Saugatuck River Watershed Based Plan

Submitted by:
AKRF, Inc.
307 Fellowship Road, Suite 214
Mt. Laurel, NJ 08054
Project 71120.2004 NJ12414

On behalf of:
The South Western Regional Planning Agency
888 Washington Boulevard, 3rd Floor
Stamford, CT 06901

December 21, 2012

Table of Contents

List of Figures

List of Tables

ACKNOWLEDGEMENTS

The Watershed Based Plan could not have been completed without the guidance and commitment of the following members of the steering committee:

Betty Brosius, Town of Ridgefield

Alexis Cherichetti, City of Norwalk

Dr. J. Thomas Failla, Town of Weston

Sally Harold, The Nature Conservancy, Saugatuck River Watershed Partnership

Richard Harris, Harbor Watch/River Watch

Nancy King, Redding Conservation Commission

Christopher Malik, Connecticut Department of Energy and Environmental Protection

Alicia Mozian, Town of Westport

David Pattee, Redding Conservation Commission

Brian Roach, Aquarion Water Company

Funded in part by the Connecticut Department of Energy & Environmental Protection through a United States Environmental Protection Agency Clean Water Act Section 604(b) Water Quality Management Planning Grant.

COMMONLY USED ACRONYMS

BMP	Best Management Practice
CBP	Chesapeake Bay Program
CFU	Colony-Forming Units
CWA	Clean Water Act
CLEAR	University of Connecticut Center for Land Use Education & Research
CTDEEP	Connecticut Department of Energy and Environmental Protection
CWP	Center for Watershed Protection
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
HW/RW	Harbor Watch/River Watch
HSG	Hydrologic Soil Group
ICM	Impervious Cover Model
IWL	Impaired Waters List
LID	Low Impact Development
LIS	Long Island Sound
MS4	Municipal Separate Storm Sewer System
N	Nitrogen
NEMO	Nonpoint Source Education for Municipal Officials
NH_4	Ammonium
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NURP	National Urban Runoff Program
O&M	Operations and Maintenance
P	Phosphorous
RBV	Rapid Bioassessment by Volunteers
SEP	Supplemental Environmental Project
SSM	Single Sample Maximum
SSURGO	Soil Survey Geographic
SVA	Stream Visual Assessment
SRWP	Saugatuck River Watershed Partnership
SWRPA	South Western Regional Planning Agency
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TNC	The Nature Conservancy
TP	Total Phosphorus
TSS	Total Suspended Solids
UConn	University of Connecticut
WBP	Watershed Based Plan

COMMONLY USED TERMS

Commonly used terms are defined for the purposes of this document as follows:

Adaptive Management – A structured, iterative approach to the management of natural resources, where monitoring feedback is used to refine management activities.

Best Management Practice (BMP) – Methods, measures, or practices designed specifically for the control of nonpoint source pollution. BMPs include structural and nonstructural controls.

Bioretention – A practice to manage and treat stormwater runoff by using a specially designed planting soil bed and planting materials to filter runoff stored in a shallow depression. The areas consist of a mix of elements, each designed to perform different functions in the reduction of pollutants and attenuation of stormwater runoff (Connecticut Department of Environmental Protection [CTDEP]) 2004, *Stormwater Quality Manual*).

Diadromous – Refers to fish species that migrate between the sea and fresh water.

Impairment – Used here to refer to reaches of stream where aquatic conditions fall below or are thought to fall below state water quality criteria. Reaches may be listed as impaired on the state Impaired Waters List (303(d) list), or they may be considered likely targets for a future listing based on field assessments or review of data.

Impervious Cover – Hard surfaces that do not allow water to infiltrate (generally roofs and different types of pavement).

Infiltration – The process by which water passes into and through the ground.

Indicator Species – A species whose presence indicates human-created abiotic conditions such as air or water pollution (often called a pollution indicator species) (Lindenmayer et al. 2000).

Low Impact Development (LID) – A planning-level approach to land development (or re-development) that seeks to minimize impacts to natural systems. With respect to streams, LID seeks to manage stormwater as close to its source as possible, with an emphasis on small-scale structural BMPs over traditional "gray" infrastructure methods of controlling stormwater (in the context of cities and streetscapes, this approach is often referred to as "green" infrastructure).

Naturalized Surface Storage Basin – Used to describe a range of large, vegetated depressions built for control of stormwater. Basins may be wet or dry, and may be designed to infiltrate any fraction of the stormwater captured. Based on these and other details, naturalized surface storage basins may be designed for flood control, water quality, channel protection, or a combination of all these functions as site constraints allow.

Nonpoint Source (NPS) Pollution – Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. NPS pollution can be divided into source activities related to either land or water use, and include failing septic tanks, improper animal-keeping practices, forestry practices, and urban and rural runoff.

Point Source Pollution – Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water, stream, or river.

Pollutant Load – The quantity of material carried in a body of water that exerts a detrimental effect on some subsequent use of that water.

Restoration – The return of an ecosystem to a close approximation of its condition prior to disturbance (National Research Council [NRC] 1992). Used most often in this document to refer to stream restoration and wetland restoration.

Retrofit – Structural alteration of an existing BMP, commonly performed to add water quality and/or channel protection functions to a basin or swale that was originally designed only for flood control.

Riparian Buffer – Used in this document to refer to any depth of forest or meadow-type vegetation planted or naturally occurring adjacent to the stream channel.

Stormwater Runoff – Rainwater which is not infiltrated into the ground and so flows directly over land, often entering structured drainage systems like gutters, storm drains, and roadside swales.

Subsurface Infiltration – The temporary storage and infiltration of stormwater in an engineered bed of partially void rock and soil built underneath gardens, lawns, or paved areas.

Subsurface Storage – The temporary storage and slow release of stormwater captured in a void subsurface chamber, often used to control stormwater runoff where space constraints prevent the use of other surface measures to control runoff.

Subwatershed – Used here to refer to smaller drainage areas within the larger watershed (see watershed definition, below).

Swale – Referred to in the *Connecticut Stormwater Quality Manual* as a "water quality swale," a vegetated, open channel designed to treat and attenuate the water quality volume and convey excess stormwater runoff (CTDEP 2004).

Water Quality Criteria – Elements of state water quality standards expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use (U.S. Environmental Protection Agency [EPA] 1994).

Water Quality Standard – Provisions of state or federal law which consist of a designated use or uses for the waters of the United States, and water quality criteria for such waters based upon such uses. Water quality standards are meant to protect public health or welfare, enhance the quality of the water, and serve the purposes of the Clean Water Act (EPA 1994).

Watershed – A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Watershed Based Planning – Refers to a science- and community-driven approach to addressing long-term management of watershed impairment (EPA 2008).

EXECUTIVE SUMMARY

One of a number of coastal rivers that empty into Long Island Sound (LIS) in southwestern Connecticut, the Saugatuck River is a significant water resource that provides drinking water and recreation opportunities for thousands of residents of Fairfield County. The river flows south from its headwaters in Ridgefield, Danbury, Bethel, Newtown, and Redding, through the Towns of Easton and Weston, before emptying into LIS in Westport. Small parts of Norwalk, Fairfield, and Wilton also drain to the lower segments of the Saugatuck River. Generally well protected by large tracts of forest in its headwaters, evidence suggests that the river's water quality and habitats are being impacted in some locations by human activities such as residential development and water withdrawals.

Land protection efforts in the Saugatuck River have insulated the river from many of the problems that confront more developed rivers in the region. Significant portions of the land draining to the Saugatuck River (known as the Saugatuck River Watershed) have been preserved through a joint partnership between the Connecticut Department of Energy and Environmental Protection (CTDEEP), Aquarion Water Company, and The Nature Conservancy (TNC). This partnership has resulted in the permanent protection of over 17,000 acres of land around and adjacent to the Saugatuck Reservoir, known as the Centennial Watershed State Forest. Local municipalities have been historically conservation-minded, with large areas preserved by the Town of Redding and multiple small land trusts that are active in the region. Devil's Den Preserve, an early project of TNC first established in the 1960s, buffers the headwaters of the West Branch and is well loved as a place for hiking and nature-watching.

Even with these protections in place, evidence suggests that human use has begun to impact the quality of habitat and the river's natural flow pattern. Water withdrawals from the Saugatuck Reservoir and private wells are now thought to have decreased the amount of water available for fish and aquatic species. Scientists studying the river have also concluded that the many small dams block fish species from accessing important habitats. Additionally, development in some areas is approaching threshold levels that are often associated with degrading stream conditions.

In response to these problems, the Saugatuck River Watershed Partnership (SRWP) was formed in 2006 through a joint initiative of TNC, Aquarion Water Company, and the 11 watershed municipalities. All members signed a conservation compact which acknowledged the significant value of the river and its resources, as well as the growing evidence that land use changes and river corridor management practices are adversely affecting the river's health. Since 2006, the SRWP has spearheaded numerous educational events, habit restoration initiatives, and efforts to characterize habitat and water quality throughout the river.

On-going restoration efforts have resulted in over nine (9) miles of restored habitat for migratory fish such as alewife (*Alosa pseudoharengus*) and American eel (*Anguilla rostrata*). Data and planning materials have been collected and developed to guide long-term decision-making. Since 2007, the SRWP has been working with Aquarion Water Company to develop a groundbreaking new reservoir management model that has promised to improve stream habitat while meeting consumptive needs through carefully timed reservoir releases. These demonstrated successes have attracted significant support, both as funding for projects and as volunteer effort on the part the local community.

The work of the SRWP and its partners has focused on resource conservation and habitat improvements. However, results of a multi-year water quality study recently indicated that high levels of bacteria have made portions of the river unsafe for recreation. It is also thought that nutrients such as nitrogen (N) and phosphorus (P) may be approaching problematic levels, although they are not there yet. These findings suggest that pollution reduction and prevention efforts will be needed to preserve and protect the long-term health of the Saugatuck River. The Watershed Based Plan (WBP) outlines measurable steps to reduce existing pollution sources and prevent future pollution while reemphasizing the need for the kind of habitat restoration and resource conservation activities that have typified the work of the SRWP.

UNDERSTANDING THE LAND/WATER CONNECTION

Aquatic scientists now understand the critical link between the health and quality of rivers and the characteristics of the land they flow through. Human changes in how land is used, through farming or urban development, result in predictable changes to rivers that lessen their value to society and decrease their ecological value. These changes have been observed in hundreds of urban rivers over the last several decades and so are now well understood. Fortunately, this understanding has led to the development of a set of strategies for better managing landscapes, strategies that can restore degraded rivers and prevent healthy rivers from becoming imperiled.

Some parts of the Saugatuck River Watershed have seen significant residential development, particularly near Route 1 and in the towns of Weston and Westport. Stream assessments and water quality data suggest that streams flowing through more developed areas have lower water and habitat quality than streams flowing through less developed areas. As in many other rivers, urban land use has affected the Saugatuck River both by changing the amount and pattern of water flowing to the Saugatuck River and by creating new sources of pollution. Specifically, the introduction of impervious surfaces associated with urban development, such as rooftops, roads, driveways, and parking lots, have altered the flow of water through the watershed. Prior to urban development, much of the rain and snow falling onto the watershed would have been absorbed into the ground or evaporated back into the atmosphere by the dense stands of forest that once covered the area. Today, however, some of the rain and snow instead falls onto hard surfaces, where it quickly flows into the Saugatuck River. This urban stormwater runoff carries an array of chemicals and pollutants including oils/grease, fertilizers and pesticides, dirt, bacteria, and trash into the Saugatuck River and the smaller streams that feed the river. Many aquatic organisms including certain fish, freshwater mussels, and aquatic insects called macroinvertebrates, are extremely sensitive to increases in pollution.

As a result of the increase in impervious surfaces, the intensity and frequency of high flows in the Saugatuck River has also increased in some locations. At the same time, small dams and walls located in and adjacent to the stream have confined the river’s flow path through residential neighborhoods in some headwater areas and areas within the lower watershed. These changes have altered the river’s natural flow patterns of erosion and sediment deposition in some areas of the river, leading to eroded stream banks in some areas, and overly mucky stream beds in others.

Harmful changes to water quality, habitats, or aquatic life that lessen the use or value of a river are referred to as impairments, and states have in many cases developed specific criteria for identifying them. In the Saugatuck River, impairments have been documented in the tributary known as the West Branch, and in a reach of stream just above the Saugatuck Reservoir. These documented impairments in combination with other observations demonstrate how human development is adversely impacting the Saugatuck River despite significant efforts to preserve the river's natural surroundings.

REVERSING THE TREND

As scientists understand the progressive harm that rivers sustain when their watersheds become urbanized, they are also working to develop ways to reverse these trends by better managing urbanizing landscapes. Such methods range from relatively simple activities that include planting trees along stream banks to reduce erosion and filter pollutants before they enter the stream, to structural stormwater best management practices (BMPs) such as wetlands, porous pavements, and underground gravel-filled chambers that help slow down, filter, and infiltrate (i.e., soak into the soil) urban stormwater runoff. Past studies have shown that these types of approaches can significantly improve the quality and health of urban streams and rivers.

A WATERSHED APPROACH

The process by which communities, scientists, municipal officials, and other groups come together to develop an action plan for protecting and restoring a resource like the Saugatuck River is called watershed planning. The watershed planning process focuses on identifying the actions that will result in a measurable and significant improvement of the health and quality of rivers and streams in a particular watershed. But the watershed planning process is also about changing everyday perceptions, attitudes, and behaviors in ways that benefit rivers and streams and is rooted in the belief that every person living in a watershed can make a positive difference to improve the health of local waterways. The watershed planning process also looks to celebrate and emphasize the importance of healthy streams and rivers to local residents' quality of life, and highlight the reduced quality of life that results from unhealthy streams and rivers. In short, watershed planning seeks to bring about social and cultural change that elevates healthy water resources from a back burner issue to a core moral value.

Most important, watershed planning is not an activity restricted to academics, water resources engineers, and technical specialists. While these professionals play a role in promoting the understanding of the subject, educating non-professionals about watershed science, and recommending solutions to problems, the heart of the watershed planning process involves the organizations, citizens, and community leaders of the watershed coming together to form an engaged and educated community ready to push for positive change.

Although the end result of watershed planning commonly includes implementing specific "on-the-ground" management actions, such as stabilizing eroding stream banks, building a BMP to filter pollutants from urban stormwater runoff, or planting trees along a stream bank, the watershed planning process involves a number of diverse activities including:

- Reviewing existing reports and background data;
- Mapping the physical, political, economic, and environmental characteristics of the watershed;
- Using computer models to estimate the total quantity of various important pollutants entering the stream and determine the amount by which these pollutants must be reduced;

- Assessing the existing condition of the water, aquatic life, and habitat in the streams and rivers;
- Meeting with community members, interested citizens, and municipal officials to understand how these diverse groups use and value the rivers and streams;
- Identifying specific areas of concern, and developing goals and strategies for improving the river in specific ways;
- Identifying and prioritizing the most beneficial and cost-effective pollution-reduction activities;
- Developing a plan for monitoring the streams and rivers to determine if their quality is improving or degrading over time;
- Developing recommendations for educating watershed residents about the importance of healthy streams and rivers and the specific actions they can implement in their own homes and businesses to reduce pollution; and
- Developing an action plan for implementing all components: pollution-reduction initiatives, educational and outreach activities, and monitoring.

The Saugatuck River Watershed has benefitted from a significant watershed based planning process, led first by TNC and then subsequently by the SRWP, that predates the development of the WBP. In particular, three (3) planning workshops held over a nine (9) month period in 2004, attended by 80 scientists, municipal officials, land managers, and other stakeholders (SRWP 2006) represented the first formal effort to collaboratively develop a plan for protecting and restoring the river. During the first meeting, conservation targets were identified through a collaborative process. These included the upper river system, the lower river system, the Saugatuck and Aspetuck Reservoirs, and diadromous fish (species that migrate between fresh and salt water). The second meeting identified threats to conservation targets, defined as small dams, development, land management techniques, water withdrawals from the reservoirs, and invasive plant and animal species. The third workshop was used to develop measurable, actionable, realistic, and time-based methods to restore the watershed and address the most significant threats to water resources. The results of this public engagement process are discussed in detail in *An Introduction to The Saugatuck River and the Saugatuck River Watershed Partnership* (SRWP 2006)

A SUCCESSFUL PARTNERSHIP

The SRWP was established to implement watershed planning activities, with a mission to "protect and enhance the health of the watershed by working collaboratively to link, maintain, and restore habitats which support healthy populations representing the natural biological diversity of the watershed system." The SRWP is made up of municipal officials representing the watershed towns, Aquarion Water Company, TNC, and others. Since it was founded in 2006, the SRWP has obtained significant grant funding and has engaged in multiple restoration, investigation, and outreach activities, which are summarized below (SRWP 2008 and S. Harold, pers. comm.).

Habitat Assessment and Restoration

Beginning in 2004, the SRWP began a series of volunteer-based streamwalk surveys to assess habitat, barriers, and riparian conditions in representative reaches of the river. Between 2004 and 2008, over 60 miles of stream were surveyed by 74 volunteers trained by Natural Resources Conservation Service (NRCS) staff (SRWP 2008). Volunteers worked in groups to assess several miles of stream at a time (SRWP 2008).

During streamwalk assessments, dams and raised culverts were identified as major problems for habitat, as these barriers block fish and aquatic species from accessing portions of the river (SRWP 2008). The SRWP has identified and successfully mitigated habitat barriers at many sites in the lower watershed, opening up approximately 37 percent of historic habitat for migratory fish species. The SRWP has continually monitored fish species above and below barriers using traps, visual assessment, and an electronic fish counter.

In 2007, the SRWP worked to assess the impact of water infrastructure in the Aspetuck Reservoir on the movement of American eels, and to identify possible methods to reduce impacts. Based on the findings of this assessment, a bypass system was installed in partnership with Aquarion Water Company to provide safe downstream passage for eels (SRWP 2009).

Also in 2007, TNC and Aquarion Water Company signed an agreement for a multi-year study of the lower Saugatuck River to develop a reservoir management model that would mimic natural flow conditions (SRWP 2008). The goal of this effort was to identify opportunities to improve habitat while providing a more reliable, managed schedule of drinking water withdrawals.

Bio-monitoring

The SRWP coordinates annual groups of volunteers to assist with water quality data collection through CTDEEP's Rapid Bioassessment by Volunteers (RBV) program. Although CTDEEP has conducted bio-assessments in the Saugatuck River Watershed for many years, this influx of volunteer assistance has significantly expanded the data set (see Chapter 2 for a full discussion of existing data). The RBV sampling program uses macroinvertebrates to indicate water quality through known pollution tolerances associated with community characteristics. In the Saugatuck River Watershed, macroinvertebrate sampling has indicated water quality that is sufficient to support diverse aquatic life.

Education, Outreach, and Volunteerism

The SRWP has initiated several ongoing volunteer programs as well as short-term education events and workshops to engage local residents and municipal officials in managing their watershed. In addition to streamwalks and RBV sampling, volunteers have assisted with data collection for fish migration studies, as discussed above; reviewed zoning information for towns within the watershed; worked to remove dams and restore streambanks; surveyed and mapped stream crossings; tagged horseshoe crabs in support of a Sacred Heart University study; and cleaned up trash and debris at multiple sites throughout the watershed.

Two free public workshops were held in 2007 to educate the public on watershed topics. Both were attended by approximately 80 members of the watershed community. The first, held in March 2007, covered stormwater management and erosion and sediment control practices. The second workshop, held in November 2007, reviewed general information on topics such as patterns of water flow, fisheries resources, and other background information (SRWP 2008). Other workshops and presentations have been held since then and have addressed such topics as lawn and garden care, habitat monitoring, and goose management.

THE SAUGATUCK RIVER WATERSHED BASED PLAN AND THE U.S. ENVIRONMENTAL PROTECTION AGENCY WATERSHED PLANNING PROCESS

The WBP builds on the extensive planning, protection, and restoration work of the SRWP, discussed above, and frames recommendations within the context of nonpoint source (NPS) pollution reduction. Funding for the development of a WBP was obtained by the South Western Regional Planning Agency (SWRPA) through a grant from CTDEEP. The source of funding for the grant comes from the Federal Section 319 program (Section 319 refers to Section 319 of the Clean Water Act [CWA]), which provides federal funding to states to help implement the CWA. Specifically, the funding is provided to develop plans to restore waterbodies that have been impaired by NPS pollution. NPS refers to sources of pollution that originate from landscape sources, such as fertilizers, bacteria, and pesticides carried to streams from urban stormwater runoff, as opposed to pollutants delivered to streams from specific point source discharges, such as wastewater treatment plants.

To assist organizations conducting watershed based planning, the U.S. Environmental Protection Agency (EPA) has developed a nine-step watershed planning process. CTDEEP requires that all watershed based plans developing using Section 319 funding follow the EPA process. The watershed based planning process emphasizes measurable goals and strategies; community involvement; and adaptive management, the process of using monitoring to assess whether the WBP is working and making continual adjustments based on monitoring information. The specific steps outlined in the EPA watershed planning process and associated sections of this WBP that address each step are as follows:

- Identify potential causes and sources of pollution (Chapter 2);
- Pollution load reduction estimates (Chapter 3);
- Management goals, strategies, and actions to address identified pollution sources (Chapters 5 and 6);
- Sources of financial and technical assistance (Appendix B);
- Recommendations for education and outreach (Chapter 8);
- Plan implementation schedule (Chapter 6);
- Interim milestones (Chapter 6);
- Implementation performance criteria (Chapter 6); and
- Recommendations for monitoring and assessment (Chapter 9).

The focus of the WBP and the EPA watershed planning process is to reduce sources of NPS pollution. However, many of the techniques that manage and reduce NPS pollution will also result in other watershed improvements. For instance, BMPs such as constructed wetlands that store and filter polluted urban stormwater runoff can also be used to reduce flooding and reduce rates of streambank erosion.

A high level of public and stakeholder involvement was incorporated during all phases of the planning process. A volunteer steering committee was formed to support development of the WBP and to review technical documents. Members provided feedback on interim drafts, and met at key points in the planning process to review the content and direction of the WBP. The steering committee was comprised of state and municipal representatives, SWRPA, and local stakeholders, many of whom are already involved in watershed planning as members of the SRWP. Members of the following organizations contributed to the steering committee:

- Aquarion Water Company;
- City of Norwalk;
- CTDEEP;
- Harbor Watch/River Watch (HW/RW);
- Redding Conservation Commission;
- SRWP;
- Town of Ridgefield;
- Town of Weston;
- Town of Westport; and
- TNC.

The public engagement process included the formation of a steering committee, and a series of three public meetings held on July 13, 2010; April 28, 2011; and November 30, 2011. The meetings were intended to collectively define the watershed's valuable uses, and to identify management goals and strategies aimed at protecting and restoring these uses. Strategies related to water quality, outreach, and managing development were identified to support the WBP goals. In addition, project consultants presented a working list of potential structural BMPs selected to begin to implement Plan goals and strategies. Stakeholders provided feedback on these BMPS and identified additional management actions to support goals and strategies.

WATERSHED BASED PLAN OVERVIEW

The following sections of the executive summary provide an overview of the primary components of the watershed planning process. Conclusions and recommendations that were developed during the process are summarized below. More extensive descriptions of the methods, results, conclusions, and recommendations associated with the WBP are presented in the various chapters and appendices.

Assessing Existing Conditions


Small, low-head dams are found throughout the watershed

Understanding the existing condition of streams and rivers, including the quality of habitats, the chemical composition of stream water, and the health and diversity of aquatic life is an important first step to developing a watershed based plan and to determining the specific actions that are recommended to improve stream conditions. Understanding the existing condition of streams and rivers within the Saugatuck River Watershed involved several steps, including looking at the overall level of development within the watershed as an indicator of the level of watershed stress; reviewing water quality and biological data collected by CTDEEP and others in past studies including SRWP-led efforts; and reviewing the designated uses and impairments that have been established by CTDEEP through its assessment programs. In addition, visual assessments of the stream channel were conducted in representative locations to assess the quality and diversity of aquatic habitats, and computer models were used to predict the quantity of key pollutants being carried into the stream in various locations.

Overall, the existing conditions assessment reveals a river that has been somewhat impacted by development and other human activities in some areas but which remains in many aspects a high-quality resource that supports a range of human and ecological uses. Key stresses on the river system include dams, water diversions, removal of streamside vegetation, malfunctioning septic systems, and unmanaged stormwater runoff from developed areas. These stresses have combined to impact the Saugatuck River in a variety of ways. In some areas, pathogenic bacteria are present in levels that make recreation unsafe according to state water quality standards. The sources of these elevated bacteria levels are mostly likely related to some combination of pet and wildlife wastes, septic failures, and urban runoff. In other areas, habitat and aquatic life are less diverse than would be expected in pristine rivers flowing through undeveloped areas, a finding that is likely due to: stormwater pollution; dams that restrict fish from accessing key habitats; and water withdrawals, which reduce the amount of water available to support aquatic life.

The sporadic and generally moderate levels of impact seen in the Saugatuck River are consistent with the overall level of development in the watershed. Impervious surfaces, a good indicator of the intensity of development, cover approximately 11 percent of the watershed's total area. National studies have shown that rivers flowing through watersheds with this level of impervious surface often show some signs of impact to aquatic habitats and water quality. As a likely result of development and the added impacts of dams and water withdrawals, bio-monitoring data shows that stream life in some areas of the Saugatuck River is less diverse and has a higher proportion of aquatic species that can survive in polluted water than would be expected in undeveloped watersheds. In general, habitat is of higher quality in the upper and central reaches of the watershed and preserved areas, a conclusion that reflects their generally less developed nature (some areas in the upper and central watershed are significantly less impervious than the watershed average). Development-related impacts, however, are evident in some semi-rural headwater regions, illustrating how sensitive streams can be to even modest changes in land use.

Near-stream development can mean that runoff from parking areas is piped directly into the stream

Despite some problem areas, the river remains a good-quality resource in most areas, with forested, stable stream banks in many locations, diverse communities of fish and other aquatic life, well-oxygenated waters, and spring runs of Alewife and American eel. Though showing impacts of development, the Saugatuck River supports a wide range of uses and a variety of aquatic life. Nevertheless, the combined impacts of stresses such as stormwater pollution, water withdrawals, and dams together represent an increasingly significant threat to the long-term health of the river.

Understanding Watershed Uses and Values

Rivers and streams are used and valued in ways that are as diverse as the resources themselves. In large rivers, hydropower and navigation are often key uses. In other rivers, the provision of water for drinking or irrigation is a key use, while for still others, active recreation uses dominate—including swimming, boating, and fishing. Rivers often provide uses that are not often recognized, such as conveying treated sanitary waste away from communities and conveying flood waters. And some rivers are valued primarily for their scenic attributes and their contribution to landscape character and sense of place.

As watersheds urbanize and streams and rivers become degraded, the overall suite of uses and values provided by a river system declines. Specific uses, such as swimming, may become inappropriate, unhealthy, or even dangerous. Or uses and values may be increasingly perceived to be at odds with each another, as pressures on water use increase due to urbanization. For instance, withdrawals of water for drinking or irrigation may be perceived as conflicting with recreational fishing, as less water is available to support fish populations. Uses and values may also vary significantly among various stakeholder groups. Members of sport fishing associations may be primarily concerned with the ability of a particular stream to support populations of popular sport fish, for example, while streamside residents may be much more concerned about the impacts of flooding or aesthetic value.

The history of river management is full of examples of river resources that have been managed to provide one overriding use to the detriment of virtually all others. Today, watershed managers understand that rivers are increasingly diversely used and valued and should be managed accordingly. A commitment to managing rivers for a diverse set of uses is not always easy, but is another central tenet of good watershed planning. As such, the twin objectives of watershed planning are first, to understand the full range of uses and values associated with a watershed’s streams and rivers, and second, to manage these resources to provide the full range of uses and values over time in a sustainable manner.

To understand how the Saugatuck River Watershed and its streams and rivers are used and valued, SWRPA convened a group of watershed stakeholders to participate in a workshop focusing on the issue of uses and values. The results of the workshop revealed that despite some water quality and habitat problems, stakeholders use and value the Saugatuck River and its smaller feeder streams in a number of important ways. Uses range from being a source of drinking water, to wildlife habitat, to carbon sequestration, to a provider of scenic character. Some stakeholders expressed concern that certain commercial uses are having a detrimental effect on habitat in parts of the river, particularly where large properties such as golf courses withdraw significant water. The discussion of uses and values highlighted an almost universal sense that the Saugatuck River Watershed is a special place of great value to its community, but one that needs to be actively managed in order to support continued use.

Members of the steering committee defined the following key uses through which the community values the Saugatuck River Watershed:

- Potable water
- Forest and open space

- Recreational opportunities
- Economic benefits
- Carbon sequestration
- Flood conveyance, storage, and stormwater
- Scenic beauty
- Wildlife support
- Cultural identity/historic value

Management Goals and Strategies for Improving the Watershed

Watershed management goals express the broad ways that streams and rivers need to be improved or enhanced to better meet the range of uses and values held by various stakeholders. Management strategies outline the specific sets of actions required to achieve the goals. As with the uses and values, the development of watershed management goals and strategies for the Saugatuck River Watershed involved working with watershed stakeholders.

TNC's *Conservation Action Plan*, which is discussed in detail in Chapter 1, identifies management "objectives," "strategies," and "actions" intended to guide long-term decision-making in the watershed. As mentioned in Chapter 1, these guiding statements were developed by TNC following a series of public meetings attended by members of the watershed community including representatives of the 11 watershed towns. The goals and strategies developed for the WBP are intended to reinforce and extend the recommendations defined in the *Conservation Action Plan*, and to frame recommendations from the Conservation Action Plan within EPA's Nine (9) Step watershed planning process.

<u>Watershed Management Goals</u>

Through the workshop process and follow up discussions with the stakeholder group, the following management goals were established for the WBP:

Protect and enhance water quality and high-quality stream communities

The Saugatuck River Watershed supplies drinking water to over 300,000 people. Due to strong protection efforts and generally good aquatic conditions, the watershed also supports an array of recreational opportunities such as fishing, swimming, and scenic enjoyment. All these activities rely on consistent, high quality water resources, which in turn depend on minimizing pollution. Improving water quality will result in a cleaner, more beautiful stream that can ensure the security of drinking water supplies and support a more diverse community of aquatic life. As water quality improves, residents' ability to use the Saugatuck River for non-contact and contact recreation will improve, as will the value of the river as a scenic and aesthetic resource.

Restore diadromous fish populations

Diadromous fish species were once a significant resource in the Saugatuck River (SRWP 2008). However, early settlers built mill dams throughout the river to power the bourgeoning industry, a trend that continued into the 20th century. Cumulatively, these structures limit the movement of diadromous fish and prevent the spawning runs that are critical to the survival of these fish. Since 2006, the SRWP has worked to remove barriers where possible, and provide for fish passage using fish ladders and fishways where removal is not feasible. In this way, the SRWP has had significant success in restoring fish passage. However, there are many more dams to be removed before fish can fully access natural spawning grounds. CTDEEP has recorded over 100 dams in the watershed (Chapter 1, Figure 2), and many more small, unmapped dams have been observed.

Restore impaired biological communities

Although the Saugatuck River Watershed is among the highest quality watersheds in the region, some areas in the lower watershed, particularly the southwestern portion (e.g., Stony Brook and the lower West Branch, etc.) have been significantly altered by urban development. Dams and private water supply wells in the watershed may also be adding to the problem by reducing the amount of flow in the river channel (and hence the wetted area available to support aquatic life) and, in the case of dams, creating a physical barrier to fish migration. Lessening the effects of urban development on streams within these areas will largely involve building stormwater management practices, such as rain gardens and constructed wetlands, and mitigating the effects of dams and consumptive use.

Preserve and enhance recreational opportunities

With its network of trails and public access points, scenic quality, and proximity to large population centers, the Saugatuck River Watershed is a key recreational resource. Devil's Den Preserve, Trout Brook Valley, and many other linked open spaces that make up the Centennial Watershed State Forest are important amenities for hikers, joggers, dog owners, and other outdoor enthusiasts. The availability of these opportunities depends strongly on protecting high-quality aquatic resources and publically accessible natural lands and identifying opportunities to protect additional lands.

<u>Watershed Management Strategies</u>

Management strategies support the achievement of watershed goals through sets of specific actions. Strategies identified by watershed stakeholders include the following:

1. Implement an early warning system to detect emerging threats

Given the high quality of many of the streams within the Saugatuck River Watershed, an early-warning monitoring system should be established to detect impairments before they become significant. The monitoring program, which can build on the existing volunteer monitoring program organized and coordinated by TNC, the work of HW/RW, and water quality monitoring conducted by Aquarion Water Company, should focus on detecting changes in sensitive and easy-to-measure parameters such as temperature, stream erosion, and fish and macroinvertebrate communities within headwater streams draining to the Saugatuck and Aspetuck Reservoirs, particularly within areas that are currently experiencing or could in the future support significant development.

2. Mitigate the impact of water diversions through adaptive management

TNC and Aquarion Water Company are currently working together to look at ways that the Saugatuck and Aspetuck Reservoirs can be better managed to provide the right amount of water for both aquatic life and drinking water supplies. In this work, computer models that allow managers to optimize reservoir releases, studies to better understand the water needs of key aquatic species, better tools for forecasting water demands, and studies to identify areas where water is being used faster than it is being replaced, are all important aspects of balancing ecological and consumptive water use. Further, the use of adaptive reservoir management, a process in which water releases are optimized over time through evaluating monitoring data, will be a key ingredient in ensuring that water resources meet both human and ecological needs.

3. Mitigate fish migration barriers through natural fishways, fish ladders, and barrier removals

Numerous small dams and culverts cross the Saugatuck River and its tributaries, many of which no longer serve their original function. These structures, while small, can have significant cumulative effect, most notably in blocking the migration of fish populations. Methods for reducing the negative effects of small dams include the installation of fish ladders and natural fishways, partial dam removal, and full dam removal. Given the large number of barriers in the watershed, the WBP first recommends the development of a comprehensive fish passage and barrier mitigation plan to prioritize management actions.

Throughout the Saugatuck Watershed, the SRWP has conducted significant work to remove fish barriers such as dams or to provide fish passage through the installation of fish ladders and fish ways. To date, many fishways have been successfully implemented in the watershed, and monitoring of fish movement conducted by the SRWP suggests positive results. Building on prioritization and assessment already completed by the SRWP, a comprehensive plan for restoring fish passage can now be developed. This plan will help attract funding through grants and private donations, and engage private land owners in the important work of removing dams and installing fish passage structures. At the same time, watershed partners can continue to identify short-term opportunities to install fish passage structures and re-design raised road culverts that also restrict the movement of fish.

In a fully restored river, migratory fish would be able to access habitat up to the point of the first natural barrier in the stream, known as the natural falls. While this point represents the limit of habitat for migratory species, there are many other non-migratory fish species that live above natural barriers and can benefit from open habitat and barrier mitigation. Once access is restored to the natural falls, or when mitigation opportunities are exhausted in the lower watershed, it may be useful to identify additional small impoundments and barriers above the natural falls work to connect habitat for resident species.

4. Reduce water quality impacts associated with unmanaged stormwater runoff through implementation of stormwater Best Management Practices

The implementation of BMPs can result in significant decreases in nutrient and sediment loading, which can in turn improve the health of the waterways within the watershed. BMPs include both structural and non-structural practices. Structural BMPs refer to built projects at a particular location, and may include rain gardens, constructed wetlands, green roofs, and other techniques for capturing, filtering, and infiltrating urban stormwater runoff. Structural BMPs can be installed in a variety of locations throughout the watershed to reduce the impact of urban stormwater runoff in developed areas. Nonstructural BMPs involve methods for decreasing sources of pollution through changes in behavior or property management techniques, and include such activities as picking up pet waste, properly maintaining septic systems, and reducing the use of lawn fertilizers.

5. Remediate bacterial impairments and enhance riparian habitat

High levels of coliform bacteria (a group of disease-causing bacteria that is the focus of public health concerns) can significantly undermine recreational uses such as swimming and fishing, even within relatively healthy watersheds. Water quality sampling within the watershed has shown that several reaches of the Saugatuck River and its feeder streams do not meet state bacteria standards for safe recreation. The source of this pollution is under some debate within the watershed community, and deserves additional research to determine whether the majority of loading is coming from the land surface (i.e., stormwater and animal wastes) or from leaking septic systems.

The restoration of riparian zones, the areas immediately adjacent to the stream channel, can play a central role in reducing bacterial impairments while providing a number of other benefits. Riparian areas provide important habitats for a variety of birds, mammals, reptiles, and amphibians; shade stream channels to keep stream water cool; provide important inputs of food (in the form of leaves, sticks, and other tree parts) on which macroinvertebrates and other aquatic life feed; and remove pollutants from stormwater runoff. In many places in the Saugatuck River Watershed, riparian areas have been altered by urban development. Reforesting these areas will help to improve water quality within the Saugatuck River and its feeder streams. The WBP identifies several site-specific riparian buffer BMPs that will improve streamside infiltration and prevent large amounts of bacteria from washing into the river. In addition to the specific BMPs outlined in the WBP, watershed groups are strongly encouraged to work with property owners to install additional buffers throughout the watershed, particularly on properties where lawn is currently mowed up to the stream edge.

6. Avoid future increases in stormwater related impacts through conservation acquisition and promotion of low impact development policies

Maintaining high-quality streams in the Saugatuck River Watershed will depend on preventing impacts from future development through the adoption of progressive, low impact development (LID) based stormwater, zoning, and development ordinances. These ordinances will help to ensure that new development is designed and built to preserve the natural environment and reduce increases in stormwater runoff and NPS pollution. This work is particularly important in the Town of Redding, within which lies a majority of the source water for subwatersheds to the Saugatuck Reservoir. Fortunately, Redding is known for its strong commitment to conservation, and has already preserved a large portion of the town's remaining developable land.

7. Pursue strategic land acquisition to protect headwater streams and other watershed lands

Continued preservation efforts are critical for the long-term protection of the watershed's sensitive headwater streams, while continued land preservation and protection of open space throughout the watershed will help to protect and enhance water quality. The SRWP and TNC are working closely with municipalities to identify and prioritize conservation acquisition targets within areas draining to headwater streams upstream of the Saugatuck and Aspetuck Reservoirs, particularly in areas with significant availability of undeveloped, unprotected, private lands. Numerous groups have been successful in preserving land in Redding, which contains most of the land upstream of the Saugatuck Reservoir. Work by TNC, local land trusts, municipalities, the SRWP and CTDEEP have driven the success in protecting open space throughout the watershed.

8. Encourage better stewardship of public and private lands by implementing education and outreach programs for landowners and municipal officials

Promoting healthy attitudes toward stewardship and general property management is an essential way of improving overall watershed health. Effective educational materials focus on helping both private citizens and public officials become more aware of the relationship between NPS pollution and local-scale actions, such as lawn care practices and pet waste management, and provide practical, easy-to-implement actions that reduce such pollution.

Education and outreach efforts will make use of the full range of media outlets and presentation possibilities available.

9. Implement the Watershed Based Plan and monitor outcomes

The WBP outlines long-term strategies for achieving each of the watershed based planning goals. Implementing the WBP will require the collective efforts of many partners to attract funding; work with private and public landowners to design, implement, and maintain BMPs; coordinate and implement outreach campaigns; and collect monitoring data. In addition to the management strategies identified in the WBP, funding will be required to support SRWP annual reports and additional activities identified in *An Introduction to the Saugatuck River Watershed and The Saugatuck River Watershed Partnership*, which includes the *Conservation Action Plan* (TNC 2006).

Implementation works best when it is an iterative process, when it is constantly honed and changed according to evaluations of monitoring data. While the strategies outlined in the WBP are based in the best and current science and have, in most instances, been successfully applied in other watersheds, collecting data about how and if the WBP is achieving its intended effects is critical. Monitoring data will provide hard evidence on whether the WBP is working as planned and if not, provide the opportunity to change the approach.

HOW MUCH IS ENOUGH?

N, P, and bacteria, common in lawn fertilizers and animal waste, can be partially responsible for poor water quality conditions.

NPS pollution collectively undermines the ability of a stream system to support diverse uses such as drinking water, habitat, and recreation. Management goals and strategies are intended to reduce NPS pollution through measureable, clearly defined steps. Levels of management (and investment) can be quantified through modeled and observed pollution levels, and future management can be tailored based on the outcomes of initial efforts. Key NPS pollutants include bacteria, N, P, and sediment. Each pollutant degrades water ways in unique but significant ways. Both computer modeling and methods that compare in-stream concentrations of pollutants with state water quality criteria can be used to develop numerical targets for the specific amount of each pollutant that should be reduced to restore high-quality conditions. As part of the WBP, the computer model WinSLAMM was used to estimate the current quantity of each pollutant entering the Saugatuck River and its feeder streams. The model uses the characteristics of the watershed, including land use, soil types, and the specific type and arrangement of impervious surfaces such as rooftops, parking lots, and roadways. A separate model was developed for each of 36 subwatersheds (smaller drainage areas within the larger watershed). The modeling process was then repeated as if it were an undeveloped area, estimating the quantity of pollutants delivered to the stream in the absence of human development. The difference between the pollutant quantities predicted in the developed and undeveloped models represents the reduction in pollution required to fully eliminate human sources of N, P, and sediment in the watershed. Since measured bacteria concentrations were available for many reaches of the stream, an alternative method using these in-stream concentrations was used to develop load reduction targets for bacteria.

Given the fact that reducing pollutant loads to predevelopment conditions is an ambitious goal, an interim target of eliminating 60 percent of the development-related pollutant load was established. Sixty percent represents a commonly accepted efficiency rate for NPS pollution-reduction BMPs. The full (100 percent) load reduction targets call for reductions of 1.0, 2.1, 50.2, and 51.8 percent in sediment (expressed as Total Suspended Solids [TSS]), P expressed as particulate P, N expressed as nitrate (NO_3), and indicator bacteria, respectively. Interim load reduction targets call for TSS, particulate P, and NO_3, and indicator bacteria reductions of 0.6, 1.3, 30.1, and 31.1 percent, respectively.

IMPLEMENTING THE PLAN

Management goals and strategies define the overall aims of the WBP and the types of activities that will help achieve the improvements articulated by the WBP goals. But goals and strategies alone do not result in an actionable plan for improving the Saugatuck River Watershed. Building on the goals and strategies, SWRPA staff with the project consultant and steering committee developed lists of specific management actions that outline the steps needed to implement the WBP.

Management actions were developed for each management strategy based on observations made during field assessments. Recommendations of stakeholders, technical reports and guidance, and best professional judgment were also taken into account. Recommended management actions include structural BMPs such as rain gardens and basin retrofits; non-structural BMPs such as policy initiatives; educational and outreach programs to promote the adoption of watershed-friendly behaviors across the watershed; and monitoring activities.

An implementation schedule was developed to achieve the goals outlined in the WBP. Management actions were recommended for short-term (one to five years/pilot phase), mid-term (five to 10 years), and long-term (10 to 20 years) implementation. It is recommended that successes and lessons learned be evaluated every five years and the WBP updated or revised as necessary.

Potential sources of funding for recommended management actions are presented in Appendix B. A number of grant programs are available through state and federal agencies, nonprofits, and corporate partnerships. Minimum and maximum dollar amounts for identified funding programs are presented, as are application deadlines and any required match money. Other financial opportunities including the use of impact fees, taxes, utility districts, and membership drives, are described briefly.

STRUCTURAL BEST MANAGEMENT PRACTICE IDENTIFICATION

Structural BMPs such as rain gardens, basins, and swales, are particularly useful for the reduction of NPS pollution because they are tangible, one-time construction projects that are relatively uncomplicated to model, design, construct, and monitor. In addition, structural BMPs are often associated with ancillary benefits; these include improved aesthetics and landscaping and education and demonstration potential. Structural BMPs often are associated with significant reductions in pollution, although efficiencies vary by BMP type and pollutant.

A basin where sediment has accumulated in the forebay and has killed off vegetation. Simple maintenance would improve the function of this structure and allow plants to use and filter the captured water.

For these reasons, structural BMPs were identified as a first step toward addressing the NPS pollution reduction targets in the watershed. The BMPs were identified through a combination of feasibility analysis, field inspection, and stakeholder recommendations. Planning-level costs and load reduction estimates were developed for each structural BMP (Appendix A).

Target Areas

In a mid-sized watershed such as the Saugatuck, hundreds of potential structural BMP opportunities exist. To target structural and non-structural BMPs where they will be most useful, the project team used a desktop analysis to select a few subwatersheds. These were identified based on location in sensitive areas (i.e., upstream of drinking water sources or contained, small headwater streams), modeled amounts of NPS pollutants, and/or identification by watershed stakeholders.

Within each target area, the team then conducted an analysis to identify potential structural BMP locations. The process involved identifying unused green spaces using aerial photographs to which runoff from large developed areas could be routed. Subsequently, project staff visited each site to further assess its feasibility and develop a more precise estimate of how much stormwater could be conveyed to and managed within each structural BMP. Using this approach, 17 structural BMPs were identified, with planning-level costs ranging from $2,000 to $1,042,000. Total cost of all structural BMPs identified through this process would be approximately $3,571,000. Two additional sites for potential structural BMPs were identified by stakeholders.

Pollution-load reduction estimates were modeled for each structural BMP identified through the targeting process. Reductions associated with the structural BMPs represent less than one (1) percent of the total target load reduction NO_3 and bacteria, and approximately 12 percent and 21 percent of the total targets for particulate P and TSS, respectively. These represent over one (1) percent of the interim targets for bacteria and NO_3, and 35 and 21 percent of the interim target, respectively, for TSS and particulate P. Although these structural BMPs will not by themselves achieve the full load reduction targets, they present potentially feasible, vetted first steps.

REACHING OUT TO CHANGE BEHAVIORS

Many sources of NPS pollution come from relatively small but widely practiced behaviors such as over-fertilization of lawns, poor inspection of septic systems, and failure to pick up pet waste. Education and outreach activities are particularly focused on helping watershed residents understand the connection between their actions and the health of the Saugatuck

River and giving home and business owners inexpensive, easy-to-implement actions that can, en masse, result in significant reductions in NPS pollution. Since so much NPS pollution originates on private property, outreach to homeowners and municipal officials is critical to the implementation of long-term management goals and strategies.

The outreach and education component of the WBP recommends a combination of media and education formats to educate residents and local businesses about the need for pollution prevention and stewardship in the Saugatuck River Watershed. Proposed outreach campaigns relate to LID approaches, buffer establishment, landscape and pet waste management, use of rain barrels, open space preservation, and septic maintenance and repair.

MONITORING OUTCOMES

Monitoring ensures that the diverse groups who will implement the WBP will understand how their collective efforts impact the health and quality of the watershed. Monitoring data can also be used to adjust and adapt the WBP to increase the effectiveness of watershed management efforts. The WBP outlines a detailed approach for measuring success through a monitoring program that includes the following components:

- **Routine in-stream monitoring** is conducted at fixed stations throughout the watershed on an annual or biannual basis. The primary purpose of routine monitoring is to detect changes in in-stream conditions over time during WBP implementation. Routine monitoring includes habitat, water quality, and biological data collection.

- **Early-warning monitoring** is a more specialized type of monitoring that helps detect emerging threats through more intensive monitoring of conditions within sensitive headwater areas, particularly those upstream of critical areas such as drinking water supplies. Early warning monitoring focuses on physical changes to the shape and size of stream channels and easy-to-measure characteristics such as water temperature.

- **Structural BMP monitoring** is conducted to identify performance and maintenance issues associated with structural BMPs and assessing the downstream effect of structural BMPs on streams. The routine monitoring plan for structural BMPs includes the assessment of vegetation, structures, downstream water quality, downstream outfalls, and sediment and debris accumulation.

One of a number of coastal rivers that empty into Long Island Sound (LIS) in southwestern Connecticut, the Saugatuck River is a significant water resource that provides drinking water and recreation opportunities for thousands of residents of Fairfield County. The Saugatuck River Watershed, which contains all the land draining into the Saugatuck River, has an area of approximately 90 square miles. The watershed spans portions of 11 municipalities, and flows south from its headwaters in Ridgefield, Danbury, Bethel, Newtown, and Redding, and through the Towns of Easton and Weston before emptying into LIS in Westport (Figure 1). Small parts of Norwalk, Fairfield, and Wilton also drain to the lower segments of the Saugatuck River. Major tributaries to the Saugatuck River include the West Branch, Jennings Brook, Beaver Brook, and Stony Brook in Westport, Wilton, Norwalk, and Westport; the Little River in Redding and Bethel; and the Aspetuck, a major eastern tributary draining parts of Bethel, Newtown, Redding, Easton, Fairfield, and Westport.

Regionally, the watershed is located in an area where dense commercial development and suburban and rural areas commonly exist adjacent to one another. Despite development in the watershed, however, the area's historic and scenic character has been well preserved by a strong tradition of land conservation and preservation. In part driven by the need to protect the watershed's significant drinking water sources, land protection efforts in the Saugatuck River Watershed have insulated the river from many of the problems that confront more developed watersheds in the region. Significant areas of the Saugatuck River Watershed have been preserved through a joint partnership between The Connecticut Department of Energy and Environmental Protection (CTDEEP), Aquarion Water Company, and the Nature Conservancy (TNC). This partnership has resulted in the permanent protection of over 17,000 acres of land around and adjacent to the Saugatuck Reservoir known as the Centennial Watershed State Forest. This area, the largest continuous forest tract in southwestern Connecticut, surrounds and buffers the Saugatuck Reservoir and plays a key role in maintaining the river's relatively good water quality and habitat. Local municipalities have been historically conservation-minded, with large areas preserved by the Town of Redding and multiple small land trusts that are active in the region. Devil's Den Preserve, an early project of TNC first established in the 1960s, buffers the headwaters of the West Branch and is well loved as a place for hiking and nature-watching.

Generally well protected by large tracts of forest in its headwaters, increasing evidence suggests that the river's water quality and habitats are being impacted in some locations by human activities such as residential development and water withdrawals. Water withdrawals from the Saugatuck Reservoir and private wells are now thought to have decreased the amount of water available for fish and other aquatic species. Scientists studying the river have concluded that the many small dams along the river block migratory fish species from accessing important habitats. Residential land along the river is in high demand, and many homeowners have modified the channel and riparian zone with small walls, dams, bridges, and landscaping. In the lower watershed, intense recreation in park areas has led to disputes over the need for better stewardship and responsible use. Additionally, development in some areas is approaching threshold levels that are often associated with degrading stream conditions.

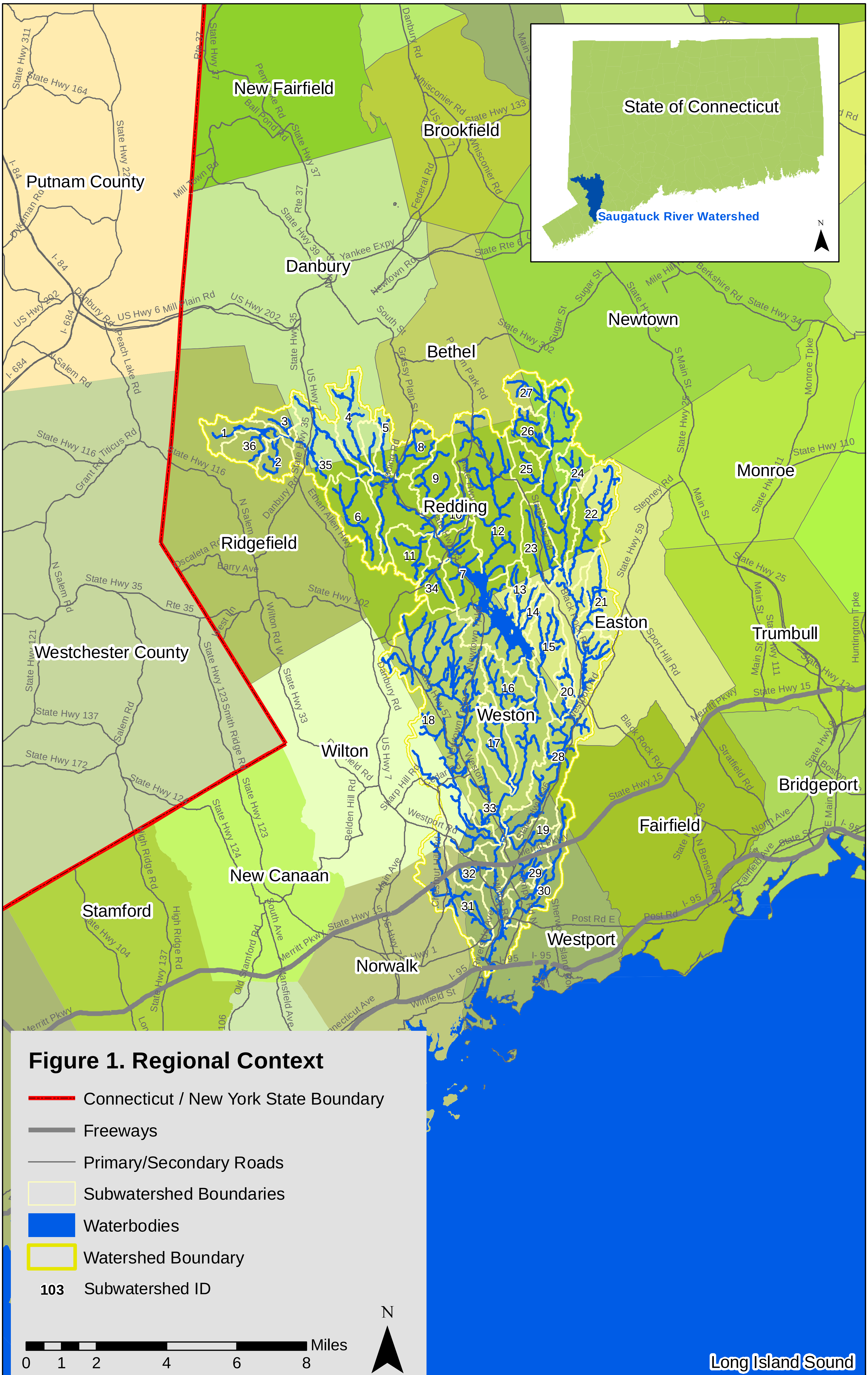


Figure 1. Regional Context

In response to these problems, the Saugatuck River Watershed Partnership (SRWP) was formed in 2006 through a joint initiative of TNC, Aquarion Water Company, and the 11 watershed municipalities. All members signed a conservation compact which acknowledges the significant value of the river and its resources, as well as the growing evidence that land use changes and river corridor management practices are adversely affecting the river's health. Since 2006, the SRWP has spearheaded numerous educational events, habit restoration initiatives, and efforts to characterize habitat and water quality throughout the river. SRWP activities are further detailed later in this chapter (see "History of Planning in the Saugatuck River Watershed").

The Saugatuck River Watershed Based Plan (WBP) is intended to build on the significant technical and planning efforts of the SRWP since 2006 as well as the long-term efforts of local land trusts, TNC, and Aquarion Water Company to protect the land and waters of the Saugatuck River.

THE URBAN STREAM SYNDROME

When watersheds become urbanized, changes in the physical and chemical stream characteristics cause a systematic and predicable decline in the health and diversity of aquatic species. Nonpoint source (NPS) pollutants, such as bacteria, sediment, nitrogen (N), and phosphorus (P) are delivered to streams in increasing quantities. Increased rates of stormwater runoff scour high-quality habitats and stress aquatic life. Riffles, (rocky, fast-moving areas of the stream that support fish-spawning and provide habitat for many aquatic insects known as macroinvertebrates) become filled with sediment. Physically, stream channels become simplified, no longer containing the complex maze of deep pools, woody debris piles, backwater areas, and rocky areas that provide habitats for a diverse community of aquatic life. Rates of bank erosion increase, further increasing pollutant loading and sedimentation of key habitats, and in many cases threatening streamside properties. Rates of flooding and associated flood damage also increase. Odor issues and dangerous levels of bacteria eliminate or significantly reduce the ability to swim, fish, and otherwise recreate in urban streams.

On the spectrum of streams impacted by urbanization, the Saugatuck River lies somewhere in the middle. Aquatic monitoring and stream assessments reveal a patchwork of conditions, some quite healthy, but some partially degraded. Regionally, the river has fared better than many of its neighbors, due mainly to land protection in the headwaters and a strong local community committed to preserving this resource.

The WBP outlines a targeted, science-based, and community-led effort to improve and protect conditions in the Saugatuck River Watershed through on-the-ground restoration and stormwater management, watershed monitoring, and education and outreach. The WBP focuses on reducing NPS pollution, the diffuse sources of which are pet waste, lawn fertilizers, and pesticides. These sources, unlike such end-of-pipe pollution sources as those generated from wastewater treatment facilities, have traditionally been difficult to identify and control.

NEED FOR A WATERSHED BASED PLAN

NPS pollution—the nutrients, bacteria, sediment, and other pollutants carried by rain water over land—is more and more a major problem for watershed managers across the country. Historically, pollution to waterbodies has been regulated through the National Pollution Discharge Elimination System (NPDES) program, which is geared toward large commercial, industrial, or public sites that discharge water to streams. Over the past several decades, this program has reduced levels of pollution and improved water quality throughout the country. However, NPDES has been less effective at managing NPS pollution.

Runoff from the municipal drainage network—mostly via roads, sewers, and swales—is partially regulated under NPDES Municipal Separate Storm Sewer System (MS4) permits. This program requires general outreach and maintenance activities to improve awareness and management of stormwater, but it does not set any specific water quality criteria. In most suburban areas, stormwater runoff comes from private, often residential properties, the individual impacts of which are minimal. Yet taken together, these many small roofs and driveways can generate a significant amount of largely unregulated runoff and NPS pollution .

Water Quality Impairments

In the Saugatuck River Watershed, development in some areas is approaching threshold levels that are commonly associated with mild to moderate water quality and aquatic habitat degradation (see Chapter 2). Sampling conducted on the Main Stem, West Branch, and Aspetuck since 2005 has indicated that at multiple sites bacteria are present in levels unsafe for recreational purposes, although the source of bacteria is not totally clear. The existing conditions assessment conducted in support of this Plan (Chapter 2) identified multiple areas where additional water quality and habitat problems may exist. Many of these problem areas are related to stormwater runoff from roads and parking lots and residential landscaping and construction along the stream banks. If current land use practices are continued, stream conditions may worsen to a point where aquatic habitat is significantly impacted. In the absence of strong regulation to deal with this problem, and because the watershed spans municipal and land use boundaries, watershed based planning is the preferable approach to dealing with these NPS pollution-related problems.

Incomplete Data for NPS Pollutants

In the Saugatuck River Watershed, the local community has already worked extensively to assess, protect, and restore the river, with significant success. The SRWP has worked to mitigate multiple fish migration barriers, resulting in over nine (9) miles of newly opened habitat in the lower river, and has conducted extensive assessment of habitat, streamflow, and fish populations (S. Harold, pers. comm). In the upper watershed, land protection efforts by TNC, Aquarion Water Company, the Town of Redding, and CTDEEP have preserved high-quality water and habitat within much of the Main Stem and its tributaries. Long-term objectives and strategies for watershed management were outlined in TNC's 2006 *Conservation Action Plan* (see "History of Planning in the Saugatuck River Watershed"), which provides the basis for the goals and strategies identified in the WBP.

While data have been gathered for many important pollutant sources, the effects of key pollutants on the river's health are not well understood. The 2008 final report of sampling activities by Harbor Watch/River Watch (HW/RW) staff indicated that other scientists working on the watershed have suggested the need for nutrient sampling in the watershed (Harris and Fraboni 2008). As an alternative to extensive sampling, the WPB uses computer modeling to estimate current levels of nutrient, bacteria, and sediment pollution based on known soil type, land use, and land cover characteristics. These data, presented in Chapter 2 and 3, represent the first effort to quantify the levels of NPS pollution in the watershed.

A Long-term Framework

Watershed based planning uses a science-based and community-driven approach to assess existing conditions; sets goals for watershed improvements; outlines strategies through which these goals will be achieved; identifies water quality and habitat problems and the causal factors responsible for these problems; develops feasible, cost-effective solutions; and provides a framework for revising the WBP during the implementation process in response to monitoring data, a process called adaptive management. Throughout the planning process, watershed stakeholders provide critical information and feedback. A plan developed with the full participation of the community will enjoy better support and will be more effectively implemented than one developed using a top-down, regulatory-driven approach.

The core purpose of the WBP is to present an actionable, quantitative framework for reducing NPS pollution. The WBP builds on previous planning, assessment, and restoration conducted by the SRWP and others by providing estimated NPS pollution levels, then framing future management in terms of potential to reduce pollution. Funded by CTDEEP, the WBP was developed in accordance with the Nine (9) Steps of Watershed Planning recommended by the U.S. Environmental Protection Agency (EPA) (EPA 2008). The planning process was administered by the South Western Regional Planning Agency (SWRPA), with technical support from project consultant AKRF.

The WBP provides a long-term framework for watershed protection and restoration. Central to its approach is the idea that the WBP will be most effectively implemented when municipalities and partner organizations continue to work together to achieve pollution reduction targets and to minimize future impacts. Management actions outlined in the WBP require varying degrees of technical and communications expertise, and as such are geared toward a variety of stakeholders, organizations, and agencies. Implementation is expected to be incremental, and identified management actions may take 20 years or more to be fully effective. At the end of this period, water quality and habitat within each stream reach is expected to meet criteria established by CTDEEP.

Many management actions recommended in the WBP are directly related to managing stormwater runoff. These types of management actions are commonly referred to as stormwater Best Management Practices (BMPs), which may include structural or non-structural components. Structural BMPs refer to built projects at a particular location, and may include rain gardens, constructed wetlands, green roofs, and other techniques for capturing, filtering, and infiltrating urban stormwater runoff. Structural BMPs can be installed in a variety of locations throughout the watershed to reduce the impact of urban stormwater runoff in developed areas. Nonstructural BMPs involve methods for decreasing sources of pollution through changes in behavior or property management techniques, and include such activities as picking up pet waste, properly maintaining septic systems, and reducing the use of lawn fertilizers.

HISTORY OF PLANNING AND ASSESSMENT FOR THE SAUGATUCK RIVER

TNC has been a major advocate for the Saugatuck River for many years, first through land conservation efforts in Devil's Den and the Centennial Watershed State Forest, and later as the driving organization behind the formation of the SRWP. From 2005 to 2006 a *Conservation Action Plan* was developed for the watershed, with objectives related to improving water quality and stream flow, removing habitat barriers for fish and other species, improving land management and development practices, and providing outreach and monitoring to support restoration and conservation work. The SRWP was founded by TNC to bring together the 11 towns within the watershed to collectively make decisions about the river as a shared water resource.

Planning and Assessment Documents

The river has benefited from strong municipal support coupled with significant research and conservation activities by scientists at TNC and Aquarion Water Company. Many other organizations and agencies have contributed to protection efforts as project partners, advisors, and volunteers. The following is a list of public technical and planning documents relating specifically to assessment and management of the Saugatuck River Watershed:

- *State of the Watershed*, (SRWP 2009);
- *Water Quality Data Reports for the Saugatuck River Watershed, 2005–2008,* (Harris and Fraboni 2008);
- *Second Report of The Nature Conservancy's Saugatuck River Watershed Partnership* (SRWP 2008);
- *Alternative On-Site Sewage Treatment Systems: Watershed Implications* (TNC 2007);
- *Saugatuck River Watershed Conservation Action Plan* (TNC 2006);
- *An Introduction to the Saugatuck River and the Saugatuck River Watershed Partnership* (SRWP 2006);
- *Saugatuck River Watershed Conservation Compact* (SRWP 2006); and
- *Weston Water Resources Guide* (Town of Weston 1993).

Within the past 10 years significant gains have been made in understanding the Saugatuck River Watershed. These have been largely due to leadership by TNC, which initiated watershed planning in the region and has strongly supported the activities of the SRWP. The following portion of this chapter summarizes the planning, education, assessment, and restoration work that has been carried out to date in the watershed.

Planning Workshops and Development of a Conservation Action Plan

Three (3) planning workshops were held over a nine (9) month period in 2004 and were attended by approximately 80 scientists, municipal officials, land managers, and other stakeholders. The goal of the meetings was to collaboratively determine the best course of action to protect the river, using TNC's "5-S" framework which identifies *systems, stresses* to systems, *sources* of stress, *strategies* for management, and measures of *success*. The following summarizes meeting results, which are discussed in greater detail in *An Introduction to The Saugatuck River and The Saugatuck River Watershed Partnership* (SRWP 2006).

Workshop No.1

Conservation targets were identified to represent the diversity of habitats and species in the watershed, and were selected jointly by meeting attendees from the 11 watershed towns. The following targets were identified:

- The upper river system above the reservoirs, where active protection has resulted in good-quality streams and diverse aquatic populations;
- The lower river system, where habitat has been compromised by urban development and many small dams and other barriers;
- The Saugatuck and Aspetuck Reservoirs, which provide drinking water to residents of New Canaan, Ridgefield, Stamford, and Greenwich;
- Diadromous fish (that is, species which migrate between fresh and salt water), threatened by the disappearance of historic spawning habitat; and consumptive water use within the reservoirs, which lessens the amount of water available for natural processes.

Workshop No. 2

Threats to the defined conservation targets were defined to "include existing conditions (for example, dams) which affect the health of the watershed, and ongoing practices and anticipated threats that are likely to affect the watershed in the next 10 years (i.e., increasing wetland loss, increased impervious surface, increased demand for water, increased threats from invasive aquatic plants and animals, and habitat loss)" (SRWP 2006). The following threats were identified:

- Development, which was assumed to be nearing threshold levels (this assumption was later confirmed by the further analysis and assessment of impervious cover, discussed in Chapter 2);
- Small dams, which disrupt natural flow patterns and the movement of sediment, and which block migratory fish species from accessing spawning habitat (over 100 dams have been mapped in the watershed [Figure 2], and many more have been observed during streamwalks);
- Land management techniques that encourage or fail to remove sources of pollution such as pet waste, grease, sand, and oil on roadways, fertilizer nutrients, litter, and leaking septic systems;
- Water withdrawals from the reservoir, streams, and groundwater aquifers which alter patterns of stream flow and limit the amount of water available for stream organisms; and
- Invasive plant and animal species, which out-compete native species for resources and thereby limit the diversity of the stream system.

Workshop No. 3

Objectives, strategies, and actions were developed to restore the watershed and address the most significant threats to its water resources. These are presented in Appendix D. During the watershed based planning process the objectives, strategies, and goals originally developed during the 2006 workshops were modified, expanded on, and reorganized slightly based on additional input from stakeholders; however, their themes and intent have strongly guided development of the goals and strategies presented in the WBP.

In 2006, a Conservation Compact was signed by the 11 municipalities, TNC, and Aquarion Water Company, recognizing the significant natural resources provided by the Saugatuck River Watershed, acknowledging the role of land use decisions on watershed conditions, and committing to work cooperatively to protect water quality, habitat, and long-term health of the system.

The Saugatuck River Watershed Partnership: Assessment, Restoration, and Education

The SRWP was established to carry out the restoration and conservation work outlined during the 2006 planning workshops, with the stated mission to "protect and enhance the health of the watershed by working collaboratively to link, maintain, and restore habitats which support healthy populations representing the natural biological diversity of the watershed system." The SRWP is made up of municipal officials representing the watershed towns; Aquarion Water Company; TNC; and others. Since it was founded in 2006, the SRWP has obtained significant grant funding and engaged in multiple restoration, assessment, and outreach activities (SRWP 2008 and S. Harold, pers. comm.) including:

- Habitat assessment and restoration activities including streamwalk assessments; in-stream flow modeling; and the installation of stream buffers, fishways, dam removal projects, and an eel bypass structure;
- Monitoring of fish and aquatic macroinvertebrates; and
- Education and outreach to members of the watershed community through public workshops and planning initiatives.

Habitat Assessment and Restoration

Beginning in 2004, the SRWP began a series of volunteer-based streamwalk surveys to assess habitat, barriers, and riparian conditions in representative reaches of the river. Between 2004 and 2008, over 60 miles of stream were surveyed by 74 volunteers trained by Natural Resources Conservation Service (NRCS) staff (SRWP 2008). Volunteers worked in groups to assess several miles of stream at a time (SRWP 2008).

In 2007, TNC hired a short-term project coordinator to assess the impact of water infrastructure in the Aspetuck Reservoir on the movement of American eels (*Anguilla rostrata*), and to identify possible methods of reducing impacts. Based on the findings of this assessment, a bypass system was installed in partnership with Aquarion Water Company to provide safe downstream passage for eels (SRWP 2009). Also in 2007, TNC and Aquarion signed a project agreement for a multi-year study of the lower Saugatuck and Aspetuck to develop a reservoir management model that would better mimic natural flow conditions while still providing adequate drinking water supplies (SRWP 2008).

During streamwalk assessments, dams and raised culverts were identified as significant impacts for fish habitat, as these barriers block fish and aquatic species from accessing portions of the river (SRWP 2008). In addition, these barriers alter the natural flow of the river and the movement of sediment through the river system. In addition to the over 100 dams within the watershed listed by CTDEEP (Figure 2), dozens of small “rockpile” dams have been identified (SRWP 2008). The SRWP has identified and successfully mitigated habitat barriers at many sites in the lower watershed, opening up approximately 37 percent of the historic habitat for migratory fish species, or 9.2 miles of stream (S. Harold pers. comm.) (Table 1). The SRWP has continually monitored fish species above and below barriers using traps, visual assessment, and an electronic fish counter.

Bio-Monitoring

The SRWP coordinates annual groups of volunteers to assist with water quality data collection through CTDEEP’s Rapid Bioassessment by Volunteers (RBV) program. Although CTDEEP has conducted bio-assessments in the Saugatuck River Watershed for many years, this influx of volunteer assistance has significantly expanded the data set (see Chapter 2 for a full discussion of existing data). The RBV sampling program uses macroinvertebrates as water quality indicators. Macroinvertebrate sampling conducted to date has indicated that water quality is sufficient to support aquatic life.

Education, Outreach, and Volunteers

The SRWP has initiated several ongoing volunteer programs as well as short-term education events and workshops to engage local residents and municipal officials in managing their watershed. The streamwalk and RBV programs described above were intended not only to

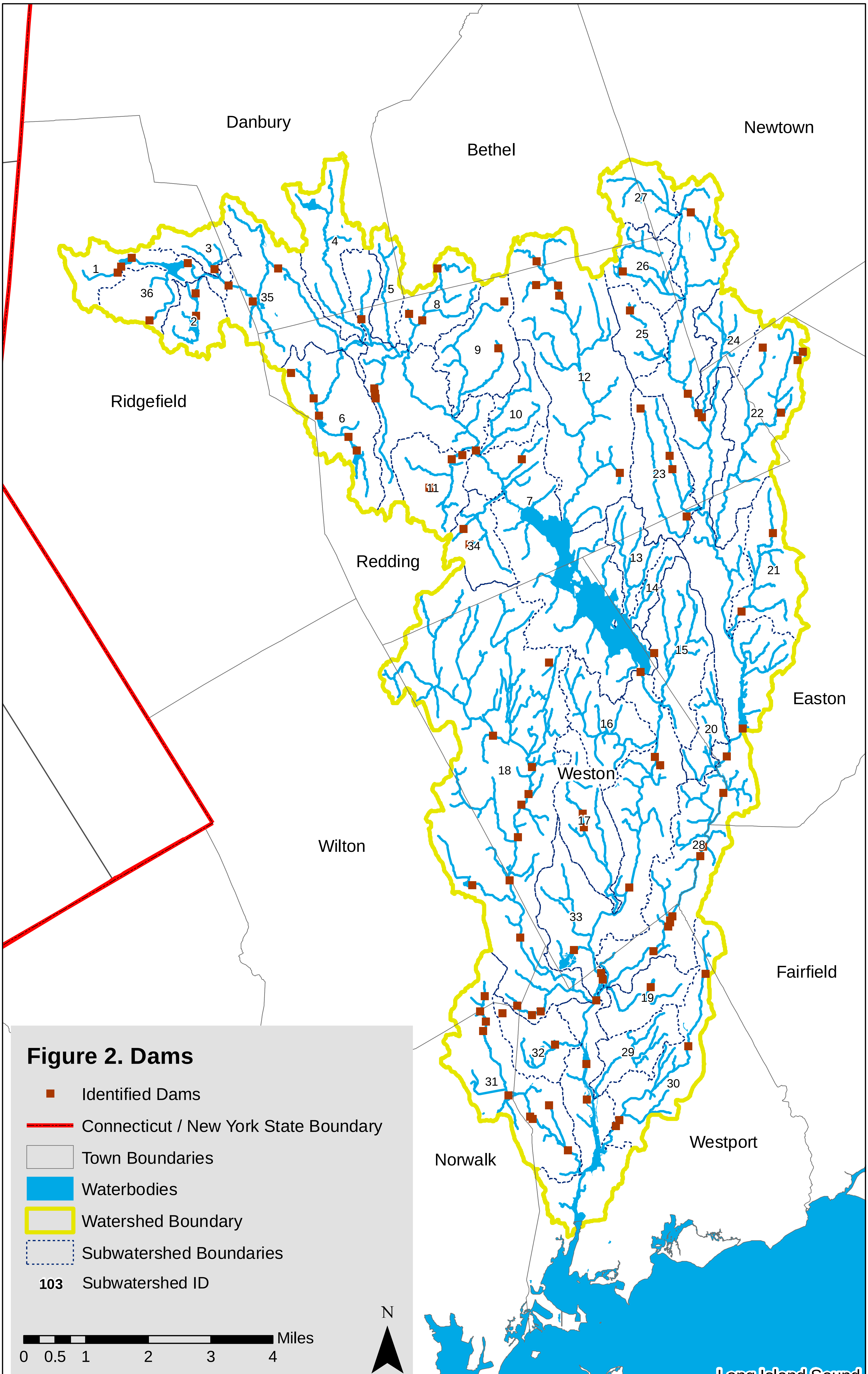


Figure 2. Dams

From the Connecticut Dams data layer, compiled and published by CTDEP (1996). Source map scale is 1:24,000.

gather data, but to provide the participants with a tangible understanding of the threats to their watershed. In addition to these programs, volunteers have assisted with data collection for fish migration studies, as discussed above; reviewed zoning information for towns within the watershed; worked to remove dams and restore streambanks; surveyed and mapped stream crossings; tagged horseshoe crabs in support of a Sacred Heart University study; and cleaned up trash and debris at multiple sites throughout the watershed (SRWP 2008; SRWP 2009).

Two free public workshops were held in 2007 to educate the public on watershed topics. Both were attended by approximately 80 members of the watershed community. The first, held in March 2007, covered stormwater management and erosion and sediment control practices. The second workshop, held in November 2007, covered a range of topics including stream flow and fisheries (SRWP 2008).

PUBLIC ENGAGEMENT & STEERING COMMITTEE

The WBP builds on the SRWP's work, and the area's history of community involvement. The WBP consolidates, synthesizes, and builds on the assessments and planning studies conducted to date, while providing a forum to revisit and reevaluate the objectives and strategies outlined in TNC's *Conservation Action Plan*. Although primarily focused on NPS pollution reduction, the goals and strategies outlined in the WBP integrate well with the habitat and conservation-focused planning that has recently been emphasized in the Saugatuck River Watershed.

The watershed based planning process provides a framework for analysis through which active members of the watershed community can shape future management activities and influence decision-making. Those who live and work in the watershed know it best, and are uniquely suited to guide goal-setting and long-term implementation. Stakeholders from the municipal, conservation, and business communities were invited to provide input from the earliest stages of WBP development through revision and publication of the final document.

The public engagement process included a series of three public meetings held on July 13, 2010; April 28, 2011; and November 30, 2011. During the first meeting, project consultants presented initial findings of the existing conditions assessment, and stakeholders defined the watershed's important uses and values, discussed the measurable attributes of the watershed and river system that provide for key uses and values, and discussed the existing impacts and emerging threats to these uses and values. Uses and values defined during the meeting included potable water, recreation, wildlife, and many other environmental and cultural attributes.

During the second meeting, the group discussed management goals that, if achieved, would preserve high-quality resources while addressing existing impacts and emerging threats. Management strategies defining specific steps required to achieve the WBP management goals were also discussed using recommendations of the *Conservation Action Plan* as guidance. Following this discussion of management goals and strategies, project consultants presented a working list of potential BMPs selected to begin to implement the management goals and strategies. Stakeholders provided feedback on these BMPs, and identified additional management actions to support goals and strategies. The third meeting was presented as a kickoff to final WBP development and implementation, and additional comments were provided by stakeholders.

In conjunction with the public engagement process, a volunteer steering committee was formed to support WBP development and review technical documents. The steering

Table 1. Fish Migration Barriers below Natural Falls[1] (SRWP 2011)

Stream	Dam[2]	Distance (mi)
Saugatuck Main Stem	I-95	0
Saugatuck Main Stem	Wood Dam	2
Saugatuck Main Stem	Lee's Pond	0.6
Saugatuck Main Stem	West Branch mouth	1
Saugatuck Main Stem	Oliver Pond	0.1
Saugatuck Main Stem	Unnamed - Chingos	0.5
Saugatuck Main Stem	Low	0.8
Saugatuck Main Stem	Hasen	1
Saugatuck Main Stem	Deutsch Pond	2.4
Saugatuck Main Stem	Natural Falls	1.1
	Miles accessible	**6**
	Total miles to natural falls	**9.5**
Saugatuck West Branch	River Mouth	0
Saugatuck West Branch	Newtown Pond	1.9
Saugatuck West Branch	Cedar Rd	1.1
Saugatuck West Branch	Natural Falls	0.5
	Miles accessible	***1.9***
	Total miles to natural falls	***3.5***
Aspetuck	Oliver Pond	0
Aspetuck	Grossman	0.9
Aspetuck	Lilian Poses	0.4
Aspetuck	Unnamed	0.6
Aspetuck	Unnamed	<0.1
Aspetuck	Unnamed	<0.1
Aspetuck	Unnamed	<0.1
Aspetuck	Unnamed	1.2
Aspetuck	Upper Aspetuck River Dam	0.15
Aspetuck	Pfeiffer Pond	1.1
Aspetuck	Kennedy's Dam	0.8
Aspetuck	Aspetuck Reservoir	0.6
Aspetuck	Hedman Pond	6
Aspetuck	Sanford Pond	<0.1
Aspetuck	Natural Falls	0.3
	Miles accessible	***4.8***
	Total miles to natural falls	***12.05***

[1]In a fully restored river, migratory fish would be able to access "historic" habitat up to the point of the first natural barrier in the stream, known as the natural falls. While this point represents the limit of habitat for migratory species, there are many other non-migratory fish species that live above natural barriers and can benefit from open habitat and barrier mitigation.

[2]Dams that block access to historic habitat, (located along the Main Stem below the natural falls), are denoted in red.

committee was composed of state and municipal representatives, and SWRPA and local stakeholders who expressed an interest in taking an active role in shaping the WBP. Members of the following organizations participated in the steering committee:

- Aquarion Water Company;
- City of Norwalk;
- CTDEEP;
- HW/RW;
- SRWP;
- TNC;
- Town of Redding;
- Town of Ridgefield;
- Town of Weston; and
- Town of Westport.

To facilitate public input across a broad demographic, a blog and interactive online map were created. Stakeholders were provided an opportunity to publish blog posts about watershed topics of their choosing. An interactive map was designed to allow users to create points of interest for potential management activities, areas of concern, or any other relevant information. In addition, project consultants shared progress updates and other relevant news and information on a weekly basis.

The draft WBP was released for public review, giving stakeholders an opportunity to review the WBP and provide feedback before the WBP was completed. The draft WBP was made available from XXX 2012 – XXXX 2012. An information session was also held on XXX 2012, where the WBP was presented to the community. Following the completion of the WBP the watershed municipalities hosted a watershed tour, which gave stakeholders a chance to view the watershed from the headwaters to the harbor. The watershed tour ended with a signing ceremony where municipal officials were invited to sign a pledge supporting the goals of the WBP.

PLAN OVERVIEW AND ORGANIZATION

At its core, the WBP establishes a framework for identifying and responding to watershed problems. In accordance with EPA guidance (EPA 2008), the WBP was developed to include the following nine (9) elements:

Identify potential causes and sources of pollution (Chapter 2)

Chapter 2 characterizes existing conditions within the watershed. The chapter provides a basic description of the physical, political, and environmental characteristics of the watershed, and characterizes the quality of aquatic resources in the watershed through a review of existing data and a stream assessment data collected during WBP development. Finally, the chapter provides estimates of NPS pollutants developed using the computer model WinSLAMM.

Pollution load reduction estimates (Chapter 3)

Chapter 3 of the WBP estimates the reductions in NPS pollutants that would be required to restore pollutant loading levels to pre-development conditions. The primary approach used to develop these estimates involved using WinSLAMM to predict the pollutant loading rates associated with an undeveloped (i.e., fully forested) watershed condition. The difference between the undeveloped loads and the actual loads presented in Chapter 2 was established as the total load reduction target. Because a 100 percent reduction in pollutant loading due to development is not feasible for all pollutants, an interim goal of 60 percent of the calculated pollution load reduction target was established.

For indicator bacteria in river sections that do not meet state standards for recreation, measured in-stream concentrations were used to develop targets. Water quality monitoring data were used to establish a statistical relationship between sampled concentrations and annual watershed loads. As with the predevelopment-based method, interim targets were established as 60 percent of the total target.

Management recommendations to address identified pollution sources (Chapters 5, 6, and 7)

Specific management recommendations required to achieve the pollutant load reductions estimated in Chapter 3 are presented in Chapters 5 and 6. Specifically, Chapter 5 outlines broad goals for the WBP and discusses management strategies for achieving these goals, which include:

- Protect and enhance water quality and high-quality stream communities;
- Restore diadromous fish populations;
- Restore impaired biological communities; and
- Preserve and enhance recreational opportunities.

Chapter 6 expands on the management strategies described in Chapter 5 by outlining specific management actions and their associated costs. Management actions include structural and non-structural BMPs as well as broader programs geared toward managing pollution across the watershed.

Chapter 7 discusses the identification and assessment of individual structural BMPs meant to reduce NPS pollution. Individual structural BMP descriptions and estimated costs and pollutant load reductions associated with each BMP are presented in Appendix A and Chapter 7.

Sources of financial and technical assistance (Appendix B)

Sources of financial and technical assistance are provided in Appendix B of the WBP. Sources include grant funding, foundation support, and other forms of funding.

Education and outreach (Chapter 8)

Chapter 8 speaks specifically to education and outreach activities that support WBP implementation. The education and outreach approach emphasizes reaching out to homeowners and business owners to educate them about the relationship between property management and watershed health, and to offer practical suggestions for simple, inexpensive actions that can be taken to reduce NPS pollution.

Plan implementation schedule (Chapter 6)

Chapter 6 provides an implementation schedule for each identified management action.

Interim milestones (Chapter 6)

Chapter 6 provides interim milestones required for the implementation of each identified management action.

Implementation performance criteria (Chapter 6)

Chapter 6 outlines performance criteria for each identified management action.

Monitoring and assessment (Chapter 9)

Chapter 9 outlines recommended steps for monitoring and assessment. Monitoring recommendations include routine monitoring of water quality, macroinvertebrates, and habitat at fixed monitoring stations; early-warning monitoring to identify emerging threats in small headwater subwatersheds; and monitoring for structural BMPs.

A watershed based plan relies on a thorough and science-based understanding of the existing conditions of streams and rivers throughout the watershed. This chapter provides a basic description of the physical, political, and environmental characteristics of the watershed, and characterizes the quality of aquatic resources in the watershed through a review of existing data sources and stream assessments performed collected during WBP development. This chapter also provides estimates of NPS pollution developed using the computer model WinSLAMM. Finally, the chapter presents the use designations established by CTDEEP for various stretches of the Saugatuck River and its tributary streams.

Overall, the existing conditions assessment reveals a river system that has been somewhat, although not extensively or severely, impacted by development and other human activities. The greatest impacts are seen in the lower half of the watershed. Somewhat surprisingly, however, the impacts of development are also evident, albeit less pronounced, in the upper reaches of the watershed, emphasizing how sensitive streams can be to even modest changes in land use. A review of CTDEEP bio-monitoring data shows healthy macroinvertebrate communities present throughout the watershed and healthy fish communities present at the majority of sampled sites. Fish communities show signs of impact in some areas south of the Saugatuck Reservoir, possibly related to the effects of in-stream barriers such as dams. Water quality sampling data show that the river is well-oxygenated in all sampling locations; however, bacteria levels are elevated in sites along the West Branch and just above the Saugatuck Reservoir (Harris and Fraboni 2008). Visual assessments conducted by AKRF in the summer of 2011 found habitats to be in fair to good habitat condition in most locations. Habitat quality was particularly good within the large preserved areas surrounding the Saugatuck Reservoir and in the Town of Redding where forested streambanks and good-quality in-stream habitats are found in abundance.

The assessment's results are generally consistent with the levels of impact that would be expected given the level of development in the watershed. The results are based on such widely accepted models as the Impervious Cover Model (ICM) (Center for Watershed Protection [CWP] 2003). The ICM postulates that the degree of water quality and habitat impact is well correlated to the amount of impervious cover in the watershed. In the Saugatuck River, impervious cover comprises approximately 11 percent of the watershed's total area. National studies have shown that rivers flowing through watersheds with this level of impervious cover will commonly begin to show impacts to habitat and water quality, although these impacts are typically not severe.

Understood as a whole, the watershed remains a place characterized in many locations by abundant and vibrant natural resources and high-quality streams but where the effects of modest urban development combined with the legacy impacts of mill damming are also evident. Because impacts to the river have not yet reached a severe state on a broad scale, the WBP must effectively balance the need to protect existing high-quality resources with the need to improve conditions in problem areas.

WATERSHED CHARACTERIZATION

The approximately 57,000-acre Saugatuck River Watershed is located in the coastal slope and lowlands of Fairfield County, Connecticut. The river flows south from its headwaters in Ridgefield, Danbury, Bethel, Newtown, and Redding, through the Towns of Easton and Weston before emptying into LIS in Westport. Small parts of Norwalk, Fairfield, and Wilton also drain to the lower segments of the Saugatuck River. The watershed is bisected by the Metro-North Railroad and by two major highways, I-95 and the Merritt Parkway (CT-15). For the purposes of the WBP, the study area ends at the point where the Metro North Railroad tracks cross over the estuary.

The Saugatuck River Watershed contains approximately 271 miles of stream, including all tributary streams. Major tributaries include the Aspetuck (73 miles), the West Branch (43 miles), the Little River (17 miles), Jennings Brook (six [6] miles), Beaver Brook (six [6] miles), Poplar Plains Brook (two [2] miles long), and many smaller, unnamed streams. The Main Stem of the Saugatuck River from below the Saugatuck Reservoir to the downstream extent of the study area is approximately 11 miles long.

The Saugatuck River Watershed is a major drinking water source that feeds three drinking water reservoirs that together comprise perhaps the most profound way that human activity has modified the river system. The Saugatuck Reservoir, located on the river's central Main Stem, provides drinking water to approximately 300,000 people. Water is impounded and diverted from the Saugatuck River to the Aspetuck Reservoir, and then further diverted to the Hemlock Reservoir and the water treatment plant (SRWP 2008). Many residential properties within the watershed are served by wells.

Land use within the watershed ranges from the significant tracts of contiguous forest cover that typify the watershed's upper region to the patchwork of urban and suburban development and smaller undeveloped lands that covers the lower watershed. Within the channel proper, heavy channelization and channel modification are absent, but numerous small mill dams, and culverts frequently interrupt flow. Over 100 dams have been identified in the Saugatuck River Watershed (Figure 2; SRWP 2008).

Water Quality

High-quality water resources are important to support the recreational, environmental, and drinking water needs of the local community. Many residents get their drinking water from private wells, which depend on clean groundwater with good rates of recharge. The upper watershed drains to the Saugatuck Reservoir, which provides drinking water to residents living within and outside of the watershed. In addition to providing a drinking water source, the Saugatuck River is also used recreationally for fishing. Boaters row and paddle the multiple small ponds along the lower reaches of the Saugatuck River. Given the diversity of uses that depend on high-quality water, water quality is a serious concern.

Both water quality sampling and bio-monitoring assessments conducted to date have indicated that water quality is sufficient to support aquatic life in the Saugatuck River (see "Stream Condition Assessment"). Indicator bacteria were found in levels considered unsafe for recreation at multiple sites in subwatersheds 18 (West Branch), and 7 (just above the Saugatuck Reservoir) (Harris and Fraboni 2008); and in subwatershed 28 (Aspetuck) (unpublished data, provided by M. Beauchene in 2011). Based on an analysis of fish and macroinvertebrates found in the stream (discussed below under "Aquatic Biota Analysis"), high concentrations of bacteria do not appear to be harming aquatic species; however, elevated bacteria levels have impacted the river's suitability for recreational use.

Land Use

Land use is one of the most important variables in understanding watershed condition. As development increases, stream conditions worsen due to changes in the hydrologic cycle. Many factors influence how a watershed responds to development. These include physical characteristics of the river and how and when the development takes place. Percentage of impervious cover is generally accepted as an indicator of overall watershed health (CWP 2003). An in-depth discussion of the impacts of impervious cover is presented later in this chapter.

Historically, the Saugatuck River has provided an important resource to the people who have lived along its banks. Prior to European settlement, the river provided fish as a food source for native groups living in the region (SRWP 2008). In fact, the name Saugatuck is a Native American word that means “river flowing out” (SRWP 2008). Prior to 1900, European settlers used the region for farming and agriculture. Many forested areas are still crossed by low stone walls left behind by farmers. In the estuary, oyster farming became a major industry, peaking in the early 20th century (www.connecticuthistory.org). Since then, the land has been cleared and developed for suburban and semi-rural neighborhoods, although large, preserved areas remain. Commercial areas are mainly concentrated near the coast. The region has experienced rapid residential and commercial development over the past 50 years, and is characterized by a robust local economy as well as a large, residential population.

Current day land use within the Saugatuck River Watershed is primarily residential (67 percent) (Table 2). The watershed has a more rural character in the upper watershed, while suburban residential communities dominate land use in the lower watershed (Figure 3, Table 2). Approximately 31 percent of the watershed is preserved as open space. The remaining two (2) percent of the watershed’s land use is designated for freeways, commercial, industrial, and institutional uses. Impervious cover is estimated to be 11 percent of the total watershed area.

Table 2. Watershed Land Use

Land use	Percent of Watershed Area
Commercial	1
Freeway	<1
Industrial	<1
Institutional	1
Other Urban/Open Space	31
Residential	67

Land use data provided by SWRPA as a composite of local land use, zoning, and open space data, and the University of Connecticut (UConn) Center for Land Use Education & Research (CLEAR).

Vegetation and Wildlife

Vegetation and wildlife are closely tied to land use and soil type characteristics. In the Saugatuck River Watershed, the plant and animal species found are generally typical of the region. Forest composition, which in most areas contains a mix of native and non-native species, is generally consistent with some level of human modification.

The upper portion of the watershed is characterized by low, rolling hills where successional oak and oak-pine forests once covered the landscape (Griffith et. al. 2009). The lower portion of the watershed is characterized as LIS Coastal Lowland, where hills give way to low-elevation coastal plain (Griffith et. al. 2009). Native forest vegetation includes oaks (*Quercus sp*.), hickories

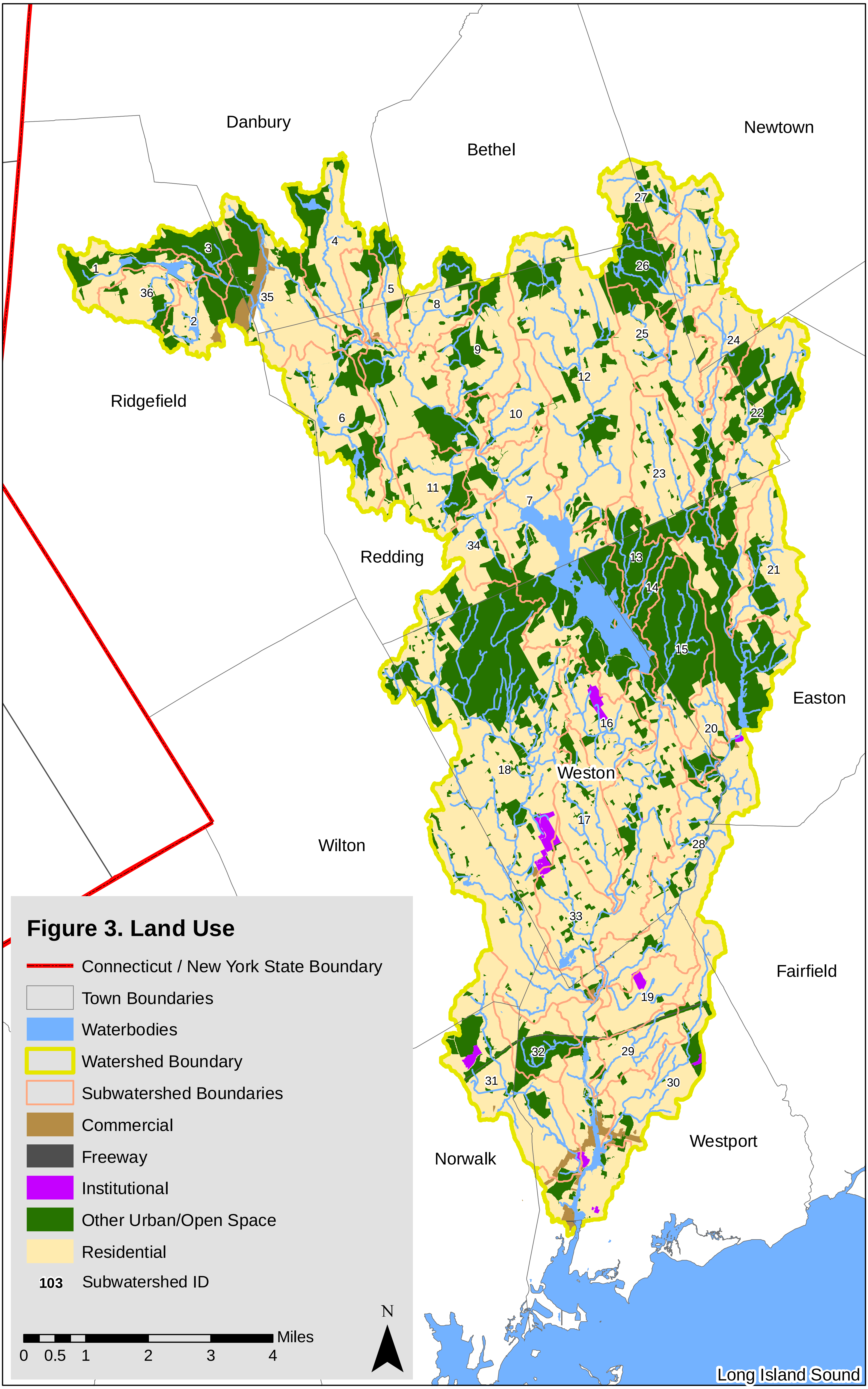


Figure 3. Land Use

Land use data provided by SWRPA as a composite of local land use, zoning, and open space data, and the Uconn CLEAR 2006 Connecticut Land Cover Data.

(*Carya sp.*), and dense brier thickets (Griffith et. al. 2009). The lower portion of the watershed represents the northernmost reach of some Piedmont-type vegetation species including holly (*Ilex sp.*), sweetgum (*Liquidambar sp*.), and post oak (*Quercus stellata*) (Griffith et. al. 2009).

The Centennial Watershed State Forest which surrounds the Saugatuck Reservoir is home to diverse plant and animal communities where several species of rare wildflowers and forest nesting birds can be found (www.nature.org, Saugatuck Forest Lands; accessed 6/26/12). Wetlands and vernal pools throughout the forest provide habitat for a variety of amphibian species, including wood frogs (*Rana sylvatica*) and several types of salamander (*Eurycea sp.*) (www.connecticutwilderness.com, accessed 6.13.12). The river itself contains migratory fish such as alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American eel, and sea lamprey (*Petromyzon marinus*), as well as many species of resident fish.

In the lower watershed, remaining forested land is becoming increasingly disturbed by development. As is typical in the region, native forest species have given way in many areas to large stands of invasive species, including bamboo (*Bambusa vulgaris*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), and others. An overabundance of white-tailed deer has led to increasing pressure to hunt these animals as a forest management measure.

Soils and Geology

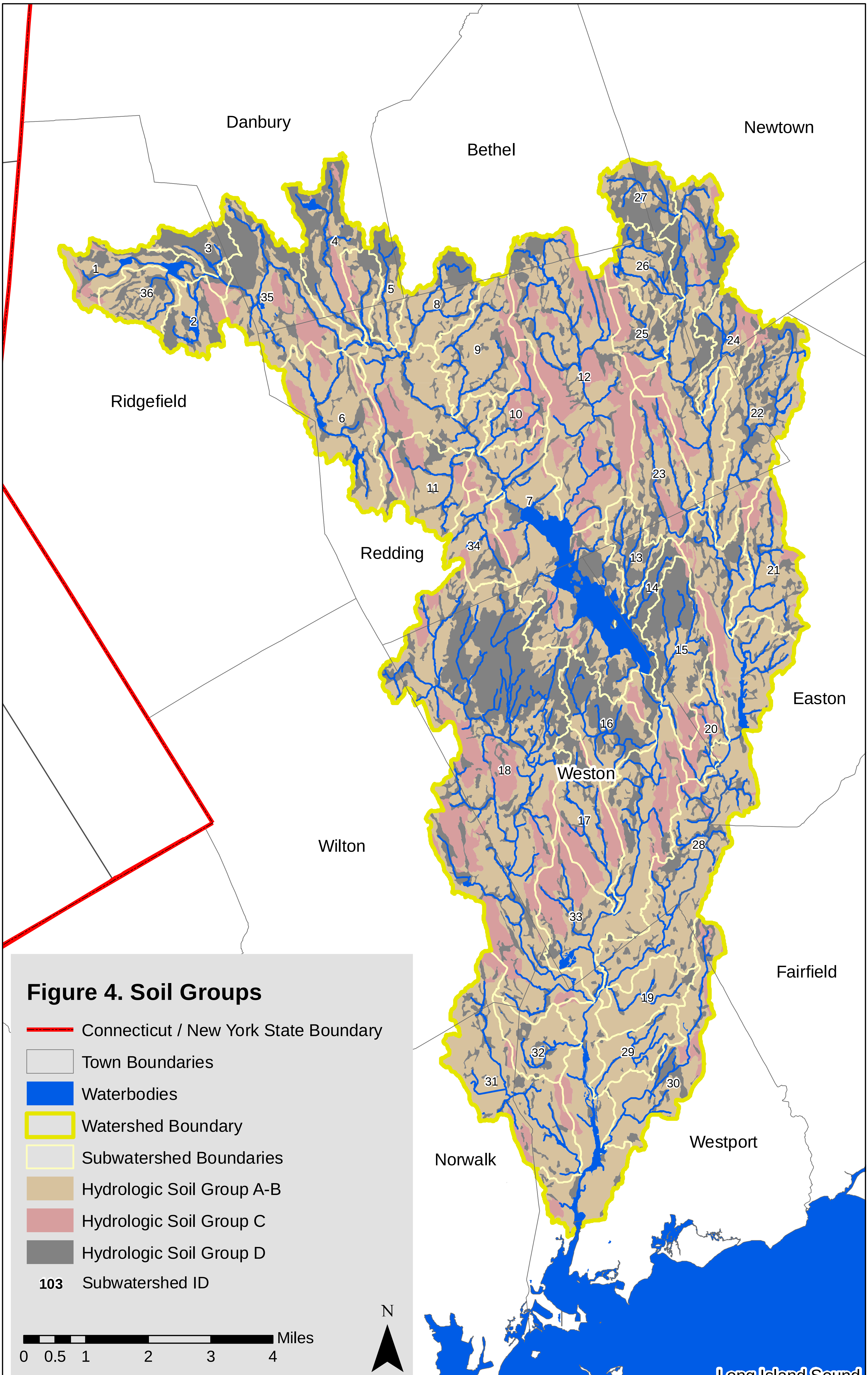
Soils and geology play an important role in stream processes. For instance, sedimentation and P cycling, two processes that strongly influence stream chemistry and habitats, are dependent on soil characteristics such as erodability and organic material content. Regional geology influences the shape and gradient of the stream channel, which in turn influences how the river flows and changes shape over time.

Soils and geology within the Saugatuck River Watershed are generally representative of the region. The watershed is underlain by metamorphosed sedimentary and igneous schist and gneiss formations of the Hartland and Gneiss Dome belts, both relatively erosion-resistant formations (Griffith et. al. 2009). Regionally the formations are located within the Connecticut Valley Synclinorium (Griffith et. al. 2009). Soils within the watershed are classified as Hydrologic Soil Group (HSG) A-B, C, or D which represent, in order, good, fair, and poor drainage conditions. Well-drained soils predominate overall, although conditions vary significantly (soil data provided by SWRPA). The majority of soils are well-drained (classified as HSG A-B), although a large additional portion of the watershed is dominated by poorly drained soils (HSG D) (Table 3, Figure 4).

Table 3. Hydrologic Soil Group Percent of Total Area

Hydrologic Soil Groups	Percent of Watershed Area
Groups A and B	53
Group C	14
Group D	30
Water	3

Manipulated soil data provided by SWRPA; Original data obtained from the SSURGO database for the State of Connecticut



Manipulated soil data provided by SWRPA; Original data obtained from the Soil Survey Geographic (SSURGO) database for the State of Connecticut

STREAM CONDITION ASSESSMENT

A stream condition assessment was conducted to understand how water quality, habitat quality, and the diversity and composition of aquatic communities vary throughout the watershed. Understanding the existing condition of streams and rivers within the Saugatuck River Watershed involved several steps, including looking at the overall level of development within the watershed as an indicator of watershed stress, reviewing past water quality studies and biological data, and conducting visual assessments of the stream channel in representative locations to assess the quality and diversity of aquatic habitats.

Based on the assessment, most portions of the watershed appear to be in good to fair condition for the support of aquatic life. Fair stream conditions were generally associated with areas of dense residential or commercial development, while good conditions were generally associated with reaches draining forested areas. Conditions were worse than expected (based on the level of development in upstream areas) at one site in the northeastern headwaters of the West Branch, and in the far headwaters of the Aspetuck, which was most likely related to locally poor conditions in otherwise undeveloped areas.

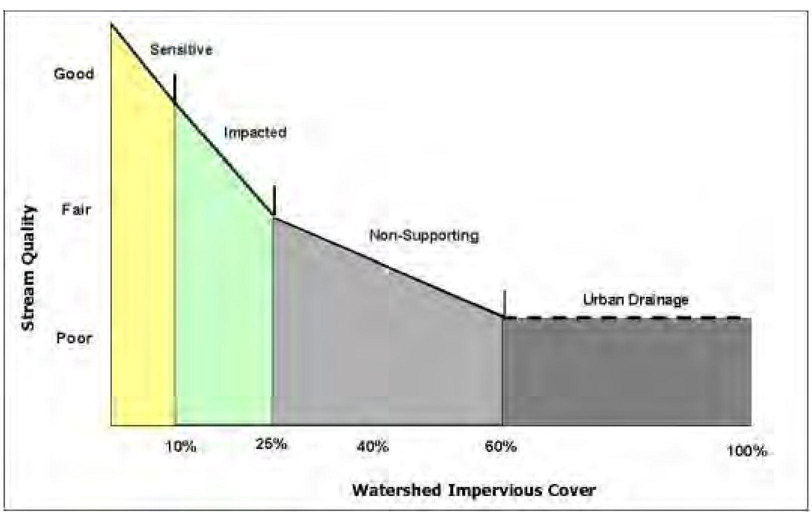
Impairments have been identified at sites on the West Branch Main Stem, and Aspetuck where bacteria are present in levels considered unsafe for recreation (CTDEP 2011, Water Quality Report). These problems do not appear to be impacting biotic communities. Stakeholders have suggested that much of the bacteria may be coming from wildlife sources rather than pollution related to development (discussed in detail in the following pages). Nevertheless, the river is used extensively for recreation, and based on state standards this use cannot be fully met in some locations until bacterial concentrations are reduced.

Impervious Cover Analysis

Impervious cover refers to land cover that does not infiltrate rainfall. Parking lots, roads, driveways, roofs, sidewalks, and other impervious areas speed the rate at which water travels over land. This ultimately leads to higher peak flows during storms, and lower rates of groundwater recharge. Stormwater from impervious surfaces tends to carry high concentrations of pollutants, particularly bacteria, nutrients, and sediment.

In mixed-use watersheds, stream condition is often correlated with total impervious cover, which serves as an index of watershed modification and urbanization. Figure 5 describes the ICM (CWP 2003), a useful tool for understanding the level of stream impacts associated with development. The ICM establishes "thresholds" of watershed imperviousness beyond which aquatic life is increasingly impacted. At approximately 10 percent impervious, signs of impact are seen in habitat and aquatic communities. At approximately 25 percent

Figure 5. Impervious Cover Model



impervious, habitat degrades below the minimum needed to support aquatic life. With impervious cover estimated at approximately 11 percent in the Saugatuck River Watershed, the river is expected to show signs of human impacts, but to support aquatic life. Visual, biotic, and water quality assessments have corroborated this prediction.

To relate impervious cover to stream conditions, the stream network was divided into a series of 36 second-order reaches, each draining a smaller basin area (referred to here as a "subwatershed"), with the Main Stem confluence serving as the downstream extent (Figure 6). Direct drainage areas to the Main Stem were delineated as one subwatershed, which was then split into segments (subwatersheds 33, 7, 35 and 36). Subwatershed 18 (West Branch) was further divided for the purpose of the impervious cover assessment only, based on highly variable land use conditions within this large subwatershed (the lower, more developed portion is referred to as 18a, while the upper, largely forested region is referred to as 18b for the purposes of this analysis). Percent impervious cover was then estimated for each subwatershed. Percent impervious cover was also estimated for a 200-foot buffer area surrounding each stream reach. The expected condition of each reach was predicted using an impervious cover score based on the ICM discussed above (Table 4, Figures 5 and 7). The percent impervious cover for both total subwatershed area and adjacent buffer area for each stream reach were assigned a score based on the following rubric:

- IC < 10 percent = 0
- IC 10–25 percent = 1
- IC > 25 percent = 2

The score for the subwatershed area and adjacent buffer area were summed and categorized according to the following rubric:

- Total score 0 = good
- Total score 1–2 = fair
- Total score 3–4 = poor

Visual Assessment

Visual assessments were conducted to check the conditions predicted by the ICM against actual conditions. The intention was to observe "areas of friction" where the ICM predictions did not accurately predict the observed condition, and to further investigate these areas to learn more about conditions specific to the Saugatuck River Watershed. Conditions not addressed by the ICM but which may have influenced the visual assessment include time period since most recent land disturbance, quality of riparian vegetation, and condition and type of pervious surfaces.

On April 15 and 16, 2011 visual assessments were conducted at nine representative locations (Table 5, Figure 8) within the Saugatuck River to evaluate the quality of in-stream and riparian habitats over a land use gradient. Assessments were conducted following high-flow conditions in March of 2011. Sample sites were selected based on expected conditions following the impervious cover analysis, independent of previous water quality monitoring or assessment locations. Sample locations were selected to include a range of impervious cover score levels, position within the watershed, and geographic breadth. Assessments were performed using the NRCS Stream Visual Assessment (SVA) Protocol (NRCS 1998). This protocol integrates

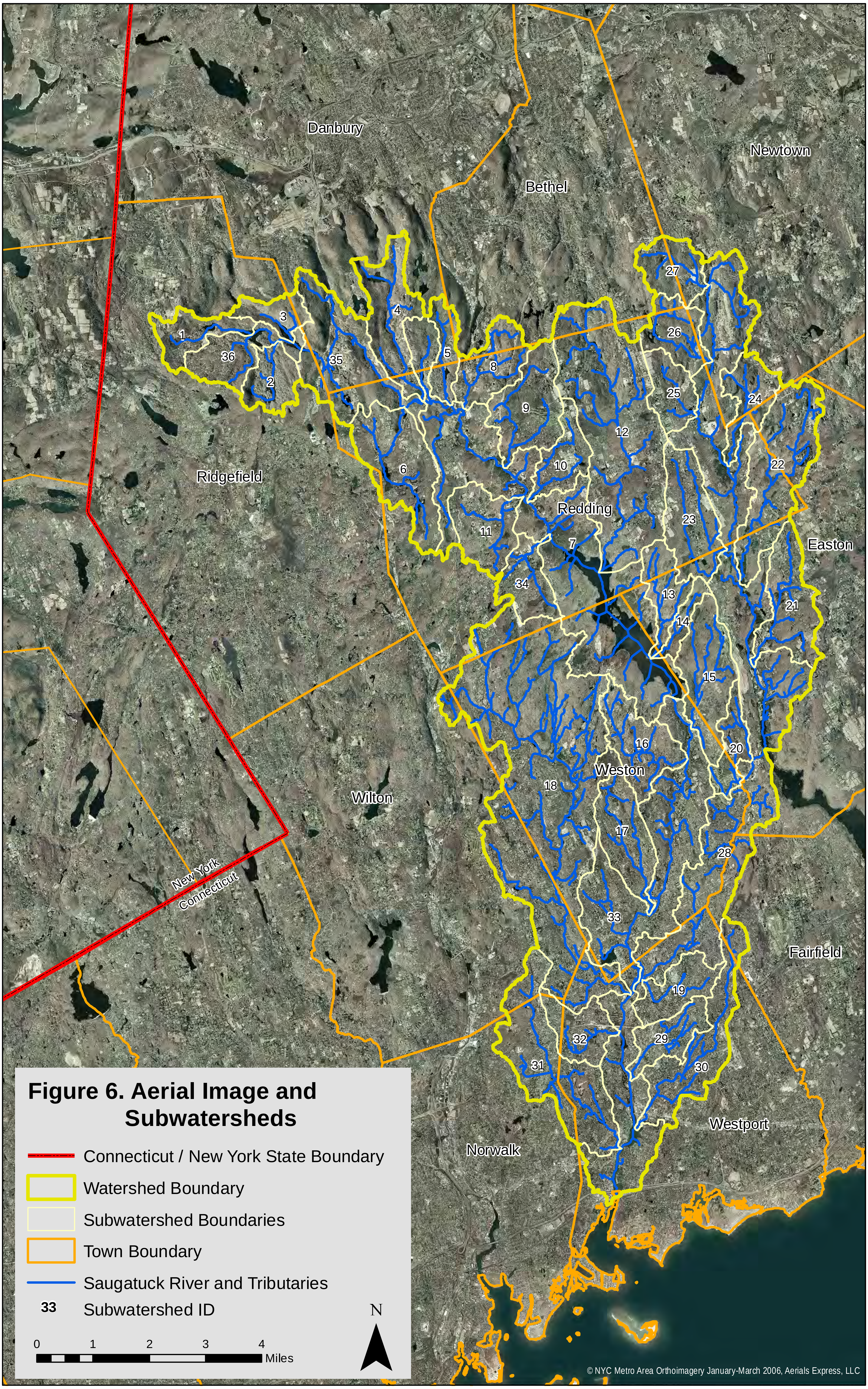


Figure 6. Aerial Image and Subwatersheds

Table 4. Impervious Cover Score

	Land cover within subwatershed					Land cover within riparian buffer					
	Land Area (acres)			Land Area Percent		Land Area (acres)			Land Area Percent		
Subwatershed	Total Area	Impervious	Pervious	% IA	%PA	Total Area	Impervious	Pervious	% IA	%PA	Impervious Cover Score
1	601.09	38.30	562.79	6	94	86.92	3.25	83.67	4	96	**0**
2	584.15	45.50	538.65	8	92	107.09	10.39	96.70	10	90	**1**
3	415.14	0.59	414.55	<1	100	63.61	0.00	63.61	<1	100	**0**
36 (Headwaters)	792.98	45.29	747.68	6	94	134.30	2.94	131.36	2	98	**0**
36 and tributaries	2393.36	129.68	2263.68	5	95	391.91	16.57	375.34	4	98	**0**
4	1175.90	61.34	1114.56	5	95	253.55	10.98	242.57	4	96	**0**
6	1525.32	144.34	1380.98	9	91	240.42	16.02	224.40	7	93	**0**
35	1855.41	269.46	1585.95	15	85	340.70	76.22	264.48	22	78	**2**
35 and tributaries	6949.99	604.83	6345.16	9	91	1226.58	119.79	1106.79	10	78	**1**
5	461.00	39.06	421.94	8	92	103.63	8.11	95.52	8	92	**0**
8	827.07	61.34	765.73	7	93	216.20	11.75	204.45	5	95	**0**
9	1175.41	46.99	1128.42	4	96	216.56	9.36	207.20	4	96	**0**
10	637.04	81.39	555.65	13	87	164.31	20.03	144.28	12	88	**2**
11	926.69	143.41	783.29	15	85	148.67	13.47	135.19	9	91	**1**
12 (Little River)	3982.96	356.98	3625.98	9	91	783.14	51.52	731.62	7	93	**0**
13	608.76	1.49	607.27	<1	100	218.03	0.28	217.75	<1	100	**0**
14	266.92	0.32	266.60	<1	100	93.34	0.00	93.34	<1	100	**0**
34	674.32	65.61	608.70	10	90	147.70	13.96	133.74	9	91	**1**
7 (Saugatuck Reservoir)	5575.53	117.90	5457.64	2	98	1150.32	19.14	1131.18	2	98	**0**
7 and tributaries	22085.70	1519.32	20566.38	7	93	4468.48	267.42	4201.06	6	98	**0**
19	680.07	95.36	584.71	14	86	104.73	13.58	91.15	13	87	**2**
20	500.54	28.88	471.66	6	94	191.20	7.96	183.24	4	96	**0**
21	1126.55	95.81	1030.75	9	91	258.87	14.16	244.71	5	95	**0**
22	1851.51	113.92	1737.59	6	94	404.39	17.25	387.14	4	96	**0**
23	1175.07	52.18	1122.89	4	96	276.84	6.06	270.78	2	98	**0**
24	666.92	10.47	656.44	2	98	162.89	2.74	160.15	2	98	**0**
25	602.23	24.03	578.20	4	96	91.26	1.21	90.05	1	99	**0**
26	695.61	2.06	693.55	<1	100	193.79	0.62	193.17	<1	100	**0**
27	676.62	8.96	667.66	1	99	140.22	1.98	138.23	1	99	**0**
28 (Aspetuck River)	6782.04	508.89	6273.15	8	92	1608.30	85.53	1522.76	5	95	**0**
28 and tributaries	14757.15	940.55	13816.60	6	94	3432.48	151.10	3281.38	4	95	**0**
15	1259.87	6.26	1253.61	<1	100	304.29	0.75	303.53	<1	100	**0**
16 (Jennings Brook)	1008.50	108.16	900.34	11	89	302.42	31.63	270.79	10	90	**2**
17 (Beaver Brook)	1095.76	128.38	967.38	12	88	261.76	30.95	230.81	12	88	**2**
18b (West Branch headwaters)	3881.24	577.03	3304.21	15	85	1114.07	54.09	1059.97	5	95	**1**
18a (Lower West Branch)	3744.69	1364.71	2379.97	36	64	871.12	110.43	760.69	13	87	**3**
18 (All West Branch, 18a + 18b)	7625.93	1941.74	5684.18	25	75	1985.19	164.53	1820.66	8	87	**3**
29	613.80	82.36	531.43	13	87	189.32	24.64	164.68	13	87	**2**
30	1430.49	208.89	1221.60	15	85	367.88	53.78	314.10	15	85	**2**
31 (Stony Brook)	2081.19	733.48	1347.70	35	65	386.35	56.94	329.41	15	85	**3**
32 (Poplar Plain Brook)	673.87	183.96	489.90	27	73	100.82	9.20	91.62	9	91	**2**
33 (Lower Saugatuck River)	4640.46	712.84	3927.61	15	85	879.26	125.78	753.49	14	86	**2**
33 and tributaries	57272.71	6565.95	50706.76	11	89	12678.25	916.70	11761.54	7	86	**2**

IA is impervious cover

PA is pervious cover

Impervious cover scores equate to the following expected stream conditions:

Poor (impervious cover score = 3 or 4)

Fair (impervious cover score = 1 or 2)

Good (impervious cover score = 0)

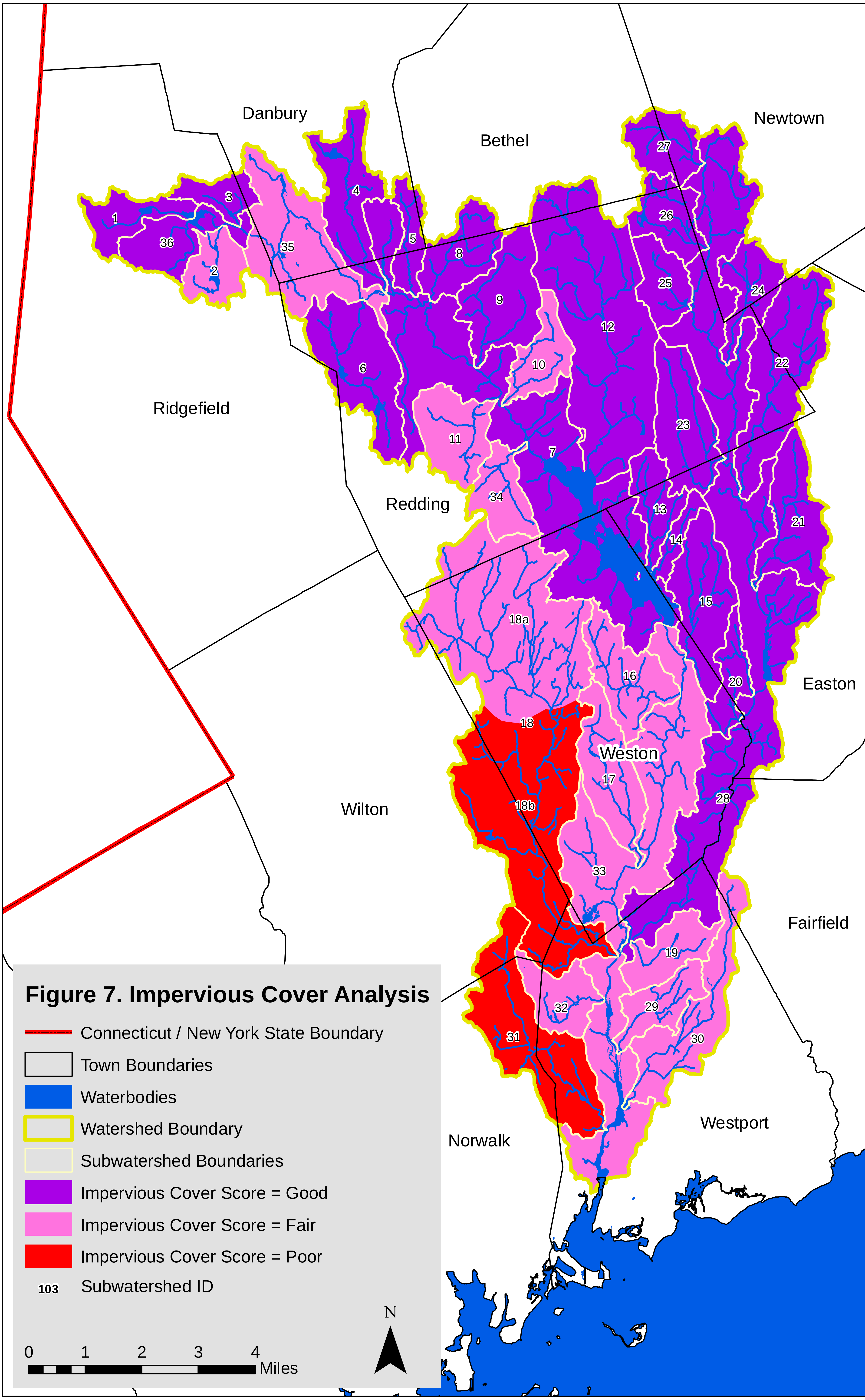


Figure 7. Impervious Cover Analysis

stream stability, water quality, and habitat into a single numeric score from 1 to 10, where 10 represents the best condition (see Appendix C for scoring criteria and results). The score for each attribute was averaged to generate the reach SVA score.

Table 5. Stream Visual Assessment Score

Sample Location ID	Subwatershed (Headwaters to outlet)	SVA Category*	Impervious Cover Score** in Same Reach as Sample
27	4	good	good
28	4	good	good
24	12 (Little River)	good	good
25	7 (Saugatuck Reservoir)	good	good
26	7 (Saugatuck Reservoir)	good	good
21	28 (Aspetuck)	good	good
22	28 (Aspetuck)	fair	good
23	28 (Aspetuck)	fair	good
29	18 (West Branch)	fair	poor
32	18 (West Branch)	poor	fair
30	33 (Lower main stem)	fair	fair
31	33 (Lower main stem)	fair	fair

***SVA categories equate to the following SVA scores:**
≤6.0 = Poor
6.1-7.4 = Fair
7.5-8.9 = Good
≥9.0 = Excellent
****Impervious cover scores equate to the following expected stream conditions:**
Poor (impervious cover score = 3 or 4)
Fair (impervious cover score = 1 or 2)
Good (impervious cover score = 0)

Aquatic Biota Analysis

Aquatic species exhibit a range of tolerance to pollution. Species with the lowest tolerance tend to be found only in the highest-quality streams, while species with higher tolerance are more widespread across a varied range of stream conditions. Typically, macroinvertebrates and fish are used as indicator species to predict water quality and habitat condition.

CTDEEP has sampled macroinvertebrates and fish as indicators of water quality on a semi-regular basis since the late 1980s. These monitoring data are used to help CTDEEP understand habitat and water quality conditions in the stream. In recent years the SRWP has coordinated large groups of volunteers to assist with more regular and extensive data collection via CTDEEP's RBV program, significantly expanding the data set. These data were provided by CTDEEP for the purpose of this analysis.

Using the CTDEEP sample data, simple metrics of pollution tolerance were applied to generate an expected aquatic biota support score for each sample location (Roth et Al., 2000; Barbour et al., 1999; Hilsenhoff 1982). For fish and macroinvertebrate metrics, categories were assigned as

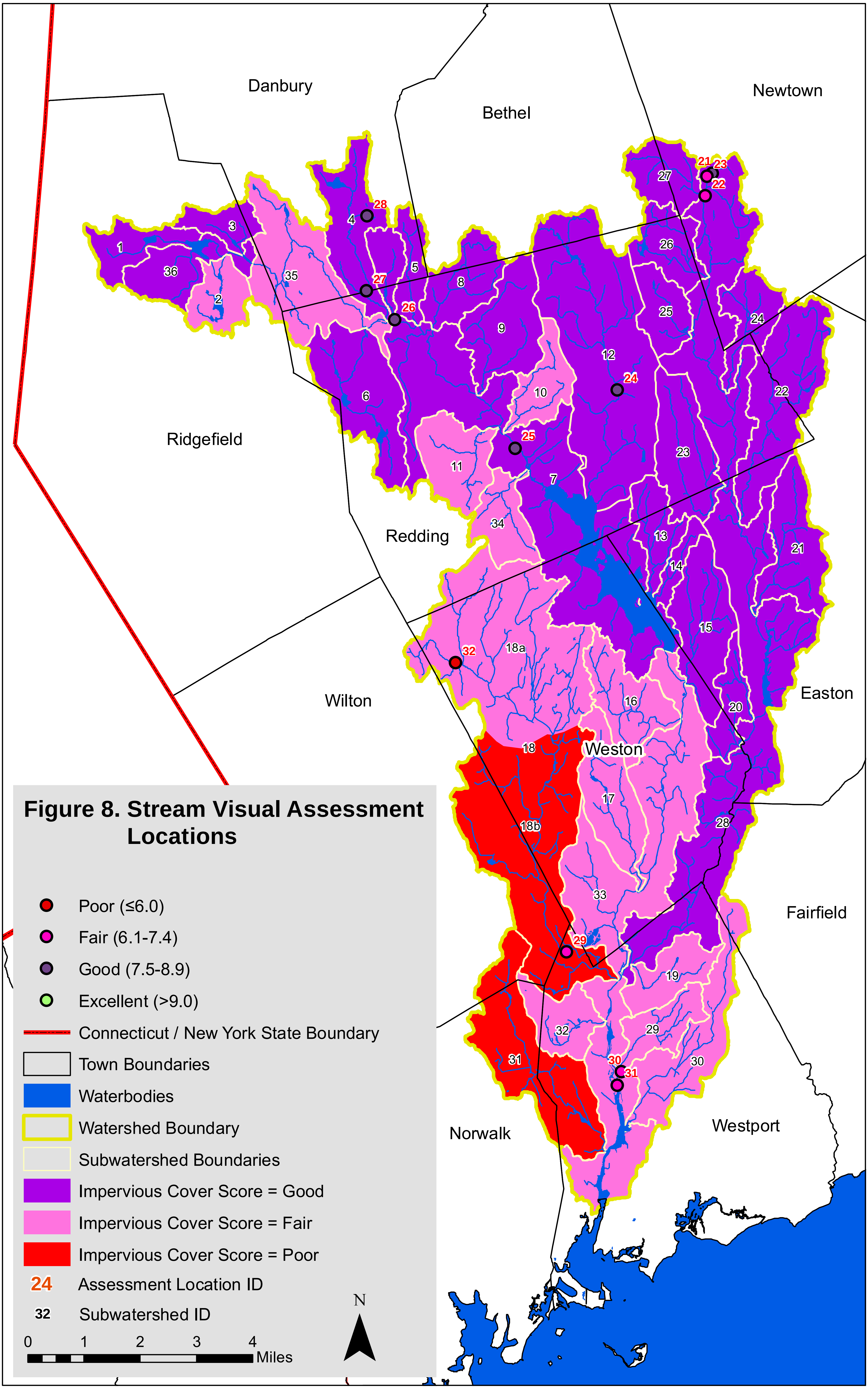


Figure 8. Stream Visual Assessment Locations

- Poor (≤6.0)
- Fair (6.1-7.4)
- Good (7.5-8.9)
- Excellent (>9.0)
- Connecticut / New York State Boundary
- Town Boundaries
- Waterbodies
- Watershed Boundary
- Subwatershed Boundaries
- Impervious Cover Score = Good
- Impervious Cover Score = Fair
- Impervious Cover Score = Poor
- 24 Assessment Location ID
- 32 Subwatershed ID

"supporting," "impaired," or "severely impaired" (Table 6, Figure 9):

- Score 0.0–5.0 = supporting
- Score 5.1–6.9 = impaired
- Score 7.0–10.0 = severely impaired

Macroinvertebrate communities at all sites included in this analysis have indicated good water quality that can support a diverse range of aquatic life. Fish community sampling has indicated possible habitat and/or water quality problems in subwatersheds 18 (West Branch), 28 (Aspetuck), and 34 (a small unnamed tributary draining to the Main Stem above the Saugatuck Reservoir). However, because fish are highly mobile, their presence or absence may be more related to barriers in the stream channel than to water quality/habitat problems; for this reason fish data in the Saugatuck River may not be truly indicative of water and/or habitat quality.

Review of Water Quality Sampling Data

An ambient water quality monitoring program was initiated by CTDEEP with HW/RW in 2005 to investigate dissolved oxygen, *Escherichia coli (E. coli),* fecal coliform, temperature, and conductivity in the West Branch, Saugatuck Main Stem, and tributaries below the Saugatuck Reservoir (Harris and Fraboni 2008) and later in the Aspetuck (data provided by CTDEEP). The results suggest that water in the Saugatuck River provides sufficient oxygen to support aquatic animals; however, bacteria in the West Branch, Aspetuck, and just above the Saugatuck Reservoir may make these areas unhealthful for recreational activities (Harris and Fraboni 2008). *E. coli* and fecal coliform—both indicators of pathogenic bacteria—were very closely correlated in this study (see Appendix E for a full discussion of correlation between *E. coli* and fecal coliform).

Some question has arisen regarding the sources of bacteria, particularly in areas surrounding the Saugatuck Reservoir which drain undeveloped land. Based on an unpublished, in-house study of fecal coliform bacteria levels of streams within areas draining to the major reservoirs, environmental analysts at the Aquarion Water Company have suggested that significant fecal coliform bacterial loading (including fecal coliform bacteria level "spikes" associated with storm events) is very likely generated by wildlife, and is not necessarily indicative of pollution (B. Roach; pers. comm.). Further study in both developed and undeveloped areas would be useful to isolate what portion of the bacterial load is coming from wildlife, versus from pet waste, leaking septic systems, urban runoff, or other factors.

Stream Condition Assessment Summary

The stream condition assessment included analyses of impervious cover, assessment and review of monitoring data, and field reconnaissance of aquatic habitat conditions. Results of this analysis reveal a river that has been somewhat impacted by urbanization but where high quality habitat and reasonably healthy aquatic communities persist in many areas. Conditions in the watershed range from good to poor across a land-use gradient, with areas in good condition generally associated with low levels of upstream impervious cover, well-established riparian buffers, and undeveloped floodplains.

Based on the impervious cover analysis, Saugatuck River conditions were predicted to range from good to poor, with good conditions predicted in the reaches draining preserved areas surrounding and above the Saugatuck Reservoir, and reaches draining to subwatershed 28 (Aspetuck) (Table 4, Figure 7). Fair conditions were predicted in subwatersheds 2, 35, 10, 11,

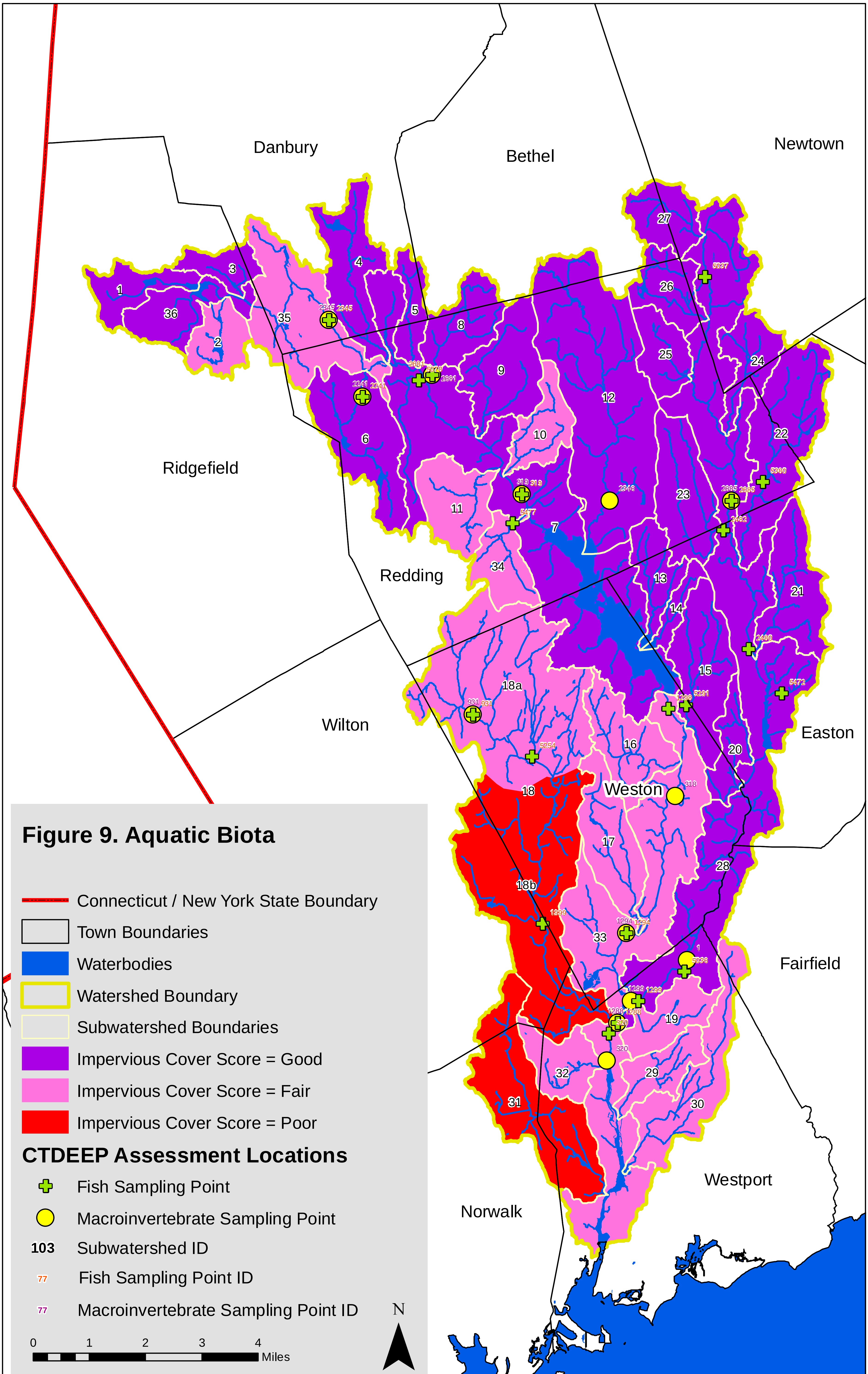
Table 6. Stream Capacity to Support Biota

Sample Location ID*	Subwatershed (Headwaters to outlet)	Fish Score**	Biotic Support Category	Macroinvertebrate Score**	Biotic Support Category
2345	35	4.5	**Supporting**	2.8	**Supporting**
2241	6	5.0	**Supporting**	2.5	**Supporting**
319	7 (Saugatuck Reservoir)	3.1	**Supporting**	1.4	**Supporting**
2681	7 (Saugatuck Reservoir)	4.5	**Supporting**	2.3	**Supporting**
5078	7 (Saugatuck Reservoir)	5.0	**Supporting**	-	-
5477	34	10.0	**Severely impaired**	-	-
2346	12 (Little River)	-	-	1.5	**Supporting**
5380	22	5.0	**Supporting**	-	-
5291	15	4.0	**Supporting**	-	-
931	18 (West Branch)	6.7	**Impaired**	2.6	**Supporting**
1999	18 (West Branch)	4.4	**Supporting**	-	-
5254	18 (West Branch)	7.5	**Severely impaired**	-	-
1	28 (Aspetuck)	-	-	2.9	**Supporting**
1299	28 (Aspetuck)	2.2	**Supporting**	3.0	**Supporting**
2480	28 (Aspetuck)	4.5	**Supporting**	-	-
2482	28 (Aspetuck)	6.0	**Impaired**	-	-
2685	28 (Aspetuck)	3.3	**Supporting**	-	-
5036	28 (Aspetuck)	2.9	**Supporting**	-	-
5037	28 (Aspetuck)	5.0	**Supporting**	-	-
5472	28 (Aspetuck)	0.0	**Supporting**	-	-
318	33 (Lower Saugatuck)	-	-	3.6	**Supporting**
320	33 (Lower Saugatuck)	2.5	**Supporting**	2.8	**Supporting**
1288	33 (Lower Saugatuck)	1.7	**Supporting**	3.8	**Supporting**
1294	33 (Lower Saugatuck)	3.9	**Supporting**	2.7	**Supporting**
1298	33 (Lower Saugatuck)	2.5	**Supporting**	-	-

The fish and macroinvertebrate scores equate to the following biotic support categories:
Score 7.0 - 10.0 = severely impaired
Score 5.1 - 6.9 = impaired
Score 0.0 - 5.0 = supporting
***CTDEEP biotic assessment sample locations**
****Scores were derived from CTDEEP biotic assessments**

34, and the upper portion of 18 (West Branch), where either poorly drained soil, locally dense development in a small subwatershed, or a combination of the two contributed to these conditions. Fair conditions were also predicted in subwatershed 33 (Lower Main Stem) and most tributaries south of the Saugatuck Reservoir. The lower portion of subwatershed 18 (West Branch) and subwatershed 31 (Stony Brook) were the only subwatersheds predicted to be in poor condition.

Visual assessment data generally corroborated predictions of the impervious cover analysis, although some reaches were found to be in better or worse condition than expected (Table 5, Figure 8). As predicted, good conditions were observed in subwatersheds 4, 12, and 7 (adjacent to and north of the Saugatuck Reservoir at sites 21, 24, 25, 26, 27, and 28), and fair conditions



Fish and macroinvertebrate sampling data provided by CTDEEP were observed in subwatershed 33 (the Lower Main Stem at sites 30 and 31). Conditions were better than expected in the lower portion of subwatershed 18 (West Branch at site 29), but worse than expected in the upper portion of subwatershed 18 (West Branch at site 32). The site sampled in the upper West Branch (site 32) was a small tributary that may be receiving significant road runoff. In the lower West Branch, better-than-expected conditions may be related to the large, protected region in its headwaters (Devil's Den) that buffers and stabilizes a significant length of stream (site 29).

Conditions were also worse than expected in the far headwaters of subwatershed 28 (Aspetuck) where a horse farm and a new residential development may be responsible for unstable channel conditions and a cleared riparian zone. The comparison of visual assessment and impervious cover analysis results in these locations suggest that in-stream conditions in the Saugatuck River Watershed are strongly influenced by watershed-scale conditions (overall imperviousness) and local-scale conditions such as poor riparian buffers and dams.

CTDEEP bio-monitoring data corroborated the impervious cover analysis at most sampling locations, although at several sites conditions were better than predicted (Table 6, Figure 9). All sites sampled for macroinvertebrates were categorized as "supporting" even in areas expected to have fair or poor stream quality based on impervious cover analysis. For example, two biotic support scores in subwatershed 18, (West Branch at sites 931 and 1999) were classified as supporting, although the impervious cover analysis predicted this region to be in fair to poor condition. These better than expected scores may be attributed to intact riparian buffers and forested headwaters. Fish biotic support scores were worse then expected (impaired or severely impaired biotic support scores in reaches expected to be good or fair, respectively) at three (3) locations in subwatersheds 28, 18, and 34, respectively (sites 2482, 5254, and 5477). The cause of these inconsistencies is unclear, but may be due to fish barriers and/or water withdrawals.

Water quality data collected by the HW/RW program indicates that dissolved oxygen in the Saugatuck River is sufficient to support aquatic life (Harris and Fraboni 2008). The same study found that indicator bacteria are present in levels which exceed state standards for safe recreation. The source of these bacteria is not clear; leaking septic systems, urban runoff, pet waste, and wildlife are all possible sources of bacterial pollution.

POLLUTANT LOADING ANALYSIS

The reduction of NPS pollutants is a central aspect of the watershed based planning process. Before pollution reduction strategies can be considered, however, an understanding of the quantity of NPS pollutants entering various steams within the watershed is needed. It is important to distinguish loading from concentration, which is presented as a quantity per volume of any given sample of water and varies when polluted waters are diluted or concentrated.

There are a few methods for estimating pollutant loading (i.e., the amount of pollutants entering the stream). Generally, these methods fall into two categories, computer simulation and direct measurements. Given the difficulty and expense of directly measuring pollutants, the WBP team decided to use computer simulation to estimate the quality of pollutants being introduced to the Saugatuck River and its tributaries. Direct measurements of pollutant loading may be conducted later in the implementation process to verify the loading estimates developed here (see the discussion of wet weather monitoring in Chapter 9).

A number of computer models have been developed to predict pollutant loading from urban watersheds. These models range from very simple spreadsheet models to very complex, physically based models that require extensive data collection and calibration. For this project, WinSLAMM was chosen. It is a model that has been specifically developed to predict NPS pollutant loading from urban areas. WinSLAMM provides a good balance between ease-of-use and technical complexity. It is not a physically based model in that it does not directly simulate the processes that generate and transport pollution through landscapes. Rather, WinSLAMM bases its estimates of pollutant loading on estimates of pollutant concentrations in the urban stormwater runoff associated with various types of urban surfaces including rooftops, various types of roadways, parking areas, as well as open spaces and from various soil types. The source of these estimates comes from a series of nationwide studies of urban runoff.

In Chapter 3, the existing pollutant load estimate will be compared with pollutant load estimates for the Saugatuck River Watershed assuming urban development had not occurred (i.e., the entire watershed was covered with forest). This comparison will be used to develop estimates of the reductions in pollutant loads required to fully restore the watershed to pre-developed conditions. The remainder of this section provides an overview of the common NPS pollutants for which load estimates were developed, provides details on the development of the pollutant load model, and summarizes the results of the pollutant load analysis.

Common Types of Nonpoint Source Pollution

NPS pollution is a general term that includes a wide variety of substances such as sediment, nutrients such as N and P, pesticides, heavy metals, oils and grease, trash, and bacteria. Of these, sediment, N, P, and bacteria are considered the most important NPS pollution parameters. WinSLAMM can simulate loading for each of these pollutants by estimating N modeling as nitrate (NO_3), P as particulate P (the portion of P that is associated with sediment particles), and using Total Suspended Solids (TSS) as an indicator of sediment loading. Finally, WinSLAMM uses fecal coliform as an indicator of pathogenic bacteria loading. The following sections provide a general overview of common NPS pollutants and their sources.

Nitrogen

N is found in streams in several forms and is essential for the growth of aquatic plant life such as algae. N is present in a variety of forms. Inorganic forms of N are those that are not incorporated into living or once-living materials, such as leaves. Most inorganic forms of N are readily dissolved in the water column and are taken up by aquatic plants to support their growth. When plants and animals die and decompose, organic forms of N are eventually reconverted back into inorganic forms.

While N is vital to stream life, elevated levels can cause an overabundance of aquatic vegetation. As this vegetation decomposes, oxygen dissolved in the stream water is rapidly used. In severe conditions, the process of decomposition can completely use up the dissolved oxygen, resulting in fish kills. Human sources of N include urban stormwater runoff, where animal waste and fertilizers are washed off into the stream; septic systems; wastewater treatment facilities; and industrial facilities.

Phosphorus

Like N, P is essential for the growth of aquatic plants and is present in streams in a variety of forms. However, unlike N, P is strongly bound to sediment particles. While the majority of P is "stuck" to sediment particles, some of it is also dissolved in the water column. This form of P is the one most easily used by aquatic plants. In certain situations, aquatic plants can also directly use P that is bound to sediment particles.

P is the factor that most commonly limits the growth of aquatic plants in streams. In undeveloped areas, levels of P in streams are very low as any P delivered to the stream is quickly taken up by aquatic plants. Therefore, increases in P loading to streams can result in rapid increases in plant growth. As these plants decompose, oxygen dissolved in the stream water is rapidly used. In severe conditions, the process of decomposition can completely use up the dissolved oxygen, resulting in fish kills. Human sources of P include overland flow from urban and suburban areas where animal waste and fertilizers are washed off into the stream and inputs from wastewater treatment and industrial facilities. Channel erosion and loose soil washed from disturbed area can also be a major source of P within streams.

Total Suspended Solids

Sediment particles, measured as TSS, wash into streams through surface and channel erosion, road runoff, and stormwater carrying loose soil from disturbed sites. Fine particles of organic material, including soil, partially decomposed plant matter, algae and other bits of debris become suspended in the water column along with fine sediment. High levels of TSS can cloud the water column, clog fish gills, cover spawning habitat, and decrease light available for photosynthesis. Particles may retain heat, leading to elevated water temperature and lowered levels of dissolved oxygen. Human sources of sediment include erosion from construction activities, wastewater and industrial effluent, tilled agricultural soils, sand spread on roadways, and sediment carried in stormwater runoff.

Bacteria

Many different species of bacteria are carried into surface waters from both developed and undeveloped areas. Most inputs are carried by overland flow during storm events, which wash bacteria off the land area and into the stream. Waste from pets and resident geese populations, local wildlife, and improperly functioning septic systems are all potential sources of bacteria. Concentrations of bacteria in the waterway may vary dramatically, but are usually highest after a rain event. Elevated levels of bacteria are often related to wet weather runoff from developed areas.

Fecal coliform was used as the modeling parameter to indicate total levels of bacteria based on constraints of the WinSLAMM model. However, in Connecticut *E. coli* is used as the indicator species for pathogenic bacteria, viruses, and protozoans in freshwater streams, and is used as criteria for state water quality standards for fresh water. *E. coli* is a type of fecal coliform bacteria commonly found in the digestive tracts of warm-blooded animals. *E. coli* and fecal coliform levels are very closely correlated, with *E. coli* generally following the same concentration patterns as fecal coliform, but at slightly lower levels (see Appendix E).

Modeling Methods

Pollutant loading was modeled for the Saugatuck River Watershed using WinSLAMM, which estimates pollutant loading from urban lands using an extensive database of field data collected during the National Urban Runoff Program (NURP) study, a nationwide study that measured the pollutant concentrations in stormwater runoff from various types of common urban surfaces across a number of U.S. cities. Briefly, WinSLAMM models pollutant loads for individual stormwater events for specific source areas (areas that have similar soil types and land cover), applying pollutant concentrations to different types of land cover based on the NURP study results. The pollutant concentrations are multiplied by the total volume of runoff, which WinSLAMM also estimates based on precipitation data to calculate the total quantity, or load, of each modeled pollutant. Loads from individual storm events are then summed to compute annual loads.

It is important to note that WinSLAMM does not model sediment and nutrient loading from stream banks and septic systems; hence, loading from these features is not included in results.

Ideally, simulation models are calibrated using field data. However, for this study locally collected hydrology or pollutant data were not available for calibration.

Data Acquisition and Processing

The following data sources were obtained and used in the WinSLAMM model to estimate pollutant loading:

- Rainfall dates, duration, and accumulation—these data were obtained for the years 2002 to 2010 from the Bridgeport Sikorsky Station (ID 060806), located in Fairfield County Connecticut (41.15833, -73.12889), provided through the National Oceanic and Atmospheric Administration (NOAA);
- Soil data—these data were obtained from the SSURGO database for the State of Connecticut);
- Land use data—these data were provided by SWRPA based on a composite of local land use, zoning, and opens space data and the UConn CLEAR 2006 Connecticut Land Cover Data.
- Runoff coefficients for source areas—provided through WinSLAMM;
- Particle sizes—provided through WinSLAMM;
- Particulate solids concentrations for source areas and land uses—provided through WinSLAMM;
- Particulate residue reduction for curb and gutter delivery systems—provided through WinSLAMM; and
- Pollutant probability distribution data for source areas and land uses—provided through WinSLAMM.

In many cases the raw data obtained for the study had to be manipulated before it could be used in the WinSLAMM model. Generally, this involved regrouping or reclassifying land use and soils data to conform to the land use and soil categories used by WinSLAMM.

Soil Data Processing

The SSURGO data set used for the study is a digital soil survey and is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. WinSLAMM cannot use these data directly. Accordingly, the soil data obtained from the SSURGO database was reclassified to the match the input categories used by WinSLAMM input categories based on the soil texture field in the SSURGO dataset.

WinSLAMM requires that soils be assigned to one of the four HSGs, which refer to ease with which water infiltrates through a particular soils:

- HSG A: Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission, and are composed of less than 10 percent clays and more than 90 percent sand or gravel.
- HSG B: Soils having a moderate infiltration rate when thoroughly wet. These consist of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission and are composed of 10–20 percent clay and 50–90 percent sand.

- HSG C: Soils having a slow infiltration rate when thoroughly wet. These consist of soils with a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission, and are composed of 20–40 percent clay and less than 50 percent sand.
- HSG D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, hydric soils, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission and are composed of at least 40 percent clay and less than 50 percent sand.

Land Use Data Processing

As with soil data, the land use data obtained for the modeling effort had to be reclassified to match the input categories used by WinSLAMM. Land use data were assigned WinSLAMM input categories (residential, other urban, commercial, industrial, highway, and institutional). The residential, other urban, and highway categories were found to oversimplify land use within each subwatershed, and were broken out into additional subcategories. For open space, subcategories included undeveloped open space, parks and other “moderately” developed open space, and “fully developed open space” characterized by large areas of managed turf. Residential areas were divided into subcategories for rural, large-lot suburban, small-lot suburban, and urban development patterns. Highway areas were distinguished by characteristic features for either the Merritt Parkway or I-95.

WinSLAMM requires the land use sub-categories to be further broken down into source areas. To determine the percent of the runoff and pollutant source areas (e.g., roof, landscaped, street, undeveloped, etc.) for each land use sub-category, representative samples (0.25-mile area) within each land use sub-category were measured using aerial imagery obtained from Microsoft Bing Maps Aerial (circa 2007). WinSLAMM also requires the user to specify certain land use characteristics. Land use characteristics (e.g., disconnection of roof leaders, density of housing, roadside swale frequency, etc.) were assigned by examining the aerial imagery and Google Maps street view (photo years vary, typically 2007–2010). A drive-through survey of the watershed was conducted April 15 and 16, 2011 to verify existing conditions and collect data on roadside conveyance systems and local storm sewer drainage.

POLLUTION LOADING MODELING RESULTS

The WinSLAMM model computed average annual loading for each of the four pollutants chosen for the study. The model results are provided in Table 7 and are presented as average annual loads and average unit area annual loads for each subwatershed (lb/yr and lb/ac/yr for particulate P, NO_3, and TSS; billion colony-forming units (cfu)/yr and billion cfu/ac/yr for indicator bacteria). Annual loads represent the total amount of pollution per year at the outlet of the subwatershed. Unit area loads represent the total annual output divided by the total acreage of the subwatershed, which allows easier comparison among subwatersheds of varying size.

Annual TSS, particulate P, and NO_3 loading in the Saugatuck River Watershed averaged approximately 38 million lb/yr of TSS, and 138,000 lb/yr each of particulate P and NO_3. TSS unit area loading varied considerably among subwatersheds, ranging from 266 lb/ac/yr in subwatershed 29 to 1442 lb/ac/yr in subwatershed 3. Unit area loading for particulate P also varied significantly among subwatersheds, ranging from a minimum of 0.7 lb/ac/yr in subwatershed 8 to 5.5 lb/ac/yr in subwatershed 27. NO_3 unit area loads ranged from 0.9 lb/ac/yr in subwatershed 7 (Saugatuck Reservoir) to 9.5 lb/ac/yr in subwatershed 31 (Stony Brook). The river generated an average annual loading of approximately 14,272,000 billion cfu of indicator bacteria. Unit area loading ranged from 103 billion cfu in subwatershed 7 (Saugatuck Reservoir) to 639 billion cfu in subwatershed 31 (Stony Brook).

The wide variations in unit area loading among subwatersheds are due to several factors internal to the WinSLAMM modeling process, including land use and soil type. For instance, poorly drained soils (HSG D) are often associated with higher particulate P and TSS loading, and areas with a high percentage of impervious cover are associated with high levels of bacteria, NO_3, particulate P, and TSS. Other factors which contribute to the variance in pollutant loading include how stormwater is handled or treated, the number and size of ditches and swales, if houses and buildings are directly connected to storm sewers, and the presence and condition of riparian buffers.

USE DESIGNATIONS AND IMPAIRMENTS

Use designations are used by the state to classify streams according to their highest function within the community. Depending on their size, condition, and location, streams may be designated for fish or shellfish consumption, recreation, drinking water, habitat, agriculture, among other uses. Section 303(d) of the Clean Water Act (CWA) requires states to compile an Impaired Waters List (IWL) to direct management actions toward waters not meeting their designated use.

To understand the river from a regulatory perspective, state water quality designations and sampling were reviewed as part of the existing conditions assessment. Uses designated for the Saugatuck River are presented in Figure 10. Use designations for freshwater streams in Connecticut are listed as follows, although only classes AA, A, and SA are found in the Saugatuck River system:

- AA: Existing or proposed drinking water supplies; habitat for fish and other aquatic life and wildlife; recreation; and water supply for industry and agriculture.
- A: Habitat for fish and other aquatic life and wildlife; potential drinking water supplies; recreation; navigation; and water supply for industry and agriculture.
- B: Habitat for fish and other aquatic life and wildlife; recreation; navigation; and industrial and agricultural water supply.
- SA: Habitat for marine fish, other aquatic life and wildlife; shellfish harvesting for direct human consumption; recreation; industrial water supply; and navigation. SB: Habitat for marine fish, other aquatic life and wildlife; commercial shellfish harvesting; recreation; industrial water supply; and navigation.

Reaches in the upper Saugatuck River Watershed that drain to either the Saugatuck or Aspetuck Reservoirs are designated Class AA streams (Figure 10), and as such are held to the strictest water quality standards. Below the reservoirs, reaches are designated as Class A streams. The Saugatuck River estuary is designated a Class SA waterbody, which means that human consumption of shellfish is permitted.

These use designations are associated with a series of quantitative and qualitative standards that define maximum concentrations for various pollutants above which a waterbody is no

Table 7. Pollutant Loading Analysis Results

Subwatershed (Headwaters to outlet)	Acres	TSS Load		Particulate P Load		NO_3 Load		Indicator Bacteria Load	
		(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(billion cfu/yr)	(billion cfu/ac/yr)
1	601.1	386,898	644	1,104	1.8	793	1.3	96,026	160
36 (Headwaters)	794.0	876,905	1,104	3,609	4.5	1,516	1.9	166,826	210
2	584.2	484,476	829	1,354	2.3	1,045	1.8	120,406	206
3	415.1	598,523	1,442	637	1.5	1,007	2.4	107,470	259
35	1,855.4	1,967,156	1,060	5,553	3.0	4,248	2.3	673,866	363
6	1,525.3	556,321	365	3,119	2.0	1,644	1.1	214,797	141
4	1,175.9	1,070,792	911	5,887	5.0	2,255	1.9	254,415	216
7 (Saugatuck Reservoir)	5,575.5	2,414,414	433	5,830	1.0	5,078	0.9	571,599	103
5	461.0	503,345	1,092	1,474	3.2	1,056	2.3	124,105	269
8	827.1	527,059	637	539	0.7	956	1.2	139,499	169
9	1,175.4	458,016	390	2,550	2.2	1,216	1.0	139,499	119
11	926.7	382,430	413	1,980	2.1	1,324	1.4	200,835	217
10	639.0	415,859	651	2,428	3.8	1,039	1.6	145,585	228
34	674.3	530,107	786	2,532	3.8	1,241	1.8	147,852	219
12 (Little River)	3,983.0	1,870,044	470	9,410	2.4	4,989	1.3	629,356	158
13	608.8	756,531	1,243	647	1.1	1,279	2.1	136,874	225
14	266.9	353,466	1,324	315	1.2	595	2.2	63,437	238
33 (Lower Saugatuck River)	4,640.5	2,910,345	627	13,923	3.0	7,218	1.6	1,037,589	224
15	1,259.9	1,050,021	833	1,473	1.2	1,833	1.5	199,045	158
16 (Jennings Brook)	1,008.5	1,126,211	1,117	5,432	5.4	2,189	2.2	307,279	305
17 (Beaver Brook)	1,095.8	882,144	805	5,095	4.6	2,272	2.1	267,900	244
27 (Aspetuck Tributary)	676.6	926,345	1,369	3,724	5.5	1,603	2.4	176,611	261
28 (Aspetuck River)	6,782.0	2,988,592	441	9,702	1.4	6,944	1.0	915,394	135
26 (Aspetuck Tributary)	695.6	622,174	894	1,131	1.6	1,077	1.5	115,895	167
25 (Aspetuck Tributary)	602.2	485,591	806	2,059	3.4	982	1.6	110,370	183
24 (Aspetuck Tributary)	666.9	497,181	745	2,598	3.9	911	1.4	103,854	156
23 (Aspetuck Tributary)	1,174.4	952,844	811	4,399	3.7	1,967	1.7	222,912	190
22 (Aspetuck Tributary)	1,850.3	1,469,481	794	8,483	4.6	2,877	1.6	355,609	192
21 (Aspetuck Tributary)	1,126.6	561,843	499	2,874	2.6	1,334	1.2	172,673	153
20 (Aspetuck Tributary)	499.2	216,319	433	925	1.9	519	1.0	62,112	124
19 (Aspetuck Tributary)	680.1	219,643	323	1,304	1.9	820	1.2	123,508	182
18 (West Branch)	7,625.9	6,989,496	917	17,778	2.3	50,159	6.6	4,196,897	550
32 (Poplar Plain Brook)	673.9	327,340	486	804	1.2	1,388	2.1	232,697	345
29	613.8	163,144	266	838	1.4	589	1.0	89,141	145
30	1,430.5	663,530	464	3,240	2.3	2,175	1.5	319,928	224
31 (Stony Brook)	2,081.2	1,043,946	502	3,201	1.5	19,719	9.5	1,330,549	639
Saugatuck Watershed:	**57,272.5**	**38,248,532**	**668**	**137,951**	**2.4**	**137,857**	**2.4**	**14,272,410**	**249**

longer considered to meet its designated use. A waterbody that is found to fail minimum quality standards for its designated use is placed on the Connecticut IWL. In the Saugatuck River Watershed, 15 sample sites yielded the following 10 sites that failed to meet minimum water quality standards (CTDEP 2011, Water Quality Report) (Figure 11):

Main Stem Saugatuck River

- A reach of the Main Stem from the inlet to the Saugatuck Reservoir at the Route 53 crossing, upstream to the confluence with Bogus Mountain Brook (near Station Road) does not meet minimum criteria for recreation. The source is unknown. This location is designated High priority on the Total Maximum Daily Load (TMDL) list.
- A reach of Hawley's Brook from the confluence with an unnamed tributary to Hawley's Brook, upstream to a private golf course is impaired for aquatic life by flow regime alterations of an unknown source. This area is not a priority for a TMDL because the impairment is not caused by a pollutant.
- A reach of Beaver Brook from its mouth at the confluence with the Saugatuck River (downstream of the Slumber Lane crossing), upstream to the confluence with Davidge Brook exceeds *E. coli* maximum criteria for safe recreation. The source is unknown. This impairment is designated a Medium TMDL priority.
- A reach of Kettle Creek from its mouth at the confluence with the Saugatuck River (downstream of Good Hill Road), upstream to the confluence with an unnamed tributary (downstream of Kettle Creek Road crossing) exceeds *E. coli* maximum criteria for safe recreation. The source is unknown. This impairment is designated a Medium TMDL priority.
- A reach of Poplar Plains Brook from its mouth at the confluence with the Saugatuck River (just downstream of Route 15 crossing), upstream to the confluence with unnamed tributary near Route 33 exceeds E. coli maximum criteria for safe recreation. The source is unknown. This impairment is designated a Medium TMDL priority.
- A reach of the Aspetuck River from the confluence with the Saugatuck River upstream to the Aspetuck Reservoir outlet dam exceeds E. coli maximum criteria for safe recreation. The source is unknown. This impairment is designated a High TMDL priority.
- A reach of the West Branch from the mouth at the confluence with the Saugatuck River upstream to the Godfrey Road West crossing exceeds E. coli maximum criteria for safe recreation. The source is unknown. This impairment is designated a High TMDL priority.
- A reach of an unnamed tributary from its mouth at the confluence with the West Branch Saugatuck River (Newtown Turnpike crossing), upstream to an unnamed pond near Birch Hill Road exceeds E. coli maximum criteria for safe recreation. The source is unknown. This impairment is designated a Medium TMDL priority.

It should be noted that impairments in the Saugatuck River Estuary also exist. Although not included as part of this study, recommendations included in this WBP may also help to alleviated impairments in the estuary.

Saugatuck River Estuary

- A reach of Grays Creek from the SA/SB water quality line at the mouth of the Saugatuck River Estuary upstream to the saltwater limit at Compo Road exceeds the fecal coliform maximum criteria for direct shellfish consumption due to multiple pollution sources. This impairment is designated a Medium TMDL priority.

- The Saugatuck Estuary from the SA/SB water quality line at the railroad crossing upstream to the saltwater limit at the Hydraulic Pond outlet dam exceeds the fecal coliform maximum criteria for direct shellfish consumption due to multiple pollution sources. This impairment is designated a Medium TMDL priority.

Use Attainment/Need for Further Investigation

Per CTDEEP policy, a stream reach is assumed to "attain" its designated use until sampling proves otherwise. A portion of a stream cannot be listed as "impaired" for its designated use until data have been collected to support this conclusion. Since samples have not been collected in all reaches of the Saugatuck River, it is impossible to know with certainty where additional water quality state-defined impairments may exist. However, based on the existing conditions assessment presented in this chapter, it is possible to suggest problem areas where additional impairments are likely to be found. Throughout this document, the term "impairment" is used generally to refer to areas expected or proven not to meet state standards.

During field reconnaissance, several sampling locations were found where conditions would likely support a 303(d) listing. For instance, the SVA analysis indicated poor or fair conditions in seven locations on Class AA designated streams, and in one location on the Class A designated Strickland Brook. Assessments in these areas indicate that habitat and water quality may be impaired for aquatic life and recreation and warrant further investigation.

As noted in the impervious cover analysis, SVA scores were commonly associated with predicted impervious cover scores based on existing land use conditions. Since field observations largely corroborated the predicted conditions, other streams with similar use designations and similarly fair impervious cover scores (subwatersheds 19, 29, 30, 32, 33, 17, 16, 34, 11, 10, and 35) as well as those with poor scores (31 and lower 18) may also warrant further investigation to determine if reaches fail to meet minimum water quality standards.

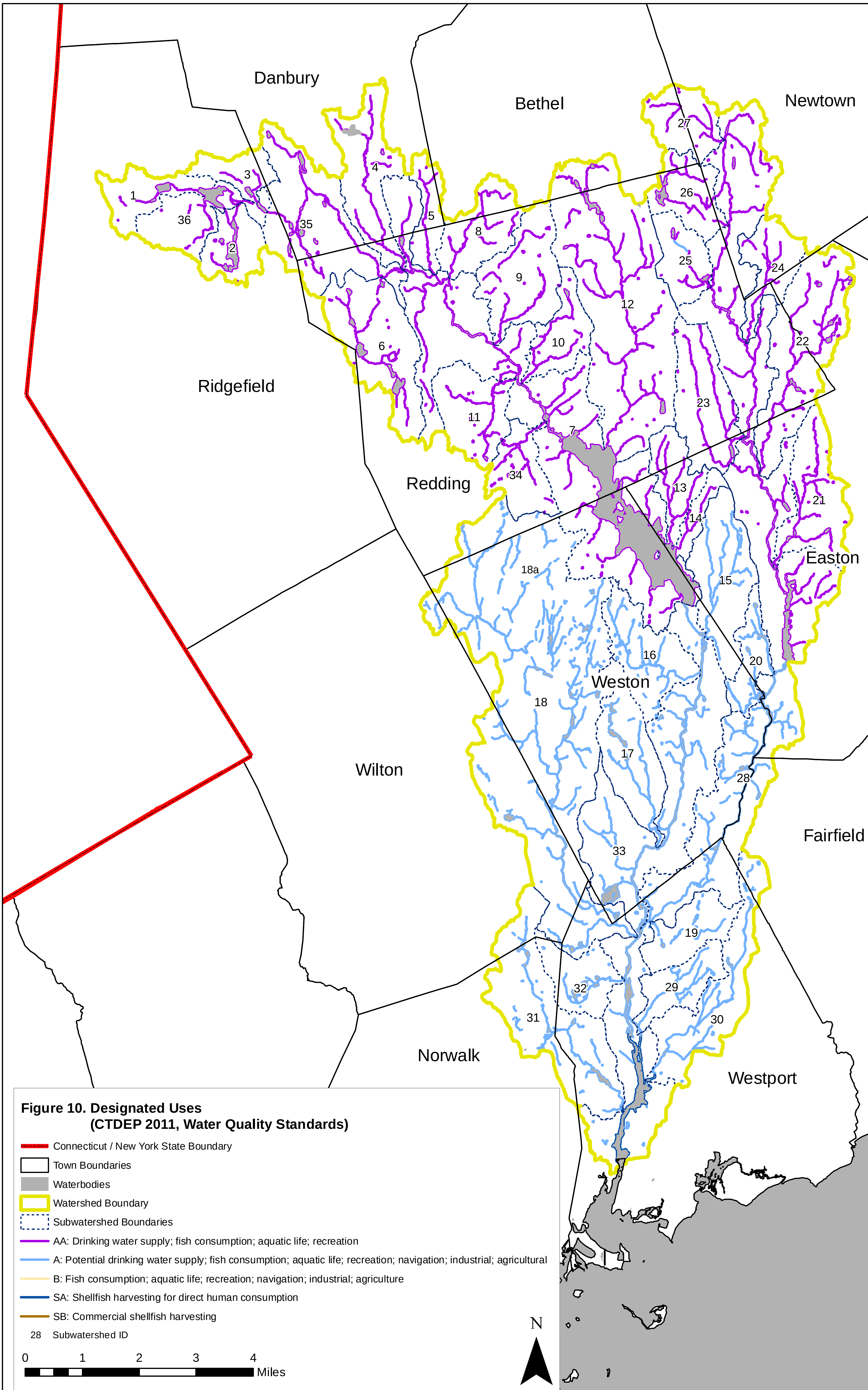


Figure 10. Designated Uses (CTDEP 2011, Water Quality Standards)

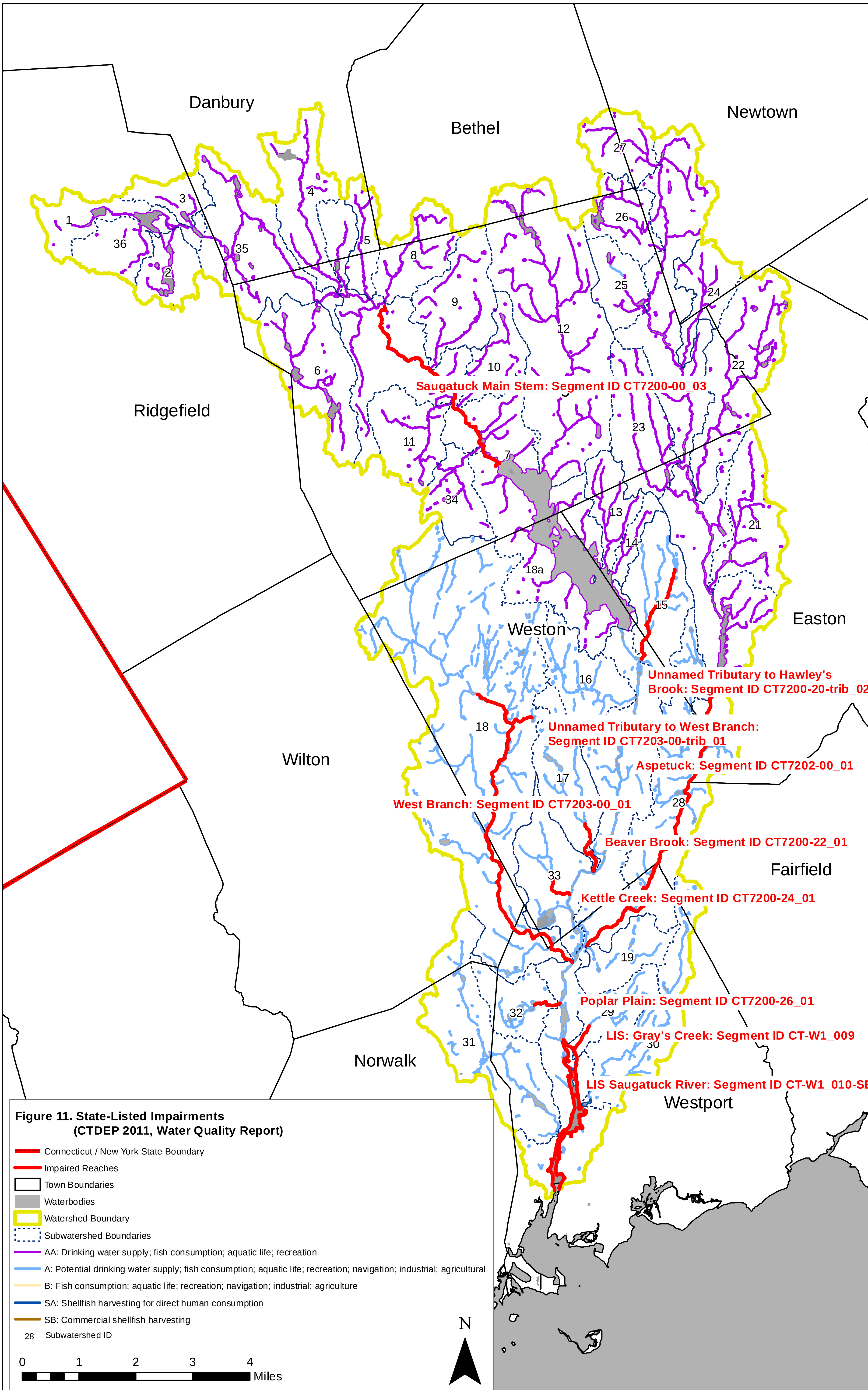


Figure 11. State-Listed Impairments (CTDEP 2011, Water Quality Report)

As discussed in Chapter 1, the main intent of the watershed based planning process is to reduce NPS pollution. In Chapter 2, results of computer simulations estimating the average annual loads of four key NPS pollutants were presented. These loads represent a best estimate of the current pollutant delivery to the Saugatuck River and its tributaries. A key question moving forward is “how much do pollutant loads need to be reduced?”

There are many ways to approach the issue of pollutant load reduction. Ideally, the answer to the question of load reductions would be answered by first determining the maximum in-stream concentrations of various pollutants that would allow the stream system to provide the full spectrum of uses and values articulated in Chapter 4 of the WBP. The required load reduction would then be the amount by which the pollutant concentrations must be lowered from their current levels to the maximum acceptable levels. This approach was used to determine reductions required for indicator bacteria for some areas of the watershed (based on sample data collected in the West Branch, Main Stem, and Aspetuck). This approach however requires extensive in-stream monitoring data that currently do not exist for N, P, and TSS pollutants in the Saugatuck River. In addition, it would be necessary to have a commonly accepted standard for maximum pollutant concentrations, but currently, state numeric standards have not been established for N, P, or TSS concentrations.

N (as NO_3), P (as particulate P), and TSS load reductions were therefore computed using an alternative and more feasible method that estimates pollutant loading in the Saugatuck River for its undeveloped condition. This method assumes the entire watershed consists of forest cover, and computes the load reduction targets as the difference between the current loading and the loading associated with an undeveloped condition. In this way, the portion of the total pollutant load that is the result of human activity in the watershed is estimated.

The following section establishes pollution reduction targets for the Saugatuck River using both the reference condition and in-stream concentration approaches described above. It is useful to think of these estimates as maximum load reduction targets. In reality, it will not be possible to eliminate all pollutant sources that derive from human activity. And given that streams can absorb some level of additional pollutant loading and still provide a full spectrum of uses and values articulated in the WBP, 100 percent reduction in development-related pollutant loads is most likely not needed to fully restore the Saugatuck River and meet the goals of the WBP. Therefore, the WBP establishes an interim, working goal of eliminating 60 percent of the development-related pollutant load.

REFERENCE CONDITION METHOD

Pollutant load reduction targets were developed for TSS, particulate P, NO_3, and indicator bacteria using WinSLAMM. Reference predevelopment conditions were modeled for using a similar method used to develop existing conditions models (methods and results described in Chapter 2); however, here the models assume that land use within the watershed is 100 percent forested. As described in the introduction to this chapter, the predevelopment load was subtracted from the existing conditions load to determine the total target pollutant load reduction for each subwatershed for each pollutant. The target was set to zero if the predevelopment load was greater than the existing conditions load (discussion of results follows). In the tables that follow, total and interim targets are presented.

Inputs to the predevelopment model were similar to those used to model existing conditions, and included rainfall, soils, land use, and subwatershed delineation data. The predevelopment model differed from the existing conditions model only in that land use for each subwatershed in the predevelopment model was defined entirely as "undeveloped land." Because land use in each predevelopment model was designated 100 percent "undeveloped," the model contained up to three source areas corresponding to three soil texture types classified according to the HSG.

As noted above, the WBP acknowledges the fact that total targets, which reduce pollutant loads to undeveloped conditions, may not be feasible in the short term. Interim pollutant load reduction targets of 60 percent of the total target were calculated to provide a realistic milestone. This number represents a typical load reduction rate for management measures as accepted by CTDEEP.

IN-STREAM CONCENTRATION METHOD

Indicator bacteria load reduction targets were calculated using an in-stream concentration-based method for drainage areas contributing to river sections that do not meet state minimum indicator bacteria criteria for recreation (Table 8, Figure 11). Because data for fecal coliform and *E. coli* counts were available for one (1) or more sample sites within most of the reaches impaired by bacteria, indicator bacteria load reduction targets could be developed by comparing the state water quality criteria with the measured in-stream concentrations. The statistical relationship was then used to determine a reduction in indicator bacterial loading from the difference between the state criteria and the measured in-stream concentration.

In computing load reductions for indicator bacteria, the state criteria for indicator bacterial impairment of freshwater were used. The criteria are based on geometric mean and single sample maximum (SSM) thresholds for *E. coli* (CTDEP 2011, Water Quality Standards). The *E. coli* criteria for recreational uses for Class AA, A, and B waters are:

- Geometric mean less than 126 cfu/100mL; and
- SSM less than 576 cfu/100mL.

To allow a direct comparison between load reductions generated using the in-stream concentration method with load reductions generated using the reference condition method, *E. coli* criteria were converted to fecal coliform criteria using a statistical function based on the HW/RW dataset (see Appendix E). This dataset demonstrated a strong relationship between *E. coli* and fecal coliform measurements in the Saugatuck River.

The required percent reduction in indicator bacteria loading was determined using a statistical method following Jagupilla et al. (2009). This method uses statistical theory to determine a reduction factor that relates the difference between in-stream pollutant concentrations and state criteria to source pollutant loads and provides a method to incorporate confidence intervals into the pollutant load reduction calculations.

Reduction targets were then calculated for each subwatershed draining to a river section impaired by bacteria by multiplying WinSLAMM-generated estimates of fecal coliform loads by the statistically-generated pollution load reduction factor. For those impaired segments with more than one (1) subwatershed within their drainage area (CT7200-00_03 and CT7202-00_01), the fractional pollutant load reduction calculated for the impaired segment was applied to each subwatershed individually, and summed. The fractional reduction calculated for the West Branch (CT7203-00_01) was also used for the unnamed tributary to the West Branch (CT7203-00-trib_01) because no reach-specific sampling data were available.

Additional WinSLAMM modeling was required to address two (2) of the stream segments with 303(d)-listed indicator bacteria impairments on reaches that had not originally been mapped as separate subwatersheds (Figure 12). For the following impaired reaches, new existing conditions pollutant load models were developed to assess indicator bacteria loads: CT7200-24_01, and CT7200-00_03. To determine indicator bacteria loads exclusively generated in the Kettle Creek subwatershed, it was delineated and modeled separately. The Kettle Creek subwatershed (CT7200-24_01) is part of subwatershed 33, and is denoted in tables and figures as 33a. As delineated for the existing conditions models, subwatershed 7 extends downstream beyond the impaired river section (CT7200-00_03). A new subwatershed model was developed for the portion of subwatershed 7 that drains to sample point SG7, at the intersection of the Saugatuck River with the Saugatuck Reservoir (subwatershed denoted as 7a).

ESTIMATED TARGETS

Indicator bacteria load reduction targets for the drainage area to 303(d) listed stream segments require annual decreases in indicator bacteria loads ranging from 48,890 billion cfu/yr to 2,075,510 billion cfu (Table 8). Total annual pollutant load reduction targets for the watershed call for a 395,480 lb/yr reduction in TSS (Table 9), a 2,896 lb/yr reduction in particulate P (Table 10), a 69,200 lb/yr reduction in NO_3 (Table 11), and a 7,391,788 billion cfu/yr reduction in indicator bacteria (Table 12). Since full implementation of the load reduction targets may not be feasible due to funding constraints, interim targets representing 60 percent of the total target were developed and are presented alongside total targets in Tables 9, 10, 11, and 12.

All subwatersheds contribute NO_3 and indicator bacteria loads in excess of predevelopment conditions, but the magnitudes vary greatly (Tables 11 and 12). NO_3 load reduction targets ranged from one (1) lb/yr to 37,035 lb/yr and the indicator bacteria reduction targets ranged from 322 billion cfu/yr to 3,105,151 billion cfu/yr for all subwatersheds.

Fewer than half of the subwatersheds contributed TSS and particulate P above predevelopment conditions. This result was typically associated with poorly drained soils (HSG D), which naturally generate higher levels of TSS and P than other soil types. In these instances, increased impervious cover in the existing conditions model may have eliminated substantial sources of TSS and particulate P, thus reducing load estimates from the predevelopment to existing conditions scenario.

Particulate P load reduction targets were as high as 973 lb/yr among the 11 subwatersheds where particulate P increased from the predevelopment scenario to the existing conditions scenario. TSS load reduction targets were as high as 355,825 lb/yr among the five (5) subwatersheds where TSS increased from the predevelopment conditions scenario to existing conditions scenario. Load reduction targets were not developed for subwatersheds for which pollutant loads predicted by the existing conditions model were lower than those predicted by the predevelopment model.

Pollutant load reduction targets require annual decreases of 1.0 (Table 9), 2.1 (Table 10), 50.2 (Table 11), and 51.8 percent (Table 12) for TSS, particulate P, NO_3, and indicator bacteria loads, respectively. Interim (60 percent) targets require decreases of 0.6, 1.3, 30.1, and 31.1 percent, for TSS, particulate P, NO_3, and indicator bacteria, respectively. Pollutant load reductions for all pollutants are summarized in Table 13. Management strategies discussed in Chapter 5, and actions recommended in Chapter 6 (Table 16) will work to meet these pollution load reduction targets using a variety of methods at a variety of spatial scales. Typical load reductions and efficiencies for the management actions recommended in the WBP are presented in Chapter 6 to guide watershed managers toward the most effective and efficient actions. Chapter 7 presents structural BMPs identified within the watershed and vetted for feasibility along with modeled pollution load reductions for each identified BMP.

Table 8. Indicator Bacteria Load Reduction Targets for State-Listed Impaired Stream Segments

Subwatershed	Segment ID	Sample Site/Year	Mean log of measured E. coli ($\overline{\log(X)}$)	Standard Deviation ($\sigma_{\log(X)}$)	Number of Samples (n)	Fractional Reduction (ρ)	Load Reduction Target (billion cfu/yr)
7a (all drainage to site SG7)	CT7200-00_03	SG7* (2006)	880*	N/A	N/A	0.273	781,413
17 (Beaver Brook)	CT7200-22_01	BB1 (2007)	2.426	0.703	9	0.772	206,885
33a (portion of the Lower Saugatuck [Kettle Creek])	CT7200-24_01	KC1 (2007)	2.173	0.36	8	0.389	48,890
32 (Poplar Plain Brook)	CT7200-26_01	PP1 (2007)	2.373	0.565	10	0.683	159,003
28 (Aspetuck)	CT7202-00_01	AR4.5 (2011)	2.7	0.748	10	0.88	2,075,510
18 (West Branch)	CT7203-00_01	WB3 (2007)	2.493	0.499	10	0.74	3,105,151

*In-stream concentrations at site SG7 exceeded State SSM, but not geomean criteria. Therefore, fractional reduction (p) calculations were performed based on the SSM criteria and in-stream measurements (880 cfu/100mL).

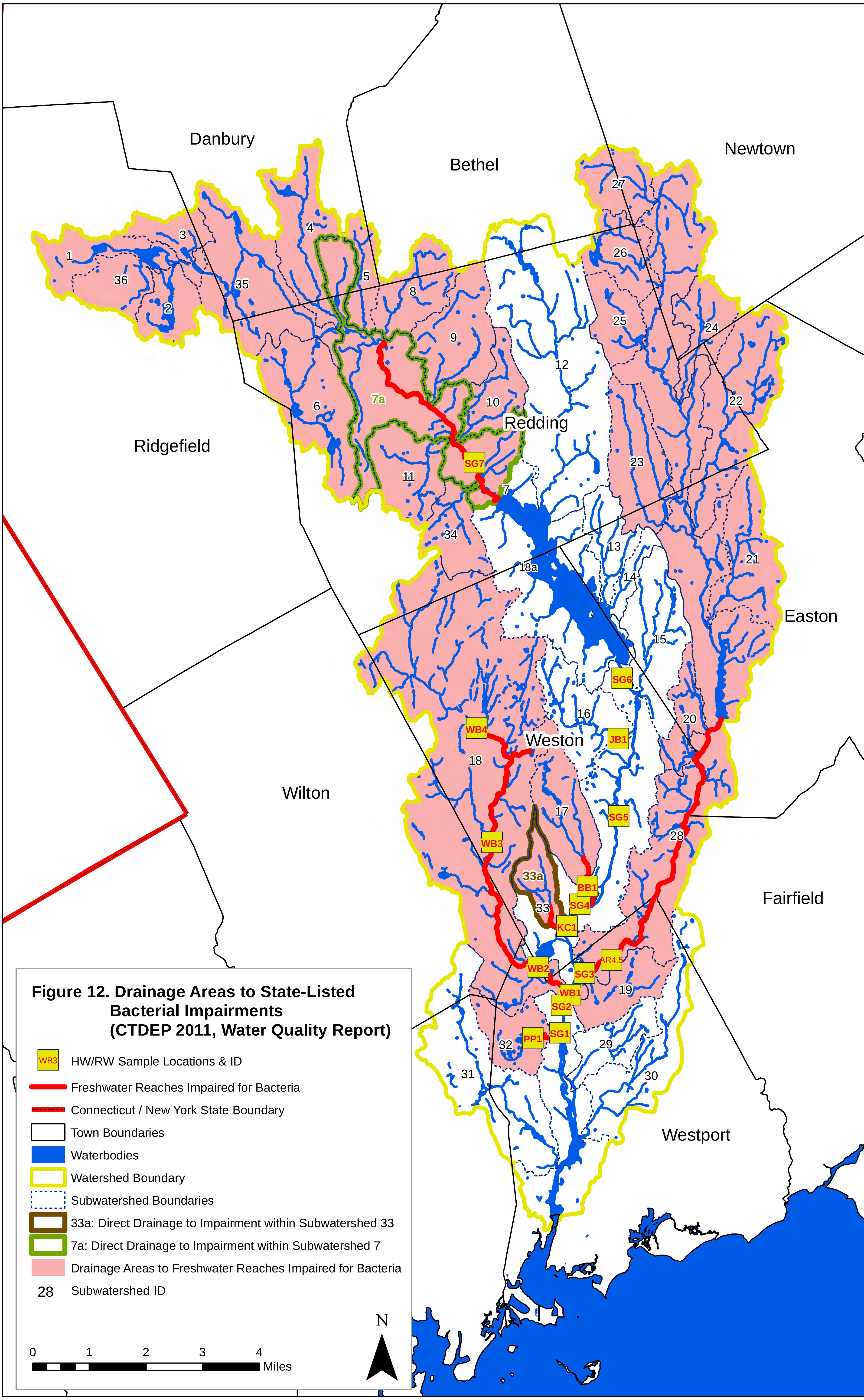


Figure 12. Drainage Areas to State-Listed Bacterial Impairments (CTDEP 2011, Water Quality Report)

Table 9. Total Suspended Solids Load Reduction Targets by Subwatershed

Subwatershed (Headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Total Load Reduction Target (lb/yr)	Total Target Percent Reduction (%)	Interim Load Reduction Target (lb/yr)
1	386,898	393,961	0	0.0%	0
36 (Headwaters)	876,905	885,749	0	0.0%	0
2	484,476	499,290	0	0.0%	0
3	598,523	598,646	0	0.0%	0
35	1,967,156	2,018,500	0	0.0%	0
6	556,321	570,429	0	0.0%	0
4	1,070,792	1,104,675	0	0.0%	0
7 (Saugatuck Reservoir)	2,414,414	2,446,393	0	0.0%	0
5	503,345	518,632	0	0.0%	0
8	527,059	531,245	0	0.0%	0
9	458,016	475,736	0	0.0%	0
11	382,430	381,939	491	0.1%	295
10	415,859	437,001	0	0.0%	0
34	530,107	551,835	0	0.0%	0
12 (Little River)	1,870,044	1,932,909	0	0.0%	0
13	756,531	757,459	0	0.0%	0
14	353,466	353,802	0	0.0%	0
33 (Lower Saugatuck River)	2,910,345	3,083,338	0	0.0%	0
15	1,050,021	1,053,053	0	0.0%	0
16 (Jennings Brook)	1,126,211	1,177,278	0	0.0%	0
17 (Beaver Brook)	882,144	935,797	0	0.0%	0
27 (Aspetuck Tributary)	926,345	938,187	0	0.0%	0
28 (Aspetuck River)	2,988,592	3,060,969	0	0.0%	0
26 (Aspetuck Tributary)	622,174	624,271	0	0.0%	0
25 (Aspetuck Tributary)	485,591	498,601	0	0.0%	0
24 (Aspetuck Tributary)	497,181	505,152	0	0.0%	0
23 (Aspetuck Tributary)	952,844	977,591	0	0.0%	0
22 (Aspetuck Tributary)	1,469,481	1,501,872	0	0.0%	0
21 (Aspetuck Tributary)	561,843	571,197	0	0.0%	0
20 (Aspetuck Tributary)	216,319	225,069	0	0.0%	0
19 (Aspetuck Tributary)	219,643	218,549	1,094	0.5%	656
18 (West Branch)	6,989,496	7,703,921	0	0.0%	0
32 (Poplar Plain Brook)	327,340	302,726	24,615	7.5%	14,769
29	163,144	149,689	13,455	8.2%	8,073
30	663,530	677,327	0	0.0%	0
31 (Stony Brook)	1,043,946	688,121	355,825	34.1%	213,495
Watershed Total:	**38,248,533**	**39,350,907**	**395,480**[1]	**1.0%**	**237,288**[1]

[1] Sum of watershed load reduction targets ≠ predevelopment – existing load because negative targets are not represented.

Table 10. Particulate Phosphorus Load Reduction Targets by Subwatershed

Subwatershed (Headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Total Load Reduction Target (lb/yr)	Total Target Percent Reduction (%)	Interim Load Reduction Target (lb/yr)
1	1,104	1,970	0	0.0%	0
36 (Headwaters)	3,609	4,429	0	0.0%	0
2	1,354	2,496	0	0.0%	0
3	637	2,993	0	0.0%	0
35	5,553	10,092	0	0.0%	0
6	3,119	2,852	267	8.6%	160
4	5,887	5,523	364	6.2%	218
7 (Saugatuck Reservoir)	5,830	12,232	0	0.0%	0
5	1,474	2,593	0	0.0%	0
8	539	2,656	0	0.0%	0
9	2,550	2,379	171	6.7%	103
11	1,980	1,910	70	3.6%	42
10	2,428	2,185	243	10.0%	146
34	2,532	2,759	0	0.0%	0
12 (Little River)	9,410	9,665	0	0.0%	0
13	647	3,787	0	0.0%	0
14	315	1,769	0	0.0%	0
33 (Lower Saugatuck River)	13,923	15,416	0	0.0%	0
15	1,473	5,265	0	0.0%	0
16 (Jennings Brook)	5,432	5,886	0	0.0%	0
17 (Beaver Brook)	5,095	4,679	416	8.2%	250
27 (Aspetuck Tributary)	3,724	4,691	0	0.0%	0
28 (Aspetuck River)	9,702	15,305	0	0.0%	0
26 (Aspetuck Tributary)	1,131	3,121	0	0.0%	0
25 (Aspetuck Tributary)	2,059	2,493	0	0.0%	0
24 (Aspetuck Tributary)	2,598	2,526	72	2.8%	43
23 (Aspetuck Tributary)	4,399	4,888	0	0.0%	0
22 (Aspetuck Tributary)	8,483	7,509	973	11.5%	584
21 (Aspetuck Tributary)	2,874	2,856	18	0.6%	11
20 (Aspetuck Tributary)	925	1,125	0	0.0%	0
19 (Aspetuck Tributary)	1,304	1,093	211	16.2%	127
18 (West Branch)	17,778	38,519	0	0.0%	0
32 (Poplar Plain Brook)	804	1,514	0	0.0%	0
29	838	748	90	10.7%	54
30	3,240	3,387	0	0.0%	0
31 (Stony Brook)	3,201	3,441	0	0.0%	0
Watershed Total:	**137,951**	**196,755**	**2,896**[1]	**2.1%**	**1,738**[1]

[1] Sum of watershed load reduction targets ≠ predevelopment – existing load because negative targets are not represented.

Table 11. Nitrate Load Reduction Targets by Subwatershed

Subwatershed (Headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Total Load Reduction Target (lb/yr)	Total Target Percent Reduction (%)	Interim Load Reduction Target (lb/yr)
1	793	689	105	13.2%	63
36 (Headwaters)	1,516	1,499	17	1.1%	10
2	1,045	855	190	18.2%	114
3	1,007	1,003	3	0.3%	2
35	4,248	3,424	824	19.4%	494
6	1,644	1,057	587	35.7%	352
4	2,255	1,889	366	16.2%	220
7 (Saugatuck Reservoir)	5,078	4,389	688	13.6%	413
5	1,056	879	178	16.8%	107
8	956	934	22	2.3%	13
9	1,216	876	340	28.0%	204
11	1,324	702	623	47.0%	374
10	1,039	764	274	26.4%	164
34	1,241	953	288	23.2%	173
12 (Little River)	4,989	3,483	1,506	30.2%	904
13	1,279	1,276	3	0.2%	2
14	595	594	1	0.2%	1
33 (Lower Saugatuck River)	7,218	5,399	1,820	25.2%	1,092
15	1,833	1,817	16	0.9%	10
16 (Jennings Brook)	2,189	1,991	198	9.1%	119
17 (Beaver Brook)	2,272	1,610	662	29.2%	397
27 (Aspetuck Tributary)	1,603	1,575	28	1.8%	17
28 (Aspetuck River)	6,944	5,565	1,379	19.9%	827
26 (Aspetuck Tributary)	1,077	1,070	7	0.6%	4
25 (Aspetuck Tributary)	982	860	121	12.4%	73
24 (Aspetuck Tributary)	911	877	34	3.7%	20
23 (Aspetuck Tributary)	1,967	1,687	280	14.2%	168
22 (Aspetuck Tributary)	2,877	2,595	282	9.8%	169
21 (Aspetuck Tributary)	1,334	1,026	308	23.1%	185
20 (Aspetuck Tributary)	519	409	111	21.3%	67
19 (Aspetuck Tributary)	820	415	404	49.3%	242
18 (West Branch)	50,159	13,123	37,035	73.8%	22,221
32 (Poplar Plain Brook)	1,388	550	838	60.4%	503
29	589	298	290	49.3%	174
30	2,175	1,224	951	43.7%	571
31 (Stony Brook)	19,719	1,300	18,419	93.4%	11,051
Watershed Total:	**137,857**	**68,657**	**69,200**	**50.2%**	**41,520**

Table 12. Indicator Bacteria Load Reduction Targets by Subwatershed

Subwatershed (headwaters to outlet)	Existing Load (billion cfu/yr)	Predevelopment Load (billion cfu/yr)	Total Load Reduction Target (billion cfu /yr)	Total Target Percent Reduction (%)	Interim Load Reduction Target (billion cfu/yr)
1	96,026	73,210	**	**	**
36 (Headwaters)	166,826	159,308	**	**	**
2	120,406	90,883	**	**	**
3	107,470	106,659	**	**	**
35	673,866	363,962	**	**	**
6	214,797	112,375	**	**	**
4	254,415	200,835	**	**	**
7 (Saugatuck Reservoir)	571,599[1]	466,587[1]	13,921[2, C]	5. 9%[3]	8,352
7a	334,000	—[4]	781,413[5, IS]	27.3%[6]	468,848
5	124,105	93,401	**	**	**
8	139,499	99,284	**	**	**
9	139,499	93,103	**	**	**
11	200,835	74,594	**	**	**
10	145,585	81,229	**	**	**
34	147,852	101,325	**	**	**
12 (Little River)	629,356	370,286	259,069[R]	41.20%	155,441
13	136,874	135,561	1,313[R]	1.00%	788
14	63,437	63,115	322[R]	0.50%	193
33 (Lower Saugatuck River)	1,037,589[8]	573866[8]	414,833[7]	40.00%	248,900
33a	125,537	—[4]	48,890[IS]	38.90%	29,334
15	199,045	193,079	5,967[R]	3.00%	3,580
16 (Jennings Brook)	307,279	211,695	95,585[R]	31.10%	57,351
17 (Beaver Brook)	267,900	171,122	206,885[IS]	77.20%	124,131
27 (Aspetuck Tributary)	176,611	167,422	*	*	*
28 (Aspetuck River)	915,394	591,527	859,774[5, IS]	36.4%[6]	515,864
26 (Aspetuck Tributary)	115,895	113,759	*	*	*
25 (Aspetuck Tributary)	110,370	91,444	*	*	*
24 (Aspetuck Tributary)	103,854	93,246	*	*	*
23 (Aspetuck Tributary)	222,912	179,236	*	*	*
22 (Aspetuck Tributary)	355,609	275,776	*	*	*
21 (Aspetuck Tributary)	172,673	109,045	*	*	*
20 (Aspetuck Tributary)	62,112	43,425	*	*	*
19 (Aspetuck Tributary)	123,508	44,141	*	*	*
18 (West Branch)	4,196,897	1,394,988	3,105,151[IS]	74.00%	1,863,091
32 (Poplar Plain Brook)	232,697	58,425	159,000[IS]	68.30%	95,400
29	89,141	31,695	57,446[R]	64.40%	34,468
30	319,928	130,072	189,857[R]	59.30%	113,914
31 (Stony Brook)	1,330,549	138,186	1,192,363[R]	89.60%	715,418
Watershed Total:	**14,272,411**	**7,297,864**	**7,391,788**	**51.80%**	**4,435,073**

[1]Includes subwatershed 7a.

[2]Load reduction was calculated by subtracting the target reduction for subwatershed 7a from the difference between predevelopment and existing condition loads for subwatershed 7.

[3]Percent reduction was calculated using the load reduction target divided by the existing load for subwatershed 7 minus the existing load for subwatershed 7a.

[4]Predevelopment load was not calculated independently.

[5]Sum of load reduction targets for all subwatersheds draining to associated impaired water body segment.

[6]Percent reduction was calculated using the load reduction target and existing loads for all subwatersheds draining to the impaired water body segment.

[7]Load reduction was calculated by subtracting the target reduction for subwatershed 33a from the difference between predevelopment and existing condition loads for subwatershed 33.

[8] Includes subwatershed 33a

** Drainage to subwatershed 7a, impaired segment of the Saugatuck River above Saugatuck Reservoir (CT7200- 00_03)

* Drainage to subwatershed 28, impaired section of the Aspetuck River (CT7202- 00_01)

[IS]In- stream concentration- based method was used to calculate target reduction

[R]Reference condition method was used to calculate target reduction

[C]in- stream concentration- based target for subwatershed 7a was subtracted from the target for subwatershed 7 and 7a combined, which was calculated using the reference condition method.

Table 13. Summary of Pollutant Load Reduction Targets

Subwatershed (Headwaters to outlet)	NO_3 Total Target (lb/yr)	NO_3 Target as Percent of Total Watershed Target	NO_3 Interim Target	Particulate P Total Target (lb/yr)	Particulate P Target as Percent of Total Watershed Target	Particulate P Interim Target	TSS Total Target (lb/yr)	TSS Total Target as Percent of Total Watershed Target	TSS Interim Target	Indicator Bacteria Total Target (billion cfu/yr)	Indicator Bacteria Total Target as Percent of Watershed Target	Indicator Bacteria Interim target
1	105	0.2%	63	0	0.0%	0	0	0.0%	0	**	**	**
36 (Headwaters)	17	0.0%	10	0	0.0%	0	0	0.0%	0	**	**	**
2	190	0.3%	114	0	0.0%	0	0	0.0%	0	**	**	**
3	3	0.0%	2	0	0.0%	0	0	0.0%	0	**	**	**
35	824	1.2%	494	0	0.0%	0	0	0.0%	0	**	**	**
6	587	0.8%	352	267	9.2%	160	0	0.0%	0	**	**	**
4	366	0.5%	220	364	12.6%	218	0	0.0%	0	**	**	**
7 (Saugatuck Reservoir)	688	1.0%	413	0	0.0%	0	0	0.0%	0	13,921	0.2%	8,353
7a	-	-	-	-	-	0	-	-	-	781,413	10.6%	468,848
5	178	0.3%	107	0	0.0%	0	0	0.0%	0	**	**	**
8	22	0.0%	13	0	0.0%	0	0	0.0%	0	**	**	**
9	340	0.5%	204	171	5.9%	103	0	0.0%	0	**	**	**
11	623	0.9%	374	70	2.4%	42	491	0.1%	295	**	**	**
10	274	0.4%	164	243	8.4%	146	0	0.0%	0	**	**	**
34	288	0.4%	173	0	0.0%	0	0	0.0%	0	**	**	**
12 (Little River)	1,506	2.2%	904	0	0.0%	0	0	0.0%	0	259,069	3.5%	155,441
13	3	0.0%	2	0	0.0%	0	0	0.0%	0	1,313	<0.1%	788
14	1	0.0%	1	0	0.0%	0	0	0.0%	0	322	<0.1%	193
33 (Lower Saugatuck River)	1,820	2.6%	1,092	0	0.0%	0	0	0.0%	0	414,833	5.6%	248,900
33a	-	-	-	-	-	0	-	-	0	48,890	0.7%	29,334
15	16	0.0%	10	0	0.0%	0	0	0.0%	0	5,967	0.1%	3,580
16 (Jennings Brook)	198	0.3%	119	0	0.0%	0	0	0.0%	0	95,585	1.3%	57,351
17 (Beaver Brook)	662	1.0%	397	416	14.4%	250	0	0.0%	0	206,885	2.8%	124,131
27 (Aspetuck Tributary)	28	0.0%	17	0	0.0%	0	0	0.0%	0	*	*	*
28 (Aspetuck River)	1,379	2.0%	827	0	0.0%	0	0	0.0%	0	859,774	11.6%	515,864
26 (Aspetuck Tributary)	7	0.0%	4	0	0.0%	0	0	0.0%	0	*	*	*
25 (Aspetuck Tributary)	121	0.2%	73	0	0.0%	0	0	0.0%	0	*	*	*
24 (Aspetuck Tributary)	34	0.0%	20	72	2.5%	43	0	0.0%	0	*	*	*
23 (Aspetuck Tributary)	280	0.4%	168	0	0.0%	0	0	0.0%	0	*	*	*
22 (Aspetuck Tributary)	282	0.4%	169	973	33.6%	584	0	0.0%	0	*	*	*
21 (Aspetuck Tributary)	308	0.4%	185	18	0.6%	11	0	0.0%	0	*	*	*
20 (Aspetuck Tributary)	111	0.2%	67	0	0.0%	0	0	0.0%	0	*	*	*
19 (Aspetuck Tributary)	404	0.6%	242	211	7.3%	127	1,094	0.3%	656	*	*	*
18 (West Branch)	37,035	53.5%	22,221	0	0.0%	0	0	0.0%	0	3,105,151	42.0%	1,863,091
32 (Poplar Plain Brook)	838	1.2%	503	0	0.0%	0	24,615	6.2%	14,769	159,000	2.2%	95,400
29	290	0.4%	174	90	3.1%	54	13,455	3.4%	8,073	57,446	0.8%	34,468
30	951	1.4%	571	0	0.0%	0	0	0.0%	0	189,857	2.6%	113,914
31 (Stony Brook)	18,419	26.6%	11,051	0	0.0%	0	355,825	90.0%	213,495	1,192,363	16.1%	715,418
Total	69,200	100.0%	41,520	2,896	100.0%	1,738	395,480	100.0%	237,288	7,391,788	100.0%	4,435,073

For indicator bacteria, subwatershed 7 was divided into the portion draining to the impaired water body segment (7a) and the drainage downstream of that point (7). Subwatersheds 33 and 33a were treated similarly. For all other pollutants subwatersheds 7 and 33 were modeled as one area.

* = Drainage to subwatershed 28, impaired section of the Aspetuck River (CT7202-00_01)

** = Drainage to subwatershed 7a, impaired segment of the Saugatuck River above Saugatuck Reservoir (CT7200-00_03)

The Saugatuck River Watershed means different things to different people. Some value its utilitarian purposes, its use as drinking water (from the Saugatuck and Aspetuck Reservoirs), and the high property values associated with ample open space. Others value it for reasons that are harder to quantify or put into monetary terms—for example, the environmental diversity the river supports, or the aesthetic character it lends to the region. Understanding how a river is used is a crucial piece of the watershed based planning process because it allows managers to set goals tailored to the values of the community.

TNC's *Introduction to the Saugatuck River Watershed and The Saugatuck River Watershed Partnership* identifies key conservation targets, many of which are reflected below. Through a public meeting format, stakeholders built on these ideas to identify "uses and values" of the watershed, and to relate these back to the watershed and stream attributes that make them possible. This chapter discusses the uses and values that were identified by the stakeholder group during this meeting and offers stakeholders' comments on the physical attributes needed to provide for these uses and values.

POTABLE WATER

The Saugatuck River Watershed is an important source of potable water, both through surface and groundwater withdrawals. Watershed stakeholders accordingly identified drinking water as a key use in the watershed, one that is associated with economic benefit. Intact forested lands above the Saugatuck and Aspetuck Reservoirs play a key role in maintaining water quality and quantity through groundwater recharge and natural filtering processes. The impact of water withdrawals on downstream flow regimes is of critical concern to many watershed stakeholders. TNC and the Aquarion Water Company are currently working together to examine the effects of water withdrawals on in-stream flows and develop more ecologically appropriate water release regimes for the Saugatuck and Aspetuck Reservoirs.

FOREST AND OPEN SPACE

Project stakeholders identified forest and open space as a key watershed value, one that provides many ecosystem functions including carbon sequestration, nutrient removal, flood storage and attenuation, scenic beauty, and wildlife habitat. Watershed partners have worked successfully to protect thousands of acres of forested lands within the watershed, and moving forward, land acquisition and protection will continue to play an important role in watershed management efforts.

Stakeholders felt that forested and open areas within the watershed, particularly in riparian and headwater areas, play a key role in maintaining the watershed's generally high water and aquatic habitat quality. Stakeholders also recognized that forested lands infiltrate and evapotranspirate precipitation, reducing the size and intensity of flood flows. Riparian trees shade small and medium-sized streams, reducing stream temperature and regulating the production of algae and other aquatic plant life. Riparian zones also play a key role in regulating nutrient inputs to streams and providing them the sources of organic matter that provide habitat and are the basis for aquatic food webs.

RECREATIONAL OPPORTUNITIES

The Saugatuck River Watershed provides a range of recreational opportunities, many of them related to the region's water resources. Hiking, bird-watching, swimming, fishing, boating, recreational shellfishing, and golfing were activities cited by stakeholders. Many of these depend on the maintenance of high-quality water and habitat and on the availability of public access opportunities (e.g., hiking trails and river access). Recreational opportunities improve the quality of life for residents and attract visitors to the watershed from across the region. Stakeholders noted the potential for improving recreational opportunities by developing additional opportunities for kayaking and canoeing, increasing shellfish harvest, improving fisheries health by reducing stream temperatures and restoring natural flows, and improving water quality through goose management and the expansion of riparian buffers.

ECONOMIC BENEFITS

Watershed stakeholders recognized and articulated many ways in which the Saugatuck River system provides economically beneficial uses. These include commercial shellfishing, logging, water for golf courses, water for pools, sale of potable water, agricultural uses, and support for landscape companies. Aesthetic and recreational services contribute to increased property values throughout the watershed.

CARBON SEQUESTRATION

Stakeholders identified carbon sequestration, the process whereby plants remove carbon dioxide from the air, as a watershed value. Watershed lands, particularly forested lands, remove carbon from the atmosphere, sequestering carbon within living and non-living organic material. As cities and regions step up efforts to restrict the production of greenhouse gases, carbon sequestration will be an increasingly vital ecosystem service.

FLOOD CONVEYANCE, STORAGE, AND STORMWATER

Stakeholders noted that natural lands, wetlands, and stream channels within the Saugatuck River Watersheds perform the critical function of absorbing and conveying runoff from precipitation events throughout the watershed. In undeveloped areas, forests infiltrate or evapotranspirate a large percentage of incoming precipitation, resulting in smaller flood peaks and higher baseflows (flow in the stream that is not the direct result of a storm event). Maintaining natural cover throughout the watershed and effectively managing stormwater is fundamental to avoiding the flooding problems that have plagued the more developed watersheds in the region.

SCENIC BEAUTY

The natural lands and high-quality streams associated with the Saugatuck River Watershed play an important role in creating the area's scenic charm, a value that that stakeholders felt translates into desirable living conditions and increased property values. Paradoxically, the desire to create open views of streams and river channels often results in the removal of riparian trees, which in turn degrades river systems. Future development could significantly undermine the very values sought by would-be property owners.

WILDLIFE SUPPORT

The more than 17,000 acres of protected lands, including the Centennial Watershed State Forest adjacent to the Saugatuck Reservoir, provide a range of habitats—wetland, upland forest, and floodplain forest. Stakeholders noted the importance of natural lands for supporting wildlife populations within the Saugatuck River Watershed. These areas support diverse plant and animal communities where several species of rare wildflowers and forest-nesting birds can be found. Alewife, sea lamprey, American eel, freshwater mussels, and other resident fish are found in the waters of the Saugatuck River Watershed. The size of forest patches and connectivity among patches are key attributes that correlate with the overall capacity of watershed lands to support intact biological communities.

CULTURAL IDENTITY/HISTORIC VALUE

Several stakeholders articulated the importance aquatic resources and natural lands have in defining residents' cultural identity and providing a vital link to the region's history. Residents of the area have used the Saugatuck River for thousands of years, beginning with the Native Americans who once fished its waters. In more recent times, the power of the Saugatuck River was harnessed to fuel the region's industrial and economic development, giving rise to extensive networks of mill dams and putting a temporary end to the migration of diadromous fish. Important efforts by TNC to restore fish passage through dam removal and the installation of fishways is ongoing.

As discussed previously, the Saugatuck River Watershed has been stressed by multiple factors relating to residential development and human use. In some areas, improvements in water and habitat quality, and biological community health are required to fully realize the great potential of the Saugatuck River as a natural, economic, cultural, and recreational resource. High-quality resources must be preserved and managed to maintain existing uses.

TNC's *Conservation Action Plan*, discussed in Chapter 1, identifies management objectives, strategies, and actions that are intended to guide long-term decision-making in the watershed. These were developed by TNC following a series of public meetings attended by members of the watershed community including representatives of the 11 watershed towns. The goals and strategies developed for the WBP are intended to reinforce and extend the recommendations defined in the *Conservation Action Plan*, and to frame this content within EPA's nine (9) step watershed planning process.

Management goals of the WBP were identified by the steering committee to define the specific long-term outcomes that will lead to a healthy, high-quality river system that meets the needs of its diverse stakeholders. Goals were developed taking into consideration the existing conditions analysis presented in Chapter 3 and the uses and values defined in Chapter 4. The management goals defined for the WBP are as follows:

- Protect and enhance water quality and high-quality stream communities;
- Restore diadromous fish populations;
- Restore impaired biological communities; and
- Preserve and enhance recreational opportunities.

Management strategies outline sets of activities that, when implemented, will result in the outcomes defined by the goals. As with the goals, the strategies were developed with important input from the steering committee and stakeholders through a series of public workshops, and are intended to reinforce and extend strategies outlined in TNC's *Conservation Action Plan*. The following management strategies were identified for the WBP:

- Implement an early warning system to detect emerging threats;
- Mitigate the impact of water diversions through adaptive management;
- Mitigate fish migration barriers through natural fishways, fish ladders, and barrier removals;
- Reduce water quality impacts associated with unmanaged stormwater runoff through implementation of stormwater BMPs;
- Remediate bacterial impairments and enhance riparian habitat;
- Avoid future increases in stormwater related impacts through conservation acquisition and promotion of low impact development (LID) policies;
- Pursue strategic land acquisition to protect headwater streams and other watershed lands;

- Encourage better stewardship of public and private lands by implementing education and outreach programs for landowners and municipal officials; and
- Implement the WBP and monitor outcomes.

Each goal and strategy is discussed in detail in the sections below.

MANAGEMENT GOALS

Building on the uses and values defined in Chapter 4, the WBP establishes management goals focused on protecting and enhancing high-quality water and stream communities, restoring diadromous fish populations, restoring impaired biological communities, and preserving and enhancing recreational opportunities in the watershed. Goals were established by watershed stakeholders through a public meeting format following identification of watershed uses and values. While there are other goals that could be developed, it is important to focus management efforts primarily on these high-priority goals.

Protect and enhance water quality and high-quality stream communities

Home to both the Saugatuck and Aspetuck Reservoirs, the Saugatuck River Watershed supplies drinking water to over 300,000 people. Due to strong protection efforts and generally good aquatic conditions, the watershed also supports an array of recreational opportunities such as fishing, swimming, and scenic enjoyment. All these activities rely on consistent, high-quality water resources, which in turn depend on minimizing inputs of pollutants. Because of conservation efforts, many of the streams in the upper Saugatuck River Watershed drain relatively undeveloped subwatersheds and contain high-quality aquatic habitats and biological communities. But despite significant conservation efforts, the potential for substantial future development exists; existing resource quality must be closely monitored and municipal land use and development regulations established to limit future impacts.

Restore diadromous fish populations

Widespread dam construction has significantly reduced access to historical spawning runs of diadromous fish, most notably the Saugatuck River's population of alewife, American eel, and blueback herring. Mitigation of migration barriers is a challenging prospect, but over time offers the potential to restore these historical fish populations. Restoring fish passage can be accomplished through the creation of fish ladders or natural fishways, or through partial or full barrier removal.

Restore impaired biological communities

Although the Saugatuck River Watershed is one of the highest-quality watersheds in the region, biological communities in some areas within the watershed have been degraded. In the lower watershed, for instance, Stony Brook and the lower West Branch have been significantly altered by urban development. Biological sampling indicates that fish communities have been negatively impacted in some areas, and although macroinvertebrate communities have not been sampled in the far lower tributaries (subwatersheds 29, 30, 31, and 32), levels of impervious cover in these areas suggest that some amount of impact to these communities is likely.

In addition to the effects of development, numerous private wells may be diminishing baseflow in the headwater reaches of the watershed. This may be negatively impacting aquatic life in these areas. Networks of small dams and impoundments create thermal pollution and block fish passage, while water use associated with the watershed's major drinking water reservoirs may also be negatively impacting downstream aquatic life. The effects of under-performing or malfunctioning septic systems may also degrade biological communities. Restoring impacted biological communities involve a range of activities: removing dams to create habitat; better managing reservoir and private well water withdrawals; and retrofitting stormwater systems to reduce hydraulic stress, increase baseflow, and improve water quality.

Preserve and enhance recreational opportunities

With its network of trails and public access points, scenic quality, and proximity to large population centers, the Saugatuck River Watershed is a key recreational resource. Devil's Den Preserve, Trout Brook Valley, and many of the other linked open spaces that make up the Centennial Watershed State Forest are important amenities for hikers, joggers, dog owners, and other outdoor enthusiasts. The availability of these opportunities depends strongly on protecting high-quality aquatic resources and publically accessible natural lands.

MANAGEMENT STRATEGIES

Management strategies define specific sets of management actions required to achieve the broad outcomes outlined in the preceding goals section. Strategies were developed considering known constraints and assets in the watershed, including the availability of open space for restoration and protection, potential for partnership among stakeholders, availability of existing data, and community priorities within the watershed. Strategies are integrative by design; that is, they often address multiple goals simultaneously. The following section discusses each of nine (9) management strategies that form the basis for implementation of the WBP. In Chapter 6, Table 16 presents a list of management actions that support each of the strategies presented below.

1. Implement an early warning system to detect emerging threats

Given the high quality of many of the streams within the Saugatuck River Watershed, an early-warning monitoring system should be established to detect impairments before they become significant. The monitoring program, which can build on the existing volunteer monitoring and streamwalk programs organized by the SRWP, the work of HW/RW, and water quality monitoring conducted by Aquarion Water Company, should focus on detecting changes in sensitive and easy-to-measure parameters such as temperature, stream erosion, and fish and macroinvertebrate communities within the headwater streams that drain to the Saugatuck and Aspetuck Reservoirs. Areas that are currently experiencing or could in the future support significant development activity would be particularly targeted.

Synergy: A significant amount of monitoring data for bacteria, temperature, dissolved oxygen, conductivity, and bioindicators have already been collected throughout the watershed.

Challenge: Water quality monitoring can be expensive, and may only be useful if implemented over an extended period of time.

Existing Resources: The HR/RW program offers training in water quality monitoring techniques through the Earthplace Water Quality Research Lab in Westport. There may be additional opportunities for volunteer monitoring groups to train with scientists from Aquarion Water Company or TNC.

Approach & Next Steps: Identify short-term opportunities to expand the current monitoring program through partnerships with NGOs, universities, and volunteer groups.

2. Mitigate the impact of water diversions through adaptive management

TNC and Aquarion Water Company are currently working together to look at ways that the Saugatuck and Aspetuck reservoirs can be better managed to provide an ecologically appropriate flow regime downstream of the reservoirs, while still providing sufficient drinking water supplies. In this work, the use of optimization computer modeling can help to hone in on release schedules that best balance consumptive and ecological needs. For these computer models to be effective, scientists working in the watershed must continue to develop and refine their understanding of flow requirements for each species of concern. Improving water-demand forecasting technology will also help to anticipate and plan for consumptive needs and allow for the possibility of larger, early-season water releases. Also, watershed partners should work to identify regions of the watershed that are in water deficit, where total baseflow from the watershed is less than the rate at which local aquifers are being recharged by infiltrating precipitation, and implement strategies to relieve them either by increasing rates of recharge or reducing withdrawals. Further, an adaptive management model that will help to ensure positive long-term outcomes could come about if TNC and Aquarion mutually agree to move toward a roughly defined "solution space," a system of releases that provides for both consumptive and ecological use. This would be achieved through the use of an iterative process of computer modeling, implementation, and biological monitoring rather than adopting, *a priori*, highly prescriptive targets.

Synergy: Releases from the reservoir may not necessarily have to be greater in volume to improve downstream conditions; changes in the timing and pattern of releases could potentially offer downstream benefits at no additional cost to reservoir managers.

Challenge: When establishing long-term flow criteria, it may be difficult to plan for future consumptive water demand; similarly, future weather conditions may not follow recent trends.

Existing Resources: TNC and Aquarion Water Company signed an agreement in 2007 to develop a sustainable flow management plan for the Saugatuck River. Existing habitat and infrastructure conditions have been assessed as part of this process.

Approach & Next Steps: Continue steps to define needs and establish long-term flow criteria.

3. Mitigate fish migration barriers through natural fishways, fish ladders, and barrier removals

Throughout the Saugatuck Watershed, the SRWP has conducted extensive fish passage restoration work, as discussed in Chapter 1 and presented in Table 1 and Figure 2. To date, many fishways have been successfully implemented in the watershed, and monitoring of fish movement conducted by SRWP suggests positive results.

Building on prioritization and assessment already completed by the SRWP, a comprehensive fish barrier mitigation plan should be developed to assist in attracting funding through grants and private donations, and to engage multiple private land owners. The plan should assess each significant existing fish barrier, including dams and culvert/bridge crossings, in terms of miles of habitat "opened"; historical significance; presence and amount of accumulated sediment; barrier height; potential for stream channel changes (e.g., stream bank erosion) or accumulated sediment to be washed downstream following dam removal; options for local material disposal; extent and magnitude of thermal pollution (i.e., heating of stream water to levels that negatively impact aquatic life); existing constraints such as the presence of subsurface utilities such as electrical or sewer lines; extent of restoration work (e.g., bank stabilization, etc.); existing ownership and usage; structural condition of the dam; landowner cooperation; potential for impacts to regulated resources (e.g., wetlands, etc.); presence of threatened and endangered species; existing safety and liability issues; and any other factors that would affect feasibility and design options (e.g., removal vs. fish passage only, etc.).

Once barriers have been assessed, mitigation may include modifying raised culverts, installing fish passage structures such as fish ladders and natural fishways, and removing small dams where feasible. These measures will be most effective if implemented where significant new habitat can be opened (i.e., where the distance to the next upstream barrier is significant). Efforts to implement fish passage projects will require close coordination with both private landowners and municipal and/or state officials.

In a fully restored river, migratory fish would be able to access habitat up to the point of the first natural barrier in the stream, known as the natural falls. Fish passage work should initially focus on migratory species, with the goal of restoring passage to this point. However, while this point represents the limit of habitat for migratory species, there are also many other non-migratory fish species that live above natural barriers and can benefit from open habitat and barrier mitigation. Once access is restored to the natural falls, or when mitigation opportunities are exhausted in the lower watershed, it may be useful to identify additional small impoundments and barriers above the natural falls, and to work to connect habitat for resident species.

Continuing to forge and strengthen partnerships with resources management agencies and funders (e.g., CTDEEP, NOAA, etc.), non-profits (e.g., American Rivers, etc.), cooperating landowners, local municipalities, historical groups, and foundations will help to avoid conflicts and attract a continuous stream of funding. Continuing to monitor outcomes (e.g., stream temperature reductions, fish passage, etc.) will be critical to documenting success and attracting future funding.

Synergy: Improved fish habitat in the river could potentially draw increased recreational fishing activity, which could create a greater demand for stewardship and enhance funding opportunities.

Challenge: The dams are so numerous that mitigation of a single structure may not open a significant reach of habitat.

Existing Resources: Multiple barriers have already been addressed by local property owners working closely with the SRWP (Table 1).

Approach & Next Steps: Obtain funding to address the remaining barriers, and work with property owners to build support for dam removal.

4. Reduce water quality impacts associated with unmanaged stormwater runoff through implementation of stormwater Best Management Practices

Watershed imperviousness within portions of the lower Saugatuck River Watershed approaches levels that are typically associated with significant impairment of biological communities. Improving biological conditions within these areas, particularly the West Branch and the Lower Main Stem, will involve a concerted effort to implement structural and non-structural stormwater BMPs throughout developed areas of the watershed.

Key management actions for reducing water quality impacts associated with unmanaged stormwater runoff include:

- Implementing structural BMPs within sensitive headwater streams that show signs of instability and erosion. Implementing BMPs within these sensitive areas can help avoid more significant stream channel erosion problems that can result in sediment and other pollutants.
- Placing BMPs in relatively small drainage areas where their effects can be more readily detected over short time frames.
- Implementing highly urban stormwater BMPs that offer a wider suite of ancillary aesthetic, economic, and social benefits (e.g., green streets, etc.). This type of comprehensive approach, while more expensive, may help to attract a broader constituency and open more diverse funding sources.
- Roadside wetlands in various conditions were observed throughout the watershed; some appeared to be handling stormwater inputs, but many appeared to be overwhelmed. In particular, drainage culverts that outfall directly into wetlands appear to be causing erosion and sediment problems. Degraded wetlands may be restored through the use of bioretention along state and local roads, to capture and infiltrate runoff before it reaches the wetland. This would require an assessment of the level of impact to roadside wetlands throughout the watershed, and partnering with the Connecticut Department of Transportation to construct and manage bioretention BMPs.
- Implementing non-structural BMPs. Non-structural BMPs such as “good housekeeping” at construction yards, nutrient management programs, or rain barrel incentive programs are important to manage nutrient and sediment loading, particularly for residential homeowners and business owners. Best management techniques for lawn care and roof runoff are difficult to implement on a large scale, but have the potential for widespread benefit.
- Municipalities leading by example. Publicly owned properties can be ideal sites for demonstration BMPs, which reduce overall pollution loading while providing an important education tool. Concurrently, municipal policies and maintenance practices (see Strategy 6) can help to set the tone for local residents and encourage good practices going forward.

Synergy: Structural BMPs such as rain gardens, constructed wetlands, and naturalized storage basins can improve habitat for birds and amphibians and other animals, and can also improve site aesthetics, if planted carefully. Residential structural BMPs, such as rain barrels, are a great way to educate homeowners about the impacts of unmanaged stormwater runoff.

Challenge: Much of the available space for BMPs is residential and privately owned; it may be difficult to obtain permission and funding for BMPs on private property.

Existing Resources: CTDEEP offers extensive guidance on BMP design and implementation through the 2004 *Connecticut Stormwater Quality Manual*.

Approach: Mixed-use watersheds provide a range of structural and non-structural BMP opportunities that vary significantly in terms of implementation cost and downstream benefits (typical costs and load reductions associated with common BMPs are discussed in greater detail in Chapter 6). Structural BMPs tend to offer the greatest certainty in terms of pollution-reduction but can be expensive to implement. When planning for structural BMPs, it is important to first look for the "low-hanging fruit" (i.e., low cost/high benefit BMPs), which often involve the following types of opportunities (see Chapter 7 for opportunities identified in the watershed):

- Regional management opportunities to treat large, impervious areas within existing open space or parkland, (e.g., schools and parks where street runoff can be diverted and managed in unused open spaces, etc.);
- Retrofits of existing stormwater basins, such as the large commercial basins/swales found along Route 1, to provide enhanced treatment; and
- Small bioretention areas within unconstrained institutional and commercial properties (e.g., schools, universities, corporate campuses etc.).

Focusing implementation on target subwatersheds (as opposed to a scattershot approach) can help to create more momentum and demonstrate results in a shorter time frame.

Next steps: Review low-cost structural BMPs identified in Chapter 7 and select several manageable BMPs for early implementation.

5. Remediate bacterial impairments and enhance riparian habitat

Bacterial impairments can significantly undermine recreation uses, even within relatively healthy watersheds. Monitoring conducted by HW/RW has documented several reaches of stream that fail to meet state bacteria standards for safe recreation. However, the source of these impairments is under some debate within the watershed community, and deserves additional research to determine whether the majority of loading is coming from the surface (i.e., from stormwater and animal wastes) or from leaking septic tanks. The SRWP, which has demonstrated success in local restoration project management, is particularly well suited to implement focused remediation efforts to remove these impairments and delist these segments from the 303(d) list. Management actions identified in the WBP address limiting bacteria sources and adding riparian buffers wherever possible. This combined approach could include a variety of activities depending on the outcome of the initial study, but will most likely employ some or all of the following:

- *Reduce the incidence of leaking septic systems*. Private septic systems are widespread throughout the watershed, and difficult for municipalities to monitor. Particularly in older developments, they can be a significant source of bacteria, especially on properties located adjacent to the stream. Following an assessment of problem areas, properties with failing septic systems can be targeted through outreach to current homeowners, and through mandatory inspections at every deed transfer.
- *Manage pet waste*. Fecal bacteria from pet waste is easy and inexpensive to manage. Cleaning up after pets is important, especially at recreational areas along the river. Outreach including media campaigns and training can all be helpful to change pet owner behavior (see Strategy 8 and Chapter 8). Placing signs, free baggies, and trash

cans at public recreation sites can get the message across and make it easy for pet owners to change their habits.

- *Create riparian buffers*. Riparian buffers can help to filter bacteria from stormwater runoff while providing a range of other benefits for streams. The several riparian buffer BMPs identified in Chapter 7 (at Astor Place Stables, Aspetuck Valley Country Club, Wayside Lane, Redding Road, New Pond Farm, and along the lower Main Stem and Aspetuck main stem) can be important first steps toward reducing bacteria loads in key areas. Additional buffers can be implemented on private properties, particularly where the lawn is currently mowed up to the stream edge. A variety of outreach approaches (see Strategy 8) can be used to encourage buffer plantings on private property, including design guidance and workshops, and targeted education campaigns.
- *Reduce nesting populations of non-migratory geese*. Colonies of geese favor open areas adjacent to streams and impoundments, especially where low grass allows a clear view of the water. At parks and golf courses, large colonies can become a significant water quality problem as well as a nuisance. Simply allowing grass to grow tall along the stream bank can discourage the geese from nesting in that location, and increasing the buffer with taller shrub plantings can be especially helpful. Where buffers are not an option, controversial methods of goose control may include harassment by dogs or limiting the viability of eggs.

Synergy: Measures to remediate bacteria such as stream buffers and other types of stormwater BMPs may also address nutrient pollution and scouring during storm events.

Challenge: Wild and domestic animals are a major source of bacteria in most watersheds, and their collective impact is difficult to manage at the scale necessary to achieve significant improvements.

Existing Resources: An extensive data set is available following four (4) years of dry weather monitoring in the lower Saugatuck River.

Approach & Next Steps: Identify sites for buffer restoration based on site suitability and available funding (see Appendix A for a preliminary list).

6. Avoid future increases in stormwater-related impacts through conservation acquisition and promotion of low impact development policies

LID policies decrease the impacts of development on natural systems by requiring or incentivizing the use of an LID design approach for new and redevelopment projects. Adopting LID policies mostly involves strengthening municipalities' existing stormwater, subdivision, and zoning and land development ordinances in highly sensitive areas. These policies help ensure that new and redevelopment projects in the watershed are constructed so as to minimize impacts on local waterways. LID techniques include reducing impervious surfaces associated with new development or redevelopment by the use of narrower roads or elimination of cul-de-sacs, and avoiding soil compaction and mass regrading of development sites. An LID approach would require developers to locate buildings, roadways, and parking lots away from streams, wetlands, floodplains, high-quality forests, and other sensitive natural resources, and involve the use of small-scale structural BMPs such as rain gardens to soak stormwater into the ground at its source. These techniques mimic the way stormwater flows through undeveloped lands such as forests.

Watershed partners should strive to adopt a consistent set of development, zoning, and stormwater ordinances across the 11 towns within the watershed. Failing full participation, Redding, Weston, Easton, Danbury, Newtown and Westport are the critical stakeholder municipalities. Consistent guidelines will help to ensure that development is not simply pushed from town to town as individual towns strengthen their ordinances.

LID policies involve a number of specific requirements that encourage a more watershed-friendly approach to development:

- Municipal stormwater requirements that are useful to reduce impacts associated with development require volume-based management of smaller storms for water quality protection (typical requirements include the infiltration of at least the first inch of runoff from impervious surfaces); peak-rate control for moderate storms to protect channels from eroding, as moderate-sized storms tend to inflict the most stream erosion over time; and management of larger storms for flood control.
- Progressive zoning provisions, such as cluster development and transit-oriented development, can limit sprawl. These approaches cluster development in a smaller area, leaving more open space, or locate development close to existing transportation and transit resources to limit the need for additional transportation infrastructure.
- Development ordinances may choose to include mandatory tree mitigation requirements (i.e., programs that require trees to be replaced if they are removed); limit road widths and parking space sizes; allow flexibility in setback requirements (requirements for building setbacks from roadways or property boundaries can limit the ability to cluster housing to protect open space and increase minimum lot sizes); strongly limit development on steep slopes; and require a conservation-oriented design approach that seeks to minimize mass grading, engineered fills, whole-scale vegetation removal, and soil compaction (these practices are commonly associated with large-scale commercial developments). Incentives for BMPs that allow for infiltration into the ground, such as use of pervious pavements, depressed islands, and vegetated swales along roadways and parking lots should also be encouraged.

To set an example for the development community, LID practices may also be used in new municipal construction and long-term planning. For example, LID approaches that incorporate such BMPs as bioretention systems and rain gardens can be incorporated into streetscaping or repaving activities to create “green streets” that add visual interest to street corridors.

In some instances, municipal code may actually discourage LID by requiring large minimum lots sizes or significant setbacks. A full review of existing land use regulations is recommended to identify barriers to LID implementation and to identify opportunities for incorporating LID into existing municipal regulations. This process has begun with work by the SRWP to evaluate municipal ordinances by looking at how municipal regulations can be better aligned or support conservation to better assist with implementing the WBP. Additionally, retraining and education programs for municipal officials and staff, construction inspectors, consulting engineers, contractors, and developers will ensure that LID regulations are properly implemented (see Strategy 8).

Synergy: The watershed based approach provides a great opportunity to engage in multi-municipal planning so that development requirements are consistent throughout the watershed.

Challenge: Uniform guidelines among watershed municipalities will help to ensure that development is not simply pushed from town to town as individual towns strengthen their ordinances.

Existing Resources: Many existing resources are available that provide model stormwater management resources including the CTDEEP's website www.ct.gov/dep, the CWP's web site (www.cwp.org) and the Low Impact Development Center (www.lowimpactdevelopment.org)

Approach & Next Steps:

- Key aspects of an effective and far reaching stormwater ordinance include providing standards for water quality protection (typically managing the first inch of runoff through infiltration), channel protection (typically managing 1–2-year storms), and flood control (peak rate control for larger storms, such as the 25-, 50-, and 100-year storms) for all new development and major redevelopment.

- A model LID ordinance may be useful to establish minimum stormwater criteria and promote LID approaches throughout the watershed.

- Municipal improvement projects may choose to utilize LID techniques wherever possible in order to present an example for business and residential communities. Demonstration sites in particular may be useful for promoting LID practices while providing water quality benefit.

7. Pursue strategic land acquisition to protect headwater streams and other watershed lands

The SRWP and TNC are working closely with municipalities to identify and prioritize conservation acquisition targets within drainages to headwater streams upstream of the Saugatuck and Aspetuck Reservoirs, particularly in areas with significant availability of undeveloped and unprotected private lands. Numerous groups have been successful in preserving land in the Town of Redding, which contains most of the land upstream of the Saugatuck Reservoir. Work by TNC, local land trusts, municipalities, the SRWP and CTDEEP have driven the success in protecting open space throughout the watershed. Continued preservation efforts are critical for the long-term protection of the area's headwater streams, while continued land preservation and protection of open space throughout the watershed will help to protect and enhance water quality. In the long term, a "conservation bank" implemented by all watershed municipalities may be useful to offset new development and add to permanently protected open space.

Synergy: Protecting open space increases opportunities for recreation, protects water quality, and may increase property values in the local vicinity.

Challenge: Due to high property values, particularly in the lower watershed, remaining available land may be expensive.

Existing Resources: TNC and several local land trusts have conducted extensive parcel prioritization, and outreach to landowners.

Approach & Next Steps: Compile conservation targets already identified by the municipalities, land trusts, and TNC; identify additional areas in target subwatersheds where parcel research has not been conducted.

8. Encourage better stewardship of public and private lands by implementing education and outreach programs for landowners and municipal officials

Promoting healthy attitudes toward stewardship and general property management is a critical step toward improving overall watershed health. Educational materials can make private citizens and public officials more aware of the connections between NPS pollution and local-scale actions such as lawn care practices and pet waste management and can provide practical, easy-to-implement actions for reducing NPS pollution. Educational initiatives can make use of the full range of media outlets and presentation mediums. The following methods may be useful for engaging and educating community members to take more active roles in management of their watershed:

- Workshops geared toward homeowners, developers, engineers, land use attorneys, and golf course managers, presented by municipal conservation boards or local naturalists (topics may include lawn maintenance and landscaping, stormwater management, riparian buffers, management of small impoundments, and proper septic care);
- Targeted e-mail and social media campaigns to direct community members to a website/online resource center with downloadable information, interactive maps, blog, and RSS feeds to news outlets for watershed professionals (state and local news sites, stakeholder pages, etc.);
- Courses and outreach for municipal officials (particularly Public Works, Parks, and Education Departments) geared toward LID practices, MS4 compliance and good housekeeping, and case studies of LID initiatives across the country;
- Courses for municipal officials geared toward open space protection and policy options for encouraging LID;
- Streamwalks, cleanups, enhanced river access points, and volunteer monitoring events geared toward developing active volunteer task forces and getting people out into the river; and
- Public service announcements for local radio and television stations, which may include messaging for landowners related to pet waste management, rainwater re-use, and septic system maintenance.

Outreach may also be targeted toward the owners and managers of properties that typically generate significant NPS pollution:

- *Municipal facilities and golf courses.* Working with municipal facilities and golf courses to develop nutrient management plans helps managers target fertilizers where they are needed most, decreases the likelihood of over-fertilizing areas that have adequate soil nutrients, times fertilizer treatments when they are less likely to run off into streams, and selects fertilizers that are less prone to washing off into streams. The practices can also result in cost savings for managers. Nutrient management planning also looks at opportunities to add shoreline and riparian vegetation, which can reduce bacteria as well as nutrients, and may limit colonization by non-migratory geese. When meeting with golf course managers, the need for sustainable irrigation may also be emphasized.

- *Equestrian facilities and small farms*. Owners of hobby farms may be eager to learn about alternative methods of waste management to reduce inputs to the stream. Simply limiting livestock access to streams is an excellent way to reduce erosion and limit direct inputs of nutrients and bacteria. Other source controls can include manure storage facilities and reducing fertilizer use.
- *Small private impoundments***.** Flocks of geese around small impoundments can be locally significant sources of nutrients and bacteria. Working with property owners, plant buffers along ponds to deter geese while filtering polluted runoff.

Synergy: A "neighborhood-by-neighborhood" approach to stewardship may be helpful to create localized improvement and spur a sense of participation and civic engagement. Education and outreach programs can be combined with nearby demonstration sites involving, for instance, the installation of structural BMPs at community centers, schools, and churches.

Challenge: Some watershed residents and officials are likely to be highly educated and motivated to implement watershed-friendly practices. Although general awareness of watershed issues has increased in recent years, for the majority of residents and municipal officials, watershed issues still lag behind other "quality of life" issues including education, crime, and health care. Linking watershed issues with quality of life issues like drinking water can help to get these issues "on the radar screen."

*Existing resources***:** The Saugatuck River Watershed benefits from a range of qualified stakeholder groups with good standing in the community. These organizations, as well as local conservation boards, will be a key resource for developing educational materials and connecting the materials with the necessary audience.

*Approach and next Steps***:** Detailed recommendations for incorporating education and outreach activities into Plan implementation is provided in Chapter 8. This chapter emphasizes proven approaches such as targeting early adopters who can set a positive example for others to follow, combining education and outreach events with existing events (e.g., community fairs) to maximize participation, and emphasizing simple messages that stress changing one or two behaviors. Chapter 8 also stresses the use of multiple media to different audiences and creation of a brand image using logos and consistent graphic styles.

9. Implement the Watershed Based Plan and monitor outcomes

Achieving the management goals outlined in the WBP will require a sustained effort among multiple partners. Implementation will benefit greatly from a commitment to measuring and monitoring outcomes, and subsequent adaptation based on monitoring data. This type of adaptive management approach will be crucial to success of the WBP. Periodic evaluation and refinement of management actions throughout the implementation process will help to ensure that resources are used in the most effective manner possible. For a detailed discussion of monitoring/maintenance, see Chapter 9.

Many of the recommendations discussed in the WBP are already partially underway, led by the SRWP with support from TNC, Aquarion Water Company, and watershed municipalities. However, continued work requires continued funding. In addition to the management strategies identified in the WBP, funding should be obtained to support SRWP annual reports and additional activities identified in *An Introduction to the Saugatuck River Watershed and The Saugatuck River Watershed Partnership*, which includes the *Conservation Action Plan*.

*Challenge***:** Implementing the WBP will require significant oversight, ideally by a single individual.

Existing resources: Many different groups are working within the watershed on a range of diverse priorities; Table 16 in Chapter 6 identifies organizations that may be well suited to implement each management action based on the groups' mission, capacity, and prior experience.

Approach & next steps: Review the WBP every 5 years, evaluating successes and lessons learned, and revise and update the WBP as necessary.

The watershed based planning process involves a series of consecutive steps, from assessment of existing conditions through community engagement and goal setting that result in an actionable plan. This chapter outlines the detailed steps, termed "management actions," required to implement the WBP. The first section of the chapter discusses how subwatersheds have been targeted for implementation, stressing the need to focus management actions in particular areas of the watershed, rather than randomly implementing management actions throughout the watershed. Focusing implementation in specific areas is central to demonstrating early success, building momentum, and attracting new sources of funding. The remainder of the chapter presents recommended management actions and further elaborates on the broad groups of implementation activities outlined in the management strategies discussed in the previous chapter. Table 16 lists the management actions associated with each management strategy; lists suggested parties responsible for the implementation of management actions; defines short-, medium-, and long-term interim milestones for management actions; and provides performance criteria through which the implementation of specific management actions can be measured.

SUBWATERSHED TARGETING

Subwatershed targeting focuses implementation efforts on sensitive areas and those that generate significant NPS pollution. Of the 36 subwatersheds in the Saugatuck River Watershed, 11 were targeted for implementation efforts based on the ranking method described below. These 11 subwatersheds included areas that drain to small headwaters, drinking water source areas, and areas that generate a significant pollution load per acre.

The targeting method incorporated two factors used to identify target areas for implementation: sensitivity and impairment. The sensitivity score measures the degree to which streams within and immediately downstream of a particular subwatershed are likely to be sensitive to changes in land use such as urban development. The sensitivity rating consisted of two measures of sensitivity: (1) stream order, which is a measure of the location of a particular stream within the overall stream network (small feeder streams have a low stream order, while large rivers have a high stream order); and (2) whether a subwatershed was source area to a drinking water reservoir. In short, the sensitivity rating favored small, sensitive steams upstream of drinking water sources.

The impairment score reflected the existing condition of streams within or immediately downstream of a particular subwatershed. Higher impairment scores reflected streams in more developed areas as measured by the percentage of the watershed with impervious cover and streams where computer modeling indicated high rates of pollutant loading.

Each of the 36 subwatersheds was assigned a final score by combining the sensitivity and impairment scores. In determining the final scores, the sensitivity score was weighted more highly than the impairment score. A detailed description of the subwatershed targeting metrics is provided in Table 14. Table 15 presents scores for each subwatershed.

Table 14. Subwatershed Targeting Metrics

Targeting Score	1	2	3
Drinking Water Source	Does not drain to a drinking water source	Drains indirectly to a drinking water source	Drains directly to a drinking water source
Stream Order	Less than 50 percent of the stream length is 1st order	50 to 99 percent of the stream length is 1st order	100 percent of the stream length is 1st order
Impervious Cover Score	Good	Fair	Poor
NO_3 Loading	Less than 1.3 lb/ac/yr	1.3 to 1.7 lb/ac/yr	Greater than 1.7 lb/ac/yr
Particulate P Loading	Less than 1.6 lb/ac/yr	1.6 to 2.5 lb/ac/yr	Greater than 2.5 lb/ac/yr
TSS Loading	Less than 500 lb/ac/yr	500 to 850 lb/ac/yr	Greater than 850 lb/ac/yr
Indicator Bacteria Loading	Less than 200 billion cfu/ac/yr	200 to 300 billion cfu/ac/yr	Greater than 300 billion cfu/ac/yr

IDENTIFIED TARGET SUBWATERSHEDS

The identified target subwatershed are depicted graphically in Figure 13. These include the 11 subwatersheds with the highest combined sensitivity and impairment scores (1, 3, 4, 10, 13, 14, 20, 27, 31 (Stony Brook), 34 and 35. In addition, non-target subwatersheds were added to the list based on observed conditions, stakeholder input, or relationship to other features or conditions in the watershed, including identified impairments. These additional subwatersheds include:

- Subwatershed 28 (Aspetuck)—The Aspetuck main stem is listed as impaired by indicator bacteria. The headwater reaches of this subwatershed are highly sensitive areas that were not identified during targeting (the area was contained within a large subwatershed). In addition, downstream of the Aspetuck Reservoir was identified by stakeholders as a problem area that may present significant opportunities for restoration.
- Subwatershed 18 (West Branch)—During the existing conditions analysis, observed conditions near the headwater region of subwatershed 18 were found to be poorer than expected at a sampling location just west of the Devil's Den Preserve.
- Subwatershed 33 (Lower Main Stem)—The downstream portion of this subwatershed contains large impervious cover areas that discharge directly to the estuary. Reducing NPS pollution from stormwater in this subwatershed will benefit the shellfish populations, which are a resource important to stakeholders.

IDENTIFIED MANAGEMENT ACTIONS

The WBP proposes a series of management actions, which include the implementation of structural and non-structural BMPs (discussed in the following pages), a variety of monitoring and education/outreach programs, as well as broader policy initiatives. Management actions

Table 15. Subwatershed Targeting Scores

Metric Ranking								
Importance rank*	1	2	3	5.5	5.5	5.5	5.5	28
Normalized rank**	0.25	0.214	0.179	0.089	0.089	0.089	0.089	0.999
Subwatershed Scoring								
Subwatershed	**Drinking Water Source**	**Stream Order**	**Impervious Cover Score**	**NO_3 Contribution**	**Particulate P Contribution**	**TSS Contribution**	**Indicator Bacteria Contribution**	**Overall Score**
34	0.75	0.642	0.179	0.267	0.267	0.178	0.178	2.461
13	0.75	0.642	0.179	0.267	0.089	0.267	0.178	2.372
27 (Aspetuck Tributary)	0.5	0.642	0.179	0.267	0.267	0.267	0.178	2.3
14	0.75	0.428	0.179	0.267	0.089	0.267	0.178	2.158
35	0.5	0.214	0.358	0.267	0.267	0.267	0.267	2.14
3	0.5	0.642	0.179	0.267	0.089	0.267	0.178	2.122
10	0.5	0.428	0.358	0.178	0.267	0.178	0.178	2.087
4	0.5	0.428	0.179	0.267	0.267	0.267	0.178	2.086
20 (Aspetuck Tributary)	0.75	0.642	0.179	0.089	0.178	0.089	0.089	2.016
31 (Stony Brook)	0.25	0.428	0.537	0.267	0.089	0.178	0.267	2.016
1	0.5	0.642	0.179	0.178	0.178	0.178	0.089	1.944
11	0.5	0.642	0.179	0.178	0.178	0.089	0.178	1.944
16 (Jennings Brook)	0.25	0.428	0.179	0.267	0.267	0.267	0.267	1.925
2	0.5	0.428	0.179	0.267	0.178	0.178	0.178	1.908
37	0.25	0.214	0.537	0.267	0.267	0.267	0.089	1.891
12 (Little River)	0.75	0.428	0.179	0.178	0.178	0.089	0.089	1.891
5	0.5	0.214	0.179	0.267	0.267	0.267	0.178	1.872
36 (Headwaters)	0.5	0.214	0.179	0.267	0.267	0.267	0.178	1.872
21 (Aspetuck Tributary)	0.5	0.642	0.179	0.089	0.267	0.089	0.089	1.855
22 (Aspetuck Tributary)	0.5	0.428	0.179	0.178	0.267	0.178	0.089	1.819
24 (Aspetuck Tributary)	0.5	0.428	0.179	0.178	0.267	0.178	0.089	1.819
9	0.5	0.642	0.179	0.089	0.178	0.089	0.089	1.766
7 (Saugatuck Reservoir)	0.75	0.428	0.179	0.089	0.089	0.089	0.089	1.713
33 (Lower Saugatuck River)	0.25	0.214	0.358	0.178	0.267	0.178	0.178	1.623
18 (West Branch)	0.25	0.214	0.179	0.267	0.178	0.267	0.267	1.622
23 (Aspetuck Tributary)	0.5	0.214	0.179	0.178	0.267	0.178	0.089	1.605
25 (Aspetuck Tributary)	0.5	0.214	0.179	0.178	0.267	0.178	0.089	1.605
26 (Aspetuck Tributary)	0.5	0.214	0.179	0.178	0.178	0.267	0.089	1.605
15	0.25	0.642	0.179	0.178	0.089	0.178	0.089	1.605
8	0.5	0.428	0.179	0.089	0.089	0.178	0.089	1.552
32 (Poplar Plain Brook)	0.25	0.214	0.358	0.267	0.089	0.089	0.267	1.534
17 (Beaver Brook)	0.25	0.214	0.179	0.267	0.267	0.178	0.178	1.533
28 (Aspetuck River)	0.75	0.214	0.179	0.089	0.089	0.089	0.089	1.499
19 (Aspetuck Tributary)	0.25	0.428	0.358	0.089	0.178	0.089	0.089	1.481
30	0.25	0.214	0.358	0.178	0.178	0.089	0.178	1.445
29	0.25	0.428	0.358	0.089	0.089	0.089	0.089	1.392
6	0.25	0.214	0.179	0.089	0.178	0.089	0.089	1.088

*IR of 1 is highest priority and the IR for metrics of equal priority are averaged

**Normalized rank = (7 - IR + 1) / 28

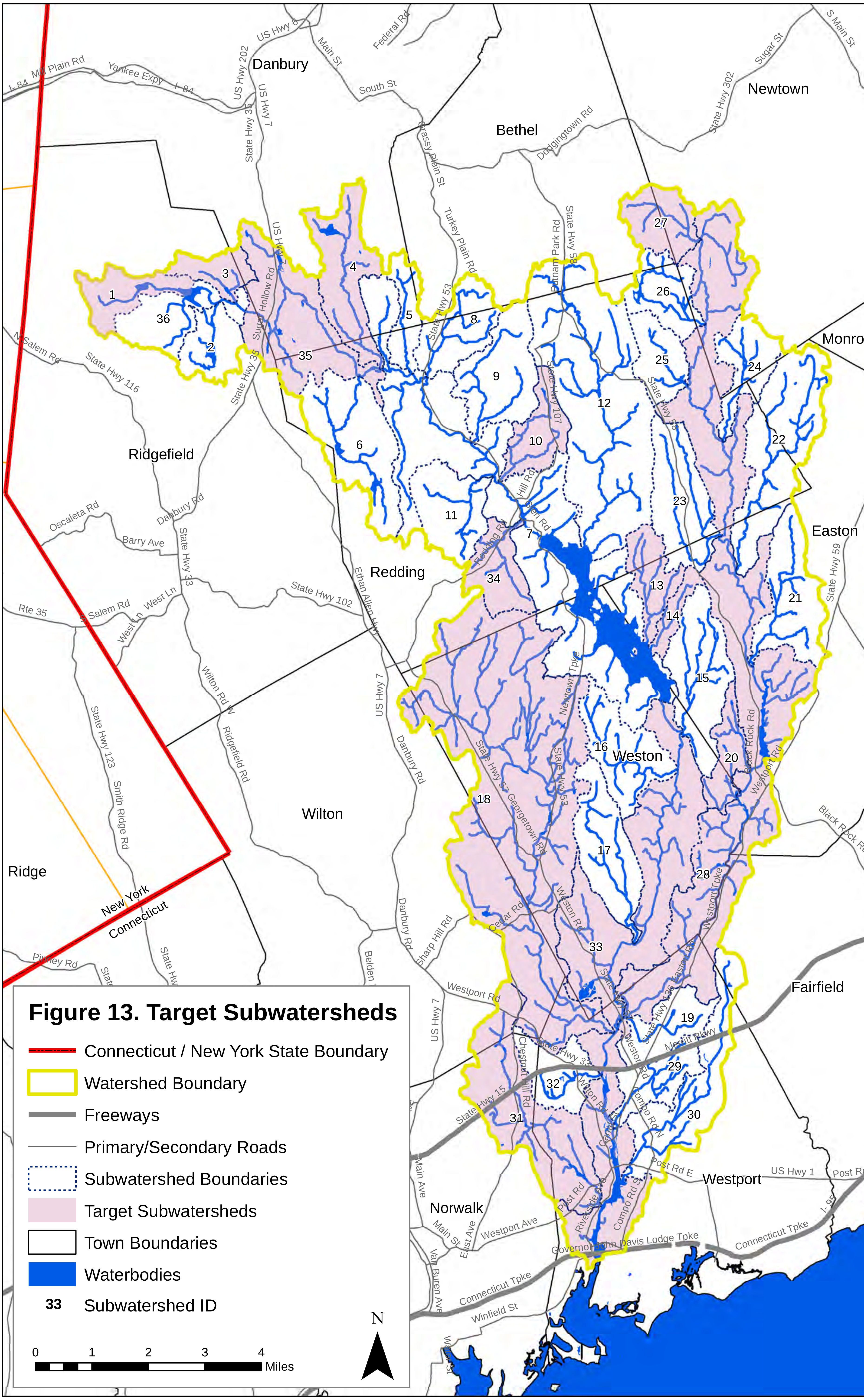


Figure 13. Target Subwatersheds

(Table 16) are associated with each management strategy proposed in Chapter 5. In some cases, similar management actions apply to multiple strategies; these instances are cross-referenced in the table text. Many management actions identified by the WBP support multiple goals. This integrated approach acknowledges that the management goals identified in the WBP are related to one another and that implementation actions often have multiple benefits. In addition to providing a brief description of the management actions, Table 16 provides a suggested schedule, implementation milestones, and quantitative or qualitative performance criteria for each management action.

Successful implementation will rely on a collaborative effort that brings together the shared knowledge and experience of the participating organizations. Accordingly, Table 16 also recommends organizations that would be well suited to implement each of the management actions, including a range of state, municipal, and nonprofit partners. Organizations were identified for implementation activities based on their legal authority, mission, and/or prior work in similar areas.

Emphasizing Best Management Practices

Whether it's building a stormwater rain garden that manages urban runoff, working with a hobby farm owner to install livestock fencing, or teaching a homeowner how to properly care for a septic system, the core approach to implementation involves putting in place BMPs that result in measurable reductions in NPS pollution. BMPs include a range of project types that reduce the negative effects of unmanaged stormwater runoff and reduce NPS pollution. For the purposes of the WBP, BMPs are categorized as either structural or non-structural. Structural BMPs refer to physical, site-specific pollution reduction projects that include rain gardens, porous pavement, livestock fencing, and constructed wetlands as well as stream restoration and riparian buffering. Non-structural BMPs are not physical structures, but equally important changes in behavior that result in NPS pollution reduction and watershed improvements. These include reductions in fertilizer use, proper septic system maintenance, and properly disposing of pet waste.

As part of an NPS reduction plan, the management actions presented in Table 16 rely heavily on a broad range of structural and non-structural BMPs. In addition, 20 site-specific structural BMPs are recommended and described in Chapter 7 (Table 21). Most of these BMPs were selected through a process of desktop identification and field vetting. Appendix A contains detailed site descriptions, costs, photos, and feasibility constraints associated with 17 of the identified site-specific structural BMPs. Three additional areas were identified by stakeholders for further analysis and potential structural BMPs or BMP maintenance.

PLAN PHASING

Although full implementation will likely require 20 or more years, the WBP emphasizes the use of interim milestones, including an initial five (5) year pilot phase, to ensure consistent progress. The first five (5) year implementation period will lay the foundation for future success through a combination of strategic planning, outreach, and small-scale management actions designed to test and demonstrate the long-term approach. As early success is crucial, short-term programs with clearly defined objectives may have a higher likelihood of success.

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	GOALs: Restore diadromous fish populations	GOALs: Restore impaired biological communities	GOALs: Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
1. Implement an early warning system to detect emerging threats																				
1.1	Develop a volunteer-driven monitoring program for select headwater streams (see action 8.10)	x				x	x	x	x					X			x	Pilot (1-5 yrs)	Year 1: Develop a 5-year plan for monitoring, including method and schedule (3 times per year; Year 2: Select 5 sample locations and constituents; Years 3-5: Engage volunteer groups and establish monitoring for selected headwater streams; Year 5: Analyze program results and determine further needs.	Number of sites monitored for bacteria, N, P, TSS, and additional constituents if necessary; Consistency of method.
1.2	Identify funding to support additional water quality monitoring	x	x	x		x	x	x			x	x		X				Pilot (1-5 yrs)	Review available funding sources and apply for grants (see Appendix B); Consider allocating an annual sum as part of general municipal operations.	Amount of funding secured
1.3	Continue streamwalk assessments conducted by the SRWP			x		x								x				Pilot (1-5 yrs)	Year 1: Review streamwalk assessments and select additional reaches for new assessment and/or further investigation; Year 2-3: Recruit and train volunteers, and cnoduct stream walks; Year 4-5: Review data and report results.	Miles of stream assessessed
1.4	Support work by TNC to analyze and identify water quality trends	x		x		x												Mid-term (5-10 yrs)	Expand monitoring to include additional parameters and sample sites (See Chapter 9); Maintain geospatial database of water quality data, preferably online and accessible to the community.	Years of monitoring record; number of parameters analyzed
1.5	Expand monitoring to include additional sites as needed; maintain data online via a live-streaming map application	x				x	x	x	x								x	Mid-term (5-10 yrs)	Select additional headwater streams and segments lower in the watershed for monitoring, as needed; Extend headwater monitoring program to incorporate additional segments; Provide data online using interactive mapping tools.	Number of sites monitored for bacteria, N, P, TSS, and additional constituents if necessary; Consistency of method; Numbers of volunteers engaged.

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	Restore diadromous fish populations	Restore impaired biological communities	Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
2. Mitigate the impact of water diversions through adaptive management																				
2.1	Continue current work with Aquarion and TNC to develop flow targets for the Saugatuck Reservoir that balance instream habitat needs with supply and demand (see recommendations of TNC's *Conservation Action Plan*	x	x	x	x	x											x	Mid-term (5-10 yrs)	Establish numeric flow criteria for target conditions below the reservoir; Establish additional modeling needs, if any; Build consensus to establish flow targets that meet habitat and drinking water supply needs.	Acres of watershed area addressed; Consensus achieved (yes/no)
2.2	Optimize flow regime for multiple uses	x	x	x	x	x											x	Long term (10-20 yrs)	Establish flexible withdrawal schedule for the Saugatuck Reservoir; Establish monitoring criteria and schedule; Tie withdrawal permits to consumptive use; Continue to revise and refine release regime and withdrawal limits based on monitoring data.	Number and quality of numeric targets; Robustness of monitoring program; Written support of stakeholders.
3. Mitigate fish migration barriers through natural fishways, fish ladders, and barrier removals																				
3.1	Following demonstrated success by the SRWP, continue efforts to restore habitat, reconnect river reaches and provide access to spawning habitat		x	x	x	x		x	x									Pilot (1-5 yrs)	Year 1-2: Use photos and owner testimonials to illustrate success; Year 1-5: Build the case for dam removal through continued monitoring of fish species and instream habitat; Year 2-5: Prioritize additional dams that may not extend diadromous runs, but which would significantly open up connected habitat.	Number of barrier sites assessed
3.2	Building on prioritization and assessment work already completed by the SRWP, develop a comprehensive barrier mitigation plan		x			x					x			x				Pilot (1-5 yrs)	Year 1-2: Engage landowners and secure funding, and identify barriers; Year 2-4: Assess all know barriers for structural condition and dimension, observable upstream/downstream habitat, ownership and usage, wetland impacts, and safety and liability issues; Year 5: Prioritize barriers and model post-removal conditions, if necessary.	Number of dams assessed; Feasibility of mitigation actions; Number of dam owners convinced to remove dams
3.3	Identify small impoundments above the natural falls where removal or modifications may be appropriate	x				x		x	x		x			x			x	Mid-term (5-10 yrs)	Conduct a geospatial analysis to identify impoundments above the natural falls; conduct outreach to property owners; partner with owners to remove or restore impoundments as necessary.	Number of impoundments assessed; number of mitigation efforts undertaken

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	Restore diadromous fish populations	Restore impaired biological communities	Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
3.4	Retrofit raised culverts, install fish passage structures, and remove small dams where feasible		x		x	x		x	x									Long term (10-20 yrs)	Conduct owner outreach to residential and commercial properties adjacent to target barriers identified in the mitigation plan; Obtain fish ladders/counters; Partner with CTDOT to retrofit culverts and remove small dams.	Fish counted on an annual basis; Miles of potential connected habitat
4. Reduce water quality impacts associated with unmanaged stormwater runoff through implementation of stormwater BMPs																				
4.1	Implement identified BMPs at Redding Garage and Elementary School in subwatershed 10	x		x	x	x	x				x							Pilot (1-5 yrs)	Year 1-2: Obtain funding and build project partnerships; define goals and obtain letters of support from Redding Schools, Town of Redding, and private landowners, where applicable; Year 3: Select consultant and complete detailed design; Year 4: Complete construction; Year 5: Conduct monitoring at basin inflow and outflow points, and evaluate functionality.	Modeled bacteria load reduction; observed habitat improvement downstream
4.2	Implement identified BMPs in subwatershed 18 (West Branch)	x		x	x	x	x				x					x		Pilot (1-5 yrs)	Year 1-2: Obtain funding and build project partnerships; define goals and obtain letters of support from Weston Schools, Town of Weston, CT Department of Transportation, and private landowners, where applicable; Year 3: Select consultant and complete detailed design; Year 4: Complete construction; Year 5: Conduct monitoring at basin inflow and outflow points, and evaluate functionality.	Modeled bacteria load reduction; Observed habitat improvement downstream
4.3	Develop rain barrel/rain garden incentive program for homeowners	x		x	x					x	x		x					Pilot (1-5 yrs)	Year 1: Define goals and strategies of rain barrel program and secure funding; Year 2: Purchase pilot rain barrels, and initiate outreach to owners of the 100 largest homes (by footprint); Year 2-4: Create incentive program and expand outreach to all homeowners; Year 5: Install 50 or more rain barrels watershed-wide.	Numbers of residential rain barrels installed
4.4	Develop an inventory of publicly-owned lands suitable for implementation of structural BMPs	x			x	x					x	x						Pilot (1-5 yrs)	Year 1: Obtain property records and conduct desktop assessments of all public properties within the watershed for drainage direction and available open space; Year 2: Prioritize sites based on feasibility, and conduct field assessments to determine drainage areas and need for additional piping; Year 3: Develop costs for each proposed BMP, and prioritize by cost per square foot of impervious area managed.	Number of properties assessed; feasibility of proposed BMPs

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	GOALs: Restore diadromous fish populations	GOALs: Restore impaired biological communities	GOALs: Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
4.5	Promote the use of bioretention along state and local roads							x			x					x		Mid-term (5-10 yrs)	Create an inventory of degraded roadside wetlands in the watershed, and present to the CT Department of Transportation; Conduct a drive-through assessment of roadside sites for proposed bioretention (aerials may not be useful).	Acres of the watershed assessed for new bioretention; Number of roadside wetlands surveyed.
4.6	Implement remaining identified structural BMPs, and identify additional similar BMPs	x		x	x	x	x				x							Long term (10-20 yrs)	Obtain funding for additional BMPs; Implement BMPs in subwatershed 18 (West Branch, subwatershed 10, and subwatershed 28 (Aspetuck); Prioritize and implement additional BMPs as funding allows.	Modeled bacteria load reduction; observed habitat improvement downstream
5. Remediate bacterial impairments and enhance riparian habitat																				
5.1	Establish buffers at identified large-scale sites (Aspetuck Country Club, Astor Place Show Stables)	x		x	x	x	x		x									Pilot (1-5 yrs)	Year 1: Reach out to land owners, obtain letters of support , establish permitting/design needs, secure funding and initiate permitting process, as necessary; Sample downstream water quality for bacteria; Year 2: Complete design and planting plans; Year 3: Complete construction; Year 4-5: Monitor water quality and goose populations, and complete analysis.	Total area of buffers established; Land area managed; Estimated bacteria load reduction
5.2	Establish buffers at identified small or medium-scale sites (Wayside Lane, Redding Road, New Pond Farm)	x		x	x	x	x		x									Pilot (1-5 yrs)	Year 1: Reach out to land owners, obtain letters of support , establish permitting/design needs, secure funding and initiate permitting process, as necessary; Sample downstream water quality for bacteria; Year 2: Complete design and planting plans; Year 3: Complete construction; Year 4-5: Monitor water quality and goose populations, and complete analysis.	Total area of buffers established; Land area managed; Estimated bacteria load reduction
5.3	Assess contribution of leaking septic systems to overall bacteria load, and develop a mitigation plan	x		x	x				x	x	x							Pilot (1-5 yrs)	Year 1: Target properties for assessment based on spatial analysis of sewer type, soil type, depth to bedrock, proximity to stream, age of development, and additional municipal records as applicable; Year 2: Conduct visual assessment during stream walks to identify failing systems; Year 3-5: Conduct targeted water quality monitoring based on visual/spatial assessment results, and develop a mitigation plan based on results.	Number of parcels assessed

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	GOALs: Restore diadromous fish populations	GOALs: Restore impaired biological communities	GOALs: Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	Uconn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
5.4	Develop pet waste management program for public recreation sites	x		x	x				x	x	x			x				Pilot (1-5 yrs)	Year 1: Outline goals and strategies of program, and inventory existing outreach/incentives; Year 2: Select public sites, and define solutions (signage, baggies, etc.); Year 3-5: Deploy outreach/incentive strategies at selected sites, and establish enforcement measures.	Estimated number of dog owners reached; Number of sites selected for management; Estimated bacteria load reduction
5.5	Identify potential locations along the Aspetuck for riparian buffer restoration and preservation	x		x		x		x										Pilot (1-5 yrs)	Year 1: Create geospatial database with all known unbuffered segments; Year 2: Prioritize buffers based on potential indicator bacteria load reductions, and on outreach already conducted by the SRWP; Year 3: Implement outreach campaign for streamside homeowners to encourage volunteers and identify potential buffer sites on private land; Year 4-5: Develop native planting plan, install buffer, and monitor results.	Square feet of additional unbuffered areas identified; Square feet of buffers constructed; Estimated bacteria load reduction
5.6	Significantly reduce nesting populations of non-migratory geese	x			x	x		x			x	x					x	Pilot (1-5 yrs)	Year 1: Implement stream buffers wherever possible to limit access to open water habitat; Year 2: Identify small impoundments that may be colonized by large populations of non-migratory geese; Year 3: Define additional acceptable strategies for management as needed (controversial options include hunting, harassment by dogs, and limiting the viability of eggs).	Number of sites addressed; Estimated number of geese
5.7	Identify potential locations along the Saugatuck Main Stem and Aspetuck for riparian buffer restoration and preservation	x		x		x		x										Pilot (1-5 yrs)	Year 1: Create geospatial database with all known unbuffered segments; Year 2: Prioritize buffers based on potential indicator bacteria load reductions, and on outreach already conducted by the SRWP; Year 3: Implement outreach campaign for streamside homeowners to encourage volunteers and identify potential buffer sites on private land; Year 4-5: Develop native planting plan, install buffer, and monitor results.	Square feet of additional unbuffered areas identified; Square feet of buffers constructed; Estimated bacteria load reduction
5.8	Continue maintenance and monitoring as necessary at Toth Park and other completed restoration locations	x		x		x	x	x										Mid-term (5-10 yrs)	Conduct regular assessments of vegetative and strutural features associated with restoration sites (see Chapter 9); For buffer sites (Toth Park, etc.) conduct goose counts to determine if buffers are effectively reducing populations.	Observed condition of structures and vegetation; number of Canada geese counted; water quality monitoring results, as needed

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	Restore diadromous fish populations	Restore impaired biological communities	Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	Uconn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
5.9	Promote proper septic maintenance and installation to reduce incidence of leaking septic systems on private property (see action 8.1 for outreach methods)	x		x	x					x	x	x		x				Long term (10-20 yrs)	Implement leaking septic mitigation and maintenance plan established during pilot phase through homeowner outreach, enhanced inspections, and/or incentive/cost share programs; Establish a municipal monitoring program for all residential and commercial properties; Track septic pump outs, based on the program in Westport.	Number of failing systems identified and replaced; Estimated N, P, and bacteria load reductions
5.10	Maximize adoption of minimum buffers on remaining private properties (see action 8.1 and recommendations of TNC's *Conservation Action Plan*)	x		x	x	x			x		x			x				Long term (10-20 yrs)	Create geospatial database with all known unbuffered segments and prioritize buffers based on indicator bacteria load reductions; Implement outreach campaign for streamside homeowners to encourage volunteers; Modify development code if necessary to create minimum buffer requirements, and create incentive/stewardship program to encourage buffers.	Square feet of additional unbuffered areas identified; Square feet of buffers constructed; Estimated bacteria load reduction
6. Avoid future increases in stormwater related impacts through conservation acquisition and promotion of LID policies																				
6.1	Building on work currently underway by the SRWP, finalize a review of existing land use regulations and standards to identify barriers to implementation of LID elements	x				x					x							Pilot (1-5 yrs)	Year 1: Determine code sections for comparison (setbacks, buffers, lot size/density, street width, parking, stormwater management, LID provisions, etc.; Year 2: Review code for Redding and Easton; Year 3: Review code for Weston and Westport; Year 4-5: Complete evaluation for remaining watershed municipalities.	Number of watershed municipalities evaluated (target = 4)
6.2	Work with headwater municipalities to develop and adopt progressive LID based land use, stormwater and zoning regulations to minimize the impacts of future development	x				x					x	x						Pilot (1-5 yrs)	Outline consistent approach to MS4 compliance for watershed municipalities; Establish minimum stormwater and LID controls, including controls for water quality and channel protection.	Number of watershed municipalities evaluated/implementing controls (target = 5)
6.4	Promote reduction of rooftop runoff with residential LID program development	x				x				x	x							Mid-term (5-10 yrs)	Establish LID requirementsfor new residential development; Educate contractors and developers on the use of rain barrels and rain gardens to manage residential roof and driveway runoff.	Numbers of residential BMPs installed

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	GOALs: Restore diadromous fish populations	GOALs: Restore impaired biological communities	GOALs: Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
6.5	Encourage LID practices for all new development and major renovations to ensure no net increase in runoff	x									x	x						Mid-term (5-10 yrs)	Establish volume and minimum disturbance criteria for residential and non-residentialdevelopment and redevelopment projects; Establish design criteria using CTDEEP's *Stormwater Design Manual* as a starting point; Build support for increased regulations at the municipal level.	Number of watershed municipalities implementing controls (target = 4)
6.6	Develop recommendations and strategies to better align local regulations as identified in action 6.1 and to promote LID practices watershed wide	x				x					x	x						Mid-term (5-10 yrs)	Develop comprehensive plan for long-term LID implementation, including headwater overlay districts, transit-oriented development scenarios, phase-in schedule for BMPs, and specific code adjustments such as smaller parking spaces, narrower streets, higher density districts, and water quality regulations for new development.	Feasibility and extent of recommendations
6.7	Incorporate LID approaches into municipal improvement projects/construction	x			x						x	x						Mid-term (5-10 yrs)	Where pavement improvements are needed in low-traffic areas, replace traditional pavement with a porous alternative; Encourage external roof leaders for new buildings; Redirect pipes/outfall structures to bioretention areas.	Number of maintenance/construction projects incorporating LID techniques

7. Pursue strategic land acquisition to protect headwater streams and other watershed lands

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	GOALs: Restore diadromous fish populations	GOALs: Restore impaired biological communities	GOALs: Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
7.1	Acquire or establish easements on high-priority properties identified for protection by TNC and/or local land trusts	x			x	x					x				x			Pilot (1-5 yrs)	Year 1-2: Designate top priorities and tasks among land trust organizations; Year 3-5: Obtain funding and conduct outreach to homeowners; Year 5: Complete additional targeted purchases/easements within key watershed protection areas (e.g., headwater streams) and establish management plan for properties.	Acres permanently protected
7.2	Identify and prioritize properties in the watershed for preservation or acquisition	x			x	x					x				x		x	Mid-term (5-10 yrs)	Conduct geospatial analysis to assess to select high-priority conservation targets; Monitor sale properties; Maintain contact with land owners; Continue to secure funding opportunities and acquire property as funding allows.	Priority acres protected

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	Restore diadromous fish populations	Restore impaired biological communities	Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
7.3	Acquire or establish easements on additional properties identified for protection	x			x	x					x				x			Long term (10-20 yrs)	Building on demonstrated success by TNC's Saugatuck Forest Lands program and multiple local land trusts, define site selection criteria and apply criteria to properties as they become available for sale; Obtain additional funding; Establish easement outreach/assistance program to encourage permanent conservation as an alternative to sale.	Acres permanently protected
7.4	Develop a "conservation bank" program for new development in the watershed	x				x					x		x		x			Long term (10-20 yrs)	Create scoping document to assess financial feasibility and to define oversight and legal requirements; Modify code at the watershed scale to include bank offsets in permitting for new development; Establish incentives/assistance/recognition to encourage early adoption by developers.	Number of transactions conducted; Acres of land preserved
8. Encourage better stewardship of public and private lands by implementing education and outreach programs for landowners and municipal officials																				
8.1	Develop a series of homeowner workshops to encourage watershed-friendly yard design and management, and proper maintenance of septic systems (see action 5.9 and recommendations of TNC's *Conservation Action Plan*)	x				x			x	x	x		x		x			Pilot (1-5 yrs)	Year 1: Establish goals, target audience, content, and schedule; Year 2: Hold first workshop with attendance by 20-30 members of the target audience; Year 3-5: Reach additional audience through partnerships with local neighborhood organizations and civic groups (two workshops per year with similar attendance).	Number of events and audience reached
8.2	Develop a training series for municipal officials to encourage low-impact development strategies (see strategy 6 and recommendations of TNC's *Conservation Action Plan*)	x				x				x			x		x			Pilot (1-5 yrs)	Year 1: Establish goals, target audience, content, and schedule; Year 2: Hold first LID workshop with attendance by municipal officials (Redding, Weston, East, and Westport municipalities represented); Year 3-5: Develop additional workshop content and continue to schedule events (2 per year).	Number of events and audience reached
8.3	Conduct email & social media campaigns to encourage stewardship of private property	x								x	x		x					Pilot (1-5 yrs)	Year 1: Define message and target audience/s and obtain contact information; Year 2: Define media vehicles (radio/TV/internet/print/social media); Year 3-5: Obtain web/social marketing consultant to develop graphics, refine message, and deploy campaigns.	Number of watershed citizens reached

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	Restore diadromous fish populations	Restore impaired biological communities	Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	Uconn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
8.4	Organize and promote priority stream-side clean up efforts	x		x	x	x	x		x		x			x				Pilot (1-5 yrs)	Year 1: Select cleanup sites in conjunction with multiple other efforts (gateways, ribbon cuttings, demonstration sites); Year 2: Partner with corporate human resource departments to obtain volunteers, and schedule multiple events within a single subwatershed.	Number of events conducted; Number of volunteers recruited
8.5	Promote roadway and parking lot "good housekeeping" practices to Public Works, Parks Departments, and Boards of Education to maintain watershed friendly operations and practices	x				x				x				x				Pilot (1-5 yrs)	Year 1: Establish interdepartmental municipal task force; Year 2: Develop employee training modules for fleet and building maintenance, sand usage and cleanup, landscape maintenance, catch basin cleaning and retrofits, and proper waste disposal; Year 3-5: Conduct training sessions.	Number and completeness of training modules (see EPA guidelines for Good Housekeeping); Number of events and audience reached
8.6	Develop a two-way channel of communication with local stakeholder groups for information flow about partnership activities	x	x	x	x	x	x		x		x	x		x	x		x	Mid-term (5-10 yrs)	Create an online presence to allow for news/data dissemination between annual reports; Continue to publish Saugatuck River Watershed Partnership annual report (see 9.2); Continue to schedule regular stakeholder meetings.	Number of meetings conducted annually; meeting attendance; number of publications/communication materials disseminated; audience reached
8.7	Implement a 'neighborhood-by-neighborhood' approach for restoration of stream reaches	x	x	x	x	x					x			x				Mid-term (5-10 yrs)	Define target residential neighborhoods adjacent to the stream; Conduct outreach via social and recreational programs; Recruit homeowners to "sponsor" buffer restoration and plantings on their property; Schedule additional education and outreach events related to lawn care, pet waste, and septics.	Number of restoration projects implemented; Estimated N, P, TSS, and bacteria load reductions
8.8	Develop programs to encourage better management of small impoundments	x		x	x	x	x	x	x		x	x						Mid-term (5-10 yrs)	Select target sites; Advocate for stream buffers, dam removal where appropriate, goose management, and reductions in fertilizer use; Offer training for property owners (see 8.1); Provide free labor in the form of volunteer work days/cleanups, etc.	Number of properties committed to improving management techniques; Number of dams removed; Estimated N, P, and bacteria load reductions.

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs: Protect and enhance water quality and high-quality stream communities	Restore diadromous fish populations	Restore impaired biological communities	Preserve and enhance recreational opportunities	PARTICIPATING ORGANIZATIONS: TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	UConn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
8.9	Develop programs to promote sustainable management at golf courses and horse farms	x		x	x	x	x	x	x		x	x						Mid-term (5-10 yrs)	Select sites for outreach; Produce a brochure for golf course managers (information on stream buffers, soil testing, organic fertilizing practices, and goose management); Produce a brochure for managers of horse farms (information on stream buffers, grazing practices, manure removal/covering, and goose management); Partner with trusted community members to conduct personal outreach at select sites.	Number of properties committed to improving management techniques; Estimated N, P, TSS, and bacteria load reductions.
8.10	Engage volunteers in monitoring tasks (see action 1.1)	x				x	x	x	x						x			Long term (10-20 yrs)	Establish task force to oversee volunteer effort in support of the WBP; Recruit volunteers for streamwalks, septic monitoring, fish and macroinvertebrate surveys, habitat assessment, and other tasks as appropriate.	Hours of volunteer service secured; Number of volunteers
8.11	Continue to hold events and workshops that promote a better understanding of the watershed and its assets	x				x					x							Long term (10-20 yrs)	Create engaging civic events geared toward the general public (a watershed day, a learn-to-fish event, an interactive educational event for elementary school students, etc.); Schedule homeowner training events as needed (see 8.1)	Number of watershed citizens reached
9. Implement the WBP and monitor outcomes																				
9.1	Review the WBP every 5 years, evaluating successes and lessons learned; revise and update the WBP as necessary	x	x	x	x	x		x			x			x			x	Pilot (1-5 yrs)	Year 4: Formal initiation of WBP review and evaluation; Year 5: Update and revise the WBP as necessary. If at anytime based on monitoring data conditions of the watershed dramatically change the WBP should be adapted to current conditions.	All above

Table 16. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	GOALs				PARTICIPATING ORGANIZATIONS												SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
		Protect and enhance water quality and high-quality stream communities	Restore diadromous fish populations	Restore impaired biological communities	Preserve and enhance recreational opportunities	TNC - Saugatuck River Watershed Partnership	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	Southwest CT Conservation District	Saugatuck Municipalities	Local Health Districts & Departments	Uconn CLEAR, NEMO, Cooperative Extension	Watershed Stakeholders	Local Land Trusts	Connecticut Department of Transportation	Aquarion Water Company			
9.2	Continue to develop and distribute SRWP annual reports	x	x			x												Mid-term (5-10 yrs)	Maintain list of subscribers/supporters; Develop and distribute report in appropriate print or online media as necessary	Number of reports distributed annually; Report is produced each year (yes/no)
9.3	Continue to support implementation of additional strategies and actions identified in the 2006 *An Introduction to the Saugatuck River Watershed and The Saugatuck River Watershed Partnership* (TNC 2006)	x	x	x	x	x		x			x			x			x	Mid-term (5-10 yrs)	Identify additional funding for implementation of strategies identified by TNC; Identify long-term support and oversight via municipal government involvement	All above

This pilot phase is intended to be a testing, incubation, and capacity-building period in which small, manageable activities are implemented. Such actions may be single structural BMPs, or outreach activities such as training events or marketing programs. Once these smaller actions have been completed—typically near the end of the five (5) year term—monitoring and assessments will provide a better understanding of which approaches need to be repeated or expanded to achieve long-term goals, and which need to be refined or scaled back.

Pilot phase implementation activities should focus on one of the target subwatersheds outlined earlier in this chapter. Implementation of multiple management actions in a single subwatershed during the pilot phase will likely yield the most measurable short-term resource improvements. Once opportunities in a particular subwatershed are exhausted and improvements have been documented, implementation activities can be replicated in other subwatersheds. This method is preferable to a more diffuse approach because it demonstrates a micro-scale version of the full implementation approach, allowing the approach to be tested and refined with limited funding. If a subwatershed-scale effort shows positive outcomes, it follows that similar methods will be successful at larger scales. In addition, this approach allows watershed partners to powerfully demonstrate the early success that is so critical for building momentum and attracting long-term funding.

At the end of the pilot implementation period, watershed partners should engage in a brief, focused, strategic planning process to outline implementation for the next five (5)-year period in detail. During the five (5)- to 10-year, mid-term implementation period, successful management actions and approaches may be implemented on a broader scale, within other target subwatersheds. Major follow-on planning activities and pilot-scale implementation activities should be complete, and a clear path to achieving long-term goals should be established. Funding and monitoring goals should be clearly defined for the following 10 years, and refined metrics for measuring success in place.

Long-term (10 to 20 years) planning incorporates the outcomes from the evaluation, planning, and preliminary implementation that occurs during the initial 10-year period. During the long-term implementation period, the pace of implementation is accelerated to reflect the gains in funding, capacity, technical "know how," and successful delivery during the first 10 years of implementation. Long-term management actions and strategies identified in the WBP are designed to be refined based on successes and lessons learned during the pilot and mid-term implementation periods. Accordingly, milestones and schedule are less precisely defined for the long-term implementation period.

Performance Criteria and Adaptive Management

Implementation of the WBP relies heavily on an adaptive management approach through which management actions are continuously refined and improved by evaluating past actions. In accordance with this approach, performance criteria were developed for each management action. In most cases, performance criteria do not represent prescriptive endpoints, but rather provide metrics with which to track outcomes over time. Water quality monitoring is suggested for common NPS pollutant types (see Chapter 9 for a full discussion of water quality constituents and monitoring methods). In some cases, targets for performance criteria for the pilot phase have been defined (e.g., number of homes implementing rain barrels) though partners should adjust these targets as needed based on their own resources and funding levels. Whether they adopt the targets set forth in the WBP or adjusted targets, partners should set realistic goals during the pilot phase that have a high likelihood of being achieved.

Achieving even modest goals during the initial implementation phase will build momentum and enthusiasm, attract funding, and set the stage for wider implementation. At the end of the pilot phase, management actions implemented in the watershed may be evaluated and priorities for the mid-term phase should be established. Regular evaluations and updates of the WBP will help to focus efforts and encourage long-term success.

Cost-Effective Implementation

With limited funding available, it is important to select management actions that maximize pollution reduction and other desired benefits while minimizing cost. While simple in concept, cost/benefit analysis can be difficult because of the uncertainty in determining pollution reduction and other benefits, particularly for broad initiatives such as outreach programs targeting wide-spread behavior changes. When selecting structural BMPs, an understanding of unit costs (that is, cost per unit of pollution or unit of stormwater managed) is useful for concept-level planning. Structural BMPs can vary widely in the cost per unit pollutant removed. For instance, highly engineered BMPs such as green roofs have extremely high unit pollutant reduction costs. On the other hand, simple BMPs such as riparian buffers, which require limited engineering and can be installed by volunteers without the use of heavy equipment, tend to have much lower unit costs. Appendix B presents a list of potential watershed funding sources.

Tables 17, 18, and 19 summarize pollutant load reductions associated with many of the management actions recommended in the WBP. Load reductions associated with management actions that remove pollutants at their source are typically presented as absolute values (amount of bacteria removed per prevented septic failure, etc.) and are presented in Tables 17 and 18. Structural BMPs function by intercepting stormwater runoff and removing a percentage of pollution from the water captured. For these BMPs, pollution reduction potential is typically presented as a percent reduction, which represents the fraction of pollutants removed from the treated runoff. Pollutant reduction efficiencies for common structural BMP types are presented in Table 19. In addition, literature values are available for some source control activities, such as riparian access control for livestock, and are also presented as percent reductions in Table 19. General ranges for capital and operations and maintenance (O&M) costs for various BMP types are presented in Table 20.

Table 17. Unit Pollutant Load Reductions from Non-Structural Best Management Practices

Pollution Source	Annual Load Reduction[1]			
	Total N (TN) (lb)	Total P (TP) (lb)	TSS (lb)	Indicator Bacteria (billion cfu)
One (1) Canada goose	12.05	10.68	N/A	2,660
One (1) dog—	6.72	0.88	N/A	408,800
One (1) malfunctioning septic system—repaired or upgraded	7.48	0.58	23.03	2,611,000
One (1) acre lawn—fertilizer use reduced by 50 percent	18.80	0.38	N/A	N/A

[1]All reductions derived using methodology outlined in Caraco 2002

Table 18. Grouped Pollutant Load Reductions from Non-Structural Best Management Practices

Pollution Source	Annual Load Reduction[1]			
	TN (lb)	TP (lb)	TSS (lb)	Indicator Bacteria (billion cfu)
Small flock of geese (10 geese)	120.5	106.8	N/A	27
100 people cleaning up after their dogs	672	88	N/A	408.8
10 homes conducting annual septic maintenance and repair	74.8	5.8	230.3	2,611,000
10 homes using ½ their normal amount of lawn fertilizer	376	7.6	N/A	N/A

[1]All reductions derived using methodology outlined in Caraco 2002

Table 19. Pollutant Reduction Efficiencies of Structural Best Management Practices
(updated from: NRWIC 20111)

		Water quality performance - Percent reductions			
BMP	**Source[2]**	**TSS**	**TN**	**TP**	**Bacteria**
Bioretention	CWP 2007	52	43	22	70
Constructed Wetland	CWP 2007	58	22	45	50
Dry Pond/Extended Detention	CWP 2007	61	25	17	30
Grassed Swale	CWP 2007	85	32	28	0
Riparian buffer	Modeled values (avg)	33	39[3]	31[4]	38
Infiltration	CWP 2007	89	42	65	not available
Livestock Riparian Access Control	Monaghan et al. (2007)	not available	not available	not available	22-35
Green Roof	CWP 2007	-	53	53	-
Porous Pavement	CWP 2007	90	70	48	70
Rain Barrel	CWP 2007	-	40	40	-
Wet Pond	CWP 2007	76	30	48	70

[1] Norwalk River Watershed Plan, 2011 (table 6-4)
[2] CWP (2007) National Pollutant Removal Performance Database (NRPRD): Version 3, 2007; median values. For permeable pavement, used infiltration practice data. Values are generally mass or load-based measurements of efficiency; NYSDEC Manual (2010): Just "phosphorus" and "nitrogen" are listed. Indicator bacteria are lumped; NYSDEC (2001) Table A.4 is from Appendix A of the 2001 manual. This appendix and table were removed in subsequent versions (2003 onward); CWP (2005) MD guide: A User's Guide to Watershed Planning in Maryland, CWP. Dry pond value assumes extended detention. For permeable pavement, used infiltration practice data; CWP (2008), Runoff Reduction Method (referred to as RR memo), CWP Runoff Reduction Method, 2008. Values are mean for Total Removal (considers change in concentration and volume).
[3] Values as NO_3, not TN
[4] Values as particulate P, not TP

Table 20. Capital and Operations and Maintenance Costs of Best Management Practices (NRWIC 2011)

BMP	Unit	Capital Cost per unit ($)	O&M Cost per unit ($)
Wet Pond	Cubic Feet	5.1–8.5	0.9–1.5
Dry Pond	Cubic Feet	2.6–6.8	0.4–1.2
Bioretention	Cubic Feet	8–20	2–5
Riparian buffer[1] (grass)	Square Feet	0–.01	N/A
Infiltration[2]	Cubic Feet	5	2
Reforestation	Planted Tree	328	N/A
Rain Barrel	Gallon	7-8	-
Porous Pavement	Square Feet	6.2	0.8
Grassed Swale	Square Feet	0.56	0.2
Green Roof	Square Feet	20–28	5–7
Illicit Discharge Detection & Elimination	per program	$23,300-101,200 Initial Cost;	$43,000-126,500 Annual Cost;
Septic maintenance[3]	Per household	-	$1,500 to 4,000
Downspout disconnection[3]	Per household	$150 to 400	-
Livestock Riparian Access Control			
Education and outreach[3]	Per program	Cost will vary significantly--examples include: $2,000 for advertising campaigns to in excess of $500,000 for a full program involving brochures, advertising, surveys, etc.	-

All PlaNYC (2008)except where otherwise noted
[1]EPA 2004, Chapter 6
[2] Maryland Cooperative Extension, Fact Sheet 774
[3] NRWIC 2011

The management actions presented in Chapter 6 describe discrete steps required to achieve the WBP's management goals. Several of these management actions involve the design and construction of structural BMPs. This chapter describes 17 structural BMPs that were identified and field vetted during WBP development as potential first steps toward meeting pollution-reduction targets. Feasibility was evaluated for each BMP through a desktop and field assessment process, which is described later in the chapter. Estimated costs, load reductions, and engineering feasibility considerations associated with each BMP are presented in Appendix A. Three (3) additional riparian buffer sites were later identified by stakeholders. These were not field vetted due to access constraints on private property, and hence are not included in Appendix A.

The structural BMPs described in this chapter do not represent an exhaustive list of opportunities in the watershed. The structural BMPs identified do, however, represent compelling and cost effective opportunities that were identified during a formal desktop and field assessment process, and through input of the watershed community. In many cases, the structural BMPs identified represent a prototypical project type that could be replicated in other similar sites throughout the watershed.

Structural BMPs identified in this chapter are primarily geared toward reducing NPS pollution. However, most BMPs can be designed to provide for multiple benefits. For instance, meadow plantings in large, extended detention areas can improve habitat for birds and small mammals. Rain gardens in public spaces can improve site aesthetics and, with signage, can function as highly visible demonstration sites. BMPs constructed at or near schools can be planted and maintained by students, providing a unique extension of environmental sciences curricula. In this way, the BMPs proposed here can advance other management actions related to education, habitat, and promoting LID in the watershed.

Descriptions for each structural BMP are presented in Appendix A, and include:

- BMP type;
- Subwatershed;
- Order-of-magnitude cost estimate;
- Potential benefits;
- Probable permitting requirements;
- Site access;
- Ownership;
- Other constraints;
- Context and rationale;
- Existing conditions; and
- Design approach and feasibility.

STRUCTURAL BEST MANAGEMENT PRACTICE IDENTIFICATION

Structural BMPs (Table 21, Figure 14) were identified within target subwatersheds through a process of desktop reconnaissance, field investigations, and stakeholder input. The process of identifying target subwatersheds is described in detail in Chapter 6.

Desktop Analysis

A desktop analysis was used to identify feasible, low-cost and high-benefit pollutant reduction BMP opportunities located in target subwatersheds. Areas were flagged for further investigation if they exhibited any of the following characteristics:

- Large, unused open spaces adjacent to and downslope from developed areas;
- Existing stormwater management basins;
- Road crossings where, based on topographic contours and adjacent land use, road runoff appears to discharge into the stream;
- The potential for unstable stream reach locations based on land cover change over the past 26 years (based on data from the UConn CLEAR program);
- Denuded riparian buffers, particularly within high nutrient and sediment loading land uses such as golf courses and farms;
- Public lands such as schools, parks, and public golf courses with potentially available open space that could be used for stormwater treatment and demonstration BMPs; and
- Privately owned open spaces located downslope of significant developed areas.

Field Vetting

To further vet structural BMP opportunities, visual field assessments were conducted at areas identified during the desktop assessment. Investigations were conducted on June 9, 13, and 14, 2011. The primary purpose of the field assessment process was to refine the type, location, and extent of pollutant reduction measures and to collect site-specific data pertaining to constraints, feasibility, cost, and benefit. Information relating to the following features was collected at most sites:

- Existing infrastructure (conveyance, existing stormwater controls, presence of non-stormwater infrastructure, potential inflow and outflow locations);
- Site topography;
- Drainage characteristics;
- Land cover and use;
- Property ownership;
- Extent, nature, and location of pollutant sources or other issues;
- In-stream habitat and physical conditions;
- Existing uses and/or structural, regulatory, or infrastructural constraints; and
- Upstream/downstream conditions within the subwatershed.

Structural BMPs Identified by Stakeholders

In addition to the 17 structural BMPs identified through the process described above, three (3) riparian buffer BMPs were suggested by members of the steering committee. These BMPs respond to site-specific problems identified by members of the local community and are described in detail, below. Costs, load reductions, and detailed descriptions for these BMPs are not provided in Appendix A due to some uncertainty regarding the project scope.

Buffer Partnership Program on the Saugatuck Main Stem

In subwatershed 33 along the Main Stem of the Saugatuck River, below the Saugatuck Reservoir along Lyons Plain Road, several large houses are built directly adjacent to the stream with no visible buffer. The private properties were not assessed during field identification, but stakeholders have suggested that there may be potential for a joint riparian buffer restoration coordinated among these streamside homeowners. Given the downstream impairments identified by the CTDEEP due to indicator bacteria, a multi-property buffer in this location would be a good first step toward de-listing the impaired reach. This BMP is listed in Table 21 as BMP Q, and recommendations are included in the management actions listed in Table 16.

Buffer Partnership Program on the Aspetuck Main Stem

Along the main stem of the Aspetuck, numerous large houses are built directly adjacent to the stream with no visible buffer, particularly between Judges Hollow Road downstream to the end of Deepwoods Lane. The private properties were not assessed during field identification, but according to the desktop analysis approximately 1,800 feet of stream could benefit from the addition of a buffer. Given the downstream impairments identified by the CTDEEP due to indicator bacteria, a buffer in this location would be a good first step toward de-listing the impaired reach. This BMP is listed in Table 21 as BMP R, and recommendations are included in the management actions listed in Table 16.

Toth Park Buffer Maintenance and Monitoring

The SRWP is in the process of completing a riparian buffer restoration to improve water quality and deter geese in subwatershed 28 (Aspetuck) at Toth Park, just south of the Aspetuck Reservoir. This effort was funded as a Supplemental Environmental Project (SEP) as part of an MS4 enforcement settlement coordinated with the Towns of Weston and Easton, and TNC. The buffer may require maintenance and additional monitoring to determine its effect on water quality and deterrence of resident geese. Installation of this buffer and continued upkeep are expected to partially address the identified impairment in the Aspetuck. This BMP is listed in Table 21 as BMP S, and referenced in the management actions listed in Table 16.

Structural Best Management Practice Costs

Order-of-magnitude cost estimates were developed for each field-vetted structural BMP and are presented in Appendix A. Estimates were developed based on unit costs derived from regional and nationwide studies, engineer's best estimate, and case studies. Unit costs are based on estimated impervious drainage area draining to each BMP or, in the case of stream restoration, on length of stream within the restoration area. The estimated costs of the 17 structural BMPs identified and field-vetted within the Saugatuck River Watershed range from approximately $1,500 to $1,042,000. The total planning-level cost to implement all of the 17 structural BMPs for which cost estimates are provided is estimated at approximately $3,571,000. Structural BMP cost is generally related to the size of the impervious drainage area and hence the amount of pollution managed by the BMP; however, some types of BMPs tend to be more expensive to construct for the same pollutant reduction benefit. While costs and benefits of implementation may vary widely, several riparian buffer BMPs were identified as inexpensive opportunities based on planning-level cost estimates:

- Aspetuck Valley Country Club ($11,000)
- Wayside Lane Stream Crossing ($3,000)
- Redding Road ($4,000)
- New Pond Farm ($2,000)

ESTIMATED POLLUTANT LOAD REDUCTIONS

Pollutant load reduction estimates were developed for each of the 17 structural BMPs included in Appendix A (BMPs A-P, BMP T). The following section summarizes the method and assumptions used to obtain load reduction values, and presents annual reductions in NO_3, particulate P, TSS, and indicator bacteria associated with each BMP.

WinSLAMM was used to develop pollutant load reduction estimates for structural BMPs. As discussed in Chapter 2, WinSLAMM applies empirically derived pollutant loading values to local rainfall, soil, and land use data to calculated NPS loads. Due to modeling constraints, unit pollutant reduction estimates derived from literature values were used to estimate pollutant load reductions for stream restoration BMPs.

Pollutant Load Reduction Estimates for Structural Best Management Practices

Field-vetted structural BMPs were modeled using WinSLAMM to determine estimated pollutant load reductions associated with each BMP. A detailed description of the WinSLAMM model and the rationale for its use in this study is provided in Chapter 2. In addition to the capabilities discussed in Chapter 2, WinSLAMM also provides the capability to model pollutant load reductions associated with structural BMPs. The following structural BMP types were modeled:

- Riparian buffer;
- Bioretention;
- Subsurface infiltration;
- Extended detention (referred to in Appendix A as “naturalized surface storage,” since rates of infiltration may vary);
- Extended detention retrofit (referred to in Appendix A as “retrofit existing basin,” since rates of infiltration may vary); and
- Grassed swale retrofit.

The first step in modeling pollutant load reductions was to develop concept-level designs for each field-vetted structural BMP. Concept designs were developed based on the maximum structural BMP area available (as determined by site constraints), local soil conditions, and design guidance provided by the *Connecticut Stormwater Quality Manual* (CTDEP 2004). Drainage areas to each structural BMP were delineated based on a combination of contour data, field assessment, a review of aerial imagery and street view photography (www.googlemaps.com and www.bingmaps.com), and infrastructure mapping, where available. Drainage areas and BMP areas should be refined during the detailed design phase, and pollution loading values should be updated accordingly.

A delineation of source areas (areas with similar land use and soil characteristics) is required by WinSLAMM as a data input. Source areas within each drainage area were delineated using spatial data. The soil type and land use within each source area were defined based on the dominant soil type and land use within that area. Other inputs to the WinSLAMM model, such as rainfall and aerial imagery, were developed according to the methods described in Chapter 2.

Using WinSLAMM, pollutant load estimates were determined for the drainage areas to each structural BMP. One model was developed to estimate the pollutant loading without the structural BMP, while a second model estimated the pollutant load when accounting for the pollutant removal effects of the structural BMP. The difference between the "with structural BMP" and "without structural BMP" models represented the estimated pollutant load reduction expected from implementing each structural BMP.

Pollutant Load Reduction Estimates for Stream Restoration Best Management Practices

Data from a stream restoration study of Spring Branch Stream in Baltimore County, MD (Chesapeake Bay Program [CBP] 2006), were used to obtain pollution reduction estimates for stream restoration BMPs. This study was selected for the following reasons:

- The study provided estimates of TN, TP, and TSS.
- Although conducted in the Chesapeake Bay drainage, the estimated pollutant reduction efficiencies for the Spring Branch Stream study may be applicable in suburban Piedmont watersheds underlain by crystalline bedrock. The Saugatuck River Watershed is in the coastal plain of Connecticut and is underlain by crystalline bedrock. These values have been applied to other coastal watersheds that are outside the Piedmont region (CBP 2006).
- Other studies and estimation methods have proposed larger reductions for TSS and TP (CBP 2006). For instance Evans et al., 2008, proposed reduction efficiencies of 36 and 95 percent for TSS and TP, respectively (Evans et al. 2008). Using the Spring Branch Stream values represents a conservative estimate for a metric that can be highly variable and lacks a large body of literature to develop more refined estimates.

The Spring Branch Stream Study found the following unit pollutant reductions for TSS, TP, and TN:

- TSS - 2.55 lb/linear foot(lf)/yr;
- TP - 0.0035 lb/lf/yr; and
- TN - 0.02 lb/lf/yr

For each stream restoration, the length of stream to be restored was measured using the software ArcGIS 10 and then multiplied by the load reduction rate for each pollutant. Because nutrient reduction values for stream restoration are given as TN and TP, they were not added to the total load reduction estimates for all BMPs, which are presented as NO_3 and particulate P. Indicator bacteria reductions are not typically associated with stream restoration.

Total Pollutant Load Reduction Estimates for Structural Best Management Practices

The total pollutant load reduction estimate for all 17 structural BMPs identified in Appendix A and Table 22 was 82,919 lb/yr of TSS, 357 lb/yr of particulate P, 544 lb/yr of NO_3, and 65,648 billion cfu/yr of indicator bacteria. The total pollutant load reduction estimate due to stream restoration (included as part of BMPs G and H) was 4.9 lb/yr for TP, and 28.0 lb/yr for TN. Pollutant load reduction estimates varied widely by site and pollutant. BMP H, Redding Elementary School, is expected to produce the greatest decrease in TSS and particulate P (24,702 lb/yr and 132.4 lb/yr, respectively). BMP D, Post Road East, is expected to produce the greatest decrease in NO_3 and indicator bacteria loads (160.6 lb/yr and 20,945 lb/yr, respectively). These sites provide a starting point for identification and implementation of similar structural BMPs throughout the watershed. Estimated pollutant load reductions for the 17 structural BMPs were lower than the total (100 percent) load reduction target or the interim (60 percent) targets defined in Chapter 3 for all pollutants.

Reductions associated with the structural BMPs represent less than one (1) percent of the total target load reduction for NO_3 and bacteria, and approximately 12 percent and 21 percent of the total targets for particulate P and TSS, respectively (Table 22). These represent 1.3, 1.5, 21, and 35 percent of the interim targets, respectively, for NO_3, bacteria, particulate P, and TSS. Since the BMPs identified will not fully meet the interim or total load reduction targets, additional structural and non-structural BMPs will be needed. For this reason, the WBP emphasizes an integrated approach to implementation using all of the varied management actions described in Table 16.

Table 21.Identified Site-Specific Structural Best Management Practices

Subwatershed	BMP Name	BMP ID	BMP Type
31 (Stony Brook)	Post Rd. West	A	Combination of subsurface storage, naturalized surface basin and bioretention
31 (Stony Brook)	Cranbury Elementary School	B	Naturalized surface storage basin
31 (Stony Brook)	Bumble Bee Lane Cul-de-Sac	C	Bioretention
33 & 30	Post Rd. East	D	Bioretention
18 (West Branch)	Weston Tower Center	E	Retrofit existing basin and bioretention
18 (West Branch)	Weston School Complex	F	Bioretention, retrofit existing basin
10	Redding Municipal Garage	G	Stream restoration & bioretention
10	Redding Elementary School & Community Center	H	Stream restoration & existing basin retrofit
28 (Aspetuck)	Farm Meadow Development	I	Retrofit existing basin
28 (Aspetuck)	Astor Place Show Stables & Equestrian Hills Development	J	Riparian buffer
28 (Aspetuck)	Aspetuck Valley Country Club	K	Riparian buffer and basin retrofit
11	Wayside Stream Crossing	L	Riparian buffer
34	Redding Road	M	Riparian buffer
7 (Saugatuck Reservoir)	New Pond Farm	N	Riparian buffer
7 (Saugatuck Reservoir)	West Redding Train Station	O	Retrofit existing swale
28 (Aspetuck)	Right-of-Way by Aspetuck Dam	P	Bioretention
33 (Lower Main Stem)	Saugatuck Main Stem Buffers	Q	Riparian buffer
28 (Aspetuck)	Between Judges Hollow Road and Deepwoods Lane	R	Riparian Buffer
28 (Aspetuck)	Toth Park	S	Riparian buffer - ongoing maintenance
1	Ridgebury Elementary School	T	Bioretention

Table 22. Pollutant Reductions from Site-Specific Structural Best Management Practices

BMP	Runoff Volume	TSS	Particulate P	Nitrate	Indicator Bacteria
	cf/yr	lb/yr	lb/yr	lb/yr	billion cfu/yr
A. Post Rd West	811,871	6,614	21.0	72.0	7,237
B. Cranbury Elementary School	427,924	6,181	35.4	15.8	5,479
C. Bumble Bee Lane Cul-de-Sac	46,502	329	0.9	6.3	665
D. Post Rd East	866,430	6,695	17.8	160.6	20,945
E. Weston Town Center	510,882	7,645	31.6	11.3	5,896
F. Weston School Complex	476,790	5,988	14.7	13.2	9,695
G. Redding Municipal Garage	62,872	8,766	25.9[1]	40.4[1]	283
H. Redding Elementary School	481,146	24,705	132.4[2]	37.2[2]	5,801
I. Farm Meadow Development	168,019	5,287	35.9	56.1	2,544
J. Astor Place Show Stables	234,845	2,586	12.5	100.1	3,290
K. Aspetuck Valley Country Club	55,552	1,626	4.0	3.4	731
L. Wayside Lane Stream Crossing	28,672	420	2.0	10.4	873
M. Redding Road Buffer	30,602	772	5.7	7.2	1,004
N. New Pond Farm	34,185	745	2.1	2.2	192
O. West Redding Train Station	5,609	300	0.9	0.2	75
P. Right-of-Way by Aspetuck Reservoir Dam	129,927	2,713	9.2	5.5	580
T. Ridgebury Elementary School	139,618	1,547	5.0	2.5	358
All BMPs	**4,511,445**	**82,919**	**199**	**467**	**65,648**

[1]Nutrient load reduction due to stream restoration: TP (lb/yr) = 3.5; TN (lb/yr) = 20.0

[2]Nutrient load reduction due to stream restoration: TP (lb/yr) = 1.4; TN (lb/yr) = 8.0

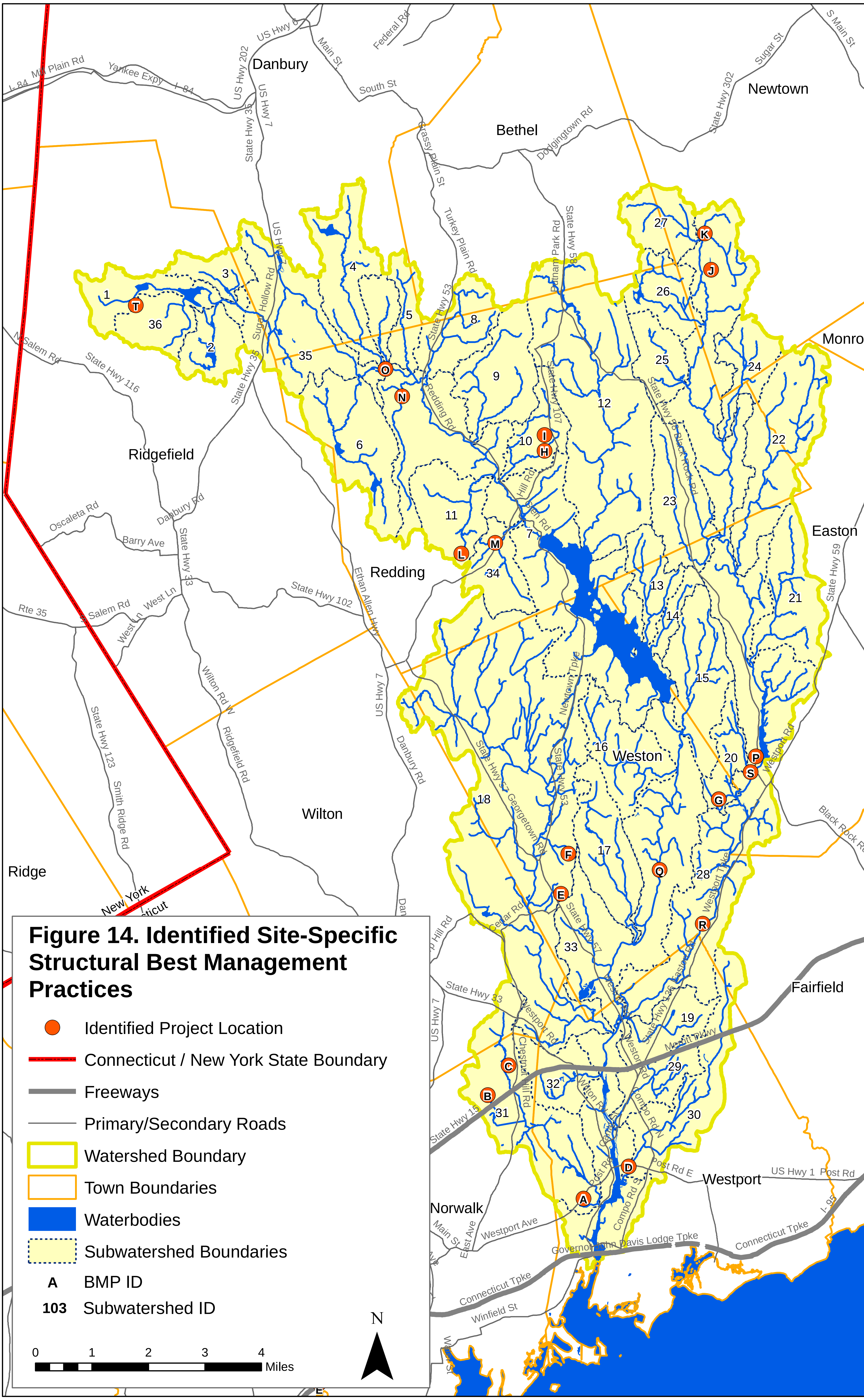


Figure 14. Identified Site-Specific Structural Best Management Practices

Community engagement, outreach, and education are essential components of WBP implementation. The diffuse nature of NPS pollution means that impacts are cumulative, and daily activities carried out on both private and public property—landscaping, recreation, property maintenance, and waste disposal—can have far-reaching effects downstream. Effective outreach and education can establish the connection between water quality issues and residents' quality of life. It can educate residents about the link between personal property care choices and the health of water sources, and provide easy-to-implement, practical steps to make homes and businesses watershed-friendly.

The sheer scale and cost of downstream management of NPS pollution can be prohibitive. Large structural BMPs, such as constructed wetlands, can be effective where space permits, but in many watersheds dominated by residential land use, opportunities to build large BMPs are limited. Under current law, municipalities and state agencies do not have statutory authority to mandate pollution reduction activities on private and municipally owned properties. Thus, inspiring residents and municipal officials to implement voluntary BMPs that improve water quality on their own properties is critical to meeting water quality goals.

DESIGNING AN EFFECTIVE CAMPAIGN

Effective education and outreach programs are targeted, succinct, and accessible to all members of the community. They are also fun, engaging, inspirational, interesting, and eye-catching. Watershed science principles can be difficult to communicate clearly and the connections between personal behaviors and large-scale water quality impacts are often not readily apparent. Clear, simple communication is critical. Whether outreach is conducted through large-scale media outlets like radio and television, or through stakeholder events and personal outreach, it is important to understand the values and preferences of the audience members and to emphasize easy-to-implement changes that have direct benefit for the audience as well as the environment. Programs should also emphasize both the financial and non-financial benefits to the audience.

The following guidelines are designed to help watershed stakeholders develop and implement an effective education and outreach plan:

- *Define the audience and customize the approach.* Location within the watershed, occupation, and access to resources can have a profound effect on how audience members interpret and react to the campaign. A variety of media types may be used wherever possible to create widespread recognition.
- *Craft a clear, actionable message.* It is important to target a single behavior or a pattern of behaviors that are impacting water quality. Once the activity is defined, leverage social factors and existing perceptions to create a sense of urgency. Create a simple message that motivates action, even if it is just one action at a time.
- *Don't "reinvent the wheel".* Partner with trusted business owners, municipal officials, and community groups to "piggyback" the message on other related programs. An understanding of which types of media have been used before, and in what way, can

guide a new campaign to either build on proven success, or branch out into fresh new territory.

- *Target early adopters.* Craft a message that encourages action among a receptive group. These can be homeowners with a demonstrated interest in environmental issues, sportsmen, or conservation advocates and commissioners. These early adopters will help redefine norms and expectations.
- *Evaluate success (and failure) and be open to change*. Metrics should relate not only to how many individuals were reached, but also to some defined measurement of what steps were taken in response (e.g., how many septic inspections were requested and how many rain barrels were purchased, etc.) These metrics may be difficult to measure and may require close partnership between advocates, local businesses, residents, and municipal officials.

Creating a Media Brand

Small community organizations often launch targeted education and outreach campaigns without first developing a companion effort to brand their organization within the community. While targeted campaigns are important for communicating a single message, a more generalized media presence is important to establish an organization's legitimacy and trustworthiness and to establish a recognizable and exciting brand.

Branding can start with developing a professional, attractive, and recognizable logo and supporting graphic theme to help residents associate seemingly disparate occurrences together (e.g., a workshop advertisement with a sign recognizing a homeowner-built rain garden or a logo on a local web site, etc.) and suggest the presence of a coordinated campaign worthy of participation and attention. An effective logo uses simple colors and lines, limited text, and usually contains the organization's title or initials. Attention to graphic detail can signal a high level of professionalism. Logos that are pixelated, photo-based, or set on a colored background reflect poorly on the organization and may not present the desired image to the public.

MEDIA FORMATS

While some media formats are better suited to conveying a certain message, the choice of media format will also depend on the audience, available funding, and desired time frame. In most cases, a combination of several media formats will be most effective.

Direct mail

E-mail and print campaigns are effective for communicating a general message to a broad audience. The format is useful when the message is simple enough to be contained in a few headline captions, and where graphics are important to highlight or communicate the message. However, direct mail, particularly print mail, can be expensive to produce, and distribution lists may be difficult or expensive to obtain or develop.

Events

Educational events offer the experience of direct interaction with experts and/or hands-on participation and the opportunity to provide in-depth information on a particular topic. Service events such as volunteer sampling efforts, trail maintenance work days, and stream cleanups combine educational and networking opportunities. Ideally these programs can be led and/or carried out by a local service organization, Boy or Girl Scouts, a church, or a group of corporate volunteers. Allowing volunteers to “get their hands dirty” may be the best way to get the message across.

In general, segmenting the message to different audiences is considered a wise practice, as it allows a single point to be tailored to the varied levels of understanding and perspective among members of the target audience. Events may be the exception to this rule, however, since they require a certain level of commitment on the part of the organizer and the attendee. Booths at local fairs and school events can be a useful way of educating the public on multiple subjects through a variety of print handouts, posters, and giveaway items, such as bumper stickers. Events that attract local sponsorship, such as fundraising dinners, runs/walks, and benefit concerts, help raise a general awareness about watershed issues.

Watershed-related events tend to automatically attract audience members that already have an interest in or affinity for the topic. Attracting participation among individuals for which watershed and water-related issues are not core concerns, however, can be difficult, particularly among young people and parents with young children. Some effective methods for increasing participation may include: scheduling events well in advance, using a variety of advertising methods, linking events with existing or recurring events, offering food or giveaways (e.g., a free rain barrel, etc.), inviting well-known speakers, scheduling events near public transportation routes and/or in locations with easy parking, and/or scheduling events around Earth Day celebrations and away from holiday or vacation periods.

Websites

An online presence is an important component of any effective outreach campaign. At best, a well-designed website simultaneously serves as a source of information, reinforces the “brand identity” of the given program, and incorporates social media components to engage site visitors. Website templates such as Blogger and Wordpress are simple to use and offer a free or almost free solution for program managers. Maps can easily be integrated into websites using applications such as Google Maps. If additional functionality or graphics are required, a web designer may be needed to implement these features.

Websites serve as clearinghouses for information, and are an inexpensive way to house a “press kit” of documents, graphics, and text for media coverage. An online press kit may contain press releases or queries to television or radio stations. The press kit webpage should contain important news releases, high-resolution photos or a logo, contact information, mission statement, and promotional brochures or videos, as desired. This information can also be made available on CD or DVD.

Social Media

Social media sites like Facebook, Twitter, Google+, and blog and wiki sites offer a wide range of new opportunities for using electronic media for outreach and education. Social media offer unique opportunities to build relationships, interact with constituencies, solicit feedback and opinion, and collaborate across audience types. Social media platforms also allow users to communicate rapidly and frequently with a large number of individuals interested in the message, and are especially important for reaching young people. However, since users selectively filter content, creating interesting, topical, humorous, or immediately useful material is crucial to the success of this type of campaign. An effective social media campaign emphasizes content that users will choose to receive, and publicizes content by creating an active, reciprocal relationship with the audience.

Depending on the message, some sites may be more appropriate than others. For instance, Twitter is useful for publicizing links and very short content; it is open to all users and does not require permission to access content. Facebook, on the other hand, allows more personalization of messaging, but is geared toward a smaller social circle. Google+ represents a middle ground between the two, with fewer restrictions on text length, images, and audience.

Over-reliance on social media may exclude groups that do not actively use these media outlets. The impact of messaging with social media can also be difficult to predict since users "opt-in" to receive content and often selectively filter content due to the staggering volume and pace of communication on social media sites. Although social media can be an effective way to reach certain audiences, it is best used in conjunction with other media sources to reach a broader group of stakeholders.

As part of the watershed based planning process, a blog and interactive online map were created so stakeholders could share comments and geographically locate problem areas. Project consultants updated the blog regularly through the planning process with relevant information, news, and work status updates. The blog was generally well received, although active participation was limited among stakeholders, possibly due to the small size of the audience.

Radio, Television, and Print News

Press releases, public service announcements, or guest appearances on local radio or TV programs are good options for raising the overall level of awareness about a specific issue, reaching a diverse and large audience, or to publicize events. Best options for TV coverage include interviews or spots on National Public Radio member stations or other local non-commercial radio stations, public service announcements on public access channels, and television news coverage of major events. Press releases to local papers are a critical means of promoting events, and may also be used to link to websites for additional content. Editorials, feature articles, and news stories in newspapers are also important and potentially effective means for raising awareness about specific issues. In addition, featured articles in municipal and organization newsletters can help distribute the message to a new audience.

Personal Contact

Direct personal outreach by partners and prominent community members can be a particularly useful tool where the target audience is small, when the message requires background or explanation, or when the outreach goal requires extensive and sustained personal contact or relationship development. In these cases it is very important to select a trusted ambassador who understands and can speak to the concerns of the audience. This type of outreach works well as a means to reach owners of large properties (e.g., golf courses, municipal departments, industrial facilities, and tracts of open space, etc.). However, it is partially dependent on the strength of existing relationships within the community, and may be counterproductive if an appropriate and effective spokesperson cannot be found.

Demonstration Best Management Practices

Visible public sites are often ideal settings for stream-friendly BMPs, such as riparian buffers, rain gardens, or rain barrels. These sites can provide a meeting space and educational opportunity for school groups, allow residents to directly participate in BMPs via volunteering, generate interest and excitement for watershed work, and provide a highly-visible demonstration of techniques that could be used on a watershed-wide basis. Demonstration sites can also help garner media attention for watershed efforts. Coverage of a watershed demonstration BMP by local TV, print, or radio media can be a huge help in raising the overall awareness of watershed issues and creating a sense of momentum.

OUTREACH AND EDUCATION GOALS

In the Saugatuck River Watershed, outreach and education activities should support the goals established in the WBP and the objectives of TNC's *Conservation Action Plan*. Activities should be aimed at increasing awareness and stewardship of watershed issues, establishing the link between personal choices and water resource quality, and encouraging easy-to-implement, low-cost, watershed-friendly practices that benefit property owners and watershed residents. Outreach efforts should be tailored to the major audiences in the watershed, including: municipal officials, residents, and business owners.

The following watershed management activities and outcomes were selected as "low-hanging fruit" targets for outreach based on their relative simplicity to implement, their importance to achieving watershed goals, and their cost effectiveness.

- **Municipal investment in LID** can help improve water quality and reduce flooding through improved infiltration in developed areas, pollutant control, and a decrease in erosive flows.
- **Riparian buffer establishment** and riparian zone maintenance can improve water quality and provide aesthetic benefits to streamside homeowners, and are simple and inexpensive to implement.
- **Improved landscape management practices** reduce pollutant loads, improve habitat, and reduce property management costs.
- **Proper disposal of animal waste** is a relatively simple, inexpensive way to reduce bacterial loadings that can have sizeable impacts on water quality.
- **Rain barrels** on residential properties can prevent high flows of roof runoff that would otherwise carry lawn pollutants (nutrients and bacteria) into the stream. Homeowners may use the collected rainwater for irrigation, outdoor washing, and other non-potable applications.
- **Inspection, maintenance, upgrade, and repair of residential septic systems** can significantly reduce bacterial and nutrient loading to streams.
- **Open space preservation** provides excellent habitat, recreational, and water quality benefits, but may be difficult to implement based on the high cost of land in the Saugatuck River Watershed.

STRATEGIES FOR IMPLEMENTATION

The following presents a discussion of strategies for each outreach goal. Appropriate audience, messaging, format, and useful existing programs are identified, along with potential challenges.

Municipal Investment in Low Impact Development

Targeted outreach efforts toward municipal officials and staff can help to encourage municipalities to voluntarily implement LID approaches, both as structural BMPs on public property and in the public right-of-way, and as non-structural BMPs and broader incentive and regulatory programs. Outreach and education efforts should focus on:

- Communicating the wide-ranging benefits of LID (e.g., enhanced aesthetics, educational benefit, etc.) through pilot demonstration BMPs conducted jointly with educational programming and materials;
- Encouraging the incorporation of LID aspects into planned capital projects such as streetscape enhancements or park renovations, and maximizing demonstration value of these sites through signage and volunteer involvement;
- Providing information concerning grant and low interest loan programs that could help fund LID;
- Encouraging LID as a way for municipalities to demonstrate environmental leadership;
- Emphasizing that some structural BMPs can be low cost and easy-to-implement and can be installed using a combination of municipal staff and volunteers;
- Educating municipal officials about the need to reduce stormwater runoff to improve stream quality and reduce flooding; and
- Providing accurate information concerning project timelines, engineering requirements, and funding requirements.

Municipal governments may be wary of LID as a new concept, particularly when there are few local examples. Demonstration BMPs may help to allay municipal concerns and provide a focal point for outreach related to specific LID practices. Several of the BMPs identified in Chapter 7 are located on public property, and could be designed with additional signage and viewing/seating areas for use as outdoor classroom areas. These BMPs may in turn lend themselves to additional publicity by offering a visual example of a technical concept.

Target Audience: Municipal officials; professional staff, particularly, engineers and public works directors; and board and commission members.

Message: An LID approach can help beautify and reduce maintenance needs on public properties and help to educate residents about the importance of protecting and enhancing local streams and the LIS.

Existing Programs and Opportunities for Partnership: There are currently no LID outreach programs underway in the Saugatuck River Watershed; however, extensive training documentation and case studies are available through the CTDEEP website (www.ct.gov/dep) and the Nonpoint Source Education for Municipal Officials (NEMO) program (www.nemo.uconn.edu). The SRWP has conducted several training events for municipal officials which included LID curricula.

Media Format: Workshops and educational programming should be the focus of LID outreach and education efforts. Because the audience is relatively small, initial outreach can be conducted via phone, personal visits, or direct mailings.

LID workshops may include a heavy case study component and provide opportunities to connect with other municipalities that have been successful in incorporating LID into their planning process. Keeping in mind that municipal officials are busy, a series of short, evening programs scheduled to coincide with regular municipal meetings may be ideal. Photos, video clips, and testimonials can help to familiarize municipal officials with LID practices. Educational materials may be selected and developed for distribution at each workshop, with special attention to tone (non-technical) and visual representation. Landscape renderings, concept plans, and photos of constructed BMPs are all extremely useful in communicating new concepts.

Riparian Buffer Establishment

In developing an outreach program for the Saugatuck River Watershed, significant attention should be given to streamside property owners, as their land has a direct connection to runoff and water quality. Property owners who take steps to establish and maintain riparian buffers can create a measureable improvement in local in-stream conditions.

Tall grass, shrub, or forested riparian buffers along the stream corridor are an efficient method of removing bacteria and to a lesser extent nutrients carried in overland flow. In addition, riparian buffers help stabilize the bank and deter geese from taking up permanent residence. Since the majority of the Saugatuck River is bounded by private residential property, outreach to streamside homeowners is the primary vehicle for implementing riparian buffers on a large scale.

Outreach efforts should focus on:

- Emphasizing the relationship between water quality and overall quality of life;
- Educating residents about the critical importance of riparian buffers, even relatively narrow buffers in improving water quality and preventing potentially damaging stream bank erosion;
- Emphasizing design details that can maintain views of and access to the stream;
- Providing tips and advice for self-installation of riparian buffers including planting tips, contact information for local nurseries, and planting lists; and
- Emphasizing the benefits of riparian buffers in improving property values, property beautification, and reductions in property maintenance.

Target Audience: Streamside property owners.

Message: Riparian buffers are easy-to-install, make your property more attractive, and help protect your local stream and LIS.

Existing Programs and Opportunities for Partnership: Recreationally-oriented nonprofits such as Trout Unlimited may be well-suited to partner with interested homeowners to install riparian buffers. Partnering with local nurseries or home improvement stores can also be an effective means of targeting homeowners. UConn CLEAR, NEMO, and CTDEEP can offer a variety of technical guidance and are well-suited to support property owners and municipalities. The SRWP has already conducted significant work to identify unbuffered stream segments and reach out to property owners.

Media Format: Workshops and volunteer/recreational events are a primary tool for outreach to streamside landowners. Local contractors may be willing to speak to groups of homeowners without direct compensation in exchange for publicity, and local nurseries may be willing to offer free or reduced cost seedlings for workshop participants. Riparian buffer workshops can also be combined with other homeowner-targeted workshops (e.g., rain barrel or rain garden workshops).

Concept designs produced by a landscape architect may be useful to help residents envision what a potential buffer restoration would look like. Through a workshop format, homeowners could then provide feedback on the design and share their concerns and suggestions (this type of design workshop is known as a “charette”). Professionals can then work with the residents to select plantings and accessibility options that mediate the resident’s needs with the need for riparian buffer placement. It may be useful to invite all streamside homeowners and present the results at a community meeting.

Riparian buffer education materials can also be effectively integrated into a variety of online destinations including municipal and community web sites and social networking sites. Print or on-line articles in local newspapers, gardening magazines, and other publications can also be an effective means to educate streamside landowners about riparian buffer BMPs. Programs that reward or recognize homeowners that install riparian buffers can be particularly effective. These programs can often be sponsored by local landscape-related service providers and/or local non-profit groups.

Finally, working with local nurseries to set up displays at retail outlets can also be an effective means to educate homeowners about riparian buffers. Timing displays during spring and fall planting seasons can help to reach homeowners when they are actively planning for and funding landscape improvements.

Improved Landscape Management Practices on Residential and Commercial Property

Private residential and commercial properties make up a large portion of the Saugatuck Watershed area. Modifying landscape management practices such as mowing and fertilization can significantly limit pollution and improve water quality. Anecdotal evidence suggests that dumping of lawn clippings and leaves directly into streams, or improper fertilization practices are common landscaping issues affecting water quality. Since many homeowners and businesses hire landscaping companies to perform landscape care services, outreach to both property owners and landscape companies is important in driving wide-scale changes in landscaping practices.

Outreach to property owners and landscape professionals should:

- Emphasize the benefits of watershed-friendly landscaping practices in improving the health and quality of local streams and LIS,
- Encourage composting as a means to reuse lawn clippings rather than dumping them in the stream,
- Encourage the use of soil testing to calibrate fertilizing requirements and eliminate excessive or unneeded fertilizer,
- Encourage the use of slow-release fertilizers,
- Encourage application of fertilizers during dry weather periods,
- Encourage lawn aeration as a means to improve infiltration and improve turf health,
- Encourage appropriate mowing heights as a means to conserve water and improve turf health, and
- Encourage reductions in turf areas as a means to reduce property management costs.

Target Audience: Residents, landscape professionals, and commercial property and business owners.

Message: (to landowners) Watershed-friendly landscaping practices are easy to adopt and good for your lawn, good for local streams, and help protect LIS. (to landscape contractors)

Watershed-friendly landscaping practices can help save your customers money and help you compete for business.

Messaging for individual campaigns is most effective when it is simple and compelling and focused on asking audience members to change one behavior (e.g., over fertilizing wastes your money and harms local streams; get a soil test before fertilizing your lawn this year, etc.) Messaging directed at landscape professionals may take the form of professional training and personal outreach (e.g., calls, e-mails, or visits by members of garden clubs or other community organizations, etc.) If possible, training sessions should leverage continuing education credits or offer some other kind of recognition for participants. Messaging may be more effective if timed to coincide with spring planting periods where homeowners and businesses typically make lawn care decisions and purchase lawn care products.

Existing Programs and Opportunities for Partnership: Local garden clubs may be ideal ambassadors for progressive property management practices. In addition, the UConn Cooperative Extension and the CT Agriculture Experiment Stations offer soil testing as well as guidance and tools for sampling and amending soil. Municipalities, non-profits, landscaping companies, home improvement centers, and nurseries can also be effective partners. The SRWP and TNC have already engaged many of these potential partners through workshops and outreach events.

Media Format: A wide variety of media formats and approaches can be used to advocate for watershed-friendly landscaping practices. Given the large number of audience members, mass media may be most useful where possible. For instance, newspaper articles and inserts in municipal newsletters are potentially effective print media-based approaches. In addition, garden clubs and watershed nonprofits may be willing to hold property owner workshops. Giveaways, such as free soil test kits, may be useful ways to increase participation, while extending sponsorship opportunities to landscape service providers could help to fund the events. Booths and exhibits at local home improvement stores or nurseries, or at local fairs or community events, could also be effective in reaching landowners. River-friendly or watershed-friendly recognition or reward programs can be used to encourage participation. Again, sponsorship from local landscape companies, non-profits, and nurseries can help to fund these programs.

Proper Disposal of Animal Waste

Bacteria have been identified as a source of impairment for safe recreation in the Saugatuck River Watershed. Pet waste represents a small but manageable portion of the overall bacterial load. While solutions are simple and inexpensive—simply cleaning up after pets—the challenge for advocates lies in reaching the multitude of pet owners, and creating a message with enough social incentive to spur a change in behavior.

In public parks, trash cans and free baggies are a simple, inexpensive solution that can encourage pet owners to clean up after their pet. In addition, signage and print handouts placed near the baggies can be used to spread the message.

It may be more difficult to influence behavior on private property. In this case, a mass-media campaign using electronic and print media may be the most effective way to reach pet owners. In other watersheds, “spokesdogs” have been nominated from the canine community to attend outreach events promoting pet waste management. Emphasizing the health and hygiene benefits of cleaning up pet waste within private properties can be an effective route to encouraging behavior change.

Horse farms are another potential bacteria contributor, especially where manure is collected near the stream channel or in a direct flow path. Managers of these facilities should be encouraged to cover manure when possible, and either compost responsibly on site or have manure hauled offsite. Since there are relatively few such facilities in the watershed, outreach may take the form of site visits and letters. The UConn Cooperative Extension program offers an award for "Horse Farms of Environmental Distinction" for equine facilities that commit to responsible waste management.

Target Audience: Pet and property owners; equine facility managers.

Message: Cleaning up after pets and large animals is easy and inexpensive and helps keep bacteria out of local streams.

Existing Programs and Opportunities for Partnership: HW/RW offers community training in water quality sampling methods and best practices; this may be an excellent way to involve streamside homeowners in the monitoring process. Partnering with local dog parks and pet stores could also be beneficial.

Media Format: A comprehensive campaign may include multiple media formats to reach the widest audience possible. In addition to signage, baggies, and flyers at public sites, a large-scale postcard mailing from each municipality to its residents might employ humorous, eye-catching graphics to direct the reader to a web page outlining the problems and solutions. Newsletter or newspaper articles or editorials can also help to raise awareness and encourage simple behavior changes. Partnering with local pet stores to set up a booth or exhibit or to sponsor the distribution of informational materials with advertisements could also be an effective means of reaching pet owners.

A "spokesdog" may be nominated using social media and photos (i.e., allow community members to vote on a photo/description of each dog using Facebook to comment, "like," etc.). The contest could be further publicized through other social media outlets and partner websites, and via local newspapers, television, and radio.

Residential Rain Barrels

Rain barrels are a simple, cost-effective way for homeowners to manage stormwater on their property before it enters the municipal drainage system. Homeowners can save money on lawn and garden watering by substituting harvested rainwater for potable water. Their savings may be increased through a partial municipal subsidy or a rain barrel giveaway program. Even then, the cost savings alone may not be enough to create an incentive. In conjunction with financial incentives, a strong outreach campaign may be necessary to "sell" the social and environmental benefits to the public.

Target Audience: Homeowners

Message: Rain barrels provide a free source of water to water your plants and help the environment by reducing water use and reducing the amount of stormwater that flows into local streams.

Existing Programs and Opportunities for Partnership: There may be partnership opportunities for municipalities and water companies to offset an additional portion of the cost, and to offer technical assistance to homeowners.

Media Format: In order to reach the widest audience, an effective rain barrel campaign should employ a range of commercial media including local news and radio, promotional videos, a website, and extensive publicity via social media. One or more workshops should be offered for interested residents, to cover topics such as installation, maintenance, and how landscaping can best be used to hide or highlight the rain barrel as desired. Where cost is a concern for homeowners, rain barrel give-away programs can be used to help overcome this barrier, especially when coordinated with workshops and promotional media.

Inspection and Maintenance of Residential Septic Systems

Failing septic systems on residential property can cause significant nutrients and bacteria loading, either as the result of concentrated and rapid discharges when systems acutely fail, or as slow leaching from old, inefficient systems. Since septic failure or potential failure rates can be difficult to quantify, encouraging routine maintenance and inspection through educational programs may be the best way to manage the problem.

Outreach and education for septic system owners should focus on:

- Educating owners of septic systems about proper maintenance and care and the benefits of a properly functioning system;
- Encouraging homeowners to conduct periodic inspections of their system to ensure proper functioning;
- Communicating the common signs of malfunctioning septic systems;
- Outlining proper steps to take if a malfunction is suspected; and
- Communicating the potential water quality issues associated with leaking or malfunctioning septic systems.

Ideally, educational materials would be distributed by the municipality or health districts to all new homeowners and at each deed transfer. These materials may include a maintenance schedule, a list of maintenance contractors, and simple graphics showing the extent and location of recreation and drinking water resources in the watershed. Outreach to homeowners may be more useful when linked with sampling programs targeted at residential properties located along the stream corridor. Volunteers trained to recognize the signs and impacts leaking septic systems will be more likely to manage their own systems correctly, and will self-police among the community.

Target Audience: Homeowners, particularly within neighborhoods draining to streams identified as having potential septic plumes should be targeted for outreach efforts.

Message: Teach septic owners to recognize the most common signs of malfunctioning septic systems, to prevent system malfunctions through regular maintenance, and to take appropriate action if a leak or malfunction is suspected.

Existing Programs and Opportunities for Partnership: Scientists at HW/RW or TNC may be available to help train neighbors to sample for bacteria near their homes.

Media Format: Distributing flyers and brochures at community meetings, at property transfers/sales, and within municipal mailings or newsletters is a good way to communicate basic information concerning septic system care. Articles on septic care can be published within local newspapers or other print media and posted on municipal websites.

Targeted workshops should focus on older areas or where monitoring shows bacterial impairment or direct evidence of septic plumes. In smaller neighborhoods, flyers or direct mail can also be effective ways to publicize events.

Open Space Preservation

An effective method of preserving water quality, open space preservation can also be difficult to implement. In the Saugatuck River Watershed, undeveloped land is limited and extremely valuable. Although funding sources (e.g., easements, grants, etc.) may be available they will often not match the prices offered by the development sector. In general, significant personal or social incentive is necessary to counterbalance market forces.

Before beginning a campaign, it will be important to identify parcels that have the highest conservation value, and to develop a strategic plan to prioritize protection efforts. Once a plan is in place, a twofold campaign may target owners of potential conservation properties as well as the general public. Respectively, these campaigns may address the personal benefit of preserving open space (e.g., creating a lasting legacy, maintaining a sense of place), and the public benefits of open space (e.g., recreation, healthy communities, livability).

Target Audience: Private owners of high-priority conservation sites, watershed residents, and business owners.

Message: Open space is a critical part of what makes a community a special and attractive place to live. Support space preservation through donations to local land trusts, conservation easements, or through preserving your own property.

Existing Programs and Opportunities for Partnership: TNC and the Redding and Aspetuck land trusts are organizations that have worked extensively in the watershed to acquire properties, facilitate easements, and in some cases host stewardship events.

Media Format: Outreach to target property owners should be personalized where possible. Letters, visits, and small social events may be particularly effective. Mass or digital media may be less emphasized, if used at all. Messaging can help property owners understand why their decision matters, and what non-financial and financial benefits a decision to preserve their land can yield. Personal connections are crucial to establishing a shared sense of purpose and trust; introductions may be made through civic groups, local government officials, clubs and leagues, etc. In contrast to outreach to landowners, outreach to the broader public may emphasize the use of electronic media. E-mail listservs may be useful if enough addresses can be collected to reach a broad audience; social media allows for a more open dialogue among users, but may not be as accessible to some audiences.

A well-designed monitoring program enables stakeholders to evaluate the results of management actions and assess progress towards meeting the management goals outlined in the WBP. Monitoring provides critical feedback through which adjustments to implementation efforts can be made through a process termed adaptive management. Monitoring also allows partners to assess the performance and condition of individual pollution reduction BMPs and to identify needed maintenance.

This section of the WBP:

- Outlines an effective approach to watershed monitoring,
- Reviews existing monitoring programs in place within the watershed,
- Reviews the important variables that should be monitored on a watershed wide basis,
- Provides in depth guidance for conducting three types of critical monitoring activities: routine monitoring, early warning monitoring, and structural BMP monitoring, and
- Provides brief guidance on monitoring other aspects of the WBP that do not lend themselves to quantitative monitoring.

MONITORING APPROACH

Watershed monitoring can be tricky business. For example, variable weather and other environmental conditions can make it difficult to detect changes in in-stream conditions, while funding availability can stifle the most well intentioned monitoring program. The following sections provide a high-level review of some critical aspects of an effective monitoring program.

Subwatershed-Scale Monitoring

Watersheds can be slow to respond to landside pollution reduction measures, and year-to-year variability can further obscure results. Where possible, routine monitoring should be conducted at fixed stations at small (i.e., one (1) to five (5)-square-mile) subwatershed outlets rather than exclusively at the subwatershed outlet. Although more costly, this approach is more likely to detect change at acceptable timescales and provide the early evidence of success that is so critical to attracting continued funding for implementation efforts.

Using Reference Reaches

Habitat and in-stream conditions are constrained by the natural setting within which streams flow. For instance, low-gradient, sand-bed streams will not provide suitable habitat for trout spawning, even in the complete absence of watershed stressors. Using a reference reach is a good way to establish realistic and place-appropriate targets for in-stream habitat, water quality, and biological communities. Reference reaches need not be located in the target watershed but will be most useful within the same ecoregion and physiographic province as the target watershed.

Lowering Monitoring Costs

Funding for monitoring is limited, and activities should be carefully selected in order to maximize value and minimize cost. Several steps can be taken to manage and lower monitoring costs. For example, the use of bio-indicators and visual assessments as the primary tools for routine monitoring can avoid the costly laboratory fees and time-consuming travel costs associated with water quality monitoring. Using volunteers, where appropriate, can also help to lower costs and provide valuable educational opportunities.

Overcoming Environmental Variability with a Smart Sampling Plan

Seasonal and climatic variations have a strong influence on stream flow, pollutant concentrations, and biological communities. Consistent multi-year monitoring at fixed stations is critical to distinguish real change in conditions driven by implementation activities or land use change from those that are due to natural variation.

Involving Volunteers Wisely

Volunteers can play a valuable role in watershed monitoring programs, but it is important to choose their tasks carefully and provide adequate training. Ideally, monitoring should be carried out concurrently with related outreach programs so that the education components of each program inform shared goals. Appropriate volunteer tasks are simple and repeatable. If special skills are required, they should limited to those that can be easily taught and tested. For example, the CTDEEP's RBV program uses short training sessions, which cover collection techniques and context information for sampling stream macroinvertebrates, but stops short of teaching the volunteers the skills required to accurately identify the species. The following are some suggested tasks suitable for volunteers:

- Collection of water quality grab samples;
- Kick-net sampling for macroinvertebrates;
- Operating a flow meter during storm events;
- Temperature monitoring;
- Partial visual assessments (e.g., water clarity, presence or absence of algae, presence or absence of barriers, etc.); and
- Structural condition and clogging of BMP features.

A Commitment to Quality Control

Regardless of the monitoring activity, quality control is a critical part of any monitoring plan. Field data collection tends to be most effective when volunteers and/or professionals are trained carefully. Monitoring equipment requires regular inspection, maintenance, and calibration. Proper chain-of-custody procedures are important when collecting and processing field samples. Following sample handling and holding time procedures and processing samples at accredited laboratories is also critical. Finally, data entry should be reviewed for accuracy.

Smart Data Management

Data management is a critical aspect of any monitoring plan. Ideally, monitoring data should be managed in a relational database, such as Microsoft Access, rather than managing data in individual spreadsheets. All data records should include the time and date of measurements and/or analysis, the site location, the person(s) and/or entities responsible for collecting, analyzing, and entering the data, and the field collection/laboratory method used. Any anomalies or irregularities in data collection or analysis procedures should also be noted. To maximize data security, a limited number of individuals should have read/write access to the database.

An Adaptive Management Approach

Adaptive management provides a framework within which monitoring is performed. At its core, an adaptive management approach suggests that implementation efforts be continually evaluated and, if needed, adjusted based on monitoring data. Routine monitoring within a particular subwatershed can be used to determine the efficacy of management actions implemented within that subwatershed. If subwatershed-scale sampling does not show anticipated improvements in in-stream conditions despite intensive implementation, for instance, this may point to problems with the design or suitability of the management actions, or suggest the presence of an alternative source of impairment that may have not been identified during the initial WBP development.

Sharing Results

Monitoring data are of interest to a number of end users including municipal officials, implementation partners, and the general public. An annual monitoring report should be prepared as the central means to communicate monitoring results. A non-technical, easy-to-read executive summary can be used to communicate monitoring results to non-technical audiences, while the body of the report can be used to communicate results to more technical audiences.

EXISTING AND PAST MONITORING PROGRAMS

Several well-established programs are in place within the Saugatuck River Watershed to monitor water quality and in-stream conditions. Existing data collection has included the following activities:

- Fish and/or macroinvertebrates have been sampled with varying consistency at 25 different sites throughout the watershed between 1982 and the present.
- Since 2004, The SRWP has conducted annual volunteer-driven macroinvertebrate sampling through CTDEEP's RBV program.
- Since 1997, CTDEEP has conducted annual sampling of water chemistry at varying locations throughout the watershed, including sites at Bayberry Lane; Lyons Plain Road; Davis Hill Road; Ford Road Fly Fishing Area; George Hill Road; Glendinning parking lot; Keene Park; Newtown Turnpike; Route 107 & Rt. 53 Junction; Whipoorwill Lane; and within the reservoir.
- Between 2005 and 2008, the Harborwatch/Riverwatch program has conducted semi-monthly summer monitoring for dissolved oxygen, conductivity, and E. Coli on the main Saugatuck, and West Branch rivers, and at the outlets of Poplar Plains Brook, Kettle Creek, Indian River, Jennings Brook, and Beaver Brook. Similar monitoring has been conducted on the Aspetuck through a private study commissioned by TNC.
- Aquarion Water Company collects regular grab samples for fecal coliform bacteria at the intersection of Routes 107 and 53 above the reservoir; and for pH, temperature, conductivity, and sodium at the impounded area upstream of the Canal Street bridge (known locally as the "Wood Dam").
- The SRWP has overseen volunteer "streamwalk" assessments since 2006. Data for these assessments are collected based on the NRCS Streamwalk Initiative, and include channel characteristics, substrate type, observed impoundments/structures, condition

of water and aquatic vegetation, exposed bank area, and adjacent land use and vegetative cover.

- An in-stream flow assessment was conducted jointly by TNC and Aquarion Water Company.

MONITORING PARAMETERS

The following section provides an overview of key monitoring parameters typically used in routine watershed-scale monitoring efforts.

Water Quality

Water quality monitoring is used to characterize the chemical constituents present in stream water including several important NPS pollutants. Water quality monitoring is more expensive than visual assessments, but is essential for evaluating progress toward resolving listed water quality impairments and assessing reductions in total pollutant loading.

- **Nitrogen**: N is an essential and naturally-occurring macronutrient for stream plants, but in excessive quantities can lead to excessive plant growth and eutrophication. N is not typically the limiting nutrient in freshwaters, but is often the limiting nutrient in marine and estuarine systems. The EPA offers reference concentrations of N for Total Kjeldahl Nitrogen (TKN) and TN (EPA 2000), but CTDEEP has not developed state-specific criteria for most NPS pollutants, including N. Modeling results indicate N "hotspots" in subwatersheds 18 (West Branch), and 31 (Stony Brook).

- **Phosphorus:** P is an essential and naturally-occurring macronutrient for stream plants, but in excessive quantities can lead to excessive plant growth and eutrophication. P is most typically the limiting nutrient in most freshwater systems. EPA offers reference concentrations for TP (EPA 2000), but as with N, CTDEEP has not developed state-specific criteria for P. Modeling results indicate P "hotspots" in subwatersheds 27, 16 (Jennings Brook), and 4.

- **Total Suspended Solids:** TSS is present in small quantities within pristine streams. Within degraded systems, however, TSS concentrations can increase by several orders of magnitude and can lead to sedimentation of benthic habitats and increases in nutrient loading, particularly P, which is strongly bound to sediment. Appropriate concentrations of TSS vary by location and natural patterns of erosion and sedimentation. CTDEEP has not developed state-specific criteria for most NPS pollutants, including TSS. TSS sampling may include visual assessment of bed sediments and water clarity as well as grab samples to determine TSS concentrations. Modeling results indicate TSS "hotspots" in subwatersheds 27, 14, and 3.

- **Bacteria:** As an indicator organism, *E. coli* is useful in predicting the level of fecal contamination in a water body. CTDEEP provides standards for *E. coli* and fecal coliform concentrations for class A and AA streams based on designated use for recreation or drinking water (CTDEP 2011, Water Quality Standards). Modeling results, which use fecal coliform rather than *E. coli* as the indicator of contamination, indicate indicator bacteria "hotspots" in subwatersheds 18 (West Branch), and 31 (Stony Brook). Fecal coliform and *E. coli* are typically very closely correlated. It is expected that fecal coliform "hotspots" will also demonstrate elevated levels of *E. coli* when sampled for that indicator. *E. coli* data collected by HW/RW was found to be consistent with this prediction (see Appendix E for full discussion).

- **Dissolved oxygen:** Dissolved oxygen is critical to the survival of all in-stream animals, but is particularly critical at higher concentrations for cold water fish species such as trout. For Class A and B streams, CTDEEP maintains a standard of not less than 5mg/L of dissolved oxygen at any time (CTDEP 2011, Water Quality Standards). Dissolved oxygen impairments have not been identified in the Saugatuck River Watershed. Warm-weather, low-flow sampling is recommended in areas with suspected nutrient and temperature problems, as these will be the most likely to be impaired.

Stream Biota

Fish and macroinvertebrates can serve as indicator species used to assess the overall health of the stream system, and to highlight needs for further monitoring. Sensitive fish and macroinvertebrate species will not survive where habitat or water quality are compromised, and so can provide an early indicator of potential impairment. Where habitat quality is good but macroinvertebrate populations have been impacted, water quality may be an issue. Macroinvertebrates and fish species are generally representative of the stream's ability to support aquatic life, and are commonly used by CTDEEP to assess watershed conditions and focus additional sampling. Because fish species are generally highly mobile when compared with other aquatic life, they can be used as indicators of habitat quality (e.g., temperature, dissolved oxygen, cover) and connectivity. Macroinvertebrates are less mobile than fish, and as such are more representative of localized habitat conditions. Some species are particularly sensitive to sediment and substrate conditions. The healthiest communities are most often associated with shallow, fast moving, rocky sections of the stream called riffles and piles of large woody material (e.g., sticks, logs, etc.) known as debris jams.

Habitat Quality and Channel Stability

Physical habitat refers to the combination of water flow, stream bottom material, vegetation, debris and other in-stream features that provide suitable environments for aquatic life to live, feed, and reproduce. Particular types of physical habitats such as deep pools, clean riffles composed of coarse gravel or fist-sized rock, and large piles of woody material such as sticks, twigs, and logs are particularly beneficial to a range of aquatic life. Several organizations have developed visual assessment methods through which both trained volunteers and professionals can assess the quality and diversity of habitat present in a particular reach of stream.

Channel stability refers to the degree to which the streams move and change over time. Streams can move from side to side, change in shape or size, or become steeper or flatter. All streams change over time, but in healthy streams these changes are often slow and gradual. When watersheds become developed, the changes in the amount of water and sediment carried to streams can cause rapid and unhealthy physical changes in streams that indicate an unstable condition.

The following types of information are often used to characterize habitat quality and channel stability.

- **Substrate** refers to the material (e.g., mud, sand, gravel, cobble, or boulders, etc.) that rest at the bottom of the stream bed. Substrate is influenced by the type and quantity of leaf litter and natural debris; by the stream's shape and steepness; by the velocity of water moving through the system; and the type of material present in the soils surrounding the stream. Clean accumulations of rocky, fist, or gravel-sized substrate that are not packed with fine sand or mud are particularly important for many aquatic organisms including macroinvertebrates and many fish species. By contrast, sand or mud-bottomed channels typically support lower-quality and less diverse aquatic life.

- **Channel morphology** refers to the physical form of the stream channel including its size, shape, steepness, and meander pattern. Rapid changes in channel morphology can indicate unstable conditions which may in turn lead to worsening habitat quality and increased rates of erosion. Channel morphology is typically assessed using approaches such as stream channel surveys performed by professionals. The presence of large accumulations of sediment within the stream bed called channel bars, increases in stream width, buried or exposed infrastructure such as stormwater pipes or bridges, or the presence of sudden grade changes that may have the appearance of a small waterfall may indicate worrisome changes in stream morphology. Measuring the extent and location of bank erosion and the quality and abundance of habitat features is also an important aspect of characterizing channel morphology. Channel classification systems, such as the Rosgen Classification System, are also often useful in communicating information regarding channel morphology in a consistent manner.
- **Woody debris** is an important habitat feature that provides cover for fish species and macroinvertebrates. Heightened storm flows can flush woody debris out of the system, destroying habitat and destabilizing banks. In unforested reaches, woody debris may take years to re-accumulate to pre-disturbance levels following reforestation.
- **Water temperature** is an important component of habitat for fish and benthic macroinvertebrates. Low temperatures tend to be richer in dissolved oxygen, while higher temperatures generally have less oxygen available. Temperature changes can be indicative of other habitat problems, including loss of over-shading vegetation and runoff from warm paved surfaces.
- **Type and density of in-stream vegetation** can be a good indicator of nutrient concentrations. Thick aquatic vegetation and dense algal blooms may be due to an overabundance of nutrients and are usually associated with anoxic or low oxygen conditions in the summer and poor habitat.

MONITORING PROGRAM

The monitoring program includes the following components (Table 23):

- **Routine in-stream monitoring.** Routine in-stream monitoring is conducted at fixed stations throughout the watershed. The primary purpose of this type of monitoring is to detect changes in in-stream conditions during implementation.
- **Early-warning monitoring.** Early-warning monitoring helps to detect emerging threats through more intensive monitoring of conditions within sensitive headwater areas, particularly those upstream of critical areas such as drinking water supplies.
- **Structural BMP monitoring.** Structural BMP monitoring allows watershed managers to evaluate the condition of structural pollution reduction measures, and to identify required maintenance.

Routine In-Stream Monitoring

Routine monitoring is the core of the watershed monitoring program. Monitoring is conducted for habitat and channel stability features, and for water quality and bio-indicators during both wet and dry weather. Sampling frequency and duration for suggested sampling parameters are provided in Table 23.

Habitat and stream stability assessment

Building on the existing conditions assessment (Chapter 2) conducted in 2011 by AKRF, additional habitat assessments should be conducted within representative reaches using a similar scoring and rating approach (see Appendix C). Since conducting habitat assessments for every stream reach within the watershed will likely be cost prohibitive, representative reaches should be selected within several subwatersheds (Table 23). Representative reaches should be free of major obstructions, barriers, or structures that could cause local scale changes or impairments to habitat quality. Existing habitat protocols such as the NRCS SVA Protocol used in the existing conditions assessment can be used as a basis for monitoring. Habitat and stream condition assessment parameters should include:

- Channel width and depth;
- The presence of erosion or in-channel bars or other indicators of instability;
- Pool abundance and depth;
- Presence and abundance of large woody debris;
- Bank angle, height, and erosion severity;
- Riparian zone condition;
- Stream temperature; and
- Riffle embeddedness.

Bio-Monitoring

Macroinvertebrate communities should be collected and assessed via the CTDEEP's RBV program. Through this program, macroinvertebrates are collected by volunteers and sent to CTDEEP staff for professional classification and data management. If possible, the current CTDEEP collection sites should be augmented with additional monitoring stations. Ideally, additional bio-monitoring sites will be located within representative reaches selected for habitat and channel stability assessment.

Dry Weather Water Quality Monitoring

With the exception of indicator bacteria, dry weather water quality monitoring should be conducted using grab samples taken quarterly at fixed stations in representative reaches within each recommended subwatershed (Table 23). Grab samples are recommended following at least 72 hours of dry weather after a significant rainfall event. Suggested parameters for dry weather monitoring are listed in Table 23, and include TP, orthophosphate, TSS, *E. coli*, TKN, NO_3, nitrite (NO_2), and ammonium (NH_4). An initial baseline monitoring program during years one to five of the monitoring program implementation is recommended, consistent with the idea of a "pilot" phase of implementation.

Table 23. Monitoring Program Overview

Monitoring Type	Location	Frequency	Duration	Variables
Routine				
Habitat and Geomorphic	Representative reaches within subwatersheds 4, 7, 10, 18, 20, 27, 28, 31, 32, 34, 35	Semi-annually	Year 1: baseline conditions, Years 2-20: routine monitoring	Channel condition, hydrologic alteration, riparian zone, bank stability and stream cross-sectional area, water appearance, nutrient enrichment, barriers to fish movement, fish cover, pools, temperature, macroinvertebrate habitat (substrate), fish community
Wet Weather	Subwatershed 7 above the reservoir; Outlets of subwatersheds 18, 28, 31, 32, and 33 above the salt line	Once per five (5) years	Periodically throughout implementation period.	TKN; NH_4; $NO_{2/3}$; TP; dissolved orthophosphate; TSS; *E coli*
Bioindicators	Representative reaches within subwatersheds 4, 7, 10, 18, 20, 27, 28, 31, 32, 34, 35	Semi-annually	Year 1: baseline conditions, Years 2-20: routine monitoring	Macroinvertebrate communities
Dry Weather Water Quality	Representative reaches within subwatersheds 4, 7, 10, 18, 20, 27, 28, 31, 32, 34, 35	Seasonally	Years 1-5: baseline conditions: Years 5-20: routine monitoring	TKN; NH_4; $NO_{2/3}$; TP; dissolved orthophosphate; TSS; *E. coli*
Early Warning	Representative reaches within subwatersheds 34, 35, 10, 4, 20, 27 and the upper portion of 18	Bi-annually	On-going through implementation period	Head cuts, significant increases in bank height or channel width or depth, exposed infrastructure, steepened riffles, loss of depth in pool areas, severe or rapid bank erosion, large sediment bars, and embedded cobbles
Structural BMPs	New and existing BMPs	Annually or bi-annually	On-going through implementation period	Vegetation type, structural condition, accumulation of sediment/debris, and condition of downstream outfalls
Reservoir Monitoring	2-3 stations in the Saugatuck Reservoir	Monthly during the growing season	On-going through implementation period	Trophic index (measured using transparancy, TP, and chlorophyll a); dissolved oxygen and temperature at varying depths

Wet Weather Water Quality Monitoring

Characterization of wet weather pollutant loading would ideally be conducted at years five (5), 10, 15, and 20 of WBP implementation, funding permitting, in order to track changes in pollutant loading due to storm events. Typically, the overwhelming portion of total pollutant loading tends to occur during storm events so wet weather pollutant loads are often good approximations of total loads. Storm events can be sampled using an automatic sampler at representative locations (Table 23). Trained volunteers can be helpful in performing a variety of tasks including monitoring weather conditions, turning on water quality autosamplers prior to use, and collecting and transporting water samples.

Typically, flow-weighted composite water samples are collected using automated water samplers. Samplers are typically housed in wooden enclosures which should be locked between events. Prior to sample collection, a flow rating curve is established to relate water stage to discharge. During sampling, water stage is measured continuously via pressure transduction and the stage/discharge relationship is used to allow the automated samplers to collect flow-weighed samples. Typically, five-to-seven storm events greater than 0.1 inch are sampled to generate event mean concentrations.

Early Warning Monitoring

The term “dynamic equilibrium” is used to describe how healthy streams shift and change shape while maintaining a characteristic form. This equilibrium exists in delicate balance with the regional hydrology. Where land cover has been modified, this dynamic equilibrium is disrupted and streams can undergo rapid and permanent changes that result in loss of habitat and increases in sediment and nutrient loading.

When channel adjustments intensify, corrective actions such as bank stabilization and channel redesign become extremely expensive and have high failure rates. Therefore, it is important to catch these changes while they are small and easy to repair. Early warning signs of changes in channel stability may include:

- Small areas of erosion or changes in stream grade;
- Significant increases in bank height or channel width or depth;
- Exposed infrastructure;
- Steepened riffles;
- Loss of depth in pool areas;
- Severe or rapid bank erosion; and
- Large sediment bars or embedded cobbles.

Early warning monitoring stations should be established within headwater (i.e., first order) drainages within 4, 10, the upper portion of 18, 20, 27, 34, 35. Monitoring should be conducted at least semi-annually and the results communicated to municipal officials.

Structural Best Management Practice Monitoring

New and existing structural BMPs should be monitored and maintained to ensure proper function. Maintenance and monitoring falls into five (5) categories:

- Vegetation;
- Structures;
- Sediment/debris;
- Downstream outfalls; and
- Downstream water quality.

Vegetation

Vegetation is important for BMP function because it reduces the volume of stormwater captured through infiltration and evapotranspiration, while filtering out nutrients and creating an aesthetic amenity. Native plant species are typically better suited to respond to local weather patterns, require less water, and are more resistant to drought, thus creating lower-maintenance landscapes. Additionally, native plants minimize the need for fertilizer. Because these species are easily crowded out by non-native invasives, structural BMPs should be weeded at the beginning and end of the growing season to maintain a target vegetative community. This is particularly important for riparian buffers, which can contribute non-native seeds into the river where they are easily exported downstream.

Structures

Headwalls, endwalls, outlets, and orifice pipes should be inspected on a regular basis to ensure that structural damage is not preventing proper function of the structural BMP. Clogging of the orifice or outlet pipes can flood the basin and cause nearby damage. Debris can accumulate in the control structure and at the inlet of the structural BMP, blocking flow into or out of the BMP. Structures should be inspected twice per year at minimum.

Sediment/Debris

Depending on the drainage area to the structural BMP, the BMP design, and the nearby soil and development conditions, sediment clogging may or may not be an issue. For structures managing runoff from roofs or other low-traffic areas, sediment clogging is not likely to be an issue. These BMPs should be inspected twice per year, and any visible accumulations of sediment should be removed. Basins with a large drainage area, or any structural BMP managing runoff from streets, parking lots, or loose soil areas can clog more quickly with sediment and other debris. Most often sediment accumulates heavily in forebay areas, over splash pads, at inflow points, and anywhere water tends to slow and settle. Appropriate removal schedules will vary by BMP, and should be established on a case-by-case basis.

Downstream Outfalls

Basin outfalls may discharge into a municipal or private storm sewer, in which case the only monitoring required is to confirm that water is passing through the outfall structure as designed. However where basins outlet directly into wooded areas or streams, serious erosion can occur if the outlet is not designed correctly. Downslope erosion is a common symptom of unprotected outfalls where water flows freely out of the pipe onto a natural surface. Downslope erosion can be prevented by stabilizing the outfall with stone and cobble for several feet along the flow path, and by avoiding siting outfall within steep areas (CTDEP 2004).

Downstream Water Quality

Where funding permits, water quality should be monitored downstream of new structural BMPs and BMP retrofits to determine their effect on in-stream conditions. For this method to provide useful results, baseline conditions for that location need to be established before the BMP is constructed. Following construction, monitoring should be carried out regularly as the rate of pollutant load reduction tends to vary with the age of the BMP and with maintenance techniques used. The sampling methodology and variables discussed above in the section “Routine In-Stream Monitoring” generally apply to sampling downstream of structural BMPs as well.

Alderisio, K.A. and DeLuca, N. 1999. Seasonal Enumeration of Fecal Coliform Bacteria from the Feces of Ring-Billed Gulls (Larus delawarensis) and Canada Geese (Branta Canadensis). Applied and Environmental Microbiology, 65 (12): 5628-5630.

Barbour, M.T., Gerritsen, J., Snyder, B.D. and Stribling, J.B. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

California Association of Sanitation Agencies (CASA). http://www.casaweb.org/definition-of-terms. Accessed 5.8.12

Caraco, D. 2002. The Watershed Treatment Model, Version 3.1. Center for Watershed Protection, Ellicott City, MD, March 2002.

Center for Watershed Protection (CWP). 2003. Impacts of impervious cover on aquatic ecosystems. Watershed Protection Research Monograph No. 1 Center for Watershed Protection, Ellicott City, MD.

Chesapeake Bay Program (CBP). 2006. Best Management Practices for Sediment Control and Water Clarity Enhancement. CBP/TRS-282-06.

Connecticut Department of Environmental Protection (CTDEP). 2011[2]. Water Quality Standards. Hartford, CT

______. 2011. State of Connecticut Integrated Water Quality Report. Hartford, CT.

______. 2008 State of Connecticut Integrated Water Quality Report. Hartford, CT.

______. 2004. Connecticut Stormwater Quality Manual. Hartford, CT.

Connecticut Wilderness. www.connecticutwilderness.com. Accessed 6.13.12

Connecticut History. www.connecticuthistory.org. accessed 6/26/12

Evans, B.M., Lehning, D.W., and Corradini, K.J. 2008. PRedICT, Version 7.1 Users Guide.

Griffith, G.E., Omernik, J.M., Bryce, S.A., Royte, J., Hoar, W.D., Homer, J.W., Keirstead, D., Metzler, K.J., and Hellyer, G., 2009, Ecoregions of New England (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,325,000).

Harris, R., and Fraboni, P. 2008. Water Quality Report for the Saugatuck River Watershed, May 2008 through September 2008. Harbor Watch/River Watch (HW/RW) Program of Earthplace; Westport, CT.

Harris, R., and Fraboni, P. 2007. Water Quality Report for the Saugatuck River Watershed, May 2007—September 2007. Harbor Watch/River Watch (HW/RW) Program of Earthplace; Westport, CT.

[1]Report published after the Connecticut Department of Environmental Protection (CTDEP) changed its name to the Connecticut Department of Energy and Environmental Protection (CTDEEP) in July 2011.

[2]Report published in 2011 before the official name change took effect.

Harris, R., and Fraboni, P. 2006. Water Quality Report for the Saugatuck River Watershed, May 2006—September 2006. Harbor Watch/River Watch (HW/RW) Program of Earthplace; Westport, CT.

Harris, R., and Fraboni, P. 2005. Water Quality Report for the Saugatuck River Watershed, May 2005—September 2005. Harbor Watch/River Watch (HW/RW) Program of Earthplace; Westport, CT.

Hilsenhoff, W.L. 1982. Using a biotic index to evaluate water quality. Wisconsin Department of Natural Resources. Technical Bulletin No. 132. Madison, WI.

Lindenmayer, D.B., Margules, C.R., and Botkin, D.B. 2000. Indicators of Biodiversity for Ecologically Sustainable Forest Management. Conservation Biology 14 (4): 941-950.

Metcalf and Eddy. 1991. Wastewater Engineering: Treatment, Disposal, and Reuse. McGraw-Hill, Inc. New York, NY.Monaghan, R.M, de Klein, C.A.M., and Muirhead, R.W. 2008. Prioritisation of farm scale remediation efforts for reducing losses of nutrients and faecal indicator organisms to waterways: A case study of New Zealand dairy farming. Journal of Environmental Management. 87 (4): 609-622.

National Research Council (NRC). 1992. Restoration of Aquatic Ecosystems. National Academy Press: Washington, D.C.

National Resources Conservation Service (NRCS). 2007. National Engineering Handbook 630 Hydrology. 210-VI-NEH.

______. 2007. Soil Survey Geographic (SSURGO) database for the State of Connecticut. http://SoilDataMart.nrcs.usda.gov. Accessed September 2009.

______. 1998. Stream Visual Assessment Protocol. National Water and Climate Center Technical Note 99-1.

New Hampshire Department of Environmental Service (NHDES). 2004. Canada Geese Facts and Management Options, Environmental Fact Sheet, BB-53. Concord NH.

Norwalk River Watershed Initiative Committee (NRWIC). 2011. Norwalk River Watershed Action Plan. Norwalk, CT.

Reese, A. 2000. NPDES Phase II Cost Estimates. In: National Conference on Tools for Urban Water Resource Management and Protection. Chicago, IL.

Roth, N.E., Southerland, M.T., Chaillou, J.C., Kazyak, P.F., and Stranko, S.A. 2000. Refinement and validation of a fish index of biotic integrity for Maryland Streams. Versar, Inc. Columbia, MD and MD Department of Natural Resources, Annapolis, MD.

Saugatuck River Watershed Partnership (SRWP). 2009. State of the Watershed.

Saugatuck River Watershed Partnership (SRWP). 2008. Second Report of The Nature Conservancy's Saugatuck River Watershed Partnership.

Saugatuck River Watershed Partnership (SRWP). 2006. An Introduction to the Saugatuck River and the Saugatuck River Watershed Partnership.

Swan, C. 2001. Watershed Protection Techniques. Urban Lake Management. 3(4): 821-834.

The Nature Conservancy (TNC). Places We Protect: Saugatuck Forest Lands. www.nature.org. Accessed 6/26/12

The Nature Conservancy (TNC). 2007. Alternative On-Site Sewage Treatment Systems: Watershed Implications. Weston, CT.

The Nature Conservancy (TNC). 2006. Saugatuck River Watershed Conservation Action Plan (Draft). Weston, CT.

Town of Weston (1993). Weston Water Resources Guide. Weston, CT.

University of Connecticut's College of Agriculture & Natural Resources Center for Land Use Education & Research (CLEAR) study on riparian corridors[3] (http://clear.uconn.edu/projects/riparian/your/town.asp).

U.S. Environmental Protection Agency (EPA). Mid-Atlantic Water: Total Maximum Daily Loads. http://www.epa.gov/reg3wapd/tmdl. Accessed 5.9.12.

_______. Polluted Runoff: Low Impact Development. http://www.epa.gov/owow/NPS/lid. Accessed 5.9.12.

_______. 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. EPA 841-B-08-002. Office of Water: Washington, DC.

_______. 2006. Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria. EPA 822-R-06-001. Office of Water: Washington, DC.

_______. 2003. Getting in Step: A Guide for ConductingWatershed Outreach Campaigns.

EPA 841-B-03-002. Office ofWater; Washington, D.C.

_______. 2000. Ambient Water Quality Criteria Recommendations. EPA 822-B-00-022. Office of Water: Washington, DC.

_______. 1992. Water Quality Standards Handbook: second edition. EPA 823-B-12-002. Office of Water: Washington, DC.

[3]Observed areas where land cover within 300 feet of streams had changed to developed or turf and grass from 1985 to 2006, assuming these areas were likely sources of increased peak flows resulting in channel instability. These data were available for both Connecticut and New York.

APPENDIX A: SITE-SPECIFIC STRUCTURAL BEST MANAGEMENT PRACTICES

BMP A. Post Rd. West

Post Rd., #300-199 in Westport, CT

Saugatuck River Watershed

BMP Type: Combination of subsurface storage, naturalized surface basin, and bioretention
Subwatershed: 31
Construction Cost Estimate: $1,042,000
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; State Coastal Zone; and USACOE Clean Water Act
Site Access: Access via road and parking lots
Ownership: Public & Private
Other Constraints: Multiple property owners; potentially low water table and shallow depth to bedrock; dug well

Existing Conditions

The dense commercial development along the Post Rd. in Westport constitutes the largest portion of impervious area in the Stony Brook subwatershed. Properties on the western side of the street drain into inlets that discharge directly into Stony Brook. Numerous properties on the east side drained to two outfalls discharging to a large open area behind the Lack & Daily property (#253). The downstream channels are eroded and eventually flow to an existing wetland.

Several inlets in the rear of Lack & Daily appear to collect drainage from the street as well as adjacent properties. One of the critical inlets is completely clogged, which is causing flow to drain overland into a channel at the base of the first outfall pipe in the open field. Here the pipe is half buried by sediment, and accumulated sediment was observed throughout the channel. Parts of the properties with businesses; Iridian Asset Management, Via Sforza Trattoria, and Greg & Tony Ouidad also appear to be draining to this location.

Proposed BMP

A regional, naturalized surface basin could be constructed in the open space behind Lack & Daily which is most easily accessed and may be owned by Gilbertie's Nursery (Photo 1). The two existing outfalls already convey storm flows to the open space. The basin would replace the eroded channels and create surface storage for water quality and channel protection treatment before discharging to an existing wetland. It should be noted that this proposed basin property is located in the Coastal Zone and underlain by clay indicating that infiltrating capacity may be limited.

Stormwater management BMPs may be feasible for several other properties on the eastern side of the Post Rd. including the Schulhoff Animal Hospital (Photo 2), Westport Resources Investment, and the right-of-way along the northern edge of the Birchwood Country Club. The Animal Hospital demonstrates good conditions for a combination of bioretention and subsurface storage in the lawn at the front and side of the building. The investment firm and golf course offer opportunities to manage public runoff using small-scale bioretention where public right-of-way adjoins private property.

1: Proposed basin behind Lack & Daily

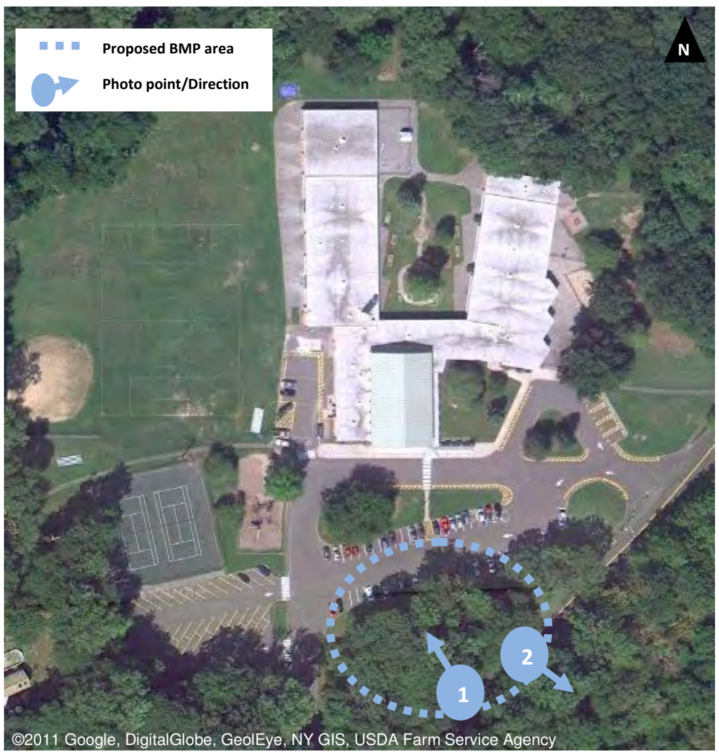
2: Proposed bioretention-Schulhoff Animal Hospital

BMP B. Cranbury Elementary School

10 Knowalot Ln., Norwalk, CT

Saugatuck River Watershed

BMP Type: Naturalized surface storage basin
Subwatershed: 31 (Stony Brook)
Construction Cost Estimate: $214,000 if front open area can be used; $2,700,000 if subsurface is required
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, and Water Diversion
Site Access: Access via road
Ownership: Public
Other Constraints: Significant tree removal required



Existing Conditions

Cranbury Elementary School is located at a regional low point in the Stony Brook subwatershed, where the residential neighborhoods on Live Oak Rd. and Bayne St. appear to be draining to a large pipe that passes under the southwestern school property and then a wooded depression between the school and Knowalot Ln. (Photo 1) before it outfalls into a forested wetland southeast of the lane (Photo 2).

Stormwater from the school property drains via a system of inlets to the southwest corner of the property where it appears to connect to the large pipe conveying water from adjacent residential streets. It is assumed that the combined flows are piped underneath the wooded island at a shallow depth.

Vegetation in the island is composed mainly of woody floodplain species. Many boulders line the forest floor. Trees appear to be generally less than 60 years old. The large pipe discharges to an unstable stream where alternating reaches of incision and sediment accumulation were observed. The stream is surrounded by forested wetlands.

Proposed BMP

Two options exist to create a regional storage facility at Cranbury Elementary School. A naturalized surface storage basin could be constructed in the wooded island in front of the school. Stormwater would be conveyed to the basin by tapping into the underground pipe and excavating storage for water quality and channel protection. The basin would overflow to the existing culvert beneath the street and would require removal of numerous mature trees.

Alternately, stormwater from the residential streets adjacent to the school could be diverted to a subsurface facility underneath the athletic field on the west side of the property. Runoff from school impervious surfaces could be diverted from inlets or through curb cuts to small bioretention areas in existing open spaces. These options would be expensive and require constructing a new manhole to allow for diversion from the main pipe.

Either option should assume a drainage area of at least 6.5 acres of impervious area and potentially more if pipes along Grumman Ave. are determined to be draining here as well. Costs presented are for the first option.


1: Proposed basin location


2: Regional outfall into woods

BMP C. Bumble Bee Lane Cul-de-Sac

Bumble Bee Ln., Norwalk, CT

Saugatuck River Watershed

BMP Type: Bioretention
Subwatershed: 31 (Stony Brook)
Construction Cost Estimate: $44,000
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: Access via road and parking lots
Ownership: Public & private
Other Constraints: Some tree removal required

Existing Conditions

The Bumble Bee Ln. cul-de-sac neighborhood is located near the top of the Stony Brook subwatershed, just uphill from the brook's main stem. The entire neighborhood drains to inlets in the cul-de-sac (Photo 1), which discharge to the woods upslope of the stream. The two (2) inlets are approximately four (4) feet to five (5) feet deep (Photo 2). The driveways in the north side of the street drain toward the street, while the south side residences drain mostly toward the woods. The grass-covered area in the center of the cul-de-sac is approximately 40 feet in diameter.

Proposed BMP

To manage stormwater from the street and the uphill driveways, a naturalized bioretention garden should be sized to treat approximately one (1) acre of impervious area within the grass-covered median in the center of the cul-de-sac. Runoff would be diverted from the upslope inlet to the cul-de-sac. The existing inlet would have to be replaced with a shallower structure to allow diversion to a shallow bioretention site. In addition, pavement replacement to divert flows would be required. Overflow would be conveyed through an existing inlet adjacent to the cul-de-sac.

To create sufficient space, the grass-covered median should be expanded uphill into the road and some of the pavement removed. Tree removal would also be required.

1: Proposed bioinfiltration location

2: Uphill drainage area – Bumble Bee Lane

BMP D. Post Rd. East

Post Rd., from the Saugatuck River to Saugatuck Nursery School in Westport, CT

Saugatuck River Watershed

BMP Type: Bioretention
Subwatershed: 33 & 30
Construction Cost Estimate: $393,000 (marsh restoration not included)
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion; and State Coastal Zone
Site Access: Access via road and parking lots
Ownership: Public & private
Other Constraints: Some tree removal required

Existing Conditions

The commercial corridor along Wesport Post Rd. continues from its crossing with the Saugatuck River uphill into subwatershed 33. The majority of the area drains into several large pipes which outlet into a tributary that enters the Saugatuck Estuary from the east. The Westport Library complex (Photo 2), including a large open lawn, is located just south of Post Rd.

Traveling east on Post Rd., the street narrows into a walkable downtown area. A large flat open space of approximately 40 feet by 100 feet in front of the Saugatuck Nursery School (Photo 1) is located down-slope of a long stretch of Post Rd. Inlets on the property are approximately two (2) feet deep, and street inlets are slightly deeper.

Main St. runs northward, perpendicular to Post Rd, and commercial buildings in this area are densely spaced. Open space is very limited and streets and driveways are narrow.

Near the intersection of Main St. and Avery Pl., the Saugatuck travels through a brackish marsh located downstream of the dam that forms the head of tide. Vegetation in the marsh is a near monoculture of common reed (*Phragmites australis*). Some erosion was observed along the edges of the marsh.

Proposed BMP

A stormwater management plan for this area should focus on the few large open areas where drainage is favorable for stormwater management. These include the Westport Library and the Saugatuck Nursery School. Because the water table is high, storage capacity will be limited. Pocket wetlands in the yard of these properties should be designed for water quality treatment, but maybe more importantly for public visibility. This portion of the commercial corridor is not located in a priority subwatershed as defined by AKRF's analysis; however due to the dense public use, the area offers some of the best potential in the watershed for public education and involvement.

Several small median areas may offer good opportunities for water quality improvement, but given their limited size these are not considered a cost-effective option to meet the goals of this plan.

Upstream, there appears to be good potential for a marsh restoration BMP to replace the large stand of phragmites with native vegetation.


1: Saugatuck Nursery School

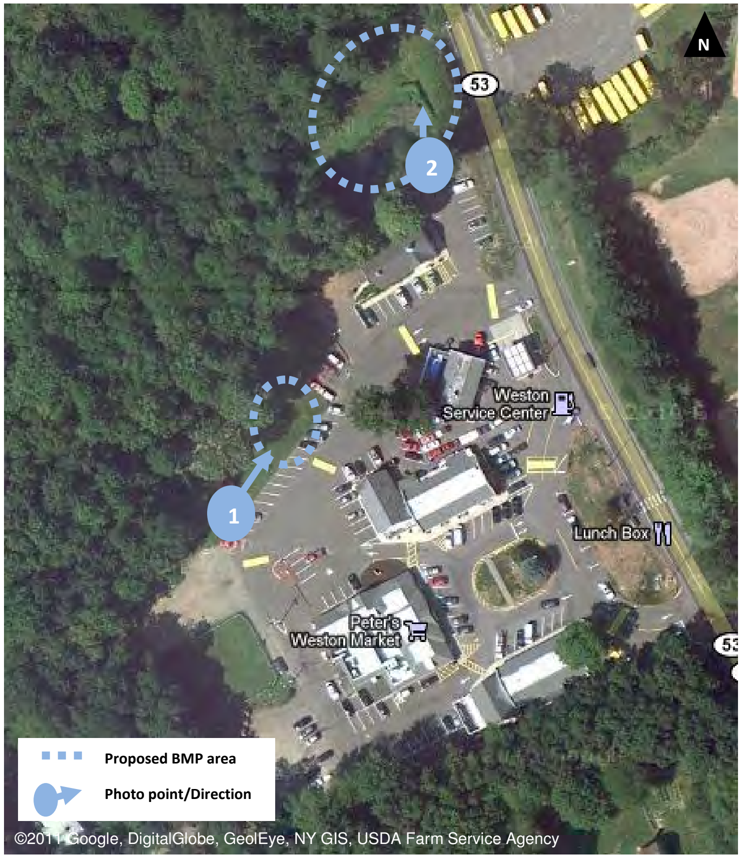

2: Westport Library Complex

BMP E. Weston Town Center

190 Weston Rd., Weston, CT

Saugatuck River Watershed

BMP Type: Retrofit existing basin and bioretention
Subwatershed: 18
Construction Cost Estimate: $220,000
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; and USACOE Clean Water Act
Site Access: Access via road and parking lots
Ownership: Public & private
Other Constraints: Some tree removal may be required



Existing Conditions

Weston Town Center is the only commercial area within the town boundaries. It is located near the eastern edge of subwatershed 18, uphill from a headwater stream draining to the West Branch of the Saugatuck River.

A wet basin at the north end of the commercial area (Photo 2) appears to be collecting runoff from the road and at least a part of the Hurlbutt Elementary School complex just uphill. The basin is approximately 40 feet by 90 feet. The basin contains a small sediment forebay and a low spillway that serves as the only outlet control. The basin was observed overtopping during a light, short-duration rainfall event, suggesting that storage is limited. The drainage area to this basin was not verified and design documents should be obtained before proceeding with a detailed design.

The parking lot and roofs appear to drain to a large central pipe that outfalls to a poor-quality wetland down-slope of the basin outlet. This flow joins a first-order stream running behind the property. Just uphill of the wetland is a grass-covered open space with picnic tables at one end.

Proposed BMP

A restoration approach to this site should emphasize water quality and channel protection due to its location uphill from a headwater tributary. Since the existing wet basin appears to have been designed for flood control only, a retrofit of the outlet structure could add channel protection and water quality benefits. Depending on the existing drainage area, additional storage could be created to manage more runoff from the school and adjacent roadways. However, due to the limited available area for expansion, it is not recommended that the basin manage runoff from more than five (5) acres of impervious area.

Additional stormwater storage could be created in the lawn beside the picnic site (Photo 1) to manage runoff from the parking lot and roofs of the commercial area. A bioretention cell with native vegetation could be installed in a turf area approximately 80 feet by 50 feet. This area appears to be sufficient in size to manage the approximately one (1) acre of impervious area draining to the nearby manhole. Stormwater would be diverted from existing infrastructure and would overflow to the adjacent forested wetland. If properly designed and marked with signage, this feature could serve as an aesthetic amenity and educational tool.


1: Proposed bioretention location

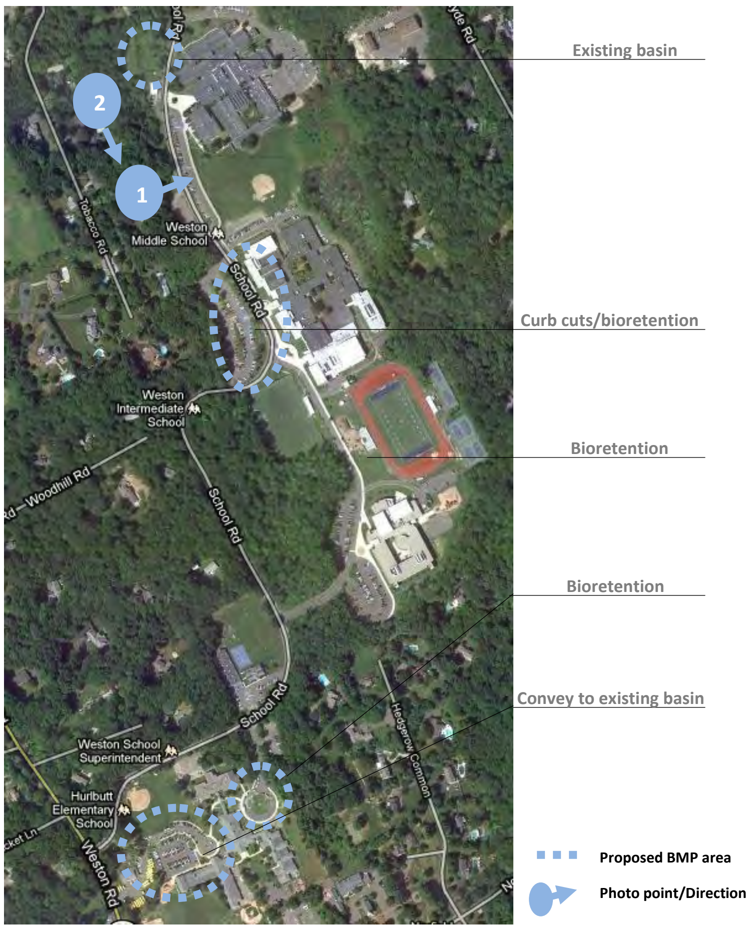

2: Existing wet basin

BMP F. Weston School Complex

School Rd., from Lords Hwy. to Weston Rd., Weston, CT

Saugatuck River Watershed

BMP Type: Bioretention, retrofit existing basin
Subwatershed: 18
Construction Cost Estimate: $260,000
Potential Benefits: Water quality, channel protection, habitat
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: Access via road and parking lots
Ownership: Public
Other Constraints: Limited unused open space available



Existing Conditions

The Weston School complex is located near the eastern edge of subwatershed 18, uphill from a headwater stream draining to the West Branch of the Saugatuck River. With the Weston Town center, this complex makes up the largest concentrated impervious area in the West Branch subwatershed.

A wet basin at the north end of School Road may have been designed for water quality and/or channel protection as well as flood control. A control structure with low flow orifices was observed. The basin discharged into the woods to the northwest. This basin appears to be managing approximately six (6) acres of impervious area from the middle school roofs and driveway.

The high school roofs and parking appear to be draining directly into the woods at two locations on the western side of School Rd. Downstream of the outlet pipes significant sedimentation was observed on the forest floor and in a channel running parallel to the road (Photo 2). Some bank erosion and headcutting was also observed.

Proposed BMP

To effectively manage stormwater on this large property, a series of small-scale BMPs are recommended to capture and infiltrate runoff at its source. Since little open space exists, BMPs will be constrained and fairly expensive. However this approach is preferable to managing the site's stormwater at the outfall locations, which would result in significant tree removal and impacts to existing wetlands.

The grass-covered spaces along School Rd. provide a good opportunity to manage road and sidewalk runoff using curb cuts into small bioretention gardens and planter boxes (Photo 1). The Middle School roof drainage (approximately six (6) acres) should be diverted from its central pipe and conveyed to a new subsurface storage unit under the adjacent football field. Drainage from the track (approximately four (4) acres) should be conveyed to the grass-covered areas on its western side where two (2) small bioretention facilities could be constructed.

While it is unclear exactly how Hurlbutt Elementary school drains, most of the parking and roof appear to enter a pipe along Weston Rd. which passes by the existing wet basin at Weston Town Center (see BMP sheet). If possible, additional drainage from the school should be added to the basin. In the rear of the Elementary School is a drive circle where several pipes from the roof and driveway come together in inlets around the grass-covered median. Curb cuts could be installed to bring water into the median, and the shallower roof drains could be diverted.


1: Proposed curb cuts/bioinfiltration

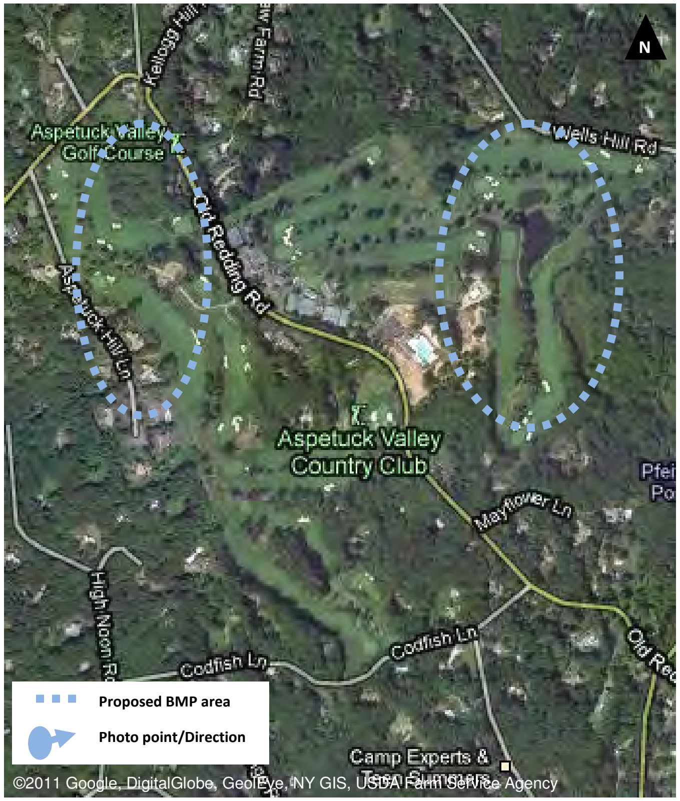

2: Erosion & sediment in woods below outfall

BMP G. Aspetuck Valley Country Club

47 Old Redding Rd., Weston, CT

Saugatuck River Watershed

BMP Type: Riparian Buffer & basin retrofit
Subwatershed: 20
Construction Cost Estimate: $8,000
Potential Benefits: Water quality, habitat, maybe channel protection and water quality
Permitting: None
Site Access: Street access
Ownership: Private
Other Constraints: Buffer plantings may interfere with golf course line of sight



Existing Conditions

Subwatershed 20 drains into the main stem of the Aspetuck River at two locations: an eastern tributary which enters the stream at Toth Park, and a western tributary which enters downstream from the park. The western portion of the subwatershed originates in the Aspetuck Valley Golf Course, where approximately 5,600 feet of denuded riparian buffer are visible from the aerial photo (site access was not gained during field reconnaissance). Downstream of the golf course, impairments have been identified by the CT DEP due to elevated coliform.

At the entrance off Old Redding Rd., a new stormwater basin that is under construction is visible from the roadside. It could not be determined what portion of the site and/or roadway was draining to this location; however a stagnant ditch was observed discharging into this area from under Old Redding Rd. An outlet control structure was visible, but it was unclear whether this basin had been designed for water quality and channel protection, or merely flood control.

Proposed BMP

In order to reduce downstream bacterial counts and improve overall water quality, a large-scale buffer restoration is recommended for this site. This would include the establishment of approximately 44,800 square feet of meadow-type buffer, assuming a buffer width of approximately eight (8) feet. The buffer should be installed along the far western tributary and pond son the west side of Old Redding Rd.; along the eastern tributary and around the ponds near Wells Hill Rd.; and along the main stem Aspetuck's north bank (there appears to be room here for a slightly wider buffer—eight (8) to 15 feet is recommended. Some portions of this bank section along the golf cart path appear to be minimally buffered, but vegetation is most likely insufficient.

As a secondary measure, a nutrient management plan should be developed to minimize excess Nitrate and Phosphorus loading due to fertilizing and lawn care.

Finally, the basin that is currently under construction should be evaluated for a potential retrofit for water quality and channel protection (not included in cost, as need is undetermined).

NO PHOTOS AVAILABLE

BMP H. Redding Municipal Garage

28 Great Oak Ln., West Redding, CT

Saugatuck River Watershed

BMP Type: Stream restoration & bioretention
Subwatershed: 10
Construction Cost Estimate: $710,000
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; and USACOE Clean Water Act
Site Access: Accessible via municipal driveway
Ownership: Public
Other Constraints: The northern reach of incised stream flows on or along the property line of several private residential properties

Existing Conditions

Redding municipal garage is located downstream of the Redding Elementary School & Community Center complex, near the mouth of subwatershed 10. Two tributaries enter the property at its northeast and northwest corners before converging at the south side of the property east of the driveway.

Three flood control basins are located northwest of the garage and treat runoff from the school and community center. The overflows from the two most upslope of these basins (north of the map extent) feed an unstable stream channel with active incision up to one (1) foot deep and past incision up to four (4) feet deep observed (Photo 1). Alternating reaches of erosion/head cutting and aggradation were observed. In the reach just upstream of the garage driveway crossing, small-sized rip rap was observed along approximately 300 feet of channel. Although there was no obvious design intent, the stone was likely placed for stabilization. On the downstream side of the driveway culvert the channel was incising and a head cut was observed.

The eastern tributary originates in the Lonetown Marsh Sanctuary and flows through a wooded buffer to its confluence with the western tributary. A drainage ditch enters this tributary from a residential property near the confluence with the western tributary, and a four (4) foot head cut has formed where this tributary drops in grade to meet the stream. At the confluence of these tributaries, the channel is over-widened with sections of active bank erosion to the Great Oak Ln. crossing.

An unvegetated sediment trap basin is located adjacent to the driveway and down slope from gravel/sand stockpiles (Photo 2). Standing water, accumulated sediment, and active erosion from overflows were observed.

Proposed BMP

Stream restoration on the garage property should be implemented in concert with enhanced stormwater management including upstream basin retrofits at the Redding Elementary School & Community Center (see BMP sheet). The existing sediment trap should also be replaced with a basin sized for channel protection and water quality and with an easily accessible forebay.

Grade controls (e.g., step pools) should be installed at actively incising/head cutting stream locations east of the driveway. Intermittent hard and soft stream restoration techniques should be installed at key locations along approximately 1,000 feet on the western tributary to stabilize the channel and improve habitat.


1: Erosion on western tributary


2: Existing sediment trap

BMP I. Redding Elementary School & Community Center

33 Lonetown Rd., West Redding, CT

Saugatuck River Watershed

BMP Type: Stream restoration & existing basin retrofit
Subwatershed: 10
Construction Cost Estimate: $312,000
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; and USACOE Clean Water Act
Site Access: Basin accessible via athletic fields; stream restoration site accessible through forest and stream channel
Ownership: Public & private
Other Constraints: Some tree removal for stream restoration and landowner cooperation required

Existing Conditions

The Redding Elementary School and Community Center Complex comprise the largest impervious area within subwatershed 10. Most of the roof and parking area appears to drain to an existing wetland/wet basin (Photo 2). Basin dimensions are approximately 150 feet by 40 feet, and water quality control was not observed on the outlet control structure. A channel has formed at the outlet and runs northeast through the woods (Photo 1). Below a stone wall, which appears to be acting as a grade control, the stream is actively incising, and a series of head cuts and near-vertical banks up to four (4) feet high were observed. The channel flows over a five (5) foot man-made stone grade control before joining a stream behind a house on Gallows Hill Rd. This stream, which originates in the Redding Country Club, appeared to be stable, but some sediment deposition was observed.

Three flood control basins are located on the western side of the property. Water quality controls were not observed at the outlets and overflow from the two northern basins appear to have caused unstable conditions (e.g., erosion up to one (1) foot deep) in a channel behind Great Oak Ln. residential properties. Eventually the channel flows along the western side of the Redding Municipal Garage property (see BMP H).

Proposed BMP

A two-step approach should be taken to address the multiple problems associated with this property. First, because the existing basins are causing channel instability downstream of their outlets, the outlets should be modified for channel protection and water quality. Additional storage may be required and ample space is available adjacent to all basins. New basins in series with existing ones could be another alternative.

Second, the gullied channel behind Gallows Hill Rd. should be addressed through a combination of soft and hard stream restoration over approximately 400 feet of stream. Some tree removal may be required for access and the project will require coordination with the homeowner downstream.

Small scale bioretention sites could also be installed closer to the impervious areas. These methods could cost a bit more, but be more visible and accessible as an educational tool (not included in cost estimate).

Stream restoration of the unstable channel fed by the western basins is described in BMP sheet H for the Redding Municipal Garage.


1: Channel erosion behind Gallows Hill Road


2: Basin north of the Redding Community Center

BMP J. Farm Meadow Development

Poverty Hollow Rd. between Farm Meadow Rd. and Wentworth Rd., Newtown, CT

Saugatuck River Watershed

BMP Type: Retrofit existing basin
Subwatershed: 28
Construction Cost Estimate: $29,000
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: Access via road and parking lots
Ownership: Public & private
Other Constraints: Some tree removal required

Existing Conditions

The residential development at Farm Meadow Rd. drains downhill to an existing basin that is located across the street from a tributary to the Aspetuck River. The basin is split in half by a high berm; the north half is dry, and the south half is wet. The dry half appears to be managing runoff from the uphill portion of the development along Wentworth Dr. The wet half is fed by a large outfall discharging from an adjacent manhole in the Poverty Hollow Rd. and from overflow from the north portion of the basin. The ponded area is stagnant and mostly vegetated; a low flow channel through the basin drains to an overflow control structure where no water quality controls were observed. Downstream of the control structure, a large amount of grass clippings and other debris were observed.

Proposed BMP

The existing basin appears to have been built for flood control and could be retrofitted for water quality by modifying the outlet control structure. If additional storage volume is needed to manage the approximately three (3) acres of impervious area draining here, it appears that there would be sufficient room to expand into the wide lawns adjacent to the basin. Water quality impairments have been observed lower on the Aspetuck at Toth Park, so this BMP offers an excellent opportunity to improve downstream conditions.


1: Near inlet to dry portion of basin


2: Wet basin near outlet control structure

BMP K. Astor Place Show Stables & Equestrian Hills Development

50 Poverty Hollow Rd., Newtown, CT

Saugatuck River Watershed

BMP Type: Riparian Buffer
Subwatershed: 28
Construction Cost Estimate: $29,000
Potential Benefits: Water quality, habitat
Permitting: None
Site Access: Access via open field
Ownership: Private
Other Constraints: Fencing around the plantings might be needed

Existing Conditions

Subwatershed 28 is located at the far northeast portion of the Saugatuck watershed. It drains to the Aspetuck River where bacterial water quality impairments have been observed. The development at Equestrian Ridge Rd. is fairly new, and stormwater management is provided by several basins and swales designed for water quality as well as flood control. The main land-use problem in this area appears to be a large horse farm near the mouth of subwatershed 27, where the stream passes through several slow-moving ponds before reaching the confluence with another tributary. Neither the ponds nor the stream banks are buffered, and horses in the pastures may graze up to the water's edge and enter the stream (however, no horses were observed during field reconnaissance).

Proposed BMP

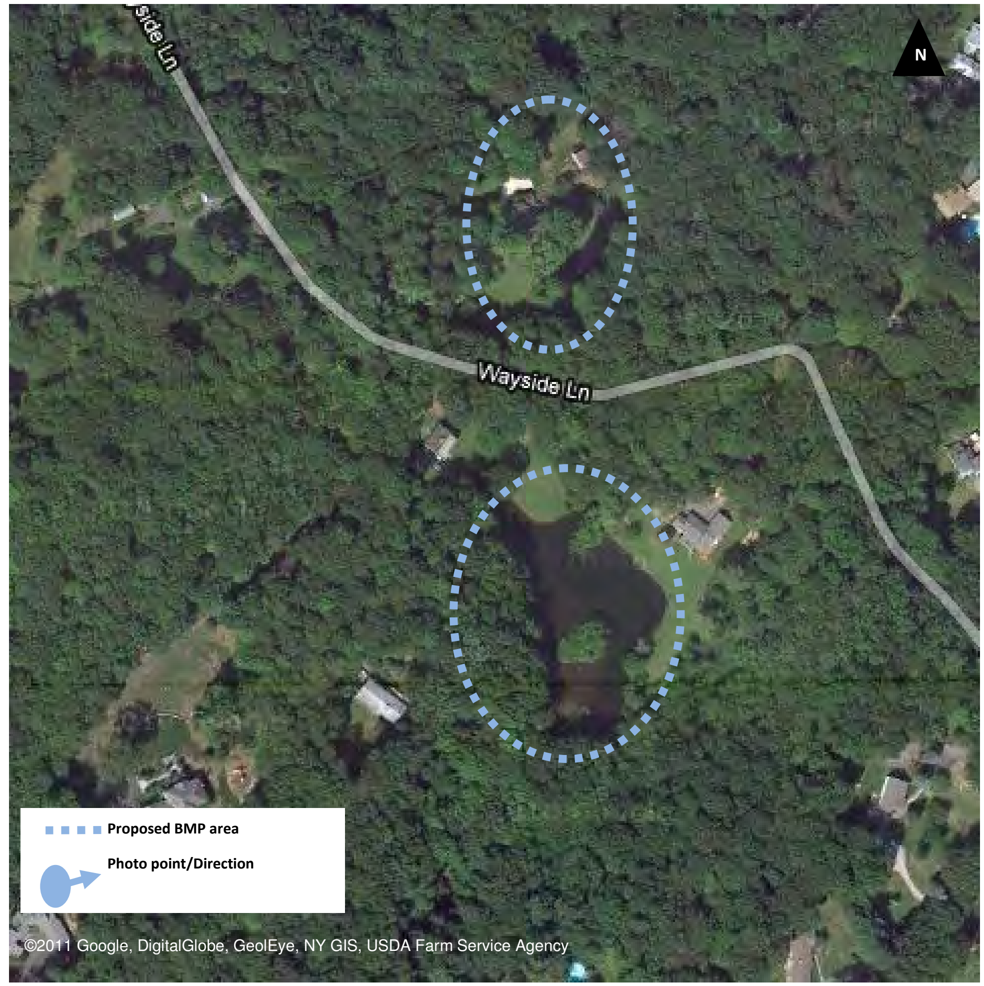
Since the uphill development appears to have good storm water controls in place, the major focus of a restoration here should be on adding buffers to the stream and ponds within the pastures. Since there appears to be plenty of space, buffers should be seeded out to 50 feet or greater where possible, ideally to 100 feet in order to trap nutrients and bacteria. After planting, a strong fence should be constructed to prevent horses from trampling the growing plants. Approximately 4,200 feet of stream would need to be addressed.

BMP L. Wayside Lane Stream Crossing

Wayside Ln., Redding, CT

Saugatuck River Watershed

BMP Type: Riparian Buffer
Subwatershed: 11
Construction Cost Estimate: $3,000
Potential Benefits: Water quality, habitat
Permitting: None
Site Access: Street access
Ownership: Private
Other Constraints: None



Existing Conditions

The southern tributary in subwatershed 11 has a pond as its origin, located on the south side of Wayside Ln. in Redding. Two large properties abut the pond, with little to no buffer. Across the street, a second impoundment is bordered on its northwestern side by a lawn with a limited buffer.

Proposed BMP

Approximately 10,000 square feet of meadow-type buffer should be added along these three properties, assuming a buffer depth of approximately 10 feet.

NOTE: Proposed BMP has not been field vetted due to access constraints on private property.

NO PHOTOS AVAILABLE

BMP M. Redding Road Buffer

324 Redding Rd., Redding, CT

Saugatuck River Watershed

BMP Type: Riparian Buffer
Subwatershed: 34
Construction Cost Estimate: $4,000
Potential Benefits: Water quality, habitat
Permitting: None
Site Access: Street access
Ownership: Private
Other Constraints: None

Existing Conditions

Just upstream of the outlet of subwatershed 34, three small tributaries come together in an open field. Four (4) ponds are located upstream and downstream of the property's private drive. While the fields do not appear to be closely cut, the streamside buffer is limited.

Proposed BMP

Approximately 20,000 square feet of meadow-type buffer should be added along this portion of stream, assuming a buffer depth of approximately 10 feet. This may be achieved through planting, or may even be possible through establishment of a no-mow zone which would allow the existing grasses to grow thicker.

NOTE: Proposed BMP has not been field vetted due to access constraints on private property.

NO PHOTOS AVAILABLE

BMP N. New Pond Farm

101 Marchant Rd., Redding, CT

Saugatuck River Watershed

BMP Type: Riparian Buffer
Subwatershed: 7
Construction Cost Estimate: $2,000
Potential Benefits: Water quality, habitat
Permitting: None
Site Access: Street access
Ownership: Private
Other Constraints: None

Existing Conditions

New Pond Farm, a small environmental education facility and working farm, is located on a tributary stream just upstream of where it enters the main stem Saugatuck River. The unbuffered area here is fairly limited (approximately 500 feet of stream and pond), but due to the fact that water quality impairments have been identified downstream on the main stem, some additional inspection here may be warranted.

Proposed BMP

Approximately 5,000 square feet of meadow-type buffer should be added along western ponds pictured at right and along the stream running between them (assuming a buffer depth of approximately 10 feet). Agricultural best management practices such as covering manure and keeping livestock out of water should be adopted, if they have not been adopted already.

NOTE: Proposed BMP has not been field vetted.

NO PHOTOS AVAILABLE

BMP O. West Redding Train Station

Station Rd. & Simpaug Tpk., Redding, CT

Saugatuck River Watershed

BMP Type: Retrofit existing swale
Subwatershed: 7
Construction Cost Estimate: $15,000
Potential Benefits: Water quality, channel protection
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: Access via train station parking lot
Ownership: Private
Other Constraints: None

Existing Conditions

An existing swale with an impervious drainage area of approximately half an acre is located at the southwestern side of the Redding Train Station parking lot. The swale is approximately 30 feet long by 180 feet wide, with a depth that varies from approximately 10 feet at the north end to approximately five (5) feet at the south end. At the south, an uncontrolled outlet drains directly to the main stem Saugatuck River. The swale receives runoff from a single pipe draining inlets throughout the parking lot. Downstream of here on the main stem, several bacterial impairments have been identified.

Proposed BMP

A controlled outlet structure should be sized for water quality and channel protection. Further excavation is not recommended due to the already steep sides and depth of the swale. Before constructing this retrofit, modeling should be conducted to verify that adequate space exists to provide for infiltration and reduction of bacterial loading.


1: Outfall into swale


2: Parking lot

BMP P. Right-of-Way by Aspetuck Reservoir Dam

Norton Rd. & Black Rock Tpk., Easton, CT

Saugatuck River Watershed

BMP Type: Bioretention
Subwatershed: 28
Construction Cost Estimate: $128,000
Potential Benefits: Water quality, channel protection
Permitting: Municipal Construction, 401 Water Quality Certification, Inland Wetlands and Watercourses, and Water Diversion
Site Access: Street access
Ownership: Assumed to be public right of way
Other Constraints: Adjacent wetland limits space for a potential BMP; delineation would have to be performed

Existing Conditions

Portions of Norton Rd., Wyldewood Rd., and Black Rock Tpk. drain to a pair of inlets on either side of the Black Rock Tpk. near the Aspetuck Reservoir dam in Easton. On the west side of the turnpike is a large open area that is at least partially wetland. The portion directly adjacent to the turnpike does not appear to be wetland, but a formal delineation would be required for this project to proceed.

The east side of the turnpike is directly adjacent to the Aspetuck Reservoir and is most likely Aquarion property. Two open spaces may be available for stormwater management, but conveyance across the street may be difficult.

Proposed BMP

One to three small-scale bioretention cells are recommended to manage approximately 1.7 acres of impervious drainage area. Ideally the right-of-way on the west side of Black Rock Turnpike should be used to manage runoff from Norton and Wyldewood Roads, and another smaller bioretention cell on the east side of the Turnpike should be used to manage runoff from that road. Depending on the results of a wetland delineation on the west side, more space may be needed on the east side of the road to avoid wetland impacts.


1: Inlet at bottom of Norton Rd.


2: West side of turnpike – proposed bioretention

BMP T. Ridgebury Elementary School

112 Bennett's Farm Rd., Ridgefield, CT

Saugatuck River Watershed

BMP Type: Bioretention
Subwatershed: 1
Construction Cost Estimate: $159,000
Potential Benefits: Water quality, channel protection
Permitting: Municipal Construction, 401 Water Quality Certification, Inland Wetlands and Watercourses, and Water Diversion
Site Access: Easy access from the school parking lot
Ownership: Public
Other Constraints: HSG D soils may limit infiltration potential. Site was not field-vetted; wetland conflicts are possible.

Existing Conditions

Ridgebury Elementary School is located just inside the drainage boundary of the Saugatuck River Watershed, in the far northwest headwaters. The school building and parking areas are located uphill from a grassy lawn where some unused open space appears to be available just west of the ball field. Farther downhill, the property is abutted by a riparian meadow that buffers Ridgebury Pond.

The road and a small portion of the parking lot appear to drain away from the property. Everything else drains downhill toward the ball field and eventually, the pond. Lawn areas adjacent to the building are fairly steep, with evidence of erosion near the main parking lot. Roof leaders are largely internal. Several inlets are located within the driveway and parking lot, most likely connecting to pipes under Bennett's Farm Rd.

Proposed BMP

A bioretention area is recommended to capture and manage as much of the roof and parking lot/driveway runoff as can feasibly be diverted. Based on existing topography, it appears likely that most of this area can be diverted; however some piping would be required, which would increase cost and difficulty. There appears to be plenty of open space in this area, so at least with respect to size the site is relatively unconstrained. Upland soils around the building are well-drained, but soils in the region of the proposed BMP are clay-rich (HSG D) meaning that infiltration rates may be low. In addition, wetland conflicts are a potential issue, as the site is located almost directly adjacent to Ridgebury Pond.

NOTE: Proposed BMP has not been field vetted.

NO PHOTOS AVAILABLE

APPENDIX B: FUNDING OPPORTUNITIES

Funding Source	Maximum Dollar amount	Minimum Dollar amount	Required match	Applications Open	Deadline
CTDEEP Watershed Funding Website					
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=335494&depNav_GID=1654&pp=12&n=1 Index of many potential funding sources for funding watershed-based planning projects.					
CTDEEP Open Space and Watershed Land Acquisition	Up to 40-60%			Twice a year	
860-424-3016 david.stygar@ct.gov http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323834&depNav_GID=1641					
CTDEEP Recreation & Natural Heritage Trust Program				Rolling	
http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav_GID=1641					
Eastman Kodak / Nat'l Geographic American Greenways Awards optional Program	$2,500	$500	Optional	April	June
kodakawards@conservationfund.org; jwhite@conservationfund.org (Jen White) http://www.conservationfund.org/kodak_awards					
EPA Healthy Communities Grant Program	$30,000	$5,000	Optional, non-federal up to 5%	March	April
617-918-1698 Padula.Jennifer@epa.gov					
Northeast Utilities Environmental Community Grant Program	$1,500				15-Sep
http://www.nu.com/environmental/grant.asp Cash incentives for non-profit organizations Patricia Baxa, baxapl@nu.com					
CTDEEP CWA Section 319 NPS			40% of total project costs (non-federal)		August
Non-point Source Management http://www.ct.gov/dep/nps Projects targeting both priority watersheds and statewide issues.					

Funding Source	Maximum Dollar amount	Minimum Dollar amount	Required match	Applications Open	Deadline
CTDEEP Section 6217 Coastal NPS			N/A		
http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323554&depNav_GID=1709 Section 6217 of the CZARA of 1990 requires the State of Connecticut to implement specific management measures to control NPS pollution in coastal waters. Management measures are economically achievable measures that reflect the best available technology for reducing non-point source pollution.					
CTDEEP Hazard Mitigation Grant Program			75% Federal/25% Local		
http://www.ct.gov/dep/cwp/view.asp?a=2720&q=325654&depNav_GID=1654 Provides financial assistance to state and local governments for projects that reduce or eliminate the long-term risk to human life and property from the effects from natural hazards.					
American Rivers-NOAA Community-Based Restoration Program Partnership	Construction: $100,000 Design: $150,000				December
http://www.americanrivers.org/our-work/restoring-rivers/dams/background/noaa-grants-program.html These grants are designed to provide support for local communities that are utilizing dam removal or fish passage to restore and protect the ecological integrity of their rivers and improve freshwater habitats important to migratory fish.					
Fish America Foundation Conservation Grants	$75,000	$10,000	At least 75% (non - federal)		April
703-519-9691 x247 fishamerica@asafishing.org	http://www.fishamerica.org/grants.html				
Municipal Flood & Erosion Control Board	1/3 project cost	2/3 project costs			
NFWF LIS Futures Fund Small Grants	$10,000	$3,000	optional (non- federal)	Fall/Winter	March
631-289-0150 Lynn Dwyer http://longislandsoundstudy.net/about/grants/lis-futures-fund					
NFWF Long Island Sound Futures Fund Large Grants	$150,000	$10,000	optional(non- federal)	Fall/Winter	April
631-289-0150 Lynn Dwyer http://longislandsoundstudy.net/about/grants/lis-futures-fund					

Funding Source	Maximum Dollar amount	Minimum Dollar amount	Required match	Applications Open	Deadline
NRCS Wildlife Habitat Incentives Program (WHIP)	$ 50,000/year	$1,000	25%	Rolling	May
Joyce Purcell, (860) 871-4028 For privately owned lands.	http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/whip				
NRCS Wetlands Reserve Program				Rolling	
Nels Barrett, (860) 871-4015 http://www.ct.nrcs.usda.gov					
USFS Watershed and Clean Water Action and Forestry Innovation Grants					
http://www.na.fs.fed.us/watershed/gp_innovation.shtm This effort between USDA FS-Northeastern Area and State Foresters to implement a challenge grant program to promote watershed health through support of state and local restoration and protection efforts.					
Corporate Wetlands Restoration Partnership (CWRP)	Typically $ 20,000	typically $5,000	3 to 1	April and August	
http://www.ctcwrp.org/9/ Can also apply for in-kind services, e.g. surveying, etc.					
River's Alliance Watershed Assistance Small Grants Program2	Typically $5,000, not to exceed $1,0000	$500	40% of total project costs		October
http://www.riversalliance.org/ 860-361-9349 rivers@riversalliance.org Funding passed through River's Alliance from CTDEEP's 319 NPS grant program for establishing new or emerging river – watershed organizations.					
USFWS National Coastal Wetlands Conservation Grant Program	$1 million		50%		
http://www.fws.gov/coastal/coastalgrants Ken Burton 703-358-2229. Only states can apply.					
EPA Green Infrastructure Funding Website					
http://water.epa.gov/infrastructure/greeninfrastructure/gi_funding.cfm Index to funding opportunities for LID practices and pollution reduction projects.					

Funding Source	Maximum Dollar amount	Minimum Dollar amount	Required match	Applications Open	Deadline
America the Beautiful Grant Program	$8,000		50%	May	June
USDA Forest Service funding through the CTDEEP Division of Forestry to support urban forestry efforts. www.ct.gov/dep/forestry					

OTHER FINANCIAL OPPORTUNITIES

Private Foundation Grants and Awards

http://www.rivernetwork.org Private foundations are potential sources of funding to support watershed management activities. Many private foundations post grant guidelines on websites. Two online resources for researching sources of potential funding are provided in the contact information.

State Appropriations – Direct State Funding
http://www.cga.ct.gov/

Membership Drives
Membership drives can provide a stable source of income to support watershed management programs.

Donations
Donations can be a major source of revenue for supporting watershed activities, and can be received in a variety of ways.

User Fees, Taxes, and Assessments
Taxes are used to fund activities that do not provide a specific benefit, but provide a more general benefit to the community.

Stormwater Utility Districts
A stormwater utility district is a legal construction that allows municipalities to designated management districts where storm sewers are maintained in order to the quality of local waters. Once the district is established, the municipality may assess a fee to all property owners.

Impact Fees
Impact fees are also known as capital contribution, facilities fees, or system development charges, among other names.

Special Assessments
Special assessments are created for the specific purpose of financing capital improvements, such as provisions, to serve a specific area.

Sales Tax/Local Option Sales Tax
Local governments, both cities and counties, have the authority to add additional taxes. Local governments can use tax revenues to provide funding for a variety of projects and activities.

Property Tax
These taxes generally support a significant portion of a county's or municipality's non-public enterprise activities.

Excise Taxes
These taxes require special legislation, and the funds generated through the tax are limited to specific uses: lodging, food, etc.

Bonds and Loans
Bonds and loans can be used to finance capital improvements. These programs are appropriate for local governments and utilities to support capital projects.

Funding Source	Maximum Dollar amount	Minimum Dollar amount	Required match	Applications Open	Deadline
Investment Income Some organizations have elected to establish their own foundations or endowment funds to provide long-term funding stability. Endowment funds can be established and managed by a single organization-specific foundation or an organization may elect to have a community foundation to hold and administer its endowment. With an endowment fund, the principal or actual cash raised is invested. The organization may elect to tap into the principal under certain established circumstances.					
EMERGIN OPPORTUNITIES FOR PROGRAM SUPPERT					
Water Quality Trading Trading allows regulated entities to purchase credits for pollutant reductions in the watershed or a specified part of the watershed to meet or exceed regulatory or voluntary goals. There are a number of variations for water quality credit trading frameworks. Credits can be traded, or bought and sold, between point sources only, between NPSs only, or between point sources and NPSs.					
Mitigation and Conservation Banking Mitigation and Conservation banks are created by property owners who restore and/or preserve their land in its natural condition. Such banks have been developed by public, nonprofit, and private entities. In exchange for preserving the land, the “bankers” get permission from appropriate state and federal agencies to sell mitigation banking credits to developers wanting to mitigate the impacts of proposed development. By purchasing the mitigation bank credits, the developer avoids having to mitigate the impacts of their development on site. Public and nonprofit mitigation banks may use the funds generated from the sale of the credits to fund the purchase of additional land for preservation and/or for the restoration of the lands to a natural state.					

Source: Norwalk River Watershed Plan (NRWIC 2011); Web-links were verified for active status by AKRF in March 2012.

APPENDIX C: STREAM VISUAL ASSESSMENT FIELD SUMMARIES

Appendix A. Stream Visual Assessment Field Summaries

									Stream Visual Assessment Parameters														
Sample Location ID	**Location**	**Subwatershed**	**ICScore***	**Land use within Drainage**	**Approximate Active Channel Width**	**Gradient**	**Channel Form**	**Dominant Substrate**	**Channel Condition**	**Hydrologic Alteration**	**Riparian Zone**	**Bank Stability**	**Water Appearance**	**Nutrient Enrichment**	**Barriers to Fish Movement**	**Instream Fish Cover**	**Pools**	**Invertebrate Habitat**	**SVA Score****	**SVA Category**	**Invertebrates Observed**	**Habitat Observed**	**Comments**
21	Taunton Hill Road	28 (Aspetuck)	good	pasture, residential, forested	7'	moderate	riffle-pool	boulder	8	8	10	10	10	7	5	6	7	9	**8.0**	**good**	Plecoptera; Tricoptera	leaf packs; boulders; undercut banks; riffles; pools; wood	wetlands surrounding
22	Poverty Hollow and Greenleaf Farms Roads	28 (Aspetuck)	good	pasture, residential, forested	15'	low	plane-bed	sand	5	5	3	8	9	8	10	3	5	5	**6.1**	**fair**	not sampled	undercut banks; leaf packs; wood	riparian buffer is grass; flows to large natural wetland
23	Poverty Hollow Road	28 (Aspetuck)	good	pasture, residential, forested	2'	moderate	riffle-pool	cobble	6	7	1	9	10	10	3	6	4	8	**6.6**	**fair**	not sampled	undercut banks; leaf packs; wood	wetlands surrounding; v-notch weir impounded upstream reach which is sediment-filled
24	Cross Highway	12 (Little River)	good	pasture, residential, forested	17'	moderate	riffle-pool	cobble	8	8	9	9	10	10	10	7	3	6	**8.0**	**good**	Plecoptera; Tricoptera	undercut banks; leaf packs; boulders; pools; wood	wetlands surrounding; minor bank erosion
25	Saugatuck Falls Preserve, Redding Road	7 (Saugatuck Reservoir)	good	pasture, residential, forested	25'	low	plane-bed	sand	10	10	10	10	9	9	10	4	7	4	**8.3**	**good**	not sampled		wetlands surrounding
26	Simpaug Turnpike, West Redding	7 (Saugatuck Reservoir)	good	pasture, residential, forested	15'	moderate	riffle-pool	boulder	9	10	10	10	10	7	10	7	9	8	**9.0**	**good**	Tricoptera; Coleoptera	boulders; wood; submerged aquatic vegetation; undercut banks; backwaters	
27	George Hull Hill Road	4	good	pasture, residential, forested	15'	moderate	riffle-pool	boulder	7	8	10	8	10	8	9	7	6	8	**8.1**	**good**	not sampled	boulders; overhanging vegetation; riffles; leaf packs; wood	wetlands surround; stone wall along one side of river; sand deposition on floodplain
28	Long Ridge Road	4	good	forested, residential	3'	moderate	riffle-pool	cobble	9	10	9	10	9	8	7	6	4	6	**7.8**	**good**	Tricoptera; Plecoptera; Chironomid; Gastropoda	boulders; riffles; leaf packs; wood; overhanging vegetation; submerged aquatic vegetation	wetlands surround; tannins in water (tea colored)
29	Broad & Newtown Pike	18 (West Branch)	poor	residential, forested	15'	moderate	riffle-pool	boulder	4	6	4	7	10	10	7	5	7	5	**6.5**	**fair**	not sampled	pools; boulders; undercut banks	bank protection/rip rap; stone wall along stream edge; some wetlands surrounding with sediment deposits; riparian buffer 1'-15'; substrate 60% embedded; tannins in water (tea colored)
30	Canal Street	33 (Lower main stem)	fair	residential, forested	7'	moderate	riffle-pool	cobble	2	4	7	2	10	7	10	6	7	7	**6.2**	**fair**	none observed	riffles; boulders; leaf packs	abundant algae; riprap lined banks
31	Canal Street	33 (Lower main stem)	fair	residential, forested	40'	low	plane-bed	boulder	5	5	5	6	10	9	10	7	7	7	**7.1**	**fair**	not sampled	boulders	
32	Samuelson Road and Route 57	37 (West Branch headwaters)	fair	residential, forested	4'	low	plane-bed	sand	3	5	7	7	10	10	7	5	3	3	**6.0**	**poor**	not sampled	undercut banks; leaf packs; wood	substrate embedded; homogonous flow and substrate; mid channel bar formation; minor bank erosion

APPENDIX D: THE NATURE CONSERVANCY'S DRAFT CONSERVATION ACTION PLAN

Steps
Development, Dams, Land and Water Use / Management, and Invasive Species.

DRAFT - March 2006

	Objective/Strategy	Activity	Strategic Action	Action Steps: 1	2	3	4	5
1 Protect and Restore Water quality								
Maintain or improve the chemical, sediment and temperature regimes of watershed streams, and thereby maintain or improve the viability of riparian and benthic habitats.								
A	**Poor Water Quality -** Identify streams and tributaries within the watershed where fishable, swim able water quality standards are not being met.	**Gather Data and Report**	_Conduct water quality monitoring at sites throughout the watershed. _Consult with local health departments and CT DEP.	_Encourage CT DEP to continue funding Water quality monitoring programs.	_Seek Local, State and private funding for monitoring programs	_Involve local schools in monitoring efforts (i.e. CT DEP Project Search Program)	_Recruit volunteers.	_Review data with environmental experts to solicit recommendations and analysis before sharing monitoring data with the public, town leaders and health officials. (Annual Report)
B	Identify sources of system degradation.	**Gather Data**	_Conduct stream walks. _Consult with fisherman, homeowners, public works departments, Aquarion Water Company, CT DEP	_Lead annual training for volunteers	_Conduct workshops for citizens about sources of degradation	_Share monitoring data with the public, town leaders and health officials. (Annual Report)	_Detect illicit discharges	
C	Educate and reach out to implement specific projects protecting and enhancing water quality	**Residential Properties - collect and disseminate information**	_Distribute available septic care brochures from Southwest Conservation District in areas where water quality data indicates potential septic concern.	_Septic System Maintenance	_Municipal Housekeeping	_Promote beneficial landowner property management		

Steps

Development, Dams, Land and Water Use / Management, and Invasive Species.

DRAFT - March 2006

	Objective/Strategy	Activity	Strategic Action	Action Steps: 1	2	3	4	5
1 Protect and Restore Water quality								
Maintain or improve the chemical, sediment and temperature regimes of watershed streams, and thereby maintain or improve the viability of riparian and benthic habitats.								
D	Create Tributary and branch specific action plans	**Assimilate data**	_Report findings to pertinent stakeholders	_Prioritize tributary and branches for study based on need	_Identify criteria impairments and resolutions	_Identify long range practices behavior changes, routine cleanups, etc.		
E	Implement projects to pre-empt future degradation	**Planning**	_Assist towns to develop effective Phase II programs. (Stormwater management)	_Identify municipal officials responsible for Phase II compliance planning.	_Determine status of each town's planning efforts.	_Identify funding needs and knowledge or resource gaps.	_Sponsor workshops to develop collaboration between Phase II planners from the eleven watershed towns	
F	Investigate and document threats to ground water quality.	**Gather Data**	_Survey town health departments to learn their concerns about well water quality and aquifer protection	_Encourage state to require well testing as part of mortgage approval.	_Compare and contrast existing regulations for conservation, planning and zoning, waste management, etc. in watershed towns	_Prepare and share review of strengths and weakness of practices and regulations website or printed report.	_Share data and concerns with the public, town leaders and health officials. (Annual Report)	

Steps

Development, Dams, Land and Water Use / Management, and Invasive Species.

DRAFT - March 2006

	Objective/Strategy	Activity	Strategic Action	Action Steps:				
2 Protect and Restore Stream Flow								
Conduct modeling of in-stream flows, especially in the lower watershed, to provide information (to inform water regulators (CT DEP) and water users) on current flow in the river and potential over allocation of the resource.								
A	Support efforts to model the hydrology of the Saugatuck River Watershed to better understand stream flow and environmental impact of water use and withdrawal.	**Hydrology Modeling**	_Use model to identify river and stream reaches stressed by water withdrawal.	_Obtain funding for reactivation of USGS Stream gauge in the lower watershed.	_ Meet with CT DEP to support State efforts to establish minimum stream flows.	_ Encourage towns and DEP to link land use decisions with water resources		
3 Land Use and Management				**1**	**2**	**3**	**4**	**5**
Engage in outreach and education to encourage better land management practices.								
A	Develop stronger collaboration between Partnership and representatives of commissions in charge of health, land use and water supply		_Seek to have an appointed staff from health, land use and water and waste control boards participate in Partnership project development.	_Develop reporting routine between partnership and commissions and policy makers	_Request that Partnership updates become agenda items for these commissions and boards.			
B	Create awareness of land stewardship and responsibilities.	**Plan and execute workshops to educate**	_Coordinate land use workshop with Sierra Club, NEMO and other partners for citizens and town officials.	_Work with towns to develop demonstration projects showcasing best management practices for land management.	_Develop instructional program for schools.	_Develop strategies for educating landscapers and those who employ them.	_Work with all stakeholders - regulators, realtors, builders, wpc, waste management, property managers…	_Poll to obtain feedback results

Steps
Development, Dams, Land and Water Use / Management, and Invasive Species.

DRAFT - March 2006

	Objective/Strategy	**Activity**	**Strategic Action**	**Action Steps**:				
C	Encourage best gardening practices	**Collaborate with garden clubs and nurseries**	_Coordinate meetings or workshops to provide guidance on best gardening practices	_Encourage towns to establish and advertise yard waste compost sites	_Involve commercial gardening centers, town garden clubs and individuals in outreach and education efforts.	_Work with local tree wardens and arborists		
D	Implement projects to protect and enhance natural watercourse buffers.	**Identify degraded or threatened stream buffers**	_Conduct vulnerability assessment to identify priority properties that impact watershed health	_Obtain permission to implement restoration projects at specific sites	_Identify projects eligible for grants.	_Engage Watershed Partnership in stream-bank/riparian zone, wetland, estuary and in-stream restoration projects.	_With local nurseries, develop planting plans to restore native streamside vegetation	
E	Encourage Implementation of Low Impact Development Strategies	**Support Educational workshops and circulation of educational material**	_Recruit workshop leaders to discuss environmental impacts of development including water, pesticide, herbicide and fertilizer use and other land management practices.	_Work with municipal leaders, conservation commissions, facilities and ground operations and municipal emergency management directors/supervisors to adopt best land management and water usage practices.				
F	Encourage towns to implement Best Management Practices for street maintenance	**Develop working groups to meet with Public Works directors of the watershed towns.**	_Develop questionnaire on street management practices.	_Identify environmentally sensitive streams and habitats most influenced by road runoff.	_Prioritize catch basin cleaning to address these areas as early after the winter as possible.	_Work with towns to identify best locations for installation of filters or swirl concentrators.		

Steps

Development, Dams, Land and Water Use / Management, and Invasive Species.

DRAFT - March 2006

	Objective/Strategy	Activity	Strategic Action	Action Steps:				
4 Invasive Species Control								
Maintain or improve the viability and diversity of aquatic species by reducing the impact of invasive species.								
A	Prevent further spread of invasive species, (plants and animals) in priority areas	**Control and limit spread of Invasive Species**	_Mobilize volunteers, staff or contractors as appropriate to eradicate established populations of invasive species.	_Work with partners to educate others about invasive species	_Support efforts by partners to develop teams for early detection and rapid elimination of invasive species	_Support bans on invasive plants, and support nurseries that do not sell them.	_Sponsor workshops and training to educate about invasives and the threats they pose to biodiveristy.	
5 Restore Diadromous Fish Passage								
Improve riverine function and increase available stream miles and accessible habitat for fish and aquatic species.								
A	Map historical distribution of diadromous fish	**Identify Restoration Needs**	_Map present distribution	_Map target area for restoration.	_Identify restoration strategies - education, streambank or habitat restoration, fishways	_Develop cost estimates and timelines.		
B	Expansion of available stream habitats for fish and other aquatic species.	**Develop Restoration Plans**	_In cooperation with CT DEP and dam owners, develop plans for fishways, dam modifications or dam removal.	_Secure landowner permission at all sites	_Secure necessary permits from State and local regulating authorities	_Secure funding for project construction and complete work plans	_Recruit volunteers and hire machine operators for construction phase	_Schedule and complete projects
6 Development Guidelines				**1**	**2**	**3**	**4**	**5**
Encourage towns to develop and adopt regulations sensitive to the health of the watershed.								
A	Compare and contrast zoning regulations in the eleven towns - and each towns plan of Conservation and Development	**Municipal regulations review**	_Develop workgroup to report back on existing regulations in the watershed towns.	_Identify towns currently rewriting plans of Conservation and Development and offer contributions.	_Work to link Towns' Plans of C & D with Zoning regulations	_Recommend environmentally sound guidelines for wetland and intermittent watercourse crossing	_Suggest counting impervious surface as lot coverage	_Encourage establishment of adequate regulated areas around wetlands and along streams

Steps
Development, Dams, Land and Water Use / Management, and Invasive Species.

DRAFT - March 2006

	Objective/Strategy	Activity	Strategic Action	Action Steps:				
7 Monitoring								
Conduct thorough monitoring programs of conservation targets throughout the watershed								
A	Develop programs to monitor targets.	**Review Conservation Targets and incorporate in program priorities**	_Compile data into a State of the Watershed Annual report	_Collaborate with Earth Place River Watch Program on water quality monitoring	_Liaison with other local committees and commissions working on Saugatuck River and its environs	_Coordinate survey of Saugatuck estuary and river mouth (Including, water quality analysis, fish and shellfish health, sediment and invasives)		
8 Communications								
Develop communication with local media and municipalities								
		Involve all stakeholder groups	_Outreach to children, school involvement	_PTA special programs - Share news of local efforts.	_Connect stakeholder groups with projects of specific interest to them.			
A	Examine best means to communicate watershed activities on a regular schedule	**Review Communications options and format**	_Develop system for specific communication practices. Consider applicability of Partnership Website.	_Develop an approval system for press releases	_Develop two-way channel of communication with local stakeholder groups for information flow about Partnership activities	_Consider newsletter for the partnership- summarizing events, opportunities, support needs. If appropriate determine frequency	_Develop municipal conservation pact that CEOs of watershed towns agree to sign.	_Consider piggybacking Partnership news on existing newsletters
B	Develop organization structure	**Establish workgroups and organization options**	_Select best organization option					

Steps
Development, Dams, Land and Water Use / Management, and Invasive Species.

DRAFT - March 2006

	Objective/Strategy	Activity	Strategic Action	Action Steps:				
9 Funding								
Develop grant proposals and solicitations to support the partnership								
A	Develop financial plan and budget systems	**Form Financial working group**	_Develop Financial plan	_Compile a list of potential grant sources for specific projects and partnership support	_Develop solicitation approach for private fundraising	_Identify lead partner for each grant.	_Develop Income and Expenditure reporting format	
10 Progress								
Review and revise Action Plan and strategies								
A	Determine Review Calendar	**Revise and review strategies and work plans as necessary**						

APPENDIX E. DERIVATION OF BACTERIA LOAD REDUCTION TARGETS FOR DRAINAGE AREAS TO STATE-LISTED IMPAIRMENTS

METHODOLOGY FOR OBTAINING TARGETS

Indicator bacteria load reduction targets were calculated using a numeric criteria-based method for drainage areas contributing to river sections on the 303(d) list (CTDEP 2011) that do not meet the minimum indicator bacteria criteria for recreation. Because data for fecal coliform and *E. coli* counts were available for one or more sample sites within each of the impaired reaches, it was possible to estimate indicator bacteria load reduction targets based on the State water quality criteria and the statistical relationship between in situ monitoring data and bacteria loads estimated using the WinSLAMM model (see Chapter 2).

In computing load reductions for indicator bacteria, State of Connecticut criteria were used for indicator bacterial impairment of freshwater, which is based on geometric mean and single sample maximum (SSM) thresholds for *Escherichia coli* (*E. coli*) (CTDEP 2011). The *E. coli* criteria for recreational uses for Class AA, A, and B waters are:

- Geometric mean less than 126 cfu/100mL; and
- SSM less than 576 cfu/100mL.

To compare numeric-criteria-generated load reductions with WinSLAMM generated load reductions, the *E. coli* criteria was first converted into fecal coliform criteria by developing a regression function that predicts fecal coliform concentration as a function of *E. coli* concentration using the HW/RW dataset (Harris and Fraboni 2008). This dataset shows a strong linear relationship between log-transformed *E. coli* and fecal coliform measurements in the Saugatuck River.

Following conversion of the state impairment criteria to fecal coliform concentration units, the required percent reduction in indicator bacteria loading was determined using a statistical method following Jagupilla et al. (2009), which is based on the Statistical Rollback Theory (STR) (Ott 1995). STR uses statistical theory to determine a reduction factor that relates the difference between in-stream pollutant concentrations and State criteria to source loads. Jagupilla et al. (2009) provides a method to incorporate statistical confidence into this calculation. Reduction targets were then calculated for each subwatershed draining to an impaired river section by multiplying WinSLAMM-generated fecal coliform loads by the pollution load reduction percentage generated through the use of the STR-based procedure.

Data Acquisition

AKRF acquired indicator bacteria monitoring data for the Saugatuck and Aspetuck Rivers from SWRPA and CTDEEP, respectively. Monitoring data was collected by HW/RW. Bimonthly sampling data collected from May through September (typically 10 samples) from 2005 to 2008 was available for the Saugatuck River. Similarly, bimonthly sampling data collected from May through September from 2000, 2001, 2003 – 2005, and 2011 was available, depending on the site, for the Aspetuck River. Indicator bacteria samples were collected at a single sample site within most impaired reaches and multiple samples sites for those associated with the Aspetuck River (CT7202-00_01) and the West Branch (CT7203-00_01). No reach-specific sampling was performed within the impaired section on the unnamed tributary to the West Branch (CT7203-00-trib_01).

Data Processing

Data from the most recent year where the geomean of the *E. coli* data exceeded the State criteria (126 cfu/100mL) were selected for use in the STR calculations (C. Malik, pers. comm.). For impaired river sections with more than one sample location, the sample location with both the highest sampled *E. coli* geomean value during the most recent year of impairment and a corresponding fecal coliform geomean that exceeded the state criteria was selected for use in the STR calculations.

For all impaired segments except for segment CT7200-00_03 (discussed below), the ratio by which indicator bacteria source area loading must be reduced to attain minimum water quality criteria was calculated using the following equation (Jagupilla et al. 2009):

$$\log \alpha \leq \log(x) - \overline{\log(\mathrm{X})} - \frac{\mathrm{z}_{0.95} \pm \sigma_{\log(\mathrm{X})}}{\sqrt{n}}$$

where,

α = reduction factor
x = 147 cfu/100mL = adjusted State fecal coliform geomean criteria
x_{SSM} = 640 cfu/100mL = adjusted State fecal coliform SSM criteria
X = fecal coliform concentration in stream samples
$\mathrm{z}_{0.95}$= 1.64 = z score that bounds 95% of the data
$\sigma_{\log(\mathrm{X})}$ = standard deviation of log X
n = total number of samples

The fractional reduction (ρ) in pollutant load required to attain State criteria is defined as one minus the reduction factor (Jagupilla et al. 2009):

$$\rho = 1 - \alpha$$

A different method of calculation was required for the impaired segment on the Main Stem Saugatuck River above the Saugatuck Reservoir (CT7200-00_03). This segment exceeded State *E. coli* SSM criteria, but not geomean criteria. This necessitated the use of the SSM criteria to calculate load reduction targets. When SSM criteria were used, including a measure of statistical confidence into the STR calculation was not possible (Jagupilla 2011, pers. comm.). Therefore a simple rollback equation was used to calculate the fractional reduction (ρ) for subwatersheds draining to this impaired segment:

$$\rho = \mathrm{X}_{\mathrm{SSM}} - x_{\mathrm{SSM}} / \mathrm{X}_{\mathrm{SSM}}$$

where,

x_{SSM} = 640 cfu/100mL = Adjusted State fecal coliform SSM criteria
$\mathrm{X}_{\mathrm{SSM}}$= SSM of the fecal coliform concentration in stream samples

After calculation of the fractional reduction, the existing fecal coliform loads generated in WinSLAMM for subwatersheds corresponding to the impaired river segments were multiplied the fractional reduction (ρ) to calculate the target load for the subwatershed. For those impaired segments with more than one subwatershed within their drainage area (CT7200-00_03 and CT7202-00_01), the fractional reduction calculated for the impaired segment was applied to each subwatershed individually, and then summed. The fractional reduction calculated for the West Branch (CT7203-00_01) was also used for the unnamed tributary to the West Branch (CT7203-00-trib_01) because no reach-specific sampling point was available.

Additional WinSLAMM modeling was required to address two (2) of the stream segments with 303(d)-listed indicator bacteria impairments on reaches that had not originally been mapped as separate subwatersheds. For the following impaired reaches, new existing conditions models were developed to assess indicator bacteria loads: (CT7200-24_01, CT7203-00-trib_01, and CT7200-00_03). The subwatershed draining to Kettle Creek (CT7200-24_01) is part of subwatershed 33. To determine indicator bacteria loads exclusively generated in the Kettle Creek subwatershed, the Kettle Creek watershed was delineated and modeled separately. Similarly, the subwatershed draining to the unnamed tributary to the West Branch (CT7203-00-trib_01) is part of subwatershed 18. To determine indicator bacteria loads exclusively generated in the unnamed tributary drainage, the watershed to the impaired segment was delineated and modeled separately. As delineated for the existing conditions models, subwatershed 7 (CT7200-00_03) extends downstream beyond the impaired river section. A new subwatershed model was developed for the portion of subwatershed 7 that drains to the intersection of the Saugatuck River with the Saugatuck Reservoir

CORRELATION BETWEEN *E. COLI* AND FECAL COLIFORM DATA

The State of Connecticut sets indicator bacterial criteria for fresh water based on *E. coli* values, whereas many water quality models, including WinSLAMM, estimate indicator bacteria based on fecal coliform values. In the Saugatuck River, HW/RW analyzed field samples for both *E. coli* and fecal coliform. To establish the relationship between these two measures of indicator bacteria in the Saugatuck River Watershed, a correlation analysis was performed.

Indicator bacteria data from the Saugatuck River were analyzed using simple correlation and linear regression analyses to characterize the relationship and predict an alternative fecal coliform-based geomean criterion.

Data Acquisition

Indicator bacteria data for the Saugatuck and Aspetuck Rivers was acquired from SWRPA and CTDEEP, respectively. Data was collected by HW/RW. Bimonthly sampling data collected from May through September (typically 10 samples) from 2005 to 2008 was available for the Saugatuck River. Similarly, bimonthly sampling data collected from May through September from 2000, 2001, 2003 – 2005, and 2011 was available depending on the site for the Aspetuck River. The available data included 918 sample points from the following 23 sites: BB1, JB1, KC1, PP1, SG1, SG2, SG3, SG4, SG5, SG6, SG7, WB1, WB2, WB3, WB4, WB5, AR-6, 186, R6, R15, R14, AR-5, and AR-4.5.

Data Processing

Raw indicator bacteria data from the Saugatuck (including the Aspetuck) River was processed before performing the correlation. *E. coli* and fecal coliform for site and date events were paired. Site and dates for which both metrics were not reported were excluded from the analysis. Data from sites not included in the WBP (e.g., Indian River, etc.) or with only a single year of data (e.g. Aspetuck site AR 5.5, etc.) were also excluded from the analysis. Both indicator bacteria metrics appeared to follow the lognormal distribution, which is typical of bacteriological pollutants (Novotny 2004 in Jagupilla et al. 2009). Therefore, both metrics were log transformed before the correlation analysis was performed. To calculate the log transformation with zero values, the convention of applying a value that is one half the limit of detection was used. Prior to transformation, all zero values were assigned a value of 0.05, one half the lowest non-zero value in the data, which was assumed to be the detection limit.

Alternative Fecal Coliform Geomean Criteria Calculation

The linear relationship found through the linear regression analysis was used to predict an alternative fecal coliform geomean criterion. The *E. coli* geomean criteria (126 cfu/100mL) and SSM criteria (576 cfu/100mL) were entered as the independent variables in their respective prediction equations.

There is a strong positive linear relationship between the log transformed *E. coli* and fecal coliform data in the Saugatuck River ($r=0.98$, $p<0.01$) (Figure A-F1). Ninety-six percent of the variation in Log fecal coliform was explained by Log *E.coli*.

The prediction equation for Log fecal coliform based on Log *E. coli* is:

$Y = 0.9678x + 0.1346$

The alternative fecal coliform geomean criterion is 147 cfu/100mL.

The alternative fecal coliform SSM criterion is 640 cfu/100mL.

Figure A-F1. Correlation between Harbor Watch / River Watch *E. coli* and fecal coliform for Saugatuck River sample sites 2000-2011