td>1/4 - 1/2 acre lots</td>
</tr>
<tr>
<td>13</td>
<td>R3</td>
<td>Residential</td>
<td>Larger than 1/2 acre lots</td>
</tr>
<tr>
<td>15</td>
<td>UC</td>
<td>Commercial</td>
<td>General urban; shopping center</td>
</tr>
<tr>
<td>16</td>
<td>UI</td>
<td>Industrial</td>
<td>Light &amp; heavy industry</td>
</tr>
</tbody>
</table>

* Because golf is the dominant land use in this category, a wastewater flow was estimated for golf land use and applied across the entire land use category.

- The following land uses were assumed to have no private septic discharge or private well withdrawal volumes:

<table>
<thead>
<tr>
<th>Land Use code</th>
<th>Abbrev.</th>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC</td>
<td>Cropland</td>
<td>Intensive agriculture</td>
</tr>
<tr>
<td>2</td>
<td>AP</td>
<td>Pasture</td>
<td>Extensive agriculture</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>Forest</td>
<td>Forest</td>
</tr>
<tr>
<td>4</td>
<td>FW</td>
<td>Wetland</td>
<td>Nonforested freshwater wetland</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>Mining</td>
<td>Sand; gravel &amp; rock</td>
</tr>
<tr>
<td>6</td>
<td>O</td>
<td>Open Land</td>
<td>Abandoned agriculture; power lines; areas of no vegetation</td>
</tr>
<tr>
<td>8*</td>
<td>RS</td>
<td>Spectator Recreation</td>
<td>Stadiums; racetracks; Fairgrounds; drive-ins</td>
</tr>
<tr>
<td>9*</td>
<td>RW</td>
<td>Water Based Recreation</td>
<td>Beaches; marinas; Swimming pools</td>
</tr>
<tr>
<td>14</td>
<td>SW</td>
<td>Salt Wetland</td>
<td>Salt marsh</td>
</tr>
<tr>
<td>17</td>
<td>UO</td>
<td>Urban Open</td>
<td>Parks; cemeteries; public &amp; institutional greenspace; also vacant undeveloped land</td>
</tr>
<tr>
<td>18</td>
<td>UT</td>
<td>Transportation</td>
<td>Airports; docks; divided highway; freight; storage; railroads</td>
</tr>
<tr>
<td>19</td>
<td>UW</td>
<td>Waste Disposal</td>
<td>Landfills; sewage lagoons</td>
</tr>
<tr>
<td>20</td>
<td>W</td>
<td>Water</td>
<td>Fresh water; coastal embayment</td>
</tr>
<tr>
<td>21</td>
<td>WP</td>
<td>Woody Perennial</td>
<td>Orchard; nursery; cranberry bog</td>
</tr>
</tbody>
</table>

* Although these land uses likely have a wastewater flow associated with them, the flow generated by these land uses in the Taunton watershed was assumed to be negligible because these land uses cover a limited area of the watershed.
Residential flow volumes:

· Residential private septic discharge volumes were calculated using the following equation:

\[ \frac{(\text{Residential Land Use Area})}{(\text{Average Lot Size})} \times (\text{Occupancy Rate}) \times (\text{Per capita wastewater flow}) \]

· Residential private water well withdrawals were calculated using the following equation:

\[ \frac{(\text{Residential Land Use Area})}{(\text{Average Lot Size})} \times (\text{Occupancy Rate}) \times (\text{Per capita water use}) \]

· The following assumptions were made for the variables in the above equations:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average &quot;smaller than 1/4 acre&quot; lot size (ac)</td>
<td>0.17</td>
<td>1986. Urban Hydrology for Small Watersheds. Technical Release 55.</td>
</tr>
<tr>
<td>Average &quot;1/4 - 1/2 acre&quot; lot size (ac)</td>
<td>0.38</td>
<td>0.375 ac.; Average between 1/4 ac. and 1/2 ac.</td>
</tr>
<tr>
<td>Average &quot;greater than 1/2 acre&quot; lot size (ac)</td>
<td>1.00</td>
<td>1986. Urban Hydrology for Small Watersheds. Technical Release 55.</td>
</tr>
<tr>
<td>Occupancy rate (people/household)</td>
<td>2.6</td>
<td>US Census Bureau. Census 2000 Summary File 1 (SF 1), Table P17. Average Household Size (for Bristol County, Plymouth County, and Norfolk County, MA).</td>
</tr>
</tbody>
</table>

Participation Recreation (Golf) flow volumes:

Assumptions for golf are presented below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
</table>
| Golf (gpd per acre)| 6     | -Title 5: 310 CMR 15.203: Golf is categorized as Country Club: Flow for the dining room, snack bar or lunch room = 10 GPD/seat; Flow for the locker room = 20 GPD/seat.  
-Assume 40 seats and 40 lockers for an average 100-acre, 9-hole golf course (source: best professional judgment)  
-Golf play is between May and October (184 days) (40*10)+(40*20) = 1200 GPD during 184 days/year.  
-Total annual flow = 1200GPD *184 days/yr = 220,800 Gallons per Year (or 605 GPD on an annualized basis) |
Commercial flow volumes:

- Commercial flow volumes were calculated using Title V design flows (Title 5: 310 CMR 15.203 (3)) multiplied by either an estimated number of gross square footage of space or number of seats, as specified in Title V for different commercial use categories. Commercial land use is divided into office space, retail space and restaurants. The following equations were used to calculate wastewater flows:
  \[
  \text{Flow for Office Space} = (\text{Gross Office Space}) \times (\text{Wastewater flow per 1000 square feet})
  \]
  \[
  \text{Flow for Retail Space} = (\text{Gross Retail Space}) \times (\text{Wastewater flow per 1000 square feet})
  \]
  \[
  \text{Flow for Restaurant Space} = (\text{Number of Seats}) \times (\text{Wastewater flow per seat})
  \]

- The total impervious area within the total commercial land use area was calculated in GIS using the MassGIS Impervious Surface data layer (2007) and the Land Use data layer (1999).

- The estimated building footprint of commercial land use was then estimated as a percentage of the impervious surface, since much of the impervious area is comprised by streets, sidewalks, and parking areas.

- The percentage of total commercial impervious area that is estimated to be building footprint (rooftop) is as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of commercial space that is composed of rooftop (%)</td>
<td>20</td>
<td>Kappiella, et. al. 2001. Impervious Cover and Land Use in the Chesapeake Bay Watershed. Center for Watershed Protection, Ellicott City, MD</td>
</tr>
</tbody>
</table>

- The total commercial building footprint was then multiplied by the average number of floors per building to determine a total commercial gross square footage using the following assumption:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of floors per commercial/industrial building (floors)</td>
<td>1.5</td>
<td>Qualitative Observation</td>
</tr>
</tbody>
</table>

- The total commercial gross square footage in each subwatershed was divided into three uses, Office, Retail, and Restaurant, according to the following percentages:

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office space (%)</td>
<td>50%</td>
<td>US Census Bureau. 2005 County Business Patterns. NAICS.</td>
</tr>
<tr>
<td>Restaurant space (%)</td>
<td>10%</td>
<td>National Restaurant Brokers Listing, February 2008.</td>
</tr>
</tbody>
</table>

- A wastewater flow volume and water well withdrawal volume were calculated for each commercial category (Office, Retail and Restaurant) using the following design flow volumes:

<table>
<thead>
<tr>
<th>Description</th>
<th>Design Flow (GPD)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office building (gpd per 1,000 gross sf)</td>
<td>75</td>
<td>Title 5: 310 CMR 15.203 (3)</td>
</tr>
<tr>
<td>Retail store (gpd per 1,000 gross sf)</td>
<td>50</td>
<td>Title 5: 310 CMR 15.203 (3)</td>
</tr>
<tr>
<td>Restaurant (gpd per seat)</td>
<td>35</td>
<td>Title 5: 310 CMR 15.203 (3)</td>
</tr>
</tbody>
</table>

- Since Restaurant wastewater design flow is based on number of seats, the average number of seats per 1,000 gross sf was calculated:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 gross sf restaurant space (seats)</td>
<td>29</td>
<td>National Restaurant Brokers Listing, February 2008.</td>
</tr>
</tbody>
</table>
· The design flow (gpd) per gross square foot for each commercial subcategory was then calculated:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office building design flow (gpd per gross sf)</td>
<td>0.075</td>
</tr>
<tr>
<td>Retail store design flow (gpd per gross sf)</td>
<td>0.05</td>
</tr>
<tr>
<td>Restaurant design flow (gpd per gross sf)</td>
<td>1.015</td>
</tr>
</tbody>
</table>

· The wastewater design flow for each commercial category was multiplied by a factor of 50% to determine a septic discharge volume and by a factor of 60% to determine an estimated water withdrawal volume, based on the following assumptions and calculations:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor water use is approximately 50% of the Title V design flow</td>
<td>50%</td>
<td>Title 5: 310 CMR 15.203 (6)</td>
</tr>
<tr>
<td>Total drinking water withdrawal volume is 60% of Title V design flow</td>
<td>60%</td>
<td>US Geological Survey. 1982. Chapter 11: National Handbook of Recommended Methods for Water Data Acquisition.</td>
</tr>
</tbody>
</table>

· Calculations:

Total water use (total water withdrawal volume) = Total indoor water use + Total outdoor water use

Total indoor water use = 85% * Total water use
Total indoor water use = Title V design flow * 50%
Total outdoor water use = 15% * Total water use

Solving for Total water use as a function of Title V design flow:

Total water use = (85% * Total water use) + (15% * Total water use)
Total water use = (Title V design flow * 50%) + (15% * Total water use)
Total water use - (15% * Total water use) = Title V design flow * 50%
Total water use * 85% = Title V design flow * 50%
Total water use = Title V design flow * (50% / 85%)
Total water use = Title V design flow * 60%

Estimated actual flow (septic discharge volume) = Title V design flow * 50%
Total indoor water use = Title V design flow * 50%
Estimated actual wastewater flow = Total indoor water use

Industrial flow volumes:

· All industrial area was assumed to have the same flow per 1000 gross square feet as office space. The water withdrawal volumes and


**Calculation of Natural Recharge**

- Existing natural recharge was calculated based on the underlying surficial geology within the subwatershed, as well as the impervious cover and wetland areas on the land surface.
- The surficial geological and wetland areas were determined using the MassGIS Surficial Geology (1:250,000) layer (October 1999) and the MassGIS DEP Wetlands (1:12,000) layer (April 2007).
- Total Impervious Area (TIA) within each surficial geological formation was calculated in GIS using the MassGIS Impervious Surface layer (February 2007).

- Research has shown that the effect of impervious surfaces in preventing recharge is only realized when impervious cover exceeds a certain threshold. Below this threshold, runoff from the impervious cover generally flows over a pervious area and is recharged to the ground. Above this threshold, runoff such as that which flows in a storm drain or roadside gutter generally concentrates and flows to a surface water, and therefore does not recharge into the ground. This threshold is known as the effective impervious area (EIA). The EIA was calculated from the TIA using the following equations (Zarriello and Ries, 2000; Zarriello and Barlow, 2002):

  \[
  \text{Effectiveness} (\%) = -22.6 + 1.774 \times \text{TIA} (\%), \min = 0%
  \]

  \[
  \text{EIA} (\%) = \frac{\text{Effectiveness} (\%)}{100} \times \text{TIA} (\%)
  \]

- The following recharge rates were used for each type of surficial geology:

<table>
<thead>
<tr>
<th>Description</th>
<th>Recharge Rate</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: sand and gravel deposits (in/yr)</td>
<td>25</td>
<td>Values assigned through water budget model calibration performed in the pilot &quot;undeveloped&quot; watershed, Rattlesnake Brook in Fall River and Freetown.</td>
</tr>
<tr>
<td>2: till or bedrock (in/yr)</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>distinguished from sand and gravel deposits (in/yr)</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>6: fine-grained deposits (in/yr)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>7: floodplain alluvium (in/yr)</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

The recharge rates for wetlands and EIA were assumed to be zero (0) ; Cranberry bogs were assumed to have a recharge rate of -17 in/yr.

<table>
<thead>
<tr>
<th>Description</th>
<th>Recharge Rate</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands (in./yr.)</td>
<td>0</td>
<td>USGS, 1992. Geohydrology and Simulated Ground-Water Flow, Plymouth-Carver Aquifer, Southeastern Massachusetts</td>
</tr>
<tr>
<td>Cranberry bogs (in./yr.)</td>
<td>-17</td>
<td>USGS, 1992. Geohydrology and Simulated Ground-Water Flow, Plymouth-Carver Aquifer, Southeastern Massachusetts</td>
</tr>
</tbody>
</table>
Calculation of Water Withdrawals from WMA data

The Water Management Act permits and registrations allow for a maximum annual volume of water to be withdrawn via a given water system. However, the actual volume that is withdrawn in a year may differ significantly in some cases from this maximum allowable withdrawal. Therefore, we used two methods to calculate the actual withdrawals for the water systems in the Taunton watershed, depending on the available data. If 2006 Annual Statistical Reports (ASR) were available from DEP for the water system, then it was used to estimate the annual withdrawal. In the absence of a 2006 ASR, a relationship between the total withdrawals reported in the 2006 ASRs and the permitted plus registered withdrawal volumes for other systems in the Taunton watershed was used to estimate the actual withdrawals. This relationship was calculated to be 48% (i.e., total annual withdrawals were an average of 48% of the registered plus permitted volumes for water withdrawals in the Taunton watershed). Out of a total of 278 permitted and/or registered water withdrawals in the watershed, the withdrawal volumes were estimated for 126, including only 7 public water supply wells.