Five Mile River Watershed Based Plan

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Pledge for the Five Mile River Watershed

WE, the undersigned, find and declare that:

- The Five Mile River Watershed is an important natural resource area that provides significant recreational, commercial and ecological benefits;

- The Watershed's living resources, water quality, and aesthetic appeal are under constant pressure from development and other human uses; and

- Restoration and protection of the Watershed's environmental quality needs focused management by a partnership of local, state, and federal governments, affected businesses, and the public.

- The *Five Mile River Watershed-based Plan* identified the watershed-wide goals to
  - 1) enhance stormwater management,
  - 2) improve water quality,
  - 3) protect and enhance wildlife habitat, and
  - 4) increase awareness and stewardship across the watershed.

WE THEREFORE PLEDGE to support the goals of the *Five Mile River Watershed-based Plan*, recognizing that rivers and watersheds need to be viewed as central features in our landscape that require organized public and private efforts across the watershed, as well as political boundaries.

<u>Signed by the Chief Elected Official of the Five Mile River Watershed Municipalities</u>:

First Selectman Robert E. Mallozzi III
Town of New Canaan, Connecticut

Mayor Richard A. Moccia
City of Norwalk, Connecticut

First Selectman Jayme Stevenson
Town of Darien, Connecticut

Signed on the 2 day of the month of August, 2012.

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COMMONLY USED ACRONYMS

BMP	Best Management Practice
CFU	Colony-Forming Units
CLEAR	University of Connecticut Center for Land Use Education & Research
CTDEEP	CT Department of Energy and Environmental Protection
CWP	Center for Watershed Protection
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
HSG	Hydrologic Soil Group
ICM	Impervious Cover Model
IDDE	Illicit Discharge Detection and Elimination
LID	Low Impact Development
LIS	Long Island Sound
N	Nitrogen
NEMO	Nonpoint Source Education for Municipal Officials
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NURP	National Urban Runoff Program
O&M	Operations and Maintenance
P	Phosphorous
POTW	Publicly Owned Treatment Works
SNEW	South Norwalk Electric and Water
SSURGO	Soil Survey Geographic
SVA	Stream Visual Assessment
SWRPA	South Western Regional Planning Agency
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UConn	University of Connecticut

COMMONLY USED TERMS

Commonly used terms are defined for this 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 (CTDEP 2004, *Stormwater Quality Manual*)

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 Listing of Impaired Waters (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 including 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 which 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 (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, *Stormwater Quality Manual*)

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 (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 small coastal rivers that empty into Long Island Sound (LIS) in southwest Connecticut, the Five Mile River is a small but important water resource that is both a local treasure and a river in peril. Its headwaters, which originate in Lewisboro, New York, and New Canaan, Connecticut, form a network of small streams and wetlands buffered by meadows and undeveloped forest. Drinking water is drawn from the New Canaan Reservoir, which marks the downstream extent of the headwater region. Farther downstream, the river passes through residential neighborhoods and dense commercial centers in New Canaan and Norwalk before emptying into LIS at Cudlipp Street in the Rowayton area of Norwalk.

Despite significant water quality problems, the Five Mile River is valued and used in many ways by the communities that surround it. Besides providing an important source of drinking water, the river, particularly in its upper reaches, is an important scenic resource, adding to the pastoral character of the landscape that makes the area an attractive place to live. But while the Five Mile River remains a valuable resource, the progressive urban development that has occurred in many of the areas surrounding the river has significantly diminished its value. Once rare, frequent and damaging floods now threaten riverside communities. Additionally, many stretches of the river no longer support the diverse community of aquatic life found in rivers flowing through less developed areas. Severe erosion frequently occurs along the banks of the Five Mile River, washing sediment and other pollutants into LIS and reducing the visual appearance of the stream.

The story of the Five Mile River is one that is being repeated in urban rivers and streams throughout the world. It is a story of the powerful and until recently poorly understood relationship between rivers and the land they flow through. These urban rivers can be saved through the efforts of communities eager to reclaim their damaged rivers and discover the great potential they hold.

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 impacts to land use 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.

Many of the land areas draining to the Five Mile River (known as the Five Mile River Watershed), particularly in the river's middle and lower reaches, have become significantly developed in recent decades. Urban development in the Five Mile River Watershed includes residential housing, commercial businesses, and associated roads and parking lots that have led to several important and worrisome changes in the river's behavior and characteristics. The harmful changes to water quality, habitats, or aquatic life that lessen the use or value of a river are referred to as impairments, and the State of Connecticut has in many cases developed specific criteria for identifying them.

First, the introduction of impervious surfaces associated with urban development, such as rooftops, roads, driveways, and parking lots, have dramatically changed the way water flows in and 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, much of that rain and snow instead falls onto hard surfaces, where it quickly flows into the Five Mile River. This urban stormwater runoff carries an array of chemicals and pollutants including oils/grease, fertilizers and pesticides, dirt, bacteria, and trash into the Five Mile River and the smaller streams that feed the river. Many aquatic organisms including some fish, freshwater mussels, and aquatic insects called macroinvertebrates, are extremely sensitive to increases in pollution. That many of these sensitive organisms are no longer found in the Five Mile River, is compelling evidence that urban pollution is taking its toll. The State of Connecticut has identified three impairments on the Main Stem Five Mile River, which are likely related to the land use factors described above.

As a result of the increase in impervious surfaces, the intensity and frequency of flooding in the Five Mile River has increased substantially. In addition to causing damage to streamside homes and businesses, increased flooding has also scoured the stream channel and banks, resulting in lower-quality habitats for fish and other aquatic life. Increased erosion also washes bank soils into the river, where they settle on the bottom of the river or are washed into LIS, further reducing the quality of habitat to support aquatic life.

REVERSING THE TREND

Even as scientists understand the progressive harm that rivers sustain when their watersheds become urbanized, the scientific community has also worked to develop ways of reversing these trends by better managing urban landscapes. These methods range from relatively simple activities such as planting trees along stream banks, which helps 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 improving and restoring a resource like the Five Mile River is called watershed planning. The watershed planning process focuses on identifying the specific set of actions that will result in a measurable and significant improvement of the health and quality of rivers and streams in a watershed. Another fundamental part of the watershed planning process is 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 cause to reverse the reduced quality of life that is a result of 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 importantly, 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 watershed community—the organizations, citizens, and community leaders who live in the watershed—coming together to form an engaged, educated community ready to lead a push for positive change.

Although the end result of watershed planning commonly includes implementing specific "on-the-ground" projects, 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 projects;
- Developing a plan for monitoring the streams and rivers to determine if their quality is improving or degrading over time;
- Developing strategies 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 of the plan's components: pollution-reduction projects, educational and outreach activities, and monitoring.

A volunteer steering committee was formed to support plan development and review technical documents. Members provided feedback on interim drafts of the plan, and met at key points in the planning process to review the content and direction of the Plan. The steering committee was comprised of state and municipal representatives, the South Western Regional Planning Agency (SWRPA), and local stakeholders who expressed an interest in taking an active role in shaping the Plan. Members of the following organizations contributed to the steering committee:

- The City of Norwalk;
- South Norwalk Electric & Water (SNEW);
- Town of New Canaan;
- The West Norwalk Association;

- Five Mile River Commission; and
- The Connecticut Department of Energy and Environmental Protection (CTDEEP).

The public engagement process included the formation of 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, development, and outreach were identified to support the Plan 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.

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

Funding for the development the Five Mile River Watershed Based Plan ("the Plan") was obtained by SWRPA through a grant from CTDEEP. The source of funding for the grant comes from the Federal Section 319 program (referencing 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 nonpoint source (NPS) pollution. NPS refers to sources of pollution that originate from landscape sources, such as fertilizers 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 Plan 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 Plan 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).

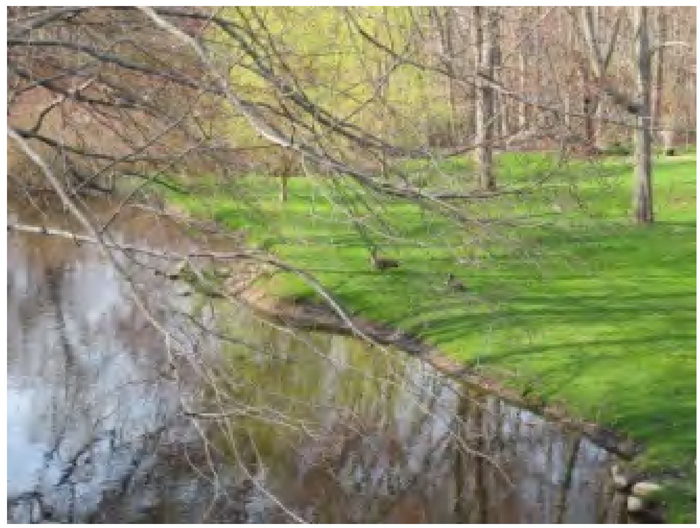
While the focus of the Plan and the EPA watershed planning process is to reduce sources of NPS pollution, many of the techniques available to accomplish this will also result in other watershed improvements. For instance, practices such as constructed wetlands that store and filter polluted urban stormwater runoff can also be used to reduce flooding and reduce rates of stream bank erosion.

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 Plan are presented in the full report and appendices.

Assessing Existing Conditions

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 Five Mile River Watershed involves 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; 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.



Near-stream development is one of the many factors affecting water quality in the Five Mile River

Overall, the existing conditions assessment reveals a river that has been clearly impacted by urban development; impervious cover comprises over 20 percent of the watershed's total area. National studies have shown that rivers flowing through watersheds with this level of impervious cover are often significantly to severely degraded. As a result of urban development, stream life in many areas of the Five Mile River is significantly less diverse than would be expected in undeveloped watersheds, and contain higher proportions of pollution-tolerant species. Species known to be sensitive to pollution are less common in the Five Mile River than in rivers that flow through less developed environments. Aquatic habitats are also significantly degraded through much of the Five Mile River Watershed.

In general, habitat and aquatic communities are of higher quality in the upper reaches of the watershed than in the lower reaches of the watershed, a conclusion that reflects the generally less developed nature of the upper watershed (some areas in the upper watershed are significantly less impervious than the watershed average). But even in upper reaches of the watershed some impacts are evident, illustrating how sensitive streams can be to even modest changes in land use. In the lower river, many stream banks have been stabilized with rip-rap and other stabilization practices and are often devoid of forested streamside vegetation. In some areas within the lower watershed, the Five Mile River's channel has been encased in concrete, resulting in almost a complete loss of stream habitat. State sampling programs have indicated that portions of the Main Stem fail to meet minimum bacteria standards, which may pose a threat to safe recreation. However, despite degraded conditions throughout the watershed, some good-quality resources persist, including fairly healthy aquatic macroinvertebrate communities on the Main Stem. In this area and in others where high levels of development would suggest otherwise, forested banks appear to be playing a role in providing better-than-expected in-stream habitat.

Understanding Watershed Uses and Values

Every river or stream is used and valued in ways that are as diverse as the rivers 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 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 or even dangerous. 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: 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 Five Mile 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 Five Mile River and its smaller feeder streams in a number of important ways. Uses range from drinking water in the headwaters to conveyance of treated wastewater below the New Canaan publicly owned treatment works (POTW) facility. Stakeholders also expressed a range of feelings toward the watershed. Many property owners who have been impacted by recent flooding suggested that the effective conveying of floods is not being achieved, and expressed concern for maintaining good-quality forests to attenuate flooding. Others expressed their love of outdoor recreation and the importance of scenic character.

Members of the steering committee defined the following key uses for which the community values the Five Mile River:

- Drinking water
- Recreation
- Wastewater conveyance
- Irrigation
- Property value
- Environmental diversity
- Wildlife habitat
- Aesthetics
- Education
- Open space
- Conveyance/floodplain management

Some of the values described above would be mutually exclusive in the same location, and are understood as being specific to certain sites or regions in the watershed (drinking water and wastewater conveyance, for example).

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 Five Mile River Watershed involved working with watershed stakeholders. SWRPA staff coordinated and led a workshop for watershed stakeholders that focused on developing goal statements and associated strategies. The workshop began with a review of the existing conditions assessment and the uses and values previously identified by the stakeholders.

Watershed Management Goals

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

Enhance stormwater management

Given the amount of urban development in the watershed, enhancing stormwater runoff management is a critical goal for improving water and habitat quality, and ultimately the health of aquatic life in the Five Mile River Watershed. Enhanced stormwater runoff management will also significantly reduce the quantities of NPS pollution delivered to the Five Mile River and its feeder streams. Improved stormwater management will reduce the severe flooding that has caused significant damage to homes and businesses along portions of the Five Mile River.

Improve water quality

The existing conditions assessment showed that water quality in many of the streams within the Five Mile River Watershed is degraded. Elevated levels of indicator bacteria, nutrients, and sediment in stream water have all been documented. Improving water quality will result in a cleaner, more beautiful stream that can support a more diverse community of aquatic life and ensure the security of drinking water supplies. As water quality improves, the ability of watershed residents to use the Five Mile River for non-contact and contact recreation will improve, as will the value of the Five Mile River as a scenic and aesthetic resource.

Protect and enhance wildlife habitat

Because so much of the Five Mile River Watershed is developed, the remaining natural areas provide critical habitat for songbirds, amphibians, and small mammals. Roadside wetlands, meadows, and even some residential properties offer refuge for species displaced by development. Yet storm flows are damaging riparian and wetland areas, and widespread development is driving some species such as deer and raccoons into uncomfortably close quarters with people. It is therefore critical that remaining high-quality habitats be set aside before they are disturbed. Where disturbance has already occurred, natural habitats can be re-created through meadow creation in open areas, creation of floodplain wetlands and vegetated stormwater practices, and the restoration of sediment-laden roadside wetlands and riparian areas.

Increase awareness and stewardship

Although the Five Mile River Watershed is clearly important to its community, the watershed lacks an established partnership or other civic organization to advocate for better management. An empowered community will be more likely to take positive actions; this represents the first step toward establishing civic advocacy for this valuable resource. It is important to begin outreach activities at the outset of any restoration or conservation activity because the local population will be responsible for maintaining and possibly replicating the activity elsewhere once the initial work has been carried out. Homeowner workshops, media campaigns, and personal outreach to key members of the community can provide individuals with the information needed to make informed decisions about how watershed resources are used.

Watershed Management Strategies

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

Avoid future increases in stormwater related impacts through adoption of low impact development policies

Low impact development (LID) comprises a set of management actions to reduce the impact of urban development on streams and waterways. The adoption of policies that require LID approaches will be critical to preventing impacts to aquatic habitat and water quality from new development in the watershed.

Reduce nonpoint source pollution, peak flow rates, channel erosion, and flow stress through implementation of structural BMPs in developed areas.

Structural BMPs 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.

Limit nutrient and bacteria sources from large properties

While structural BMPs can be used to remove stormwater runoff, reducing the quantity of pollutants that are exposed to stormwater runoff or are otherwise introduced the streams is also a key means of improving water quality. For instance, reducing the use of lawn fertilizers by home and business owners is a good way to reduce the amount of nitrogen (N) and phosphorus (P), key NPS pollutants, from being introduced to streams.

Improve riparian habitats and protect undeveloped areas within the watershed
Riparian habitats are the areas immediately adjacent to the stream channel. These 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 Five Mile River Watershed, riparian areas have been altered by urban development. Reforesting these areas will help to improve water quality within the Five Mile River and its feeder streams.

Many of the remaining open space areas are unmanaged private property that is at risk of development. Permanent conservation of these lands will be important to maintaining habitat values and preventing further increases in flooding downstream. Once parcels are protected, adaptive management of invasive species and restoration of destabilized banks can improve habitat within the stream and the riparian forest.

Identify and eliminate illicit discharges and improve solid and liquid waste management
Illicit discharges refer to undocumented discharges of industrial, commercial, and residential pollution that flow into streams. Car washes, laundry or industrial facilities, and leaking septic systems are common culprits, but almost any residence or business could potentially be a source. Identifying and eliminating these sources of pollution can be time-consuming and difficult, but represents a key method improving water quality within the Five Mile River Watershed.

Reduce the frequency and severity of flooding
As the Five Mile River Watershed has developed, recurrent flooding has become a problem. In addition to taking a financial toll, the flooding problems create the perception that the Five Mile River is a nuisance rather than a resource. Although a comprehensive solution to fixing flooding problems in the Five Mile River Watershed is beyond the scope of this document, many of the management actions for improving stormwater management discussed in this Plan can also help to reduce flooding.

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

Promoting healthy attitudes toward stewardship and general property management is a critical way of improving overall watershed health. Educational materials may 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. They may also provide practical, easy-to-implement actions that help to reduce NPS pollution. Educational initiatives should make use of the full range of media outlets and presentation mediums.

Implement a water quality monitoring program

Water quality monitoring provides feedback about what management actions are working (or not), and allows managers to adjust techniques to improve outcomes. Adaptive management provides the framework within which monitoring is performed, and as such requires an approach that is both iterative and responsive to feedback. A well-designed monitoring plan supports watershed goals and informs future decisions. The monitoring program for the Five Mile River Watershed includes routine monitoring of in-stream conditions, an early-warning monitoring component to identify emerging threats, and performance monitoring for structural BMPs to ensure their continued function.

HOW MUCH IS ENOUGH?

Key NPS pollutants include bacteria, N, P, and sediment. Each pollutant degrades waterways in unique but significant ways. And computer modeling can be used to develop numerical targets for the specific amount of each pollutant that should be reduced to restore high-quality conditions.

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

As part of the Plan, the computer model WinSLAMM was used to estimate the current quantity of each pollutant entering the Five Mile 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 16 subwatersheds (smaller drainage areas within the larger watershed). The modeling process was then repeated as if the watershed were undeveloped, estimating the quantity of pollutants delivered to the stream in the absence of human settlement. 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 common NPS pollutants in the watershed.

Given the fact that management back to predevelopment conditions is an ambitious goal, an interim target was also developed based on a reduction of 60 percent of the anthropogenic load. Sixty percent represents a commonly accepted efficiency rate for NPS pollution-reduction BMPs. The full (100 percent) load reduction targets call for reductions of 6.2, 7.8, 87.0, and 82.8 percent in sediment (expressed as Total Suspended Solids [TSS]), P expressed as particulate P, N expressed as nitrate (NO_3), and indicator bacteria, respectively (Table E1). Interim (60 percent) load reduction targets call for TSS, particulate P, and NO_3, and indicator bacteria reductions of 3.7, 4.7, 52.2, and 49.7 percent, respectively.

Table E1. Pollutant Load Reduction Targets Summary

Pollutant	Total Target (lb/yr)	Total Percent Reduction (%)	Interim Target (lb/yr)	Interim Percent Reduction (%)
NO_3	51,257	87.0	30,754	52.2
Particulate P	1,694	7.8	1,016	4.7
TSS	281,345	6.2	168,807	3.7
Indicator bacteria	3,911,459	82.8	2,346,875	49.7

IMPLEMENTING THE PLAN

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

Management actions were developed for each management strategy based on observations made during field assessments. Recommendations from 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 green roofs; 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 existing swale identified for potential retrofit to improve stormwater management capability

An implementation schedule was developed to achieve the goals outlined in the Plan. 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 Plan 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 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.

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

Even in a relatively small watershed such as the Five Mile, hundreds of potential structural BMP opportunities exist. To target 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 engineers 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, 19 structural BMPs were identified, with planning-level costs ranging from $4,000 to $1,035,000. Total cost of all structural BMPs identified would be approximately $3,905,000.

Pollution-load reduction estimates were modeled for each structural BMP. Total load reductions represent approximately one (1) percent of the total target load reduction for both NO_3 and bacteria; and approximately 13 percent and 21 percent of the total targets for particulate P and TSS, respectively. These represent 2.1, 2.5, 21.3, and 33.6 percent of the interim targets, respectively, for NO_3, bacteria, particulate P, and TSS. 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 Five Mile 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 Plan recommends a combination of media and education formats to educate residents and local businesses about the need for pollution prevention and stewardship in the Five Mile River Watershed. Proposed outreach campaigns relate to LID practices, 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 groups who will implement the Plan 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 Plan to increase the effectiveness of watershed management efforts.

The Plan 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 plan 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.

Chapter 1 INTRODUCTION

One of a number of coastal rivers that empty into the Long Island Sound (LIS) in southwest Connecticut, the Five Mile River is a small but important water resource that is both a local treasure and a river in peril. The river flows from north to south, through suburban residential neighborhoods in Lewisboro and north New Canaan, to denser patterns of development along the Route 1 and I-95 corridors in Norwalk. Major tributaries include Keeler's Brook and Holy Ghost Father's Brook.

For a small river, the character of the Five Mile River is diverse. It winds through picturesque residential neighborhoods and bustling commercial centers. Its banks are bounded in the upper watershed by deep forests, and in the lower watershed by riprap and concrete. Past characterizations have alternately painted the river as a flood-prone nuisance and a precious natural treasure. What seems to be generally agreed on is the river's wide array of assets, which include not only its significance as a drinking water source, but also its aesthetic character, which represents so much of the culture and history of southwestern Connecticut.

Watershed Setting

The Five Mile River Watershed has a drainage area of approximately 12.5 square miles, located primarily in Fairfield County in the southwest coastal region of Connecticut. The watershed boundary includes portions of the City of Norwalk, the Town of New Canaan, the Town of Darien, and a small portion of Lewisboro, New York (Figure 1). Regionally, the watershed is located in an area where dense commercial development and suburban and rural areas commonly exist adjacent to one another. Its historic and scenic character has typically been valued by residents of Fairfield County, and many forested areas and open spaces have been permanently preserved in the greater region. Within the watershed, however, preserved open spaces are limited, and development has progressed in many areas, particularly in downtown New Canaan and coastal Norwalk. Despite a general lack of protection of the remaining open parcels, significant forested areas still exist.

The Urban Stream Syndrome

When watersheds become urbanized, predictable 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.

In the spectrum of streams impacted by urbanization, the Five Mile River lies somewhere in the middle. Recurring flooding in the Five Mile River Watershed has become increasingly severe along the Main Stem, and aquatic monitoring and stream assessments reveal a patchwork of conditions, in some cases relatively healthy and in others significantly degraded. Luckily for the Five Mile River, despite being significantly degraded by urbanization in many areas, it is still very much a resource worth saving.

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

NEED FOR A WATERSHED BASED PLAN

NPS pollution, that is, 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 water bodies 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 largely ineffective at managing NPS pollution.

Runoff from the municipal drainage network—mostly via roads, sewers, and swales—is partially regulated under the Municipal Separate Storm Sewer System (MS4) permit. 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 runoff and NPS pollution which is largely unregulated.

In the Five Mile River Watershed, development has reached a critical threshold (see Chapter 2). The Connecticut Department of Energy and Environmental Protection (CTDEEP) has identified sites where water quality and habitat conditions are inadequate for aquatic life and/or safe recreation. The existing conditions assessment (Chapter 2) identifies multiple other areas where water quality and habitat problems are may be found. If unmitigated development is allowed to continue, stream conditions may degrade to a point where restoration is no longer feasible. 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 NPS pollution-related problems.

Watershed based planning uses a science-based and community-driven approach to assess existing conditions; set goals for watershed improvements; outline strategies through which these goals will be achieved; identify water quality and habitat problems and the causal factors responsible for these problems; develop feasible, cost-effective solutions; and provide a framework for revising the

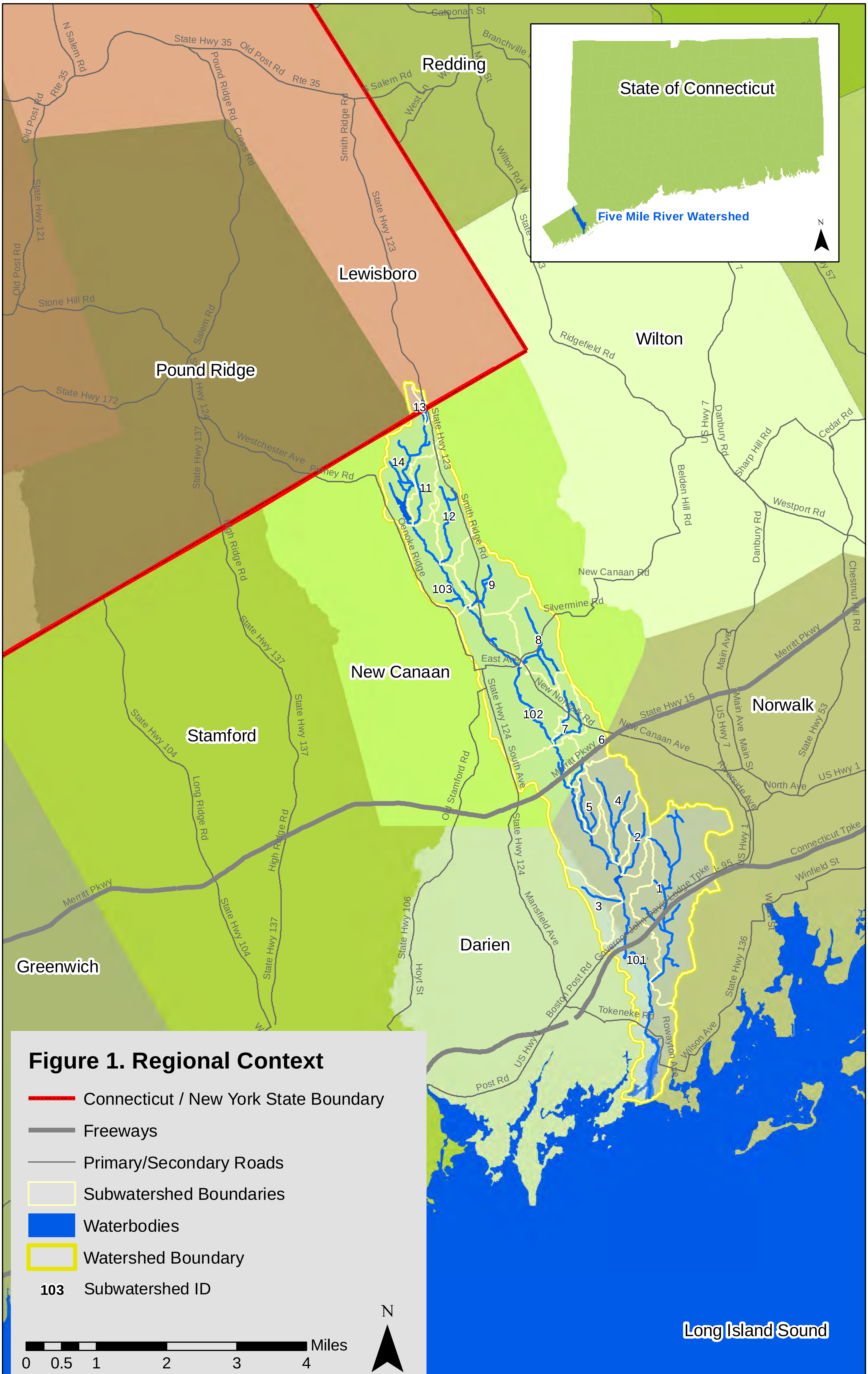


Figure 1. Regional Context

Plan 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 in the long run that one that is developed using a top-down, regulatory-driven approach.

The Plan was developed in response to water quality and habitat problems associated with NPS pollution. The core purpose of the Plan is to develop an actionable strategy for reducing NPS pollution, and to consider other ways that the water resources within the watershed can be improved (including improving habitat and reducing flooding). Funded by CTDEEP, the Plan was developed in accordance with the Nine 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, Inc.

The Plan is intended to provide a long-term guide for watershed restoration. Central to its goals is the idea that municipalities and partner organizations work together to achieve pollution reduction targets. Management actions outlined in the Plan 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 designated use criteria established by CTDEEP (Figure 9).

HISTORY OF PLANNING FOR THE FIVE MILE RIVER

The Five Mile River Watershed lacks a dedicated organization to provide overarching support and advocacy. Planning initiatives and reports have been sporadic, and related to site-specific flooding problems rather than watershed-wide patterns of development. Planning and evaluation documents published with specific regard to the Five Mile River include the following:

- Five Mile River Watershed Evaluation, Milone & MacBroom, 2010;
- Five Mile River Watershed Investigation Report, Soil Conservation Service with Connecticut Department of Environmental Protection (CTDEP), 1990; and
- The Five Mile River Impact of Recent Flooding, West Norwalk Association, 2007.

These documents detail specific incidences of recurrent flooding in the watershed, mainly observed below New Canaan Center. The 1990 and 2010 reports suggest large infrastructure modifications such as dikes and culvert/bridge replacements. In both reports, costs are estimated for these modifications.

As watershed management techniques continue to evolve, it may be useful to reframe the flood control conversation as related but ancillary to the goals of stormwater management, a major tool used to address NPS pollution. Stormwater management by itself will not completely solve the flooding issues in the Five Mile River. As a primarily NPS pollution-reduction document, solving the persistent flooding issues in the Five Mile River is not specifically within the scope of the Plan. However, if implemented on the broad scale proposed here, stormwater controls will significantly reduce runoff volume, which in turn may help to reduce flooding.

PUBLIC ENGAGEMENT & STEERING COMMITTEE

A central intent of the watershed based planning process is to provide a framework through which active members of the watershed community may shape future management activities and influence decision-making. The individuals and organizations living and working in the watershed know it best, and are uniquely suited to guide goal-setting and long-term implementation. With this goal, stakeholders from the municipal, conservation, and business communities were invited to provide input from the earliest stages of Plan 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 while 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 drinking 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 management goals were also discussed. 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 Plan 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 plan development and review technical documents. The steering committee was composed of state and municipal representatives as well as local stakeholders who expressed an interest in taking an active role in shaping the Plan. Members of the following organizations contributed to the steering committee:

- The City of Norwalk;
- South Norwalk Electric & Water (SNEW);
- Town of New Canaan;
- The West Norwalk Association;
- Five Mile River Commission; and
- CTDEEP.

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 Plan was released for public review, giving stakeholders an opportunity to review the Plan and provide feedback before the Plan was completed. The draft Plan was made available from June

6, 2012 – July 6, 2012. An information session was held on June 19, 2012, when the Plan was presented to the community. Following the completion of the Plan a signing ceremony was held, and municipal officials were invited to sign a pledge supporting the goals of the Plan. Following the signing ceremony, the municipalities hosted a watershed tour, which gave stakeholders a chance to view the watershed from the headwaters to the harbor.

PLAN OVERVIEW AND ORGANIZATION

At its core, the Plan establishes a framework for identifying and responding to watershed impairments. In accordance with EPA guidance (EPA 2008), the Plan was developed to include the following nine 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 plan 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 Plan estimates reductions in NPS pollutants that would be required to restore pollutant loading levels to pre-development conditions. WinSLAMM was the primary means used to develop estimates and 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 pollutant load reduction target. Because a 100 percent reduction in pollutant loading due to development is not feasible, an interim goal of 60 percent of the calculated pollution load reduction target was established.

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 Plan and discusses management strategies for achieving these goals, which include:

- Enhancing stormwater management;
- Improving water quality;
- Protecting and enhancing wildlife habitat; and
- Increasing awareness and stewardship.

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 projects and estimated costs and pollutant load reductions associated with each project are presented in Appendix A.

Plan implementation schedule (Chapter 6)

Chapter 6 provides a plan 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.

Education and outreach (Chapter 8)

Chapter 8 speaks specifically to education and outreach activities that support plan implementation. The education and outreach approach emphasizes reaching out to homeowners and commercial property 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.

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 program to identify emerging threats in small headwater watersheds; and a monitoring program for structural BMPs.

Sources of financial and technical assistance (Appendix B)

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

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 and stream assessment data collected during plan 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 Five Mile River and its tributary streams, and reviews the portions of the Five Mile River that have been officially designated as impaired by CTDEEP sampling.

Overall, the existing conditions assessment reveals a river that has been clearly impacted by urban development. Impervious cover—the hard surfaces such as paving and rooftops that prevent water from soaking into the soil—comprises more than 20 percent of the watershed's total area. National studies have shown that rivers flowing through watersheds with this level of impervious cover are often significantly to severely degraded. As a result of urban development, aquatic macroinvertebrate and fish communities in many areas of the Five Mile River are significantly less diverse than would be expected in undeveloped watersheds, and have higher proportions of species that are known to be tolerant of polluted water. Species that are known to be sensitive to pollution are less prevalent in the Five Mile River than in similar rivers flowing through less developed environments. Aquatic habitats are also significantly degraded through much of the watershed.

In general, habitat and aquatic communities were of higher quality in the upper reaches of the watershed than in the lower reaches of the watershed, a conclusion that reflects the generally less developed nature of the upper watershed (some areas in the upper watershed are significantly less impervious than the watershed average). But even in upper reaches of the watershed some impacts were evident, emphasizing how sensitive streams can be to even modest changes in land use. In the lower river, streambanks are increasingly modified with rip-rap and other stabilization practices and devoid of forested streamside vegetation. In some areas within the lower watershed, the Five Mile River's channel has been encased in concrete, resulting in a near complete loss of stream habitat. State sampling programs have indicated that portions of the Main Stem fail to meet minimum bacteria standards, which may pose a threat to safe recreation.

Despite degraded conditions throughout the watershed, some good-quality resources persist, including fairly healthy aquatic macroinvertebrate communities on the Main Stem and in some areas where high levels of development and degraded habitat quality suggest otherwise, forested banks in many areas throughout the watershed, and better-than-expected in-stream habitat in some locations with high levels of watershed development.

WATERSHED CHARACTERIZATION

The approximately 7,995-acre Five Mile River Watershed is located in the southwest corner of Connecticut, in the coastal slope and lowlands of Fairfield County, Connecticut. The river flows south from its headwaters in Lewisboro, New York, and New Canaan, Connecticut, through the City of Norwalk and a small portion of Darien before reaching its outlet in LIS (Figure 1). Major tributaries include Keeler's Brook, which drains approximately 1,280 acres, Holy Ghost Father's Brook, which drains approximately 394 acres, and several smaller streams. The study area ends at the salt line at Cudlipp Street in Norwalk, where the downstream non-tidal extent of the river joins the estuary.

The Five Mile River Watershed contains approximately 34 miles of stream, including tributaries. Keeler's Brook, the largest tributary, is approximately five miles long; Holy Ghost Father's Brook is approximately two miles long. The Main Stem of the Five Mile River from below the New Canaan Reservoir to its outlet to LIS is approximately 11 miles long.

The stream channel is straight and narrow, with small discontinuous floodplains and several areas of steep slopes (Milone & MacBroom 2010). In the lower watershed, the river has been partially confined by a concrete channel. The central Main Stem in New Canaan is confined in several areas where banks are armored by riprap or by steep, elevated banks.

Water Quality

High-quality water resources are important to support the recreational 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 New Canaan Reservoir, which provides drinking water to many residents living within and outside of the watershed. Anglers fish the river's waters. Boaters row and paddle the multiple small ponds along the Lower Main Stem.

For all of these reasons, water quality is a serious concern. There has been limited sampling within the watershed, so it is unclear to what extent water quality meets or fails to meet requirements. State sampling programs (discussed in more detail later in this chapter) have indicated that portions of the Main Stem fail to meet minimum bacteria standards, which may pose a threat to safe recreation. Prior to development of the Plan it has been generally presumed that many additional reaches also fail standards for recreation or habitat. The existing conditions assessment developed in this chapter is meant to highlight the most likely problem areas in order to guide management decisions.

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. Total impervious cover is generally accepted as an indicator of overall watershed health (Center for Watershed Protection [CWP] 2003). An in-depth discussion of the impacts of impervious cover is presented later in this chapter.

Prior to 1900, early land uses in the Five Mile River Watershed were largely related to farming. In the estuary, oyster farming was a major industry, peaking in the early 20th century (www.connecticuthistory.org). Since then, land has been largely cleared and developed for suburban neighborhoods. Commercial corridors are found near the coast and in downtown New Canaan. 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.

Land use within the Five Mile River Watershed is primarily residential (81 percent) with a more suburban character in the upper watershed and denser residential communities in the lower watershed (Table 1, Figure 2). Total impervious cover in the watershed is estimated to be 22 percent; approximately 13 percent is preserved as open space. Approximately six percent of total land use is designated for commercial and institutional uses. The watershed is bisected by the Metro-North Railroad and by two major highways, I-95 and the Merritt Parkway (CT-15).

Table 1. Watershed Land Use

Land use	Percent of Watershed Area
Commercial	3
Freeway	1
Industrial	0
Institutional	2
Other Urban/Open Space	13
Residential	81

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 Five Mile River Watershed, 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 the level of anthropogenic 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. Native forest vegetation includes oaks (*Quercus sp.*), hickories (*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).

Nearly all forested land within the watershed has some history of disturbance, whether related to land development or historic farming. As is typical in Connecticut, native forest species have given way in many areas to large stands of invasive species, including bamboo, Japanese barberry, Norway maple, and others. An overabundance of white-tailed deer has led to increasing pressure to hunt these animals as a forest management measure. In the lower watershed, most remaining open space is managed as recreational parkland.

According to the Natural Diversity Database maintained by CTDEEP, one area in the upper watershed is thought to contain habitat for a significant state and federal listed natural community. CTDEEP has indicated that a bat colony has historically been located in the area just below the New Canaan Reservoir between Oenoke Ridge Road and Father Peter's Lane (Milone & MacBroom 2010).

Any groundbreaking activities proposed in this area are required to consider the impact to this species during project planning.

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.

Located along the eastern coastal plain, soils and geology within the Five Mile River Watershed are generally representative of the region. The river follows a fairly low gradient from the rolling hills of New Canaan into coastal Norwalk, where the river meets the estuary. Well-drained soils predominate overall, although conditions vary throughout (Table 2, Figure 3).

Table 2. Hydrologic Soil Group Percent of Total Area

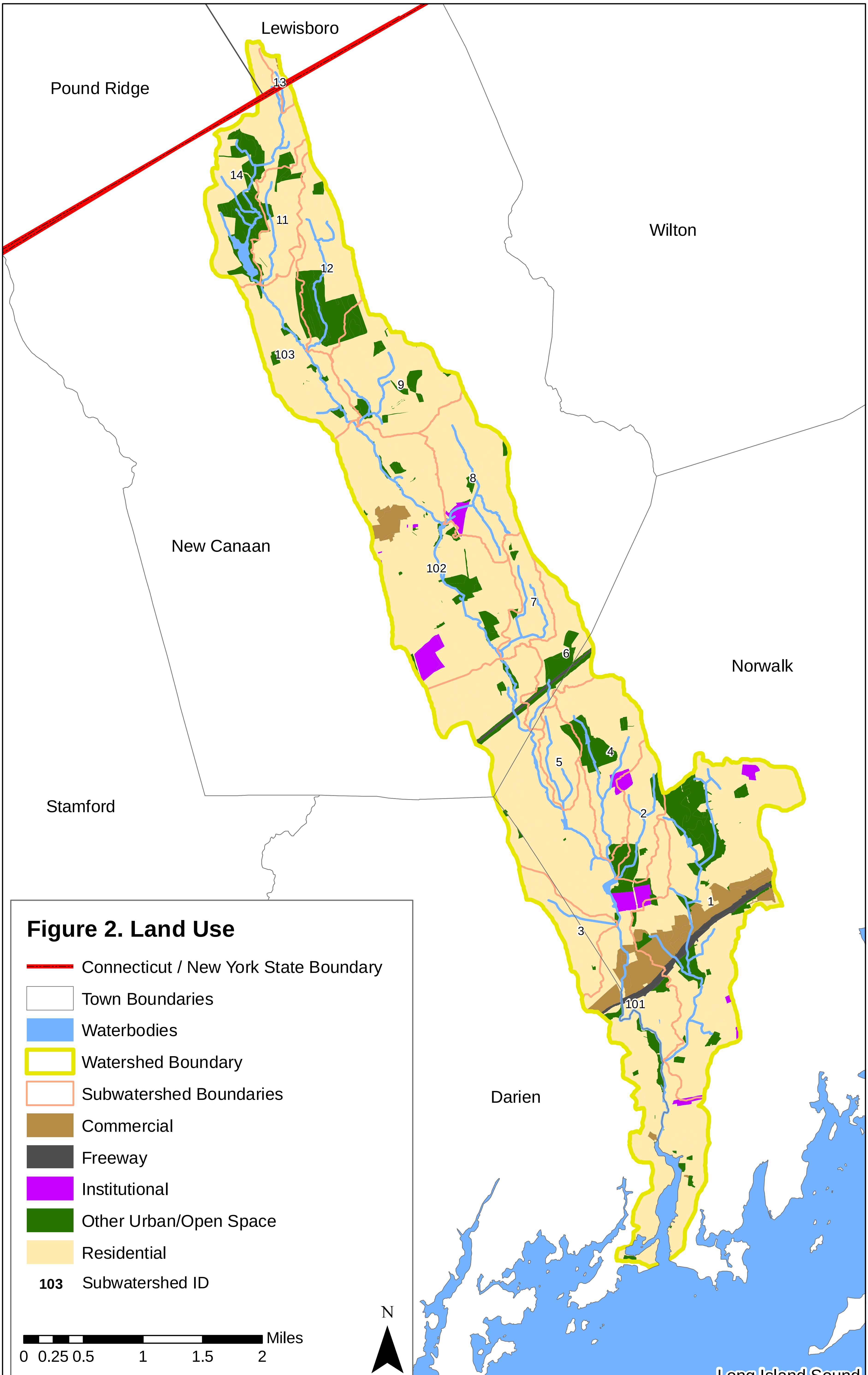
Hydrologic Soil Group	Percent of Watershed Area
Group A-B	55
Group C	27
Group D	17
Water	2

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

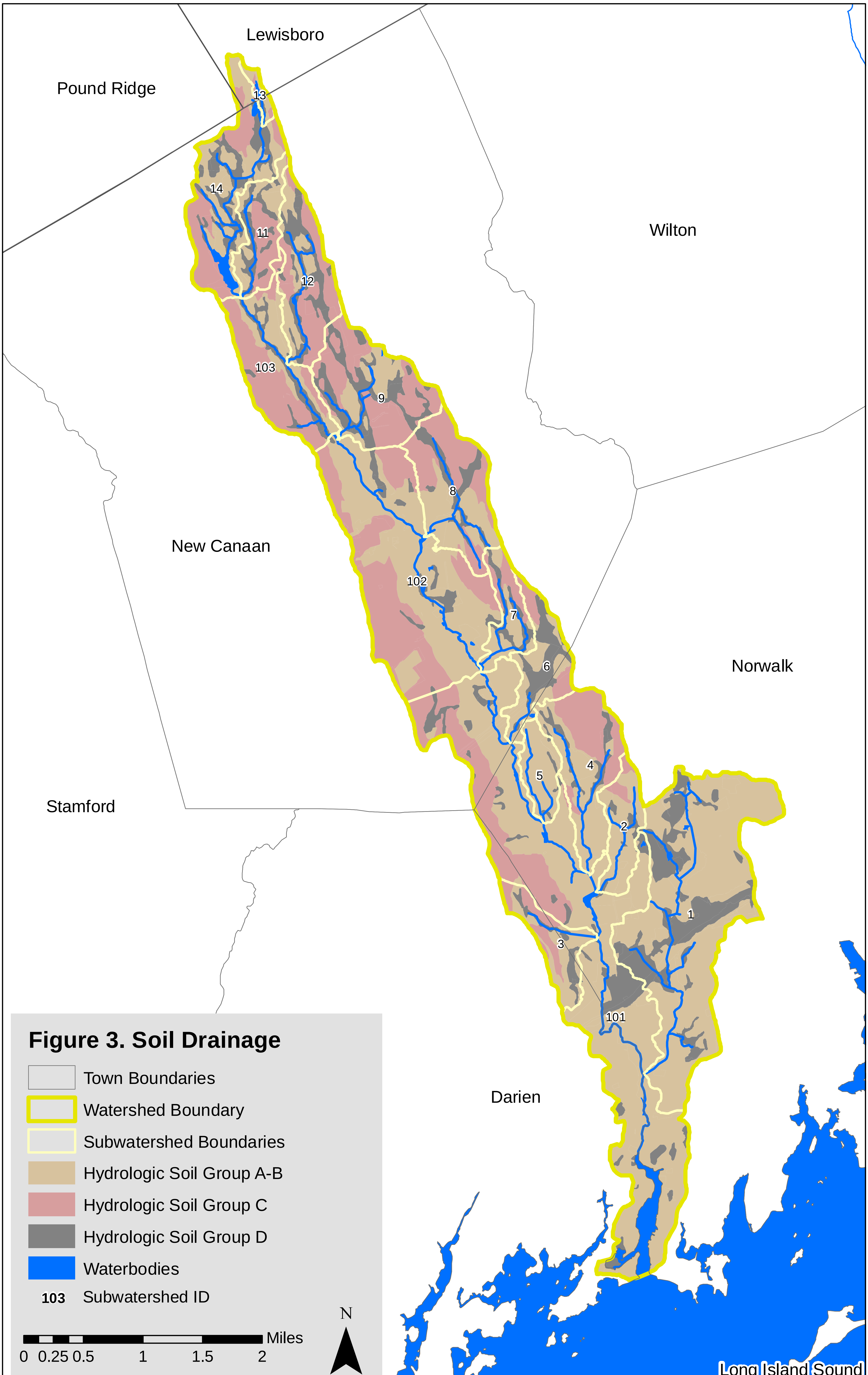
The watershed is underlain by metamorphosed sedimentary and igneous schist and gneiss formations of the Hartland and Gneiss Dome belts, both relatively erosion-resistant formations (Griffith et. al. 2009). Regionally the formations are located within the Connecticut Valley Synclinorium (Griffith et. 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. The majority of soils are classified as A-B or C, with several areas of locally poor drainage (HSG D). The area surrounding the Lower Main Stem is well drained, with the exception of a large patch of clay-type soils located along the I-95 corridor in Norwalk.

Precipitation, Flooding, and Stream Flow

Stream flow is closely linked to precipitation and land cover patterns. As watersheds develop, peak flow conditions become elevated. According to Milone & MacBroom (2010), flood flows within the Five Mile River are 1.5 percent higher than would be expected under undeveloped conditions. In addition, annual mean precipitation has increased through the last century by approximately 0.96 inches per decade (Milone & MacBroom 2010). The factors indicate an increasingly flood-prone river where conditions may be expected to worsen as development increases and climate conditions shift. Multiple reports have described recent significant flooding along the Main Stem of the Five Mile River.



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.



Manipulated soil data provided by SWRPA; Original data obtained from the 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 Five Mile 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 from past studies, reviewing the designated uses and impairments that have been established by CTDEEP through their assessment programs, and conducting visual assessments of the stream channel in representative locations to assess the quality and diversity of aquatic habitats.

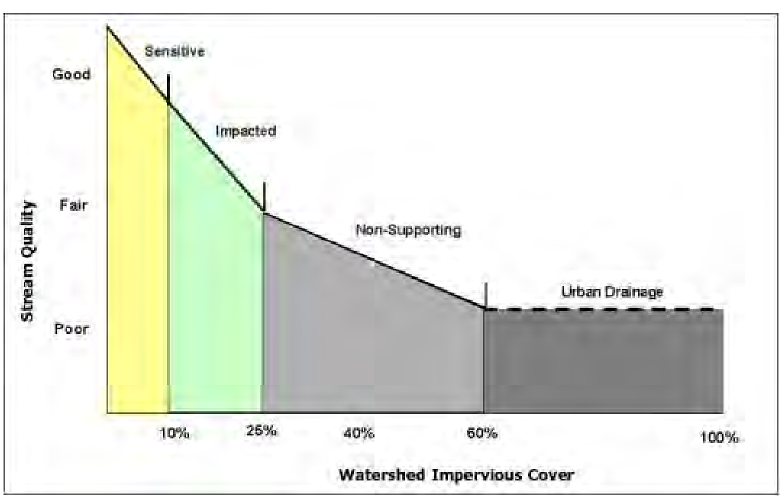
Based on the assessment, most portions of the watershed appear to be in fair to poor condition for the support of recreation and aquatic life. Poor stream conditions were generally associated with areas of dense residential and commercial development. Anthropogenic impacts were especially notable in Keeler's Brook.

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 4 describes the Impervious Cover Model (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 impervious, habitat degrades below the minimum needed to support aquatic life. With impervious cover estimated at approximately 22 percent in the Five Mile River Watershed, the river is approaching a dangerous threshold.

Figure 4. The Impervious Cover Model



To relate impervious cover to stream conditions, the stream network was divided into a series of 16 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 5). Direct drainage areas to the Main Stem were delineated as one subwatershed, which was then split into segments (subwatersheds 101, 102, and 103). Percent impervious cover was 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 3, Figure 6). 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

Table 3. Impervious Cover Score

	Land cover within subwatershed					Land cover within riparian buffer					
	Land Area (acres)			Land Area Percent		Land Area (acres)			Land Area Percent		Impervious
Subwatershed	Total Area	Impervious	Pervious	% IA	%PA	Total Area	Impervious	Pervious	% IA	%PA	Cover Score
13	32.54	3.99	28.54	12	88	15.71	1.46	14.24	9	91	1
14 (Headwaters)	498.78	32.61	466.16	7	93	161.56	6.12	155.44	4	96	0
14 and tributaries	531.31	36.61	494.71	7	93	177.27	7.58	169.69	4	96	0
11	202.14	14.39	187.76	7	93	46.56	3.15	43.41	7	93	0
12	349.62	29.71	319.91	8	92	78.76	6.19	72.57	8	92	0
103 (Father Peter's Brook)	408.33	72.32	336.01	18	82	81.60	7.57	74.03	9	91	1
103 and tributaries	1491.40	153.02	1338.38	10	90	384.20	24.49	359.71	6	94	1
7	162.57	16.55	146.02	10	90	75.89	7.87	68.02	10	90	2
8	415.86	51.67	364.19	12	88	96.25	14.36	81.89	15	85	2
9	469.00	54.21	414.79	12	88	64.95	7.46	57.49	11	89	2
102 (New Canaan Center)	1147.87	312.59	835.28	27	73	131.62	29.60	102.02	22	78	3
102 and tributaries	3686.69	588.04	3098.65	16	84	752.91	83.79	669.13	11	89	2
1 (Keeler's Brook)	1279.74	389.51	890.23	30	70	238.57	65.08	173.49	27	73	4
2	182.46	42.19	140.27	23	77	61.50	11.21	50.29	18	82	2
3	190.75	47.82	142.93	25	75	31.67	7.87	23.80	25	75	4
4 (Holy Ghost Father's Brook)	394.36	98.16	296.20	25	75	94.26	23.41	70.86	25	75	4
5	133.64	33.02	100.61	25	75	56.29	14.18	42.10	25	75	4
6	235.81	31.32	204.49	13	87	24.50	3.00	21.50	12	88	2
101 (Lower Main Stem)	1887.90	521.02	1366.88	28	72	306.92	81.78	225.15	27	73	4
101 and tributaries	7991.36	1751.08	6240.27	22	78	1566.63	290.32	1276.31	19	81	2

IA is impervious area

PA is pervious area

Impervious cover scores equate to the following expected stream conditions:

Poor (IC score = 3 or 4)

Fair (IC score = 1 or 2)

Good (IC score = 0)

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 level of impairment, and to further investigate these areas to learn more about conditions specific to the Five Mile 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 4, Figure 7) along the Five Mile River to evaluate the quality of in-stream and riparian habitats over a land use gradient (Appendix C). These sample sites were selected based on expected condition following the IC 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 Natural Resources Conservation Service (NRCS) Stream Visual Assessment (SVA) Protocol (NRCS 1998). This protocol integrates 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 4. Stream Visual Assessment Score

Sample Location ID	Subwatershed (headwaters to outlet)	SVA Category*	Impervious Cover Score** in Same Reach as Sample
1	14	good	good
2	11	poor	good
3	103 (Father Peter's Brook)	good	fair
4	101 (Lower main stem)	poor	poor
7	101 (Lower main stem)	fair	poor
9	101 (Lower main stem)	fair	poor
5	4 (Holy Ghost Father's Brook)	poor	poor
6	1 (Keeler's Brook)	poor	poor
8	1 (Keeler's Brook)	poor	poor

*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)

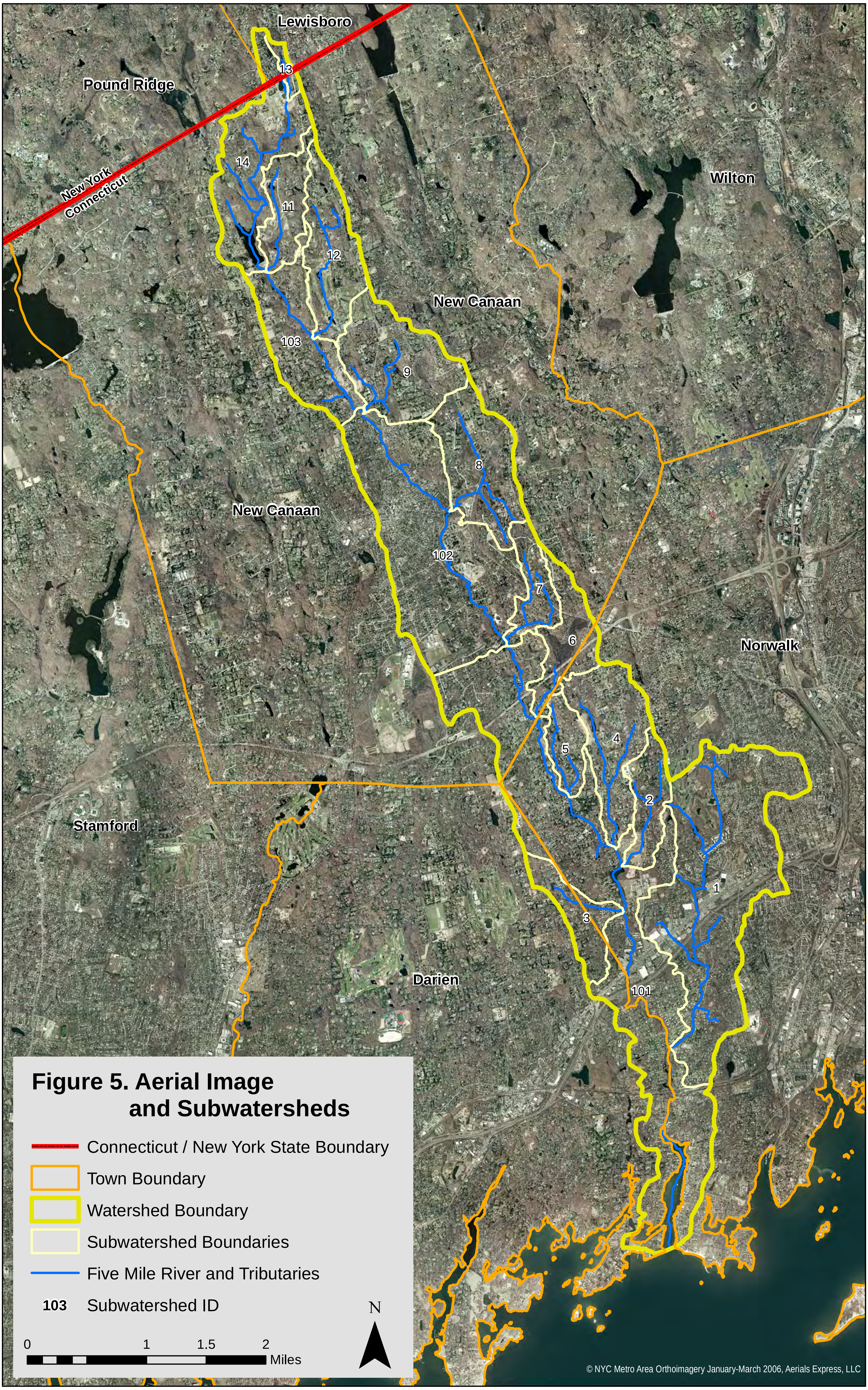
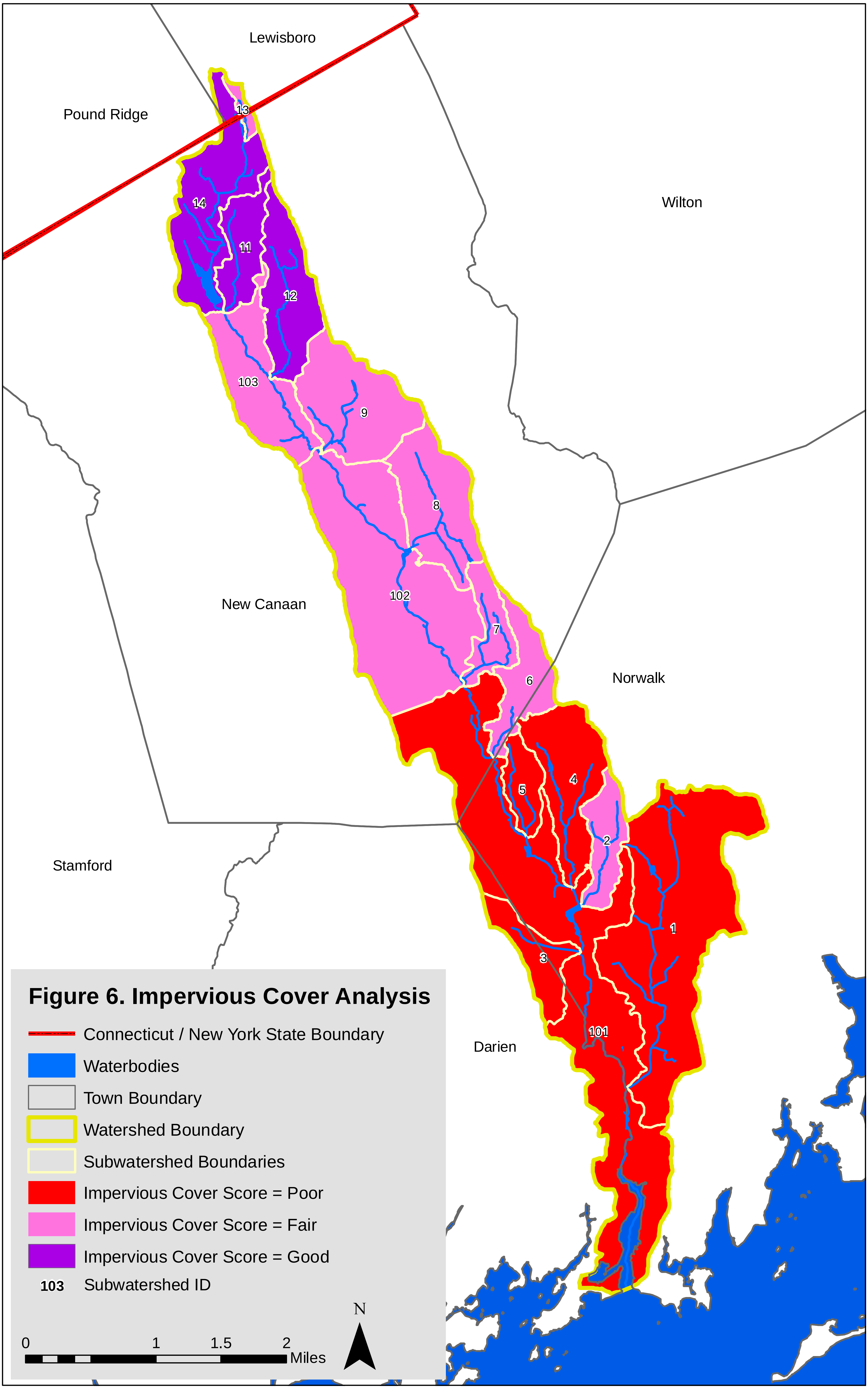


Figure 5. Aerial Image and Subwatersheds


Lewisboro
Pound Ridge
Wilton
New Canaan
Norwalk
Stamford
Darien
13
14
11
12
103
9
8
102
7
6
5
4
2
1
3
101
Figure 6. Impervious Cover Analysis
Connecticut / New York State Boundary
Waterbodies
Town Boundary
Watershed Boundary
Subwatershed Boundaries
Impervious Cover Score = Poor
Impervious Cover Score = Fair
Impervious Cover Score = Good
103 Subwatershed ID
0
1
1.5
2
Miles
N

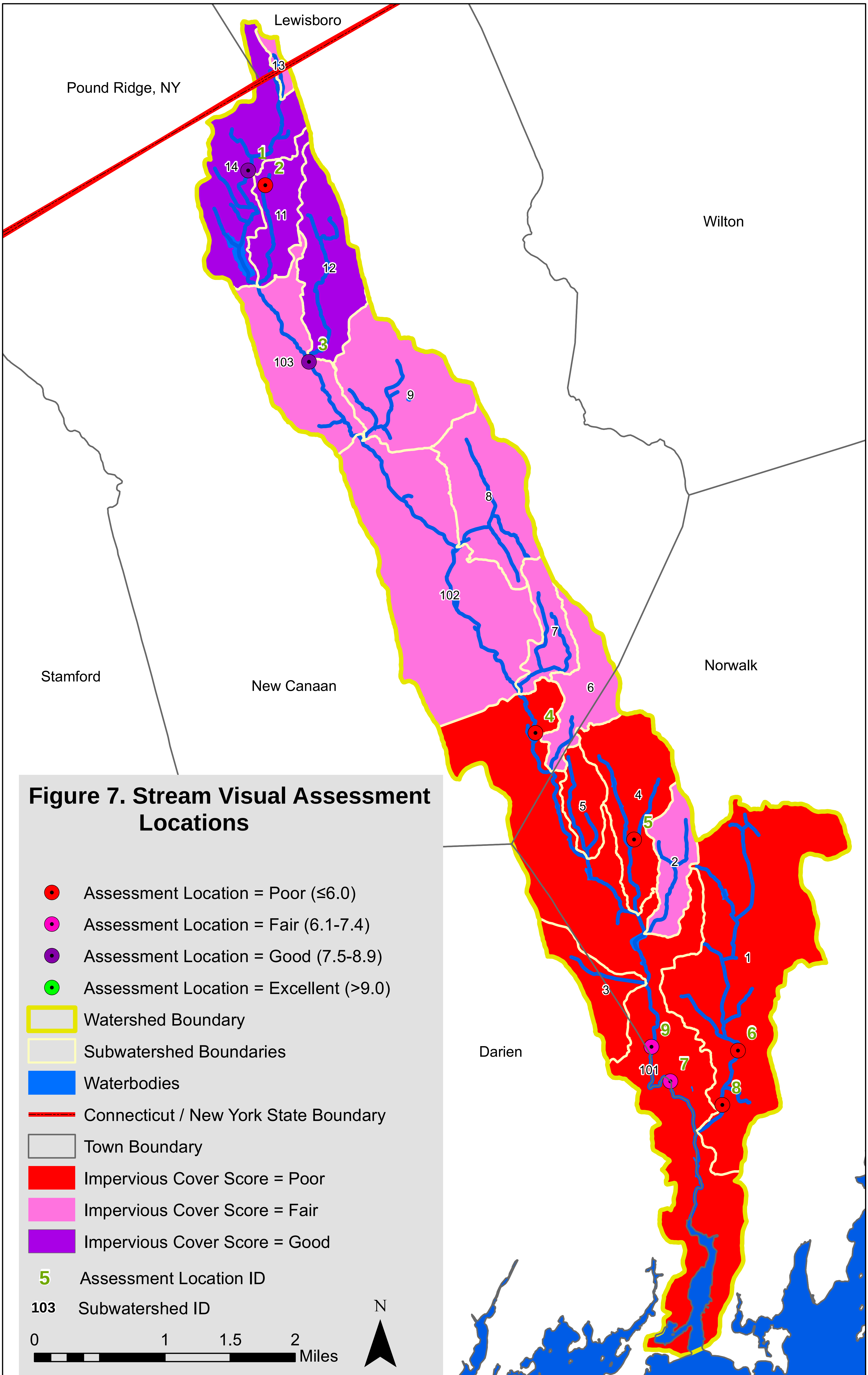


Figure 7. Stream Visual Assessment Locations

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.

For the purpose of this analysis, sampling data for fish and macroinvertebrate species was provided by CTDEEP. 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 "supporting," "impaired," or "severely impaired" (Table 5, Figure 8).

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

Table 5. Stream Capacity to Support Biota

Sample Location ID*	Subwatershed (headwaters to outlet)	Fish Score**	Biotic Support Category	Macroinvertebrate Score**	Biotic Support Category
5223	103 (Father Peter's Brook)	8.3	**Severely impaired**	-	-
76	102 (New Canaan Center)	6.7	**Impaired**	2.3	**Supporting**
77	102 (New Canaan Center)	7.0	**Severely impaired**	2.4	**Supporting**
5222	101 (Lower Main Stem)	5.7	**Impaired**	-	-
5467	8	10.0	**Severely impaired**	-	-
5348	1 (Keeler's Brook)	5.0	**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**

STREAM CONDITION ASSESSMENT SUMMARY

The stream condition assessment included analyses of impervious cover, assessment of biological monitoring data, and field reconnaissance of aquatic habitat conditions. Results of this analysis reveal a river that has been clearly impacted by urbanization but where some pockets of high-quality habitat and reasonably healthy aquatic communities persist. Conditions in the watershed generally range from fair to poor across a land-use gradient, with several areas in good condition associated with well established riparian buffers and undeveloped floodplains or areas that are minimally developed in the headwater reaches of the watershed.

Based on the IC analysis, Five Mile River conditions were predicted to range from good to poor moving from north to south, with the majority of the stream reaches expected to be in fair or poor condition (Table 3, Figure 6). Only the headwaters (subwatersheds 11, 13, and 14) and a tributary to Father Peter's Brook (subwatershed 12) were predicted to have good stream conditions.

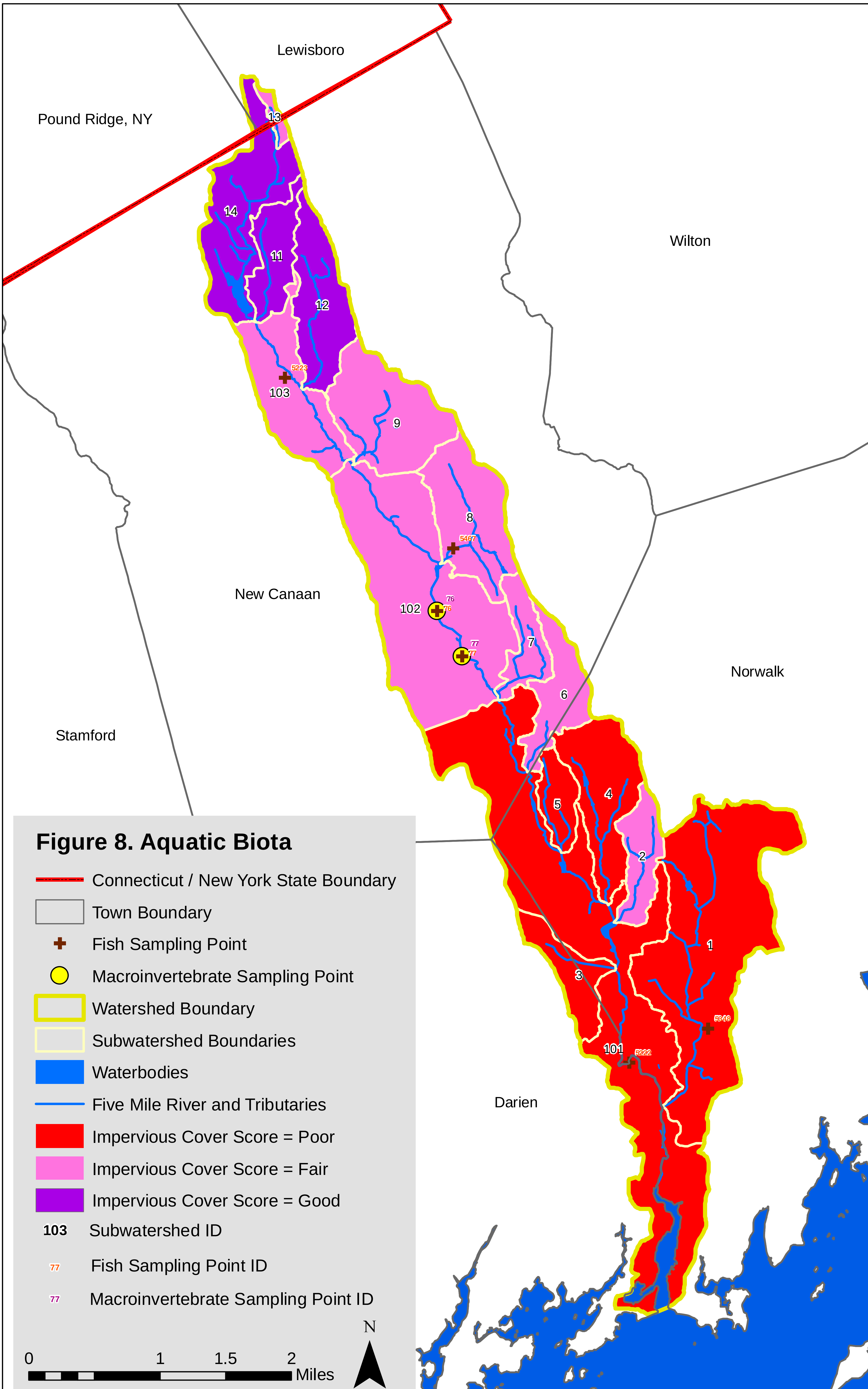


Figure 8. Aquatic Biota
Connecticut / New York State Boundary
Town Boundary
Fish Sampling Point
Macroinvertebrate Sampling Point
Watershed Boundary
Subwatershed Boundaries
Waterbodies
Five Mile River and Tributaries
Impervious Cover Score = Poor
Impervious Cover Score = Fair
Impervious Cover Score = Good
103 Subwatershed ID
77 Fish Sampling Point ID
77 Macroinvertebrate Sampling Point ID
0 1 1.5 2 Miles
N
Lewisboro
Pound Ridge, NY
Wilton
New Canaan
Norwalk
Stamford
Darien
13
14
11
12
103
9
8
102
7
6
5
4
2
1
3
101

Visual assessment generally corroborated predictions of the IC analysis. Good conditions were observed in the northern headwaters (subwatersheds 14 and 103) and were associated with moderately steep streams with forested riparian buffers as documented during the visual assessment. In reaches draining subwatersheds with highly impervious cover (e.g., Keeler's Brook and the Lower Main Stem, etc.), aquatic habitats were generally of lower quality. For instance, in Keeler's Brook (subwatershed 1), the IC analysis and visual assessment both indicated poor conditions. Reaches suffer from poorly managed streamside development and a limited or nonexistent riparian buffer. Habitat impairments observed in these areas are likely related to a combination of physical modifications of the stream channel, floodplain, and riparian areas (e.g., impounded or channelized reaches, streamside vegetation removal, etc.) and the hydraulic stress and increased rates of NPS pollution caused by unmanaged urban stormwater runoff.

While the visual assessment confirmed the predictions of the IC analysis in most locations, in some cases visual assessment data suggested either better or more degraded conditions than were suggested by the IC analysis (Table 4, Figure 7). This conclusion suggests that in-stream conditions are strongly influenced by both watershed-scale conditions (i.e., levels of overall imperviousness) and local-scale conditions. For example, poor stream conditions were observed in locations associated with low-head dams, even when levels of watershed imperviousness suggested better conditions. In subwatershed 12 (site 2), conditions were worse than expected, presumably due to locally concentrated streamside development and anthropogenic modifications. The stream at this location flows under a street and through private yards, has been dammed to make a small pond, and has rip-rap stabilized banks. Alternating patterns of sedimentation and erosion were also observed. In subwatershed 101 (sites 7 and 9) on the Main Stem, conditions were better than expected, likely due to riparian buffers present at both locations. At site 7, the boulder-dominated substrate may also help to armor the bed, making the river more resistant to increased stormwater flows. At site 9, the intact and undeveloped floodplain on the west side of the river likely also contributes to the stream's better-than-expected condition.

Biotic data generally corroborated the IC results (Table 5, Figure 8). However, in two cases the fish biotic support results suggested conditions less supportive than expected based on the IC analysis. In subwatersheds 102 and 103 (sites 77 and 5223, respectively), the fish data indicated severely impaired conditions while the Impervious cover score for the reach was fair. Site 77 is located just downstream from New Canaan Town Center, where imperious cover is locally more intense than within the rest of the subwatershed. The increase in IC possibly contributed to the lower than expected fish biotic support score. Causes for the site 5223 discrepancy are unclear. In subwatershed 1 (site 5348) the fish data showed conditions better (supporting) than the Impervious cover score (poor) suggested. In this case, the sampling site was located in a tributary where local conditions, such as riparian cover, may have been better than typically seen in Keeler's Brook.

Macroinvertebrate data were inconsistent at the two sampling locations in subwatershed 102. Both sample locations were categorized as supporting, while fish samples taken in similar locations suggested impaired or severely impaired conditions. Several fish species were observed at both locations, but the majority of individuals sampled were either blacknose dace (*Rhinichthys atratulus*) or white suckers (*Catastomus comersonii*), both considered pollution-tolerant species. Differences in fish and macroinvertebrate communities may be attributed to in-stream barriers prohibiting fish movement. It is also possible that other parameters, such as temperature, contributed to the absence of pollution-tolerant fish species.

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 direction measurements. Given the difficulty and expense of directly measuring pollutants, the Plan team decided to use computer simulation to estimate the quality of pollutants being introduced to the Five Mile 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 (the quantity of pollution in a given volume of water) associated with urban stormwater runoff from various types of common urban surfaces including rooftops, various types of roadways, parking areas, as well as open spaces and from various soil types such as clayey, silty, and sandy soils. 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 Five Mile 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 required 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 coliform bacteria. Of these, sediment, N, P, and indicator 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 TSS as an indicator of sediment loading. Finally, WinSLAMM uses fecal coliform as an estimate 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 forms of N 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 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 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, such as algae, 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 into the stream as well as 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 Total Suspended Solids (TSS), wash into streams through surface and channel erosion, road runoff, and storm water 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 storm water runoff.

Bacteria

Many different species of bacteria are carried into surface waters from 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 *Escherichia coli* (*E. coli*) is used as the indicator species for pathogenic bacteria, viruses, and protozoans in freshwater streams, and 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.

Modeling Methods

Pollutant loading was modeled for the Five Mile 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 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, 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 Soil Survey Geographic (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 University of Connecticut (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 modified 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. Instead, the soil data obtained from the SSURGO database were reclassified to match the input categories used by WinSLAMM based on the soil texture field in the SSURGO dataset.

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

- 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 project 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 different 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, road side 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 6 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 Five Mile River watershed averaged approximately 4 million, 22,000 and 59,000 lb/yr, respectively. TSS unit area loading varied considerably among subwatersheds, ranging from 276 lb/ac/yr in subwatershed 5 to 948 lb/ac/yr in subwatershed 14. Unit area loading for particulate P also varied significantly among subwatersheds, ranging from a minimum of 1.4 lb/ac/yr in subwatershed 2 to a maximum of 4.9 lb/ac/yr in subwatershed 7. NO_3 unit area loads were more variable among subwatersheds than either particulate P or TSS, ranging from 1.3 lb/ac/yr in subwatersheds 5 and 13, to 15.1 lb/ac/yr in subwatershed 3. The river generated an average annual loading of approximately 4,725,000 billion cfu) of indicator bacteria. Unit area loading ranged significantly among subwatersheds, from 190 billion cfu in subwatershed 5 to 922 billion cfu in subwatershed 3.

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 storm water 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.

POINT SOURCE LOADING

A single point source has been identified in the Five Mile River Watershed. The New Canaan Publicly Owned Treatment Works (POTW) is a municipal wastewater treatment facility which operates under a NPDES permit. The discharge point is located on the Main Stem of the river between Old Norwalk Road and Lakeview Avenue. The New Canaan Transfer Station, a waste and recycling facility, is located adjacent to the POTW, although this facility is not a permitted discharger.

A nutrient enrichment analysis was conducted by CTDEEP for a portion of the Main Stem below the POTW outfall. A target limit of 1.47 lb/day of Total P (TP) has been established for the facility (Table 7). This represents a reduction in current discharge of approximately 8.98 lb/day (CTDEEP 2011). Loads associated with this point source are not included in WinSLAMM model results, which represent pollution loads from NPS only.

Table 6. Pollutant Loading Analysis Results

Subwatershed	Area	Avg TSS Load		Avg particulate P Load		Avg NO_3 Load		Avg Indicator Bacteria Load	
	(ac)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(billion cfu/yr)	(billion cfu/yr)
13	32.6	14,301	439	84	2.6	41	1.3	7,082	217
14 (Headwaters)	498.9	472,783	948	1,725	3.5	967	1.9	114,368	229
11	202.1	162,557	804	860	4.3	366	1.8	43,234	214
103 (Father Peter's Brook)	1,148.7	568,386	495	3,149	2.7	13,638	11.9	911,337	793
12	349.6	285,060	815	1,333	3.8	645	1.8	84,511	242
102 (New Canaan Center)	409.0	320,699	784	1,818	4.4	4,024	9.8	274,105	670
9	469.0	395,657	844	2,060	4.4	939	2.0	117,840	251
8	415.9	331,294	797	1,918	4.6	813	2.0	142,005	341
7	162.6	138,454	852	795	4.9	282	1.7	40,060	246
101 (Lower Main Stem)	1,889.6	658,115	348	3,094	1.6	23,249	12.3	1,636,038	866
6	235.8	182,227	773	737	3.1	1,053	4.5	95,024	403
5	133.6	36,926	276	202	1.5	167	1.3	25,346	190
4 (Holy Ghost Father's Brook)	394.4	152,964	388	690	1.7	5,004	12.7	332,816	844
2	182.5	60,499	332	249	1.4	2,081	11.4	155,370	851
3	190.8	58,837	308	289	1.5	2,890	15.1	175,895	922
1 (Keeler's Brook)	1,279.7	668,919	523	2,710	2.1	2,751	2.1	570,048	445
Five Mile Watershed:	**7,995**	**4,507,678**	**564**	**21,713**	**2.7**	**58,910**	**7.4**	**4,725,079**	**591**

Table 7. Phosphorus Enrichment Overview, New Canaan Publicly Owned Treatment Works

NPDES	Upstream NPDES Load (lb/day)	Estimated Land Use Export Load (lb/day)	Forested Condition Load (lb/day)	Proposed Enrichment Factor (EF)	Proposed Upstream NPDES Load (lb/day)
NEW CANAAN WPCF, CT0101273	10.45	1.26	0.33	8.30	1.47

(CTDEEP 2011)

USE DESIGNATIONS AND EXISTING IMPAIRMENTS

Use designations are used by CTDEEP to classify streams according to their function within the community. Depending on their size, condition, and location, streams may be designated for fish or shellfish consumption, for recreation, drinking water, habitat, or 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 Five Mile River are presented in Figure 9. Use designations for a freshwater stream in Connecticut are listed below. All classes but SA are found in the Five Mile 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.

Most reaches in the Five Mile River Watershed are designated Class A streams (Figure 9). The Main Stem below the POTW is designated a Class B stream. The uppermost portion of the river draining to the New Canaan Reservoir is designated Class AA, as it drains to a drinking water source. The estuary is designated a Class SB waterbody, which means that commercial shellfishing is permitted, but direct human consumption is not.

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 longer considered to meet its designated use. A water body that is found to fail minimum quality standards for its designated use is placed on the Connecticut IWL. In the Five Mile River watershed, five sample sites in both freshwater and saltwater areas yielded the three impaired reaches, which are described below (CTDEP 2011, Integrated Water Quality Report) (Figure 10).

Several impairments are documented on the Connecticut 303(d) list due to elevated levels of bacteria and stormwater-related impacts to habitat. While identified impairments are clustered on the Main Stem, patterns of land use and existing monitoring data suggest that additional bacteria and habitat impairments are most likely present throughout the watershed. All documented impairments, for the freshwater and estuary portions of the river, are presented below.

Main Stem Five Mile River

- The reach of stream from the Old Norwalk Road crossing (0.2 miles downstream from the New Canaan POTW) upstream to the confluence with the New Canaan POTW outfall exceeds maximum criteria for *E. coli* for safe recreation, and fails to support aquatic life due to an "unknown cause." Possible sources of impairment cited in the report are point source discharges from the nearby landfill and POTW, and urban stormwater. The recreation impairment is designated as a high priority for development of a total maximum daily load (TMDL) by CTDEEP, while the aquatic life impairment is designated low priority.

- The reach of stream from the confluence with the New Canaan POTW outfall upstream to the confluence with an unnamed tributary (upstream of the Route 123 crossing, on the northeastern side of Parade Hill Road near the cemetery) does not meet minimum criteria for aquatic life support. The cited cause is "unknown" although urban stormwater is cited as a potential source. This impairment is designated low on the TMDL priority list.

Five Mile River Estuary

Although not included as part of the focus of the Plan, the Estuary is expected to benefit from Plan implementation.

- The western portion of LIS's Inner Estuary, from the mouth of the Harbor (Butlers Island to Roton Point) upstream to the saltwater limit at the Cudlipp Street crossing (Route 136), exceeds maximum indicator bacteria criteria for the support of commercial shellfishing. This impairment is designated medium on the TMDL priority list.

The above impairments in the watershed have been identified based on limited sampling locations. There are portions of the watershed, including Keeler's Brook, that have not been assessed for 305(b)/303(d) impairments. Based on data collected during separate monitoring efforts, these portions of the watershed likely to exhibit the same conditions as sampled streams that have been found to be impaired.

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 sufficient data has been collected to support this conclusion. Since sampling in the Five Mile River Watershed has been limited, it is impossible to know with certainty where additional state defined water quality impairments may exist. However, based on the existing conditions assessment presented in this chapter, it is possible to suggest problem areas where impairments are likely to be found.

In the Five Mile River, five reaches of stream were included in the 2011 Connecticut Water Quality Report. Three of these sites did not meet water quality or habitat criteria required to support their designated use. Again, it should not be assumed that these locations are the only sites where impairments exist; rather, they are the only sites where impairments were assessed and found.

During field reconnaissance, several sample sites were found where conditions would likely support a 303(d) listing for the reach of stream assessed. For instance, the SVA analysis indicated poor conditions in four locations on a Class A designated stream, and in one location on the Class B designated Main Stem. Assessments indicate that habitat and water quality may be impaired for aquatic life and recreation; observed conditions warrant further investigation.

As noted in the Impervious Cover Analysis, SVA scores were associated with predicted impervious cover scores based on existing land use conditions. Since field observations largely corroborated the predicted conditions, it may be assumed that other streams with similar use designations and similarly poor Impervious cover scores (subwatersheds 101, 5, 4, and 1) may also warrant further investigation to determine if impairments are present.

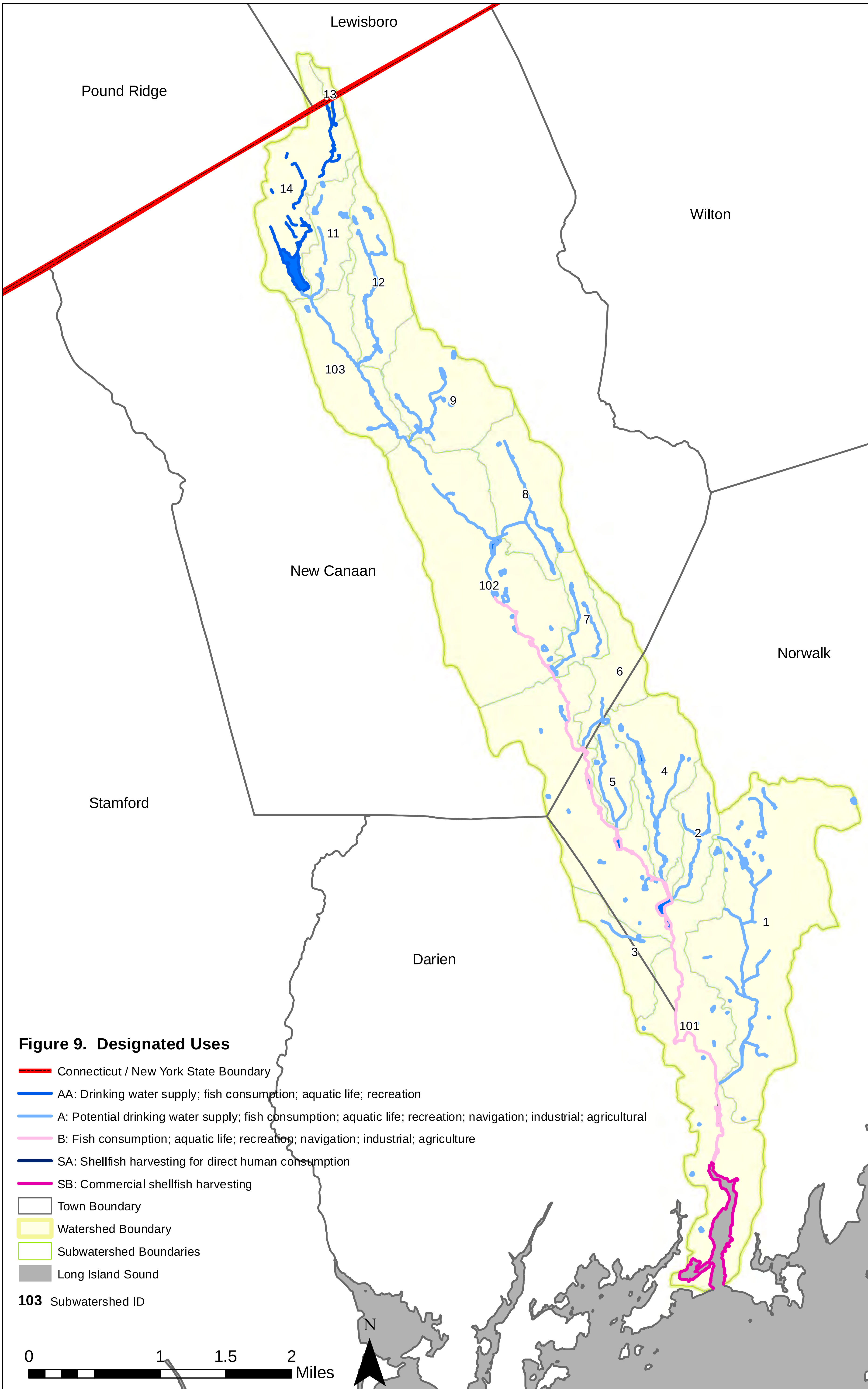
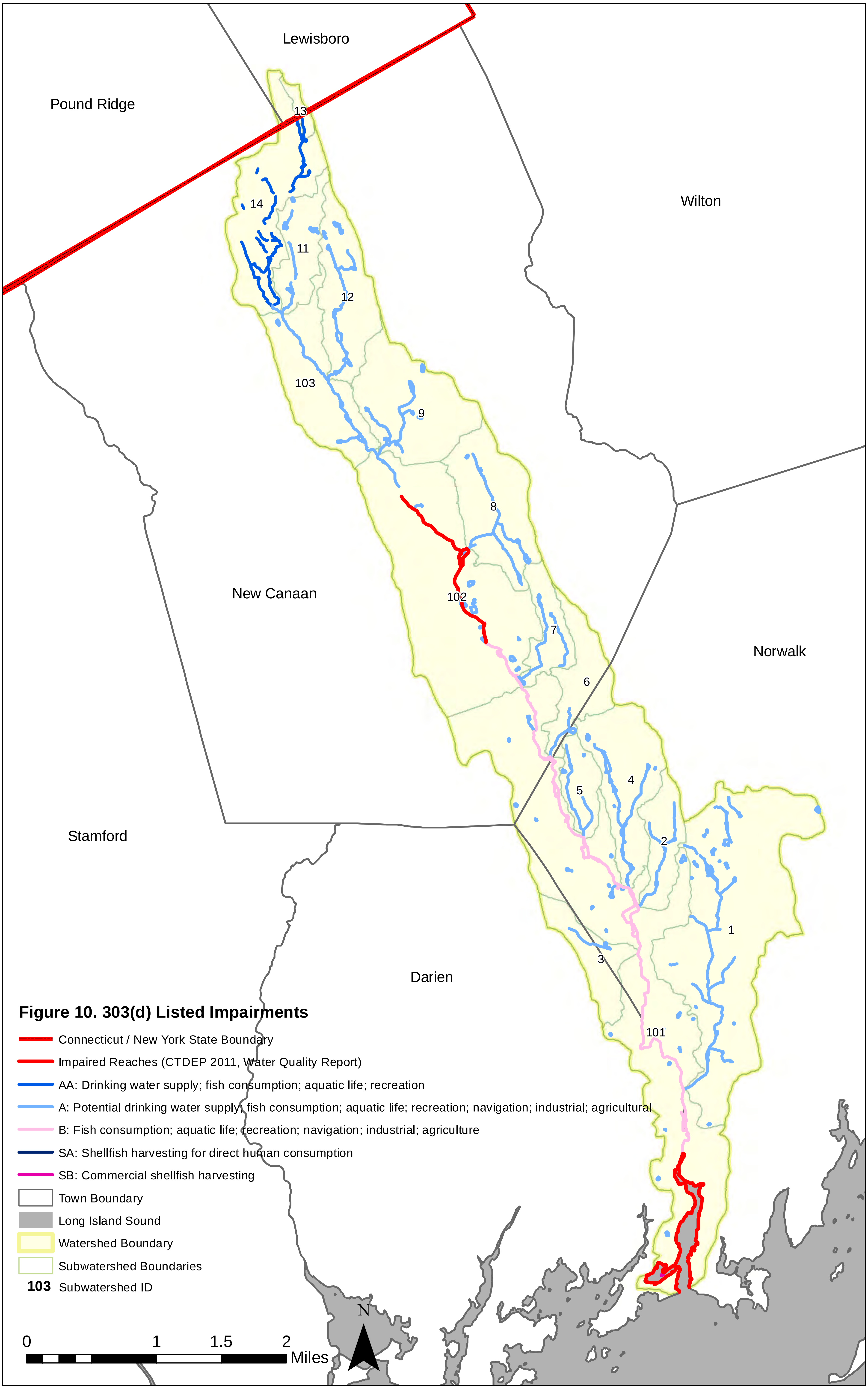


Figure 9. Designated Uses


Lewisboro
Pound Ridge
Wilton
New Canaan
Norwalk
Stamford
Darien
13
14
11
12
103
9
8
102
7
6
5
4
2
1
3
101
Figure 10. 303(d) Listed Impairments
Connecticut / New York State Boundary
Impaired Reaches (CTDEP 2011, Water Quality Report)
AA: Drinking water supply; fish consumption; aquatic life; recreation
A: Potential drinking water supply; fish consumption; aquatic life; recreation; navigation; industrial; agricultural
B: Fish consumption; aquatic life; recreation; navigation; industrial; agriculture
SA: Shellfish harvesting for direct human consumption
SB: Commercial shellfish harvesting
Town Boundary
Long Island Sound
Watershed Boundary
Subwatershed Boundaries
103 Subwatershed ID
0
1
1.5
2
Miles
N

As discussed in the introduction to this Plan the 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 Five Mile River and its tributaries. A key question moving forward is "how much do pollutant loads need to be reduced?" This is a central question that needs to be asked and answered in order for the Plan to be a meaningful and useful document.

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 Plan. The required load reduction would then be that required to lower the pollutant concentrations from their current levels to the maximum acceptable levels. Using this approach, however, requires extensive in-stream monitoring data that currently do not exist for the Five Mile River. In addition, this approach requires an agreed upon standard for the acceptable maximum pollutant concentrations for each segment of the Five Mile River and its tributaries. Currently, state standards have not been established for N, P, and TSS concentrations, and although they do exist for indicator bacteria, sufficient sampling data to characterize in-stream concentrations of indicator bacteria throughout the Five Mile River and its tributaries do not.

An alternative and more feasible method to determine pollutant load reduction targets is to estimate the pollutant loading in the Five Mile River for its undeveloped condition, that is to assume the entire watershed consists of forest cover, and compute the load reduction targets as the difference between the current loading and the loading associated with an undeveloped condition. With this information, it is possible to estimate the portion of the total pollutant load that is the result of human activity in the watershed.

The following section establishes pollution reduction targets for the Five Mile River using the reference condition approach 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. Given that streams can absorb some level of additional pollutant loading and still provide full spectrum of uses and values articulated in the Plan, a 100 percent reduction in development-related pollutant loads is most likely not needed to fully restore the Five Mile River and meet the Plan's goals. Therefore, the Plan establishes an interim, working goal of eliminating 60 percent of the development-related pollutant load.

MODELING METHODS

Pollutant load reduction targets were developed for TSS, particulate P, NO_3, and indicator bacteria using WinSLAMM. Predevelopment conditions were modeled using a similar method used to develop existing conditions models (methods and results described in Chapter 2); however here the models assumes 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 (see results discussion below). In the following tables, total and interim targets are presented.

Model inputs

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 soil HSG.

As noted above, the Plan 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.

MODEL RESULTS

Total annual pollutant load reduction targets for the watershed call for a 281,345 lb/yr reduction in TSS (Table 8), a 1,694 lb/yr reduction in particulate P (Table 9), a 51,257 lb/yr reduction in NO_3 (Table 10), and a 3,911,459 billion cfu/yr reduction in indicator bacteria (Table 11). Since the load reductions reflect a return to baseline pollutant loading, achievement of these targets is expected to meet and exceed state standards for in-stream habitat and pollutant concentrations. Interim targets representing 60 percent of the total target are presented alongside total targets in Tables 8, 9, 10, and 11.

All subwatersheds contribute NO_3 and indicator bacteria loads in excess of predevelopment conditions, but the magnitudes vary greatly (Tables 10 and 11). NO_3 load reduction targets range from 16 lb/yr to 22,265 lb/yr and the indicator bacteria reduction targets range from 4,391 billion cfu/yr to 1,531,468 billion cfu/yr for all subwatersheds (this represents a total rather than per unit area target). Conversely, not all subwatersheds contribute TSS and particulate P above predevelopment conditions (Tables 8 and 9). Load reduction targets were developed only for those subwatersheds with development-derived TSS and particulate P loads in excess of predevelopment estimates. Particulate P load reduction targets were as large as 549 lb/yr in the 11 subwatersheds where particulate P increased from predevelopment conditions. TSS load reduction targets were as large as 149,161 lb/yr in the seven subwatersheds where TSS increased from predevelopment conditions.

As noted above, TSS and particulate P loads decreased from the predevelopment scenario to existing conditions scenario for several subwatersheds. This result was typically associated with poorly drained soils (HSG D), which naturally generate higher levels of suspended sediment 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. For subwatersheds where TSS and/or particulate P loads decreased in existing conditions, no load reduction targets were developed for the respective constituent.

For the Five Mile River Watershed, total pollution reduction targets require annual decreases of 6.2 (Table 8), 7.8 (Table 9), 87.0 (Table 10), and 82.8 percent (Table 11) for TSS, particulate P, NO_3, and indicator bacteria loads, respectively. Interim (60 percent) targets require decreases of 3.7, 4.7, 52.2, and 49.7 percent, for TSS, particulate P, and NO_3, and indicator bacteria, respectively. All parameters are summarized in Table 12. Typical load reductions and efficiencies for the management actions recommended in the Plan are presented in Chapter 6.

Table 8. Total Suspended Solids Load Reduction Targets

Sub-watershed (headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Load Reduction Target (lb/yr)	Percent Reduction (%)	60% Target (lb/yr)
13	14,301	13,979	322	2.3%	193
14 (Headwaters)	472,783	484,769	0	0.0%	0
11	162,557	168,023	0	0.0%	0
103 (Father Peter's Brook)	568,386	521,986	46,400	8.2%	27,840
12	285,060	289,792	0	0.0%	0
102 (New Canaan Center)	320,699	345,978	0	0.0%	0
9	395,657	398,631	0	0.0%	0
8	331,294	339,123	0	0.0%	0
7	138,454	140,937	0	0.0%	0
101 (Lower Main Stem)	658,115	508,954	149,161	22.7%	89,497
6	182,227	191,402	0	0.0%	0
5	36,926	37,360	0	0.0%	0
4 (Holy Ghost Father's Brook)	152,964	138,036	14,928	9.8%	8,957
2	60,499	44,767	15,732	26.0%	9,439
3	58,837	45,185	13,652	23.2%	8,191
1 (Keeler's Brook)	668,919	627,769	41,150	6.2%	24,690
Watershed Total:	**4,507,679**	**4,296,690**	**281,345**[1]	**6.2%**	**168,807**

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

Table 9. Particulate Phosphorus Load Reduction Targets

Sub-watershed (headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Load Reduction Target (lb/yr)	Percent Reduction (%)	60% Target (lb/yr)
13	84	70	14	16.7%	8
14 (Headwaters)	1,725	2,424	0	0.0%	0
11	860	840	20	2.3%	12
103 (Father Peter's Brook)	3,149	2,610	539	17.1%	323
12	1,333	1,449	0	0.0%	0
102 (New Canaan Center)	1,818	1,730	88	4.8%	53
9	2,060	1,993	67	3.3%	40
8	1,918	1,696	223	11.6%	134
7	795	705	90	11.3%	54
101 (Lower Main Stem)	3,094	2,545	549	17.7%	329
6	737	957	0	0.0%	0
5	202	187	15	7.4%	9
4 (Holy Ghost Father's Brook)	690	690	0	0.0%	0
2	249	224	25	10.0%	15
3	289	226	64	22.1%	38
1 (Keeler's Brook)	2,710	3,139	0	0.0%	0
Watershed Total:	**21,713**	**21,483**	**1,694**[1]	**7.8%**	**1,016**

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

Table 10. Nitrate Load Reduction Targets

Sub-watershed (headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Load Reduction Target (lb/yr)	Percent Reduction (%)	60% Target (lb/yr)
13	41	25	16	39.0%	10
14 (Headwaters)	967	826	141	14.6%	85
11	366	290	76	20.8%	46
103 (Father Peter's Brook)	13,638	948	12,690	93.0%	7,614
12	645	500	145	22.5%	87
102 (New Canaan Center)	4,024	596	3,428	85.2%	2,057
9	939	686	253	26.9%	152
8	813	586	227	27.9%	136
7	282	242	40	14.2%	24
101 (Lower Main Stem)	23,249	984	22,265	95.8%	13,359
6	1,053	330	722	68.6%	433
5	167	73	94	56.3%	56
4 (Holy Ghost Father's Brook)	5,004	259	4,746	94.8%	2,848
2	2,081	89	1,992	95.7%	1,195
3	2,890	91	2,799	96.9%	1,679
1 (Keeler's Brook)	2,751	1,129	1,622	59.0%	973
Watershed Total:	**58,911**	**7,655**	**51,257**	**87.0%**	**30,754**

Table 11. Indicator Bacteria Load Reduction Targets

Sub-watershed (headwaters to outlet)	Existing Load (billion cfu/yr)	Predevelopment Load (billion cfu/yr)	Load Reduction Target (billion cfu/yr)	Percent Reduction (%)	60% Target (billion cfu/yr)
13	7,082	2,691	4,391	62.0%	2,635
14 (Headwaters)	114,368	87,804	26,563	23.2%	15,938
11	43,234	30,811	12,422	28.7%	7,453
103 (Father Peter's Brook)	911,337	100,752	810,585	88.9%	486,351
12	84,511	53,138	31,372	37.1%	18,823
102 (New Canaan Center)	274,105	63,377	210,728	76.9%	126,437
9	117,840	72,959	44,881	38.1%	26,929
8	142,005	62,291	79,714	56.1%	47,828
7	40,060	25,764	14,296	35.7%	8,578
101 (Lower Main Stem)	1,636,038	104,570	1,531,468	93.6%	918,881
6	95,024	35,107	59,916	63.1%	35,950
5	25,346	7,715	17,631	69.6%	10,579
4 (Holy Ghost Father's Brook)	332,816	27,494	305,322	91.7%	183,193
2	155,370	9,473	145,897	93.9%	87,538
3	175,895	9,623	166,272	94.5%	99,763
1 (Keeler's Brook)	570,048	120,048	450,000	78.9%	270,000
Watershed Total:	**4,725,078**	**813,618**	**3,911,459**	**82.8%**	**2,346,875**

Table 12. Pollutant Load Reduction Total Targets and Percent Reductions

	NO_3			Particulate P			TSS			Indicator Bacteria		
Subwatershed (headwaters to outlet)	Total Target (lb/yr)	60% Target (lb/yr)	Total Target as Percent of Total Watershed Target	Target (lb/yr)	60% Target (lb/yr)	Total Target as Percent of Total Watershed Target	Target (lb/yr)	60% Target (lb/yr)	Total Target as Percent of Total Watershed Target	Target (billion cfu/yr)	60% Target (billion cfu/yr)	Total Target as Percent of Total Watershed Target
13	16	9.6	0.0%	14	8.4	0.8%	322	193.2	0.1%	4,391	2,635	0.1%
14 (Headwaters)	141	84.6	0.3%	0	0	0.0%	0	0	0.0%	26,563	15,938	0.7%
11	76	45.6	0.2%	20	12	1.2%	0	0	0.0%	12,422	7,453	0.3%
103 (Father Peter's Brook)	12,690	7,614	24.8%	539	323	31.8%	46,400	27,840	16.5%	810,585	486,351	20.7%
12	145	87	0.3%	0	0	0.0%	0	0	0.0%	31,372	18,823	0.8%
102 (New Canaan Center)	3,428	2,057	6.7%	88	53	5.2%	0	0	0.0%	210,728	126,437	5.4%
9	253	151.8	0.5%	67	40.2	3.9%	0	0	0.0%	44,881	26,929	1.2%
8	227	136.2	0.4%	223	133.8	13.1%	0	0	0.0%	79,714	47,828	2.0%
7	40	24	0.1%	90	54	5.3%	0	0	0.0%	14,296	8,578	0.4%
101 (Lower Main Stem)	22,265	13,359	43.4%	549	329	32.4%	149,161	89,497	53.0%	1,531,468	918,881	39.2%
6	722	433.2	1.4%	0	0	0.0%	0	0	0.0%	59,916	35,950	1.5%
5	94	56.4	0.2%	15	9	0.9%	0	0	0.0%	17,631	10,579	0.5%
4 (Holy Ghost Father's Brook)	4,746	2,848	9.3%	0	0	0.0%	14,928	8,957	5.3%	305,322	183,193	7.8%
2	1,992	1,195	3.9%	25	15	1.5%	15,732	9,439	5.6%	145,897	87,538	3.7%
3	2,799	1,679	5.5%	64	38	3.8%	13,652	8,191	4.9%	166,272	99,763	4.3%
1 (Keeler's Brook)	1,622	973	3.2%	0	0	0.0%	41,150	24,690	14.6%	450,000	270,000	11.5%
Watershed Total	**51,257**	**30,754**	**100.0%**	**1,694**	**1,016**	**100.0%**	**281,345**	**168,807**	**100.0%**	**3,911,459**	**2,346,875**	**100.0%**

The Five Mile River means different things to different people. Some value its many utilitarian purposes, such as drinking water and conveyance. 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 needs [values?] of the community.

During a public meeting, stakeholders articulated key ways that the watershed is used and valued. This chapter discusses the uses and values that were identified by the stakeholder group during this meeting as well as comments on the physical attributes required to provide for these uses and values.

DRINKING WATER

The Five Mile River is an important source of potable water. Surface water is collected and stored in the New Canaan Reservoir prior to distribution and treatment. Continuing to meet drinking water demands depends strongly on maintaining water quantity and high water quality within the source areas to the New Canaan Reservoir. Urban development represents the primary threat to water quantity and quality, and efforts to limit additional development within source water areas to the New Canaan Reservoir are a management priority. Urban development can undermine drinking water uses through increasing rates of sediment and nutrient and bacteria loading to the New Canaan Reservoir and through reducing flow to the reservoir during critical periods. The impacts of drinking water withdrawals on downstream habitats are poorly understood at present, but may be exacerbating the effects of urban runoff on downstream aquatic communities.

RECREATION

Although the Five Mile River is not a regionally significant recreational destination and lacks the substantive networks of publically accessible open lands that typify other nearby watersheds, stakeholders associated a range of recreational uses, including fishing, swimming, and deer and duck hunting, within the Five Mile River Watershed. Increasingly, impacts from urban runoff, which increase bacteria levels, degrade stream channels, and impair water quality, are likely reducing the potential for key recreational uses, such as swimming and fishing.

WASTEWATER CONVEYANCE

Watershed stakeholders identified wastewater conveyance as a necessary function of the Five Mile River. The Five Mile River transports treated wastewater discharges. Treated wastewater discharges have a tendency to increase nutrient levels within the Five-Mile River and may be contributing to observed algal blooms in the lower stretches of the river. Failing wastewater conveyance systems, such as pumping stations, were identified as possible point sources of pollution (D. Harris, Per. Comm.), while illicit discharges and improperly functioning septic systems could also contribute to increased nutrient and bacteria levels in the river.

IRRIGATION

In addition to providing a source of drinking water, water from the Five Mile River is used to irrigate golf courses, nurseries, and other commercial businesses. The cumulative impacts of water withdrawals on other uses and values are poorly understood at present, but are worthy of further study. Extensive withdrawals from the river may conflict with other uses that depend on steady base flow, such as environmental diversity and drinking water availability. Yet as a source of irrigation the river provides significant value for large property owners, and this value should not be ignored.

PROPERTY VALUE

Watershed stakeholders recognized that property values could either be positively or negatively affected by the river. Property values often increase when scenic views, access to preserved land, or recreational opportunities (e.g., fishing, trails, etc.) are available. For example, the view of protected forest and the Five Mile River from properties along Oenoke Ridge likely contribute to high property values in this area. In contrast, homes that have experienced or could experience flooding risk negative impacts to property values due to flooding. Many residential properties are constructed within low-lying floodplains, in some cases within 10 feet of the river (e.g., Ledgebrook Condominiums in Norwalk). Other residential properties are situated on the floodplains of unstable stream reaches (e.g., near the intersection of Flax Hill Road and Primrose Court) and are at risk from bank erosion and channel migration. Land use changes within the drainage area to such properties may have altered the risks associated with building within the floodplain. Conversely, construction without setbacks on these properties has invariably impacted downstream watercourses and riparian areas. Further urbanization will only increase the variability of storm flow and channel alterations, thereby increasing the risk to properties located within floodplains. This in turn could negatively impact property values.

ENVIRONMENTAL DIVERSITY

Although in-stream and riparian habitats have been somewhat degraded by urbanization, stakeholders recognized the aquatic and riparian habitats within the Five Mile River watershed as valuable sources of environmental diversity. Particularly in less developed headwaters, high-quality riparian and aquatic habitats are still found within the watershed despite significant levels of urban development. It is commonly observed that in developed areas, small patches of habitat become more important to sustaining wildlife as more desirable habitat is unavailable.

WILDLIFE HABITAT

Although not well documented, less developed regions of the watershed, particularly along stream corridors, provide significant wildlife habitat for a variety of plant and animal species in an otherwise significantly developed landscape. Even within regions dominated by impervious cover (e.g., the Rt. 1 and I-95 corridors), significant tracts of open space such as the Hoyt Swamp (wetland), the power line right-of-way (shrub), and areas adjacent to Holy Ghost Father's Pond (meadow), provide diverse habitat for plants and wildlife. Wildlife resources within the Five Mile River Watershed have not been extensively documented but most likely consist of plant and animal communities that are typical of the region and relatively tolerant of urban conditions.

AESTHETICS

Despite significant impacts from urbanization, the Five Mile River provides a source of scenic beauty in many locations, adding to the charm and character of the region. The river's aesthetic qualities have been undermined due to stream incision, bank erosion, and in-stream sedimentation. Displeasing algal blooms have also been reported within portions of the river. A microcosm for this pattern is represented by the small, low-head dams that have been constructed to enhance aesthetics, and have instead become stagnant pools filled with algae. Overland sources of sediment from developed areas and increased rates of channel erosion have filled ponds with sediment and nutrients, resulting in eutrophic conditions and excessive algae.

EDUCATION

Watershed stakeholders recognized the value of the Five Mile River as an educational resource through which residents can learn about river ecology and watershed stewardship. The Five Mile River offers a suitable diversity of habitats and conditions to support a wide-range of educational programming. Stewardship and monitoring as well as recreationally oriented programs all are excellent ways for the community to experience and learn about the watershed.

OPEN SPACE

Watershed stakeholders identified open space within the Five Mile River watershed as a valued resource. Although extensive tracts of publically accessible open spaces are not located within the watershed, a network of smaller parks and privately owned open lands provide important benefits for residents. Opportunities for connecting existing open space and preserved land may exist, especially within the power line right-of-way.

CONVEYANCE/FLOOD PLAIN MANAGEMENT

Stakeholders view conveyance and flood control as a key watershed value, and one that is currently not fully met. Several communities along the Five Mile River, including the Towns of New Canaan and Darien and the City of Norwalk, have been plagued by recurrent flooding in recent years. Severe flooding in 2006 and 2007 intensified interest in finding solutions to flooding problems within the watershed. Identifying ways to reduce the incidence of flooding is a primary management concern for the stakeholder group. Since flooding is largely related to alterations in the hydrologic cycle associated with increased development, ideal flood control projects will limit the volume of stormwater that passes into streams. Management actions that control runoff at its source (e.g., parcel-scale bioretention and extended detention) can help to limit downstream flooding. In addition, existing forested and undeveloped areas play a key role in infiltrating stormwater. Limiting additional development within these lands will be critical to ensuring that flooding problems do not worsen.

As discussed in earlier chapters, the Five Mile River Watershed has been stressed and degraded by multiple factors relating to urban development and human use. Significant improvements in water and habitat quality, and biological community health are required to fully realize the great potential of the Five Mile River as a positive community resource.

Management goals move past the notion that the Five Mile River needs to be improved 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 by the project steering committee, 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 Plan are as follows:

- Enhance stormwater management;
- Improve water quality;
- Protect and enhance wildlife habitat; and
- Increase awareness and stewardship.

Management strategies outline sets of activities that, when implemented, will result in the outcomes defined by the goals. As with goals, the strategies were developed with important input from the project steering committee through a series of public workshops. Each goal and strategy is discussed in detail in the sections below.

The following management strategies were identified:

- Avoid future increases in stormwater related impacts through adoption of LID policies;
- Reduce NPS pollution, peak flow rates, channel erosion, and flow stress through implementation of structural BMPs in developed areas;
- Limit nutrient and bacteria sources from large properties;
- Improve riparian habitats and protect undeveloped areas within the watershed;
- Identify and eliminate illicit discharges and improve solid and liquid waste management
- Reduce the frequency and severity of flooding;
- Encourage better stewardship of public and private lands by implementing education and outreach programs for homeowners and municipal officials; and
- Implement a water quality monitoring program.

MANAGEMENT GOALS

Building on the uses and values defined in Chapter 3, the Plan establishes primary management goals focused on enhancing stormwater management, protecting and improving water quality, preserving wildlife habitat, and engaging community members in the management of 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.

Enhance stormwater management

Biological, aesthetic, and recreational value are all collectively undermined by the impacts of unmanaged stormwater. Review of existing data and field assessment suggests that stormwater-related impacts have significantly impaired many areas of the Five Mile River and its tributaries. Unmanaged stormwater disrupts local habitats, creates high-flow conditions that stress aquatic organisms, convey pollutants that negatively affect aquatic life, and increase bank erosion rates. This in turn leads to higher nutrient loading, algae blooms, and sedimentation. Unmanaged stormwater also undermines recreational and aesthetic value by creating unsightly conditions (e.g., trash, eroding banks, gully-like channels, etc.) and carrying bacteria, which impairs safe contact activities such as swimming and fishing. A coordinated effort to better manage stormwater will result in improvements to biological conditions as well as a more beautiful river with enhanced recreational opportunities.

Improve water quality

Protecting water quality through watershed based planning is a primary goal. Good water quality is important for drinking water supply, recreation, aesthetics, property value, and diverse, healthy biological communities. Water quality is affected by a variety of factors, including adjacent and regional development patterns. Of particular importance in lower-density residential neighborhoods is the protection of roadside wetlands that may receive and manage road runoff. While many of these wetlands were observed to be in fair condition during field assessments, many more appear to have been overwhelmed by the quantity of stormwater piped in during storm events.

Protect and enhance wildlife habitat

Because so much of the Five Mile River Watershed is developed, the remaining natural areas provide critical habitat for songbirds, amphibians, and small mammals. Roadside wetlands, meadows, and even some residential properties offer refuge for species displaced by development. Yet storm flows are damaging riparian and wetland areas, and widespread development is driving some species such as deer and raccoons into uncomfortably close quarters with people. It is therefore critical that the remaining high-quality habitats be set aside before they are disturbed. Where disturbance has already occurred, natural habitats can be re-created through meadow creation in open areas, creation of floodplain wetlands and vegetated stormwater practices, and the restoration of sediment-laden roadside wetlands and riparian areas.

Increase awareness and stewardship

Given the importance of the Five Mile River Watershed to its community, the watershed could benefit from an established partnership or other civic organization to advocate for better management. When public officials, residents, and other watershed stakeholders are aware of and educated about the issues facing the watershed, they are more likely to take positive actions that benefit the river. In particular, given the large portion of the Five Mile River Watershed that is in private landownership, engaging residents and business owners in implementing watershed-friendly practices on their properties will be a central component of implementing the Plan. Education programs give residents easy to implement activities that also benefit their lives in other ways (e.g., rain gardens that could help to reduce local property issues or beautify a neglected planting bed) Incentive programs, technical assistance, recognition, and cost-sharing programs can also help put awareness into action.

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 eight management strategies that form the basis for Plan implementation, and later in this chapter is a list of management actions that support each of the strategies presented below.

1. Avoid future increases in stormwater-related impacts through adoption of low impact development policies

Low impact development (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 involves strengthening municipalities' existing stormwater, subdivision, and zoning and land development ordinances which require more stringent controls in highly sensitive areas. These policies help ensure that new and redevelopment projects in the watershed are constructed in ways that minimize impacts to local waterways. LID techniques include reducing impervious surfaces associated with development through the use of narrower roads or elimination of cul-du-sacs, which avoid soil compaction and large scale 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. It would also involve the use of small-scale stormwater treatment practices 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.

Although LID approaches are important throughout the watershed, the strongest development controls are meant to be implemented in headwater watersheds, where streams are in relatively good condition and where new sources of unmanaged stormwater could quickly lead to increased rates of stream channel and bank erosion, and upstream of New Canaan Reservoir, where water quality requirements are the more stringent. In particular, the upper Five Mile River Watershed in the town of New Canaan has seen a recent increase in residential development of very large single-family residences that lack stormwater controls. Requiring an LID approach to this type of development will ensure that future development does not result in an increase in stormwater runoff and NPS pollution.

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

- Municipal stormwater regulations that 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 (moderate-sized storms tend to inflict the most stream erosion over time); and management of larger storms for flood control are all useful methods to reduce impacts associated with development.

- Progressive planning and 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 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 sometimes 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 large scale grading, engineered fills, whole-scale vegetation removal, and soil compaction (these practices are commonly associated with large-scale commercial developments). Incentives for practices 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 practices such as bioretention systems and rain gardens can be incorporated into streetscaping or repaving projects to create “green streets” that add visual interest to street corridors. Similarly, new municipal facilities can incorporate LID practice such as rain gardens instead of traditional landscaping.

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. Additionally, retraining and education programs for municipal officials and staff, construction inspectors, consulting engineers, contractors, and developers will help to ensure that LID regulations are properly implemented.

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

***Existing resources*:** Many existing resources are available that provide model stormwater management resources including the CTDEEP’s website (www.ct.gov/dep/cwp), the CWP’s web site (cwp.org), the Low Impact Development Center (lowimpactdevelopment.org) and the CT Nonpoint Source Education for Municipal Officials (NEMO) program (nemo.uconn.edu).

***Approach*:**

- 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 watershed wide.
- 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.

Next steps:

Form a multi-municipal planning group to review existing ordinances and work toward enabling LID.

2. Reduce nonpoint source pollution, peak flow rates, channel erosion, and flow stress through implementation of structural BMPs in developed areas

As discussed in previous chapters, unmanaged stormwater runoff degrades waterways in numerous ways. Stormwater runoff carries NPS pollutants into local waterways, increases flooding, causes stream channels to more quickly erode, and physically stresses aquatic life. While LID policies will help reduce these impacts for new or redevelopment sites, the areas of the watershed that are already developed will require the construction of new stormwater management practices or structural BMPs to remove pollutants and reduce the volume of stormwater entering local streams. Structural BMPs consist of many of the same techniques called for in LID designs but are installed to manage runoff in already developed areas.

Synergy**:** Structural BMPs offer many benefits for improving the health of local streams and for enhancing neighborhoods, private properties, and commercial districts. For example, incorporating rain gardens within a public park adds visual interest to the park landscape and reduces maintenance costs associated with turf management. Similarly, installing rain gardens or wetlands on a school campus provides opportunities for teachers to involve students in learning about watersheds and stormwater. Finding opportunities to pool funding resources among park departments, school districts, and private donors and "piggy back" structural BMP projects onto other capital improvement projects can help to significantly reduce costs.

Warning**:** While structural BMPs are effective at managing stormwater from small storms, they are often not large enough to reduce flooding associated with very large storms. Therefore, while structural BMPs can help to reduce flooding, larger flood control facilities will be required to control the large floods that are most often responsible for property damage.

Study needs**:** A comprehensive study is needed to determine the impact of various levels of both traditional infrastructure and BMP-type treatment (i.e., "green" infrastructure) on flood elevations within flood prone areas. This study will help to understand the degree to which structural BMPs can help to resolve the most significant flooding problems in the watershed.

Approach**:**

- The Five Mile River Watershed provides a range of structural BMP opportunities that vary significantly in terms of implementation cost and benefit. Generally the "low-hanging fruit" (i.e., low-cost/high-benefit management actions) involve the following types of opportunities:

  - Opportunities to treat runoff from large developed 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 water quality benefits (existing stormwater basins were often designed primarily for flood control and do little to remove pollutants from the small storms that deliver most of the NPS pollution to streams); and
  - Small-scale structural BMPs within institutional and commercial properties that have large unused open spaces (e.g., schools, universities, corporate campuses). These projects often provide the opportunities to accrue other benefits (e.g., educational or beautification benefit) and can be located within existing turf areas that are not actively used.
- Concentrating projects within specific areas of the watershed (as opposed to a scatter-shot approach involving implementation throughout the entire watershed) can help to create more momentum and demonstrate results in a shorter time.
- Efforts should be focused on portions of the watershed that drain to stream segments listed as impaired by the CTDEEP 303(d) list of impaired waters.

3. Limit nutrient and bacteria sources from large properties

Bacteria have been identified as a source of recreational impairment in the watershed. Dense algal growth has been observed on the Main Stem, indicating that nutrient levels may also be elevated. While observed impairments are concentrated on the Central and Lower Main Stem, it is generally thought that nutrient and bacteria problems are widespread throughout the watershed.

Nutrients and bacteria are carried to streams via stormwater runoff. Structural BMPs can help remove these pollutants from stormwater runoff prior to entering streams. However, structural BMPs can be expensive, ownership and space constraints can limit the number of viable project sites, and structural BMPs typically only remove a percentage of the pollution they receive.

A complementary strategy to structural BMPs complimentary approach involves managing developed areas in ways that limit the amount of pollution that is exposed to stormwater runoff. This action focuses on working with large landowners, including municipal facilities, golf course owners, hobby farm owners, and pond owners, to reduce the amount of NPS pollution they generate. Additional approaches for reducing NPS pollution for residential homeowners are discussed in strategy 7.

***Synergy*:** Because structural BMPs typically only remove a percentage of the pollution delivered, limiting pollution sources can further reduce pollutant loading.

***Warning*:** Because pollution from residential properties is so diffuse, it may be difficult to create meaningful incentive for homeowners to change their actions (see strategy 7).

Approach: During the existing conditions assessment (Chapter 2), several land use conditions were identified that likely play a role in generating nutrient and bacteria pollution in the watershed. These areas included golf courses, where large turf areas are heavily fertilized; unbuffered ponds and small impoundments, where geese colonize and non-native aquatic vegetation may be prevalent; and small hobby farms where livestock have unlimited access to streams.

Activities to address reduction of NPS pollution in these areas include the following:

- **Developing nutrient management plans for 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, avoid over-fertilizing areas that have adequate soil nutrients, time fertilizer treatments when they are less likely to runoff into streams, and select fertilizers that are less prone to washing off into streams. The practices can also result in cost savings for the course operators. Nutrient management planning also looks at opportunities to add shoreline and riparian vegetation to filter runoff from play areas that may contribute NPS pollution.
- **Developing nutrient management plans for hobby 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.
- **Improve small pond management by adding buffers**. Flocks of geese around small ponds can be locally significant often sources of nutrients and bacteria. Working with property owners to plant buffers along their ponds can deter geese while filtering polluted runoff.

4. Improve riparian habitats and protect undeveloped areas within the watershed

Riparian buffers, areas of natural vegetation immediately around a stream or waterbody, provide multiple benefits for streams including reducing stream temperatures, providing food inputs for aquatic organisms, and filtering pollutants. Planting riparian buffers along unbuffered areas can help to significantly reduce NPS pollution, particularly along stretches of stream adjacent to land uses that typically generate high pollutant loads, such as golf courses and farms. Multiple locations have been identified for potential riparian buffers (Appendix A).

While planting riparian buffers along unbuffered streams can reduce pollutant loads, protecting existing riparian buffers and other undeveloped lands is also critical for limiting the amount of new developed in the watershed, limiting the potential for further increases in NPS pollution and flooding, protecting critical habitats, and maintaining the scenic and recreational benefits of open space. Many of the remaining open space areas in the Five Mile River Watershed are unmanaged private properties that are at risk of development. Permanent conservation of these lands will be important to maintaining habitat values and may help to prevent further increases in flooding downstream. Once parcels are protected, management of invasive species and restoration of destabilized banks can improve habitat within the stream and the riparian forest.

There may also be some opportunities for increasing flood storage within parklands, utility rights-of-way, or otherwise undeveloped areas. Enhancing flood storage in these areas can be coupled with restoring riparian vegetation communities for maximum in-stream benefit. Where floodplain restoration work is not feasible, simple riparian buffers and planting may be a desirable alternative.

Synergy**:** Acquiring undeveloped lands adjacent to the river can also provide the beginnings of a connected greenway that will provide enhanced recreational opportunities and enhanced riparian habitats within the watershed.

Warning: Constructed wetlands and otherwise modified riparian areas may be controversial and require varying degrees of public outreach. Perspectives on this complex issue should be openly discussed with a goal of achieving a consensus policy among the community.

Approach: A number of specific riparian buffer projects have been proposed and are presented in Appendix A. Riparian buffer projects can also be incorporated into source control projects suggested in strategy 4 and homeowner outreach efforts outlined in strategy 7.

A feasibility analysis will assist in understanding the potential scope of specific floodplain restoration projects as a means to reduce flooding. Initial site walks conducted during this study suggest that opportunities for increasing flood storage along the Five Mile River will be limited, given the level of existing development and general lack of public properties.

Likewise, opportunities for conservation acquisition may be somewhat limited given the relative scarcity of undeveloped land. However, acquiring and protecting undeveloped tracts of forested lands in the upper reaches of the watershed should be a conservation priority. These lands provide the greatest concentration of high-quality upland and aquatic habitats and are critical for ensuring the health of sensitive headwater areas and drinking water supplies.

5. Identify and eliminate illicit discharges and improve solid and liquid waste management

Illicit discharges are unpermitted piped pollution sources typically associated with commercial and industrial facilities and leaking septic systems. Car washes, laundry or industrial facilities, and leaking septic systems are common culprits, but almost any residence or business could potentially be a source. Illicit Discharge Detection and Elimination (IDDE) programs (i.e., track-down programs) that combine water quality monitoring, outreach, and municipal enforcement have been effective methods to remediate potential impairments.

***Synergy*:** Septic system surveys and educational materials can be effectively combined with other homeowner outreach activities outlined in strategy 7.

***Warning*:** Because impairments are not well documented, it may be useful to establish baseline bacteria and nutrient conditions within the watershed before launching a full-scale IDDE program.

Approach: IDDE programs are typically implemented by municipalities. The process typically first involves conducting stream assessment to identify and document suspected illicit discharges and subsequently working with individual property owners to either eliminate the discharge or bringing the discharge into compliance with applicable regulations. Databases are useful for keeping track of suspected and confirmed illicit discharges and any activities that have been undertaken to eliminate or otherwise resolve the discharge. Many municipalities and state agencies have well developed IDDE programs and detailed guidance for developing IDDE programs is widely available on the internet.

Identifying and fixing leaking or otherwise malfunctioning septic system can be a challenge. Typically, the process involves first conducting a desktop inventory using existing data would help identify target areas in each municipality where poorly-functioning septic systems are likely to be a problem. Following this assessment, track-down water quality monitoring may be conducted to detect plumes and concentrated bacterial or nutrient impairments. Surveys can also be used to identify potentially malfunctioning systems. Educational and outreach programs can help homeowners take preventative steps and routine maintenance to prevent malfunction, recognize the signs of a malfunction, and understand the appropriate steps required to repair or replace faulty systems.

6. Reduce the frequency and severity of flooding

Intense stream-side development and high levels of urban development have led to recurring incidences of flooding in the mid- and lower watershed. These problems have been well documented. Stormwater management and LID practices identified in the Plan may be helpful to reduce flooding, although their effectiveness may be limited in reducing the intensity of large floods. In addition, culvert and bridge modifications have been recommended to reduce surface elevations in identified flood-prone neighborhoods (Milone & MacBroom 2010). Additional flood mitigation initiatives may include flood proofing, voluntary buy-outs of properties with repeated flood insurance claims, structural measures such as levees and berms, and creating additional flood storage within open spaces located in floodplain areas.

Synergy: Some reduction in flooding frequency will occur as an ancillary benefit of implementing many of the multiple NPS management actions proposed in the Plan. These include riparian restoration, structural BMPs that emphasize storage and infiltration, and LID planning.

Warning: Structural BMPs designed for channel protection and improved water quality may require additional space and different design elements provide a flood control function.

Approach: It is important to emphasize that this Plan is not intended to offer a comprehensive flood mitigation strategy for the Five Mile River. However, strategically located structural BMPs implemented to reduce pollutant loading may also be useful to improve flooding conditions. Specifically, a detailed assessment is recommended for potential restoration work in the Mill Pond area, possibly coupled with widespread implementation of structural BMPs and LID policies in downtown New Canaan. Extensive modeling has already been conducted in this area (Milone & MacBroom 2010), so modeling for proposed management actions may be relatively straightforward.

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

Promoting healthy attitudes toward stewardship and general property management is a critical step toward improving overall watershed health. Educational materials can focus on helping both private citizens and public officials become 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; management of small ponds and 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 gray-to-green 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.

Synergy: A "neighborhood-by-neighborhood" approach to stewardship may be helpful both to create localized improvement and to spur a sense of participation and civic engagement. Education and outreach programs can be combined with nearby demonstration projects 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."

Approach: A detailed plan for incorporating education and outreach activities into Plan implementation is provided in Chapter 7. This Plan 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. The education and outreach plan also stresses the use of multiple media forms to multiple audiences and creating a brand image using logos and consistent graphic styles.

8. Implement a water quality monitoring program

The Plan outlines specific steps that, based on prior experience and best science, are likely to result in significant stream and watershed improvements. As stakeholders work to implement the Plan, feedback on whether the Plan is working is critical. Using a process termed "adaptive management," water quality monitoring provides critical information concerning what management actions are working, and allows for adjustments to the Plan in ways that improve outcomes. Monitoring data can also be effectively used as an outreach tool for attracting additional funding.

Synergy: Visual assessments and water quality sample collection are excellent opportunities to involve volunteers and streamside residents. As volunteers take an active role in stewardship, their awareness of related watershed issues will increase.

Warning: Monitoring programs can be time-intensive, and may require extensive training, expensive equipment or technical expertise. Sharing monitoring equipment with other nearby watershed programs may help to reduce costs.

Approach: A detailed monitoring and maintenance plan is provided in Chapter 9 of the Plan. This section of the Plan details three related monitoring programs. First, a routine monitoring program is proposed to evaluate in-stream conditions through water quality and aquatic macroinvertebrate sampling and habitat assessments. Routine monitoring is conducted at a fixed station throughout the watershed on an annual or biannual basis. In addition to routine monitoring, an early warning monitoring program is proposed to detect changes in sensitive high-quality streams. The early warning monitoring program primarily involves looking for small, headwater changes such as increases in bank erosion and stream temperature, which may indicate urban development is affecting these sensitive areas. Chapter 9 includes a plan for monitoring structural BMPs to ensure their continued function.

Chapter 6 PLAN IMPLEMENTATION

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," to implementing the Plan. 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 projects 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 15 lists the management actions associated with each management strategy; suggests parties responsible for implementing the 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 in sensitive areas and those that generate significant NPS pollution. Of the 16 subwatersheds in the greater Five Mile River Watershed, six were targeted for implementation efforts based on the ranking method described below. These six subwatersheds included areas that drain to small headwaters, drinking water source areas, and portions of the Main Stem with the highest per unit area pollution loading. Three additional subwatersheds were added based on poor habitat condition or "areas of friction" observed during the existing conditions analysis (Chapter 2).

The targeting method incorporated two factors 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.

A total score for each of the 16 subwatersheds was calculated 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 13. Table 14 presents scores for each subwatershed.

Table 13. 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 1.9 lb/ac/yr	1.9 to 10.0 lb/ac/yr	Greater than 10.0 lb/ac/yr
Particulate P Loading	Less than 2.0 lb/ac/yr	2.0 to 3.9 lb/ac/yr	Greater than 3.9 lb/ac/yr
TSS Loading	Less than 500 lb/ac/yr	500 to 700 lb/ac/yr	Greater than 700 lb/ac/yr
Indicator Bacteria Loading	Less than 240 billion cfu/ac/yr	240 to 400 billion cfu/ac/yr	Greater than 400 billion cfu/ac/yr

IDENTIFIED TARGET SUBWATERSHEDS

The nine identified target subwatershed are depicted graphically in Figure 11. These include the six subwatersheds with the highest combined sensitivity and impairment scores (4, 8, 13, 14, 101, and 102). Three additional subwatersheds were included as target watersheds:

- *Subwatershed 11*—During the existing conditions analysis, observed conditions in subwatershed 11 were found to be significantly poorer than expected.
- *Subwatershed 12*—During field assessment efforts in subwatershed 11, conditions in the adjacent subwatershed 12 were observed and found to be poorer than expected.
- *Subwatershed 1 (Keeler's Brook)*—Keeler's Brook was included as a target subwatershed because it was identified by stakeholders as a problem area.

IDENTIFIED MANAGEMENT ACTIONS

The Plan proposes a series of management actions, which include the development of structural and non-structural BMPs (discussed below), implemented through a variety of monitoring and education/outreach programs, as well as broader policy initiatives. Management actions (Table 15) 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 Plan support multiple goals. This integrated approach acknowledges that the management goals identified in the Plan are related to one another and that implementation actions often have multiple benefits. In addition to providing a brief description of the management action, Table 15 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 15 also recommends organizations that would be well suited to implement each of the management actions, including a range of state, municipal, and NGO partners. Organizations were identified for implementation activities based on their legal authority, mission, and/or prior work in similar areas.

Table 14. Subwatershed Targeting Scores

Metric Ranking

Importance rank (IR)*	1	2	3	5.5	5.5	5.5	5.5
Normalized rank**	0.25	0.21	0.18	0.09	0.09	0.09	0.09

Subwatershed Scoring

Subwatershed	Drinking Water Source	Stream Order	Impervious Cover Score	NO_3 Contribution	Particulate P Contribution	TSS Contribution	Indicator Bacteria Contribution	Overall Score
4 (Holy Ghost Father's Brook)	0.25	0.642	0.537	0.267	0.089	0.089	0.267	2.141
101 (Lower Main Stem)	0.25	0.642	0.537	0.267	0.089	0.089	0.267	2.141
14 (Headwaters)	0.75	0.428	0.179	0.178	0.178	0.267	0.089	2.069
13	0.75	0.642	0.179	0.089	0.178	0.089	0.089	2.016
102 (New Canaan Center)	0.25	0.214	0.537	0.178	0.267	0.267	0.267	1.98
8	0.25	0.428	0.358	0.178	0.267	0.267	0.178	1.926
9	0.25	0.428	0.358	0.178	0.267	0.267	0.178	1.926
6	0.25	0.214	0.537	0.178	0.178	0.178	0.267	1.837
1	0.25	0.642	0.179	0.178	0.178	0.178	0.267	1.802
11	0.25	0.428	0.358	0.089	0.267	0.267	0.089	1.783
3	0.25	0.214	0.537	0.267	0.089	0.089	0.267	1.713
103 (Father Peter's Brook)	0.25	0.214	0.537	0.267	0.178	0.089	0.267	1.658
7	0.25	0.214	0.358	0.089	0.267	0.267	0.178	1.623
2	0.25	0.428	0.179	0.267	0.089	0.089	0.267	1.534
5	0.25	0.214	0.358	0.089	0.089	0.089	0.089	1.357
12	0.25	0.214	0.179	0.089	0.178	0.267	0.178	1.355

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

metrics with equivalent importance are assigned an average importance rank

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

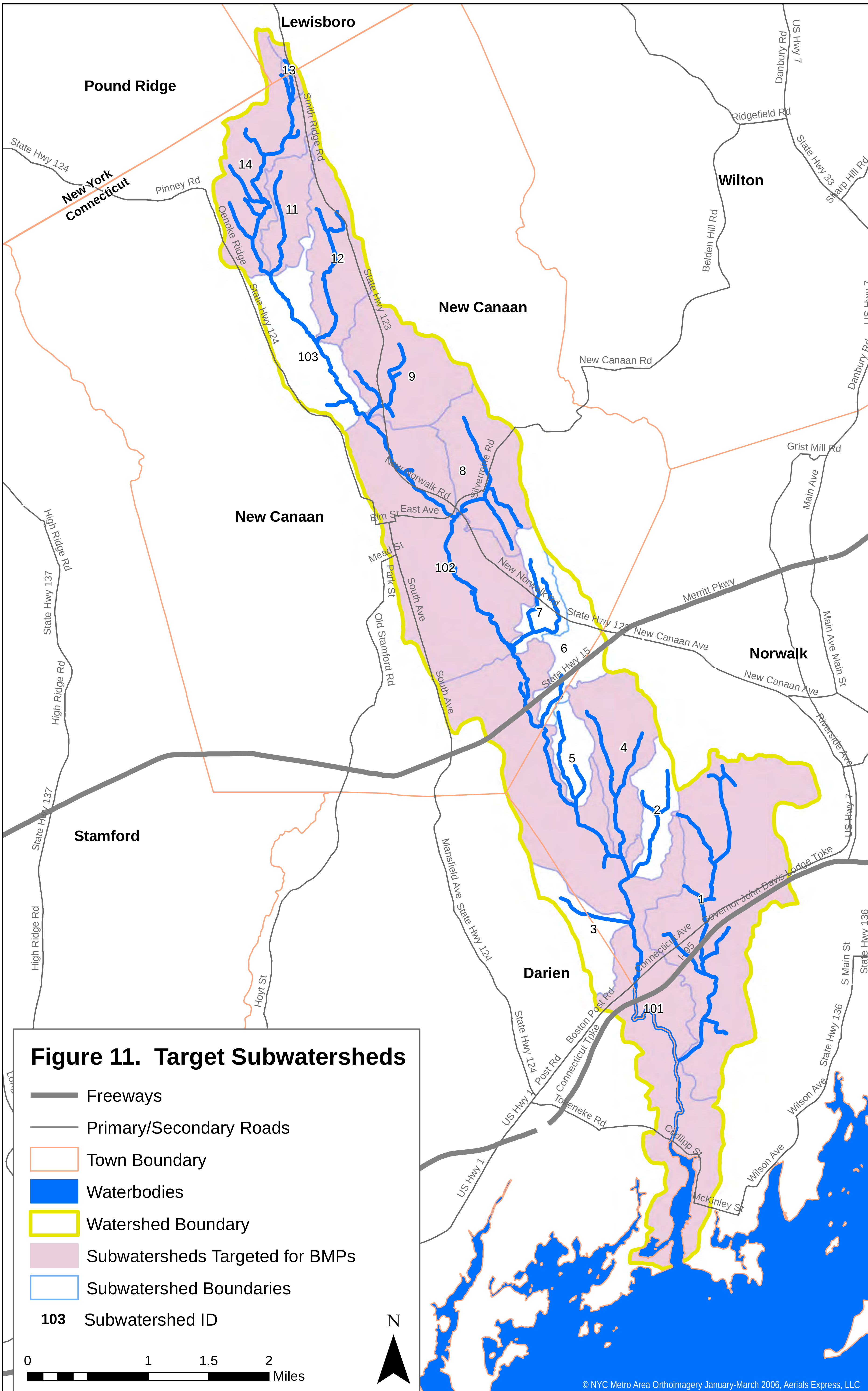


Figure 11. Target Subwatersheds

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS: Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	PARTICIPATING ORGANIZATIONS: Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
1. Avoid future increases in stormwater related impacts through adoption of low impact development policies																						
1.1	Review existing land use regulations and standards to identify barriers to implementation of LID elements, and modify municipal regulations to promote LID watershed-wide.	x						x			x	x	x							Pilot (1-5 yrs)	Year 1: Determine code sections for comparison (setbacks, buffers, lot size/density, street width, parking lot size, stormwater management, LID provisions, etc.; Year 2: Review code for Darien, New Canaan and Norwalk; Year 3: Complete evaluation; Year 4-5: Modify municipal regulations as needed to encourage density, limit new impervious areas, and create incentive for retrofits.	Number of watershed municipalities evaluated/implementing controls (target = 3)
1.2	Identify medium to high density residential areas that can be targeted for roof leader disconnection/rain barrel program.	x			x			x			x	x	x							Pilot (1-5 yrs)	Year 1-3: Evaluate zoning and property records in Norwalk, New Canaan, and Darien; Year 4-5: Track programs implemented by subwatershed.	Acres of watershed evaluated; Number of properties disconnected/rain barrels installed.
1.3	Promote reduction of rooftop runoff with residential BMPs/rain barrel/disconnection program development (see 7.3, 7.10).	x			x	x		x	x		x	x	x							Pilot (1-5 yrs)	Year 1: Define goals and strategies of residential BMP program and secure funding; Year 2: Purchase pilot rain barrels, and initiate outreach to owners of the 100 largest homes (by footprint); Year 3-4: Create incentive program and expand outreach to all homeowners in a single subwatershed; Year 5: Install 50 or more BMPS within a target subwatershed, and begin to expand the program to additional target subwatersheds.	Numbers of residential BMPs installed.
1.4	Promote "green streets" through the use of bioretention practices along state and local roads.	x					x				x	x	x			x				Mid-term (5-10 yrs)	Create an inventory of degraded roadside wetlands in the watershed, and present to DOT; Conduct a drive-through assessment of roadside sites for proposed bioretention (aerials may not be useful); Partner with DOT to establish guidelines for new roads and maintenance/repair of existing roads.	Acres of the watershed assessed for new bioretention; Number of roadside wetlands surveyed.
1.5	Create a model LID ordinance to promote LID practices watershed-wide.	x			x						x	x	x						x	Mid-term (5-10 yrs)	Outline consistent approach to MS4 compliance for watershed municipalities; Establish minimum stormwater and LID controls, including controls for water quality and channel protection; Design ordinance to require some or all of the following: tree mitigation, limited road widths and parking space sizes, flexible set backs/cluster incentives, limited development on steep slopes, and conservation design criteria (for siting, clearing, and earthwork practices).	% MS4 compliance; % adoption of ordinance.
1.6	Incorporate LID into municipal improvement projects and 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.

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS: Enhance stormwater management	MANAGEMENT GOALS: Improve water quality	MANAGEMENT GOALS: Protect and enhance wildlife habitat	MANAGEMENT GOALS: Increase awareness and stewardship	PARTICIPATING ORGANIZATIONS: Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
1.7	Encourage LID practices for all new development and major renovations to ensure no net increase in runoff, with special attention to headwaters and tributary streams.	x									x	x	x						x	Long term (10-20 yrs)	Establish water quality volume and minimum disturbance criteria for residential and non-residential development; Establish design criteria using CTDEEP's Stormwater Design Manual as a starting point; Build support for increased regulations at the municipal level; Direct the the most stringent controls at headwater regions (subwatersheds 13 and 14) and small tributary subwatersheds draining to the Main Stem.	Number of watershed municipalities implementing controls (target = 3).
1.8	Encourage progressive, watershed-friendly zoning and development ordinances	x	x	x							x	x	x			x				Long term (10-20 yrs)	Emphasize clustered, transit-oriented development patterns through zoning alterations; Advocate for improved public transit options in targeted downtown areas where feasible; Implement requirements consistent with the model ordinance described above (see 1.5).	Number of watershed municipalities that update zoning (target = 3).

2. Reduce nonpoint source pollution, peak flow rates, channel erosion, and flow stress through implementation of structural BMPs in developed areas

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
2.1	Implement 1-2 surface storage BMPs identified in subwatershed 102 (New Canaan Center).	x										x								Pilot (1-5 yrs)	Year 1: Select BMP sites and obtain letters of support from property owners and agencies; Year 2: Obtain funding and initiate permitting; Year 3: Select consultant and complete detailed design; Year 4: Complete construction and permitting; Year 5: Conduct monitoring at inflow and outflow points, and evaluate functionality.	Acres of impervious area managed; Modeled N, P, TSS, and bacteria load reduction.
2.2	Implement one or more basin retrofit BMPs identified in subwatersheds 101 (Lower Main Stem) or 102 (New Canaan Center).	x									x	x								Pilot (1-5 yrs)	Year 1: Obtain letters of support from property owners and agencies; Year 2: Obtain funding and initiate permitting; Year 3: Select consultant and complete detailed design; Year 4: Complete construction and permitting; Year 5: Conduct monitoring at basin inflow and outflow points, and evaluate functionality.	Acres of impervious area managed; Modeled N, P, TSS, and bacteria load reduction.
2.3	Develop an inventory of publicly-owned lands suitable for implementation of structural BMPs.	x					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 3-5: Develop costs for each proposed BMP, and prioritize by cost per square foot of impervious managed.	Number of properties assessed; Feasibility of proposed BMPs.
2.4	Implement remaining identified BMPs, and assess potential for additional BMP sites.	x									x	x	x							Mid-term (5-10 yrs)	Obtain additional funding; Implement BMPs in subwatershed 102 (New Canaan center), subwatershed 1 (Keeler's Brook), and subwatershed 101 (Lower Main Stem).	Acres of impervious area managed; Modeled N, P, TSS, and bacteria load reduction.

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS: Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	PARTICIPATING ORGANIZATIONS: Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
2.5	Identify and implement additional BMPs focused in targeted subwatersheds or areas draining to impaired stream segments.	x									x	x	x							Long term (10-20 yrs)	Obtain additional funding; Implement BMPs in additional target subwatersheds (8, 11, 12, 13, 14).	Acres of impervious area managed; Modeled N, P, TSS, and bacteria load reduction.
3. Limit nutrient and bacteria sources from large properties																						
3.1	Limit the use of fertilizers on municipal property (see 7.5).			x							x	x	x							Pilot (1-5 yrs)	Year 1: Conduct soil tests at all municipally-maintained green space; Year 2: Based on test results, establish minimum/maximum quantities of fertilizers to be used at each site, and incorporate into existing maintenance plan; Year 3-5: Train program managers and landscape staff to implement the new fertilizer targets.	Total reduction in annual N and P inputs (lb/yr).
3.2	Develop pet waste management program for public recreation sites.				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.
3.3	Significantly reduce nesting populations of non-migratory Canada 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 2-5: 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.
3.4	Limit overuse of fertilizers and encourage stream buffers on golf courses and other large turf areas (see 7.10).	x	x	x	x	x		x	x	x	x	x	x							Mid-term (5-10 yrs)	Conduct outreach and obtain owner permission to address nutrient and bacteria loading (see action 7.10); Conduct soil testing to determine how much fertilizer is required; Develop nutrient management plan to prescribe quantities of each type of fertilizer; establish low buffer plantings to filter runoff and limit colonization by non-migratory Canada geese.	Number of properties committed to improving management techniques; Estimated N, P, and bacteria load reductions.

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS: Enhance stormwater management	MANAGEMENT GOALS: Improve water quality	MANAGEMENT GOALS: Protect and enhance wildlife habitat	MANAGEMENT GOALS: Increase awareness and stewardship	PARTICIPATING ORGANIZATIONS: Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
3.5	Encourage sustainable management at small farms.	x	x	x	x	x		x	x	x	x	x	x							Mid-term (5-10 yrs)	Conduct outreach and obtain owner permission to address nutrient and bacteria loading (see action 7.10); Advocate for alternative management techniques to improve manure management, limit livestock access to streams, and promote the adoption of buffers wherever feasible.	Number of properties committed to improving management techniques; Estimated N, P, and bacteria load reductions.
3.6	Encourage better management of small ponds and impoundments.	x	x	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 7.3); 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.
4. Improve riparian habitats and protect undeveloped areas within the watershed																						
4.1	Determine feasibility of bank restoration/storage projects from Riverbank Ct. upstream to crossing with Lambert Rd.			x			x					x						x		Pilot (1-5 yrs)	Year 1: Obtain funding and project feasibility evaluations; Year 2: Select consultant and complete field work; Year 3: Complete modeling; Year 4: Pending feasibility, complete detailed design and initiate permitting; Year 5: Complete construction and permitting.	Modeled decrease in water surface elevations; Acres of riparian habitat restored.
4.2	Determine feasibility of bank storage/floodplain reconnection just below the Merritt Parkway, and in the area surrounding Millard Pond.			x			x				x							x		Pilot (1-5 yrs)	Year 1: Obtain funding and project feasibility evaluations; Year 2: Select consultant and complete field work; Year 3: Complete modeling; Year 4: Pending feasibility, complete detailed design and initiate permitting; Year 5: Complete construction and permitting.	Modeled decrease in water surface elevations; Acres of riparian habitat restored.
4.3	Establish buffers at identified sites (Oak Hills Golf Course, Ledgebrook Condominiums, Puddin Hill Road).	x		x							x	x								Pilot (1-5 yrs)	Year 1: Obtain letters of support from landowners, and establish permitting/design needs, and secure funding; Sample downstream water quality for bacteria; Year 2: Select consultant, as necessary, and complete design; Year 3: Complete construction; Year 4-5: Monitor water quality and goose populations, and complete analysis.	Total area of buffers established; Estimated N, P, and bacteria load reductions.
4.4	Identify opportunities for acquisition and preservation of open space, especially undeveloped land adjacent to the river or within the 100 year floodplain.	x		x			x				x	x	x	x			x			Pilot (1-5 yrs)	Year 1: Create GIS database with all known undeveloped parcels adjacent to the river or within the 100 year floodplain; Year 2: Prioritize parcels based on location, current ownership, cost, and feasibility; Year 3-5: Reach out to property owners and arrange for easements or purchases.	Acres of preserved property adjacent to the stream.

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS				PARTICIPATING ORGANIZATIONS														SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
		Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO			
4.5	Maximize adoption of minimum buffers on remaining private properties.	x	x	x	x						x	x	x							Mid-term (5-10 yrs)	Create GIS database with all known unbuffered segments and prioritize buffers based on indicator bacteria load reductions; Implement outreach campaign for streamside homeowners to encourage volunteer projects (see 7.11); 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.

5. Identify and eliminate illicit discharges and improve solid and liquid waste management

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO	SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
5.1	Implement a watershed wide Illicit Discharge Detection and Elimination program.		x								x	x	x							Pilot (1-5 yrs)	Year 1: Create a storm system map; Year 2: Create an ordinance prohibiting illicit discharges, and a plan for detection; Year 3-5: Implement detection plan, with special attention to industrial facilities, car washes, dump sites, laundromats, and ageing residential properties (septics)	Number of watershed municipalities implementing plan (target = 3).
5.2	Secure funding for 'track-down' water quality monitoring efforts (see 8.2).		x			x	x				x	x	x							Pilot (1-5 yrs)	Year 1: Secure funding; Year 2: Secure field staff and equipment, and begin dry-weather reconnaissance at outfalls; Year 3: Complete outfall reconnaissance; Year 4-5: Conduct in-stream dry weather sampling for bacteria and nutrients (additional sensing equipment may be needed at sites where a septic plume is found).	Number of sites sampled; Quantity of funding secured; Number of man-hours spent tracking down impairments.
5.3	Develop an outreach program to publicize and promote proper septic maintenance and use (see 7.3).		x			x	x				x	x	x							Pilot (1-5 yrs)	Year 1: Establish goals, target audience, content, and schedule; Year 2: Require mandatory septic inspections for all deed transfers; 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.
5.4	Conduct an inventory of areas in each municipality where the greatest potential for poorly functioning onsite septic systems exists.		x								x	x	x							Pilot (1-5 yrs)	Year 1-3: 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 4-5: Conduct targeted visual assessment during stream walks to ID failing systems.	Number of subwatersheds assessed.
5.5	Assess contribution of leaking septics to overall bacteria load, and develop a mitigation plan (see 5.1, 5.3, 5.4).		x			x		x			x	x	x							Mid-term (5-10 yrs)	Following the analysis outlined in action 5.4, conduct water quality monitoring in stream reaches near properties with a high likelihood of septic failure; Compare bacteria concentrations at these sites against concentrations taken in areas with a low likelihood of failure.	Number of parcels assessed.

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS				PARTICIPATING ORGANIZATIONS														SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
		Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO			
5.6	Implement a septic inspection and maintenance program.		x								x	x	x							Mid-term (5-10 yrs)	Implement leaking septic mitigation plan established during the pilot phase (3.3) through outreach, enhanced inspections, and/or incentive/cost share programs; Establish a municipal monitoring program for all residential and commercial properties.	Number of failing systems identified and replaced; Estimated N, P, and bacteria load reductions.
6. Reduce the frequency and severity of flooding																						
6.1	Building on the 2010 Milone & MacBroom report, develop additional structural BMP alternatives to decrease flooding in the Town of New Canaan and the Mill Pond area.	x										x								Pilot (1-5 yrs)	Year 1: Obtain funding; Year 2: Review existing plans, determine objectives, and select consultant to conduct analysis; Year 3-5: Complete BMP feasibility assessments with full hydraulic and hydrologic analysis for New Canaan's downtown district and the Mill Pond drainage area.	Acres of watershed assessed.
6.2	Building on the 2010 Milone & MacBroom report, conduct a similar analysis for the Five Mile River below Meeting Grove Lane.	x									x									Pilot (1-5 yrs)	Year 1: Obtain funding; Year 2: Review existing plans, determine objectives, and select consultant to conduct analysis; Year 3: Complete field work and modeling; Year 4-5: Establish volume reduction requirements and estimated project costs.	Acres of watershed assessed.
6.3	Add culvert & bridge improvements at Nursery Road and the Merritt Parkway Bridge (Milone & MacBroom 2010).	x					x					x				x				Mid-term (5-10 yrs)	Determine project scope, funding, and oversight in partnership with CTDOT; secure project funding; Complete construction and final permitting.	Modeled decrease (in ft.) in water surface elevations; Number of flood-related complaints following construction.
7. Encourage better stewardship of public and private lands by implementing education and outreach programs for homeowners and municipal officials																						
7.1	Identify appropriate areas for public access to the river that further conservation and awareness.				x		x			x	x	x	x	x			x			Pilot (1-5 yrs)	Year 1-2: Prioritize public park spaces adjacent to the river for use as "gateways" (Pinkney Park, Devil's Garden, Oak Hills Golf Course, Fox Run Open Space, Kiwanis Park, Mill Pond Park, New Canaan Country Club, New Canaan Reservoir property); Year 3-4: Identify and implement appropriate demonstration projects, signage, and events to promote conservation; Year 5: Address additional small park sites and private land for enhanced public access.	Number of river gateway sites designed; Number of audience members at ribbon cutting and other events; Estimated audience reached by promotional materials (press, television, radio).
7.2	Develop an intermunicipal partnership to implement the Plan, and hire a coordinator to assist with implementation.	x	x	x	x						x	x	x	x						Pilot (1-5 yrs)	Year 1: Establish a watershed compact or other Memorandum of Understanding (MOU) document to endorse watershed-wide planning efforts among the watershed municipalities; Year 2: Identify and obtain funding for a program coordinator; Year 3: Secure funding for programs and establish a regular schedule of meetings; Year 4-5: Implement pilot management actions.	Number of watershed municipalities represented by partnership (target = 3); Amount of funding secured for the watershed.

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS				PARTICIPATING ORGANIZATIONS														SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
		Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO			
7.3	Develop a series of workshops for homeowners, developers, engineers, land use attorneys, and golf course managers to encourage watershed-friendly landscape design and maintenance (see 1.3, 5.3, 7.10).		x	x	x			x		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.
7.4	Develop a training series for municipal officials to encourage LID strategies.		x	x	x					x	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 (New Canaan and Norwalk municipalities represented); Year 3-5: Develop additional workshop content and continue to schedule events (2 per year).	Number of events and audience reached.
7.5	Promote roadway and parking lot "good housekeeping" practices to Public Works, Parks Departments, and Boards of Education to maintain watershed friendly operations and practices (see also 3.1).				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, 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.
7.6	Engage volunteers in monitoring tasks.		x	x	x	x	x	x			x	x	x				x			Pilot (1-5 yrs)	Year 1-2: Conduct outreach to built volunteer support for monitoring efforts, and provide detailed training; Year 3-5: Deploy volunteers for grab sample collection and, where appropriate, visual inspections (maintain oversight and quality controls).	Hours of volunteer service secured; Number of volunteers.
7.7	Conduct email & social media campaigns to encourage stewardship of private property.				x					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); Year 3-5: Obtain web/social marketing consultant to develop graphics, refine message, and deploy campaigns.	Number of watershed citizens reached.
7.8	Develop a public service announcement for local radio and television stations				x			x			x	x	x	x						Pilot (1-5 yrs)	Year 1: Define message (target to address specific actionable goals, e.g. fertilizer use, pet waste, rain barrels, etc.); Year 2: Partner with local businesses to sponsor the announcement, and with local radio and television stations to record and schedule.	Estimated audience reached.

Table 15. Implementation of Management Goals, Strategies, and Actions

MANAGEMENT STRATEGIES	MANAGEMENT ACTIONS	MANAGEMENT GOALS				PARTICIPATING ORGANIZATIONS														SCHEDULE	INTERIM MILESTONES	PERFORMANCE CRITERIA
		Enhance stormwater management	Improve water quality	Protect and enhance wildlife habitat	Increase awareness and stewardship	Harbor Watch/River Watch	CTDEEP	Trout Unlimited	West Norwalk Association	Southwest CT Conservation District	City of Norwalk	Town of New Canaan	Town of Darien	SNEW	UConn Cooperative Forestry Extension	CT Department of Transportation	Norwalk Land Trust	NRCS	UConn CLEAR & NEMO			
7.9	Organize and promote priority stream-side clean up efforts.		x	x	x	x		x	x		x	x	x							Pilot (1-5 yrs)	Year 1: Select cleanup sites in conjunction with multiple other projects (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.
7.10	Conduct personal outreach to the owners and managers of golf courses and small farms located within the watershed to promote improved nutrient management, stream buffers, and stabilization of any stream access points (see 3.4, 3.5).		x		x	x		x		x	x	x	x							Pilot (1-5 yrs)	Year 1: Select sites for outreach; Year 2: Produce two brochures, for golf course managers (information on stream buffers, soil testing, organic fertilizing practices, and goose management) and for managers of small farms (information on stream buffers, grazing practices, manure removal/covering, and goose management); Year 3-5: Partner with trusted community members to conduct personal outreach at select sites.	Number of properties committed to improving management techniques; Estimated N, P, and bacteria load reductions.
7.11	Foster a 'neighborhood-by-neighborhood' approach for restoration of stream reaches (see 7.1, 7.6, 7.9).	x	x	x	x	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, and bacteria load reductions.
8. Implement a water quality monitoring program																						
8.1	Identify and secure funding for continued water quality monitoring.	x	x	x		x	x				x	x	x							Pilot (1-5 yrs)	Year 1: Identify funding opportunities; Year 2: Establish monitoring program; Year 3-4: Expand baseline assessment to include additional variables as needed; Year 5: Analyze program results and determine further needs.	Number of sites monitored for habitat, bioindicators, bacteria, N, P, TSS, and additional constituents if necessary; Duration of monitoring program.
8.2	Develop a volunteer-driven monitoring program to establish baseline conditions and begin early warning monitoring in headwaters (see 5.2 and Chapter 9).		x			x		x		x										Pilot (1-5 yrs)	Year 1: Begin assessment of baseline conditions at recommended sites throughout the watershed; Year 2: Engage volunteer groups for continued monitoring; Year 3-4: Expand baseline assessment to include additional variables as needed; Year 5: Analyze program results and determine further needs.	Number of sites monitored for habitat, bioindicators, bacteria, N, P, TSS, and additional constituents if necessary; Consistency of method.
8.3	Expand monitoring to include additional sites as needed (see Chapter 9); maintain data online via a live-streaming map application.		x			x		x		x										Mid-term (5-10 yrs)	Select additional headwater streams and segments lower in the watershed for monitoring, as needed; Extend 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.

Emphasizing Best Management Practices

Whether it is 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 of the implementation plan involves putting in place BMPs that result in measurable reductions in NPS pollution. BMPs include a range of project types that reduce NPS pollution and other negative effects of unmanaged stormwater runoff. For the purposes of this Plan, BMPs are categorized as either structural or non-structural BMPs. Structural BMPs refer to physical, site-specific pollution reduction projects that include stormwater practices such as rain gardens, porous pavement, livestock fencing, and constructed wetlands as well as stream restoration and riparian buffering projects. Equally important, non-structural BMPs are changes in behavior that result in NPS pollution reduction and watershed improvements. These include reductions in fertilizer use, proper septic system maintenance, and proper disposal of pet waste.

As part of a NPS reduction plan, the management actions presented in Table 15 rely heavily on a broad range of structural and non-structural BMPs. In addition, 19 specific structural BMP projects are recommended and described in Chapter 7. 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 specific structural BMP projects.

Plan Phasing

Although full Plan implementation will likely require 20 or more years, the Plan emphasizes the use of interim milestones, including an initial five year pilot phase, to ensure consistent progress. The first five 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 a long-term approach. As early success is crucial, short-term programs with clearly defined objectives may have a higher likelihood of success. 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 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.

Pilot phase implementation activities may focus on one of the target subwatersheds outlined earlier in this chapter. Implementation of multiple management actions in a single subwatershed during the five year 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 more powerfully demonstrate the early success that is so critical for building momentum and attracting long term funding.

At the end of the five year implementation period, watershed partners should engage in a brief, focused, strategic planning process to outline the implementation plan for the next five year period.

During the five-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 may be established. Funding and monitoring goals should be clearly defined for the following 10 years, and refined metrics for measuring success should be put 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 project implementation is accelerated to reflect the gains in funding, capacity, technical “know how,” and project delivery during the first 10 years of implementation. Long-term management actions and strategies identified in the Plan are designed to be refined based on success 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 Plan 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 criteria are suggested generally 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 first five years have been defined (e.g., number of homes implementing rain barrels) though partners may feel free to adjust these targets based on their own resources and funding levels. Whether they adopt the targets set forth in the Plan or adjusted targets, partners should set realistic goals during the five year 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 five year pilot phase, management actions implemented in the watershed may be evaluated and priorities for the next five years should be established. Regular evaluations and updates of the Plan 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 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 practices such as green roofs have extremely high unit pollutant costs. On the other hand, simple projects such as riparian buffers, which require limited engineering, can be installed by volunteers without the use of heavy equipment and tend to have much lower unit costs. Appendix B presents a list of potential watershed funding sources.

Tables 16, 17, and 18 summarize pollutant load reductions associated with many of the management actions recommended in the Plan. Load reductions associated with management actions that remove pollutants at their source are typically presented as absolute values (amount of bacteria kept out of the stream per prevented septic failure, etc.) and are presented in Tables 16 and 17. 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 18. 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 18. General ranges for capital and operations and maintenance (O&M) costs for various BMP types are presented in Table 19.

Table 16. Unit Pollutant Load Reductions from Non-Structural Best Management Practices

	Annual Load Reduction[1]			
Pollution Source	TN (lb)	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 17. Grouped Pollutant Load Reductions from Non-Structural Best Management Practices

	Annual Load Reduction[1]			
Pollution Source	TN (lb)	TP (lb)	TSS (lb)	Indicator Bacteria (billion cfu)
Small flock of geese (10 geese)	120.5	106.8	N/A	26,600
100 people cleaning up after their dogs	672	88	N/A	40,880,000
10 homes conducting annual septic maintenance and repair	74.8	5.8	230.3	26,110,000
10 homes using ½ their normal amount of lawn fertilizer	188	3.8	N/A	N/A

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

Table 18. Pollutant Reduction Efficiencies of Structural Best Management Practices (updated from: NRWIC 2011[1])

BMP	Source[2]	Water quality performance - Percent reductions			
		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.)	29	26[3]	40[4]	40
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 is 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 19. 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
IDDE	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 disconnection3	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

Chapter 7 STRUCTURAL BEST MANAGEMENT PRACTICES

The management actions presented in Chapter 6 describe discrete steps required to the achieve Plan's management goals. Several of these management actions involve the design and construction of structural BMPs. This chapter identifies 19 structural BMPs that were identified and field vetted during the Plan development as potential first steps toward meeting the Plan's 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.

The structural BMPs described in this chapter do not represent an exhaustive list of project opportunities in the watershed. In fact, they probably represent a fairly small percentage of the total number of project opportunities in the Five Mile River Watershed. The structural BMPs identified do, however, represent some of the most compelling and cost effective opportunities that were identified during a formal desktop and field assessment process. 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 achieving measurable pollution reduction goals. However, most projects can be designed to provide for multiple benefits. 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 some signage, become highly visible demonstration sites. BMPs constructed at or near schools can be planted and maintained by students, providing a unique extension of typical earth sciences coursework. In this way, the BMPs proposed here can be implemented in conjunction with multiple 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 20, Figure 12) were identified within target subwatersheds through a process of desktop reconnaissance and field investigations. 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 6–8, 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.

New Canaan Structural Best Management Practice Concepts

Downtown New Canaan constitutes a large, developed area that eventually drains to the Main Stem of the Five Mile River near Mill Pond. Upstream of the downtown area, reports of flooding are limited, whereas downstream they are numerous. The downstream flooding problem highlights the need for improved stormwater management. Unfortunately, the downtown area is densely developed and has limited space for the type of large structural BMP often required for flood control. A structural BMP approach involving the use of multiple small BMPs in concert could improve water quality and possibly provide enough flood storage to improve the downstream flooding problem. Specifically, a series of structural BMPs including bioretention systems to manage stormwater from parking lots, small rain gardens, and "green streets" lined with planter boxes and tree trenches that manage stormwater could potentially offer enough combined flood storage to markedly improve flooding conditions downstream. While this project would involve a considerable investment, the flood control, town beautification, and water quality benefits could be substantial.

An alternative concept would involve the use of Mill Pond as a large-scale structural BMP. Topographic contours indicate that most of the downtown area drains regionally toward Mill Pond, which may be a better candidate than the downtown area for combined flood control/pollution reduction. The pond, which is located in line with the river, is currently impounded by a small dam. Wetlands adjacent to the pond have been visibly impacted by stormwater, particularly where outfall pipes from local developed areas discharge directly to the forest floor. Hydrologic analysis would be useful to determine what type of restoration, if any, would be useful to improve downstream conditions. Possible structural BMPs in the Mill Pond Area may include wetland and floodplain restoration, dam removal, and creation of additional flood storage.

Due to the considerable uncertainty associated with the concepts discussed above, load reductions and cost estimates have not been developed. The area is referred to as BMP Q in Table 20, and a feasibility study to further evaluate both the downtown and Mill Pond concepts is included in the management actions listed in Table 15.

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 planning-level cost to implement all of the 19 identified structural BMPs is estimated at approximately $3,905,000. Structural BMP cost is generally related to the size of the impervious drainage area and hence the amount of pollution managed by the practice; however, some practices tend to be more expensive to construct for the same pollutant reduction benefit. While costs and benefits of implementation may vary widely, the following structural BMPs represent relatively inexpensive opportunities based on planning-level cost estimates:

- Ledgebrook Condominiums Buffer ($5,000)
- River Park Swale Retrofit ($38,000)
- Avalon Apartments Basin Retrofit ($19,000)
- South Salem Park Bioretention ($25,000)
- Puddin Hill Road Estate ($4,000)

Table 20. Recommended Structural Best Management Practices

Subwatershed	BMP Name	BMP ID	BMP Type
1 (Keeler's Brook)	Colonial Village (NHA)	A	Naturalized surface storage basin
1 (Keeler's Brook)	Kendall Elementary School	B	Subsurface infiltration
1 (Keeler's Brook)	Oak Hills Park	C	Pocket wetlands, stream restoration, riparian buffer
1 (Keeler's Brook)	Ledgebrook Condominiums	D	Riparian buffer
101 (Lower Main Stem)	Costco/ Double Tree Inn	E	Retrofit existing storm water basin
101 (Lower Main Stem)	River Park	F	Retrofit surface storage swale
101 (Lower Main Stem)	Norwalk Community College	G	Naturalized surface storage basin
101 (Lower Main Stem)	Saint John's Cemetery	H	Naturalized surface storage basin
4 (Holy Ghost Father's Brook)	Fireside Ct. Cul-de-Sac	I	Bioretention
2 & 4 (Holy Ghost Father's Brook)	Fox Run Elementary School	J	2-3 naturalized surface storage basin or bioretention
102 (New Canaan Center)	Kiwanis Park	K	Naturalized surface storage basin
102 (New Canaan Center)	New Canaan YMCA	L	Naturalized surface storage basin
102 (New Canaan Center)	Saxe Middle School	M	Naturalized surface storage basin
102 (New Canaan Center)	Avalon Apartments	N	Retrofit surface storage basin
102 (New Canaan Center)	Smith Ridge Rd. Median	O	Naturalized surface storage basin
8	East Elementary School	P	Naturalized surface basin & bioretention
102 (New Canaan Center)	Mill Pond Park	Q	Wetland Restoration
13	South Salem Community Park	R	Bioretention
14 (Headwaters)	Estate at Puddin Hill Road	S	Riparian buffer

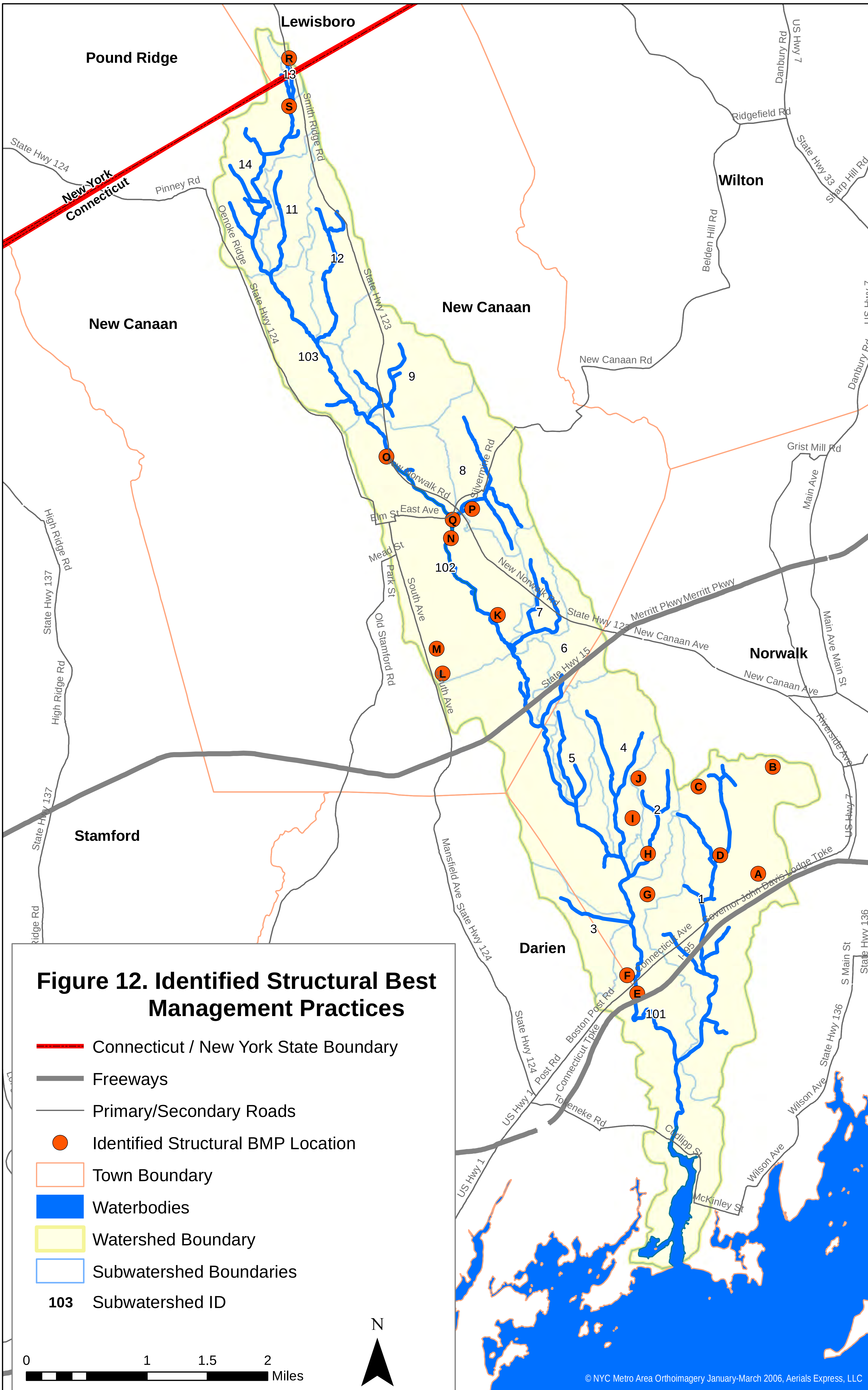


Figure 12. Identified Structural Best Management Practices

ESTIMATED POLLUTANT LOAD REDUCTIONS

Estimates of pollutant load reductions were developed for each of the 19 structural BMPs included in Appendix A. 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.

The WinSLAMM model was used to develop pollutant load reduction estimates for structural BMPs. As discussed in Chapter 2, this approach 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. A detailed description of the WinSLAMM model and the rationale for its use in this study is provided in Chapter 2. For purposes of this chapter, WinSLAMM includes the capability to model pollutant 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 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 of any project that is implemented, and pollution loading values updated accordingly.

Source areas within each drainage area (areas with similar land use and soil characteristics) were also delineated. A delineation of source areas is required by WinSLAMM as a data input. 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 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 estimated the pollutant loading without the structural BMP, while a second model included the pollutant reduction effect of the structural BMP. The difference between the “with structural BMP” and “without structural BMP” models was used to compute 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 project study of Spring Branch Stream in Baltimore County, MD (CBP 2006), were used to pollution reduction estimates for stream restoration BMPs. This study was selected for the following reasons:

- The study provided estimates of Total N (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 Five Mile 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. 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 19 structural BMPs identified in the Plan was 58,373 lb/yr of TSS, 216 lb/yr of particulate P, 666 lb/yr of NO_3, and 58,404 billion cfu/yr of indicator bacteria. Pollutant load reduction estimates varied widely by site and pollutant. BMP B, Kendall Elementary School, is expected to produce the greatest decrease in TSS loads. BMPs O and M, the Smith Ridge Road median and Saxe Middle School, are expected to have the largest particulate P and NO_3 reductions, respectively. Implementation of BMP J, Fox Run Elementary School, is expected to produce the greatest reduction in indicator bacteria. These sites provide a starting point for identification and implementation of similar structural BMPs throughout the watershed.

Estimated pollutant load reductions for the 19 structural BMPs were lower than the total (100 percent) load reduction target or the interim (60 percent) targets defined in Chapter 3. Reductions associated with the structural BMPs represent approximately one percent of the total target load reduction for both NO_3 and bacteria and approximately 13 percent and 21 percent of the total targets for particulate P and TSS, respectively (Table 21). These represent 2.1, 2.5, 21.3, and 33.6 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 in order to meet the goals of the Plan. For this reason, the Plan emphasizes an integrated approach to implementation using all of the varied management actions described in Table 15.

Table 21. Pollutant Reductions from Identified Structural Best Management Practices

Structural BMP Name	Runoff Volume (cf/yr)	TSS (lb/yr)	P (lb/yr)	N (lb/yr)	Indicator Bacteria (billion cfu/yr)
1. Colonial Village; NHA	227,327	2,008	8.89	79.86	4,073
2. Kendall Elementary School	1,225,489	8,114	33.42	0	0
3. Oak Hills Park	195,227	3,769	3.22[1]	8.75[1]	3,545
4. Ledgebrook Condominiums	538,783	1,687	1.25	21.29	6,695
5. Costco	153,580	6,379	17.92	1.68	541
6. River Park	216,796	2,185	4.84	7.14	5,239
7. Norwalk Community College	170,883	3,796	7.84	3.23	2,172
8. St. John's Cemetery	123,150	1,761	7.3	26.3	1,081
9. Fireside Ct. Cul-de-Sac	112,291	793	3.11	21.11	1,808
10. Fox Run Elementary School	529,783	2,866	9.67	19.91	8,301
11. Kiwanis Park	220,977	2,570	8.09	65.88	3,380
12. New Canaan YMCA	164,320	2,121	8.7	21.12	885
13. Saxe Middle School	675,060	5,797	25.75	198.81	7,295
14. Avalon Apartments	35,436	568	1.72	10.16	266
15. Smith Ridge Rd. Median	758,473	7,502	38.35	160.26	6,134
16. East Elementary School	426,965	2,739	9.42	14.28	5,363
17. Mill Pond Park[2]	NA	NA	NA	NA	NA
18. South Salem Community Park	47,157	486	1.51	1.69	1,167
19. Estate at Puddin Hill Road	54,267	3,232	25.28	4.35	461
All Watershed Projects	**5,875,963**	**58,373**	**216.28**	**665.81**	**58,404**

[1] Nutrient load reduction due to stream restoration: TP (lb/yr) = 2.5; TN (lb/yr) = 14.0
[2] This BMP could not be modeled in WinSLAMM due to scale and scope of potential retrofit. A full hydrologic and hydraulic analysis is required to determine pollution reduction benefits.

Community engagement, outreach, and education are essential components of Plan 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. An effective outreach and education plan establishes the connection between water quality issues and residents' quality of life. It can inform 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 practices, such as constructed wetlands, can be effective where space permits, but in many watersheds dominated by residential land use, opportunities to build large practices are limited. Under current law, municipalities and state agencies do not have statutory authority to mandate pollution reduction projects on privately owned properties. Thus, inspiring residents and municipal officials to voluntarily implement practices 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 interested 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). These metrics may be difficult to measure and may require close partnership between advocates, local business, residents, and municipal officials.

Creating a Media Brand

Many times, small community organizations launch targeted 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 as legitimate and trustworthy 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 (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 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 present a worse image to the pubic than no logo at all.

MEDIA FORMATS

Some media formats will be better suited to a certain message, and will 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 monitoring programs, trail maintenance crews, and stream cleanups offer the opportunity to combine education and networking. 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 messages is considered a wise practice. 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.

It should be noted that events tend to attract audience members that already have an interest in or affinity for the area. Where interest is limited, attendance can be poor, particularly among young people and parents with young children. 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), 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, are all effective methods for increasing participation levels.

Websites

A web presence is important for any effective outreach campaign. At best, a well-designed website simultaneously serves as a source of information, enforces 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 using Google Maps functions. 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. The press kit is usually a simple link that can be distributed with press releases or queries to television or radio stations. The press kit page may 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 disk.

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 also offer the opportunity 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, humorous, or genuinely useful material is crucial to the success of this type of campaign. An effective social media campaign will (a) provide content that users choose to receive, and (b) publicize content by creating an active, reciprocal relationship with the audience.

Depending on the message, some sites may be more appropriate than others. 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 length, images, and audience.

It is important to note that over-reliance on social media may exclude groups that do not actively use these media outlets for information. 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 might 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 (NPR) 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 influence owners of large properties (e.g., golf courses, municipal departments, industrial facilities, and tracts of open space, etc.). However, it is partially dependent on existing relationships within the community, and may be counterproductive if an appropriate 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 to create a sense of momentum.

OUTREACH AND EDUCATION GOALS

In the Five Mile River Watershed, outreach and education activities should support the goals established in the Plan. Activities should be aimed at increasing awareness and stewardship of watershed issues, establishing the link between one's 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 may be tailored to the major audiences in the watershed, including: municipal officials, residents, and business owners.

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

- **Municipal investment in LID practices** 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 maintenance practices** improve water quality, provide 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, bacteria) into 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 Five Mile 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 build LID practices on public property and in the public right-of-way. Outreach and education efforts should focus on:

- Communicating the wide-ranging benefits (enhanced aesthetics, educational benefit, etc.) of LID 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. Educational workshops can help officials overcome their initial concerns. Photos and success stories about other LID programs can help to ease the fear of early adoption. 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: LID practices 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 LIS.

Existing Programs and Opportunities for Partnership: There are currently no LID outreach programs underway in the Five Mile River Watershed; however, extensive training documentation and case studies are available through the CTDEEP website (ct.gov/dep) and CT NEMO program (nemo.uconn.edu).

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 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 Five Mile 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 a very 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 Five Mile 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 plantings lists; and
- Emphasizing the benefits of riparian buffers in improving property values, property beautification, and reductions in property maintenance.

Select volunteer homeowners for a riparian buffer design charette working with a partner organization such as a well-known landscape contractor or landscape architect. These professionals can work with the volunteers to select plantings and accessibility options that mediate the owner's needs with the need for riparian buffer placement. Send out invitations to all streamside homeowners and present the results at a community meeting. Concurrently, it may be helpful to create a sense of community among streamside owners using online media and other social events. As a privileged group of individuals, these owners may also be more likely to share a sense of stewardship for their common resource.

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. Partnership 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.

Media Format: Workshops and volunteer/recreational events may be 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).

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 property make up a large portion of the total 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, as well as over or improper fertilization seem to be the most 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 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 reduce your operating costs.

Messaging for individual campaigns is best when it is simple and compelling and focused on asking audience members to change one behavior (e.g., overfertilizing wastes your money and harms local streams; get a soil test before fertilizing your lawn this year). Messaging directed landscape professionals may take the form of professional training and personal outreach (calls, e-mails, or visits by members of garden clubs or other community organizations). If possible, training sessions should leverage continuing education credits or offer some kind of alternate form of recognition for participants. Messaging may be 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: The Norwalk, New Canaan, and Darien 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 partnerships.

Media Format: A wide variety of media formats and approaches can be used to advocate 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 approaches to print media.

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 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

Bacterial impairments have been documented in the Five Mile River Watershed. Pet waste represents a small but manageable source of the overall bacterial load. While solutions are simple and inexpensive—cleaning up after pets—the challenge for advocates lies in reaching the multitude of dog 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.

Small hobby 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 may be encouraged to cover manure when possible, and either compost responsibly or have it hauled offsite. Since there are relatively few hobby farms in the watershed, outreach may take the form of site visits and letters.

Target Audience: Pet and property owners; farm managers.

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

Existing Programs and Opportunities for Partnership: Bacteria monitoring through the Harbor Watch/River Watch program may be helpful for both acquiring data and involving local community members 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 for your plants and help the environment by reducing water use and 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 may employ a range of commercial media including local news and radio, promotional videos, a website, and extensive publicity via social media. One to two workshops should be offered for interested residents.

Inspection and Maintenance of Residential Septic Systems

Failing septic systems on residential property can cause significant loading of nutrients and bacteria, either as discharges when the system fails, or as slow leaching from old, inefficient systems. Adverse effects to water quality are typical become more severe for properties that are located close to the stream. Since septic failure or potential failure rates can be difficult to quantify, preventative measures including homeowner education may be the best way to manage this 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 have periodic inspections of their septic system to ensure proper functioning,
- Common signs of malfunctioning septic systems,
- 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 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 detect signs and impacts from leaking septic systems will be more likely to manage their own systems correctly, and will self-police among the community. In addition, neighborhoods draining to streams identified as having potential septic plumes should be targeted for outreach efforts.

Target Audience: Homeowners.

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

Existing Programs and Opportunities for Partnership: The Weston Westport Health District contains general information, brochures, outreach materials and a "mocumentary" on septic systems (www.wwhd.org/septic.html). The Harbor Watch/River Watch monitoring program can help train neighbors to sample for bacteria near their homes.

Media Format: Flyers and brochures may be distributed at community meetings, at property transfers/sales, and within municipal mailings or newsletters. Articles on septic care can be published within local newspapers or other print media and posted on municipal websites.

Targeted workshops may 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 way to publicize events.

Open Space Preservation

An effective method of preserving water quality, open space preservation can also be difficult to implement. In the Five Mile 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 development interests. 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 open space preservation through donations to local land trusts, conservation easements, or by preserving your own property.

Existing Programs and Opportunities for Partnership: The Norwalk Land Trust acquires properties, facilitates easements, and hosts stewardship events and an "outdoor classroom" for elementary school children.

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 plan enables stakeholders to evaluate the results of management actions and assess progress towards meeting the management goals outlined in the Plan. 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 Plan:

- 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 Plan 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 (e.g., 1- to 5-square-mile) subwatershed outlets rather than exclusively at the outlet to the main stem. 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 be easily taught and tested. For example, the CTDEEP's Rapid Bioassessment by Volunteers (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 to be handled by volunteers:

- Collection of water quality grab samples;
- Kick-net sampling for macroinvertebrates;
- Operating a flow meter during storm events;
- Temperature monitoring;
- Partial visual assessments (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 plan implementation 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 implementation practices, or suggest the presence of an alternative source of impairment that may have not been identified during the initial Plan development.

Sharing Results

Monitoring data is 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

Limited programs are in place within the Five Mile River Watershed to monitor water quality and in-stream conditions. The following data have been collected:

- Two sites have been monitored intermittently (and continue to be monitored) by the CTDEEP for bio-indicators and a variety of chemical parameters including nutrients, salts, pH, bacteria, turbidity, and metals. The earliest recorded data was collected in 1997. Monitoring below the New Canaan POTW outfall and upstream near Lakeview Avenue resulted in two 303(d) listed impairments (Chapter 2, Figure 10) for *E. coli* and unspecified urban stormwater.
- Fish sampling was conducted by CTDEEP at stream crossings at Kings Highway, Indian Rock Road, Flax Hill Road, and Little Brook Road in 1990; at crossings with Lakeview Avenue and Old Norwalk Road in 1999; and at Old Norwalk Road in 2003. With the exception of the crossing on Keeler's Brook, which was categorized as "supporting" using a biotic index, all other sample locations were found to be "impaired" or "severely impaired" (Chapter 2, Table 5).
- Channel morphology was assessed in 2010 by the consulting firm Milone & MacBroom for a portion of the Main Stem running from the pond at Meeting Grove Lane in New Canaan to just below the New Canaan Reservoir. The study reported generally elevated banks and a disconnected floodplain, with some channel erosion observed. Significant anthropogenic effects are indicated.

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. Modeling results indicate "hotspots" in subwatersheds 2, 3, 4, 101, and 103.
- **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 most NPS pollutants. Modeling results indicate "hotspots" in subwatersheds 7, 8, 9, 11, and 103. In addition, the New Canaan POTW is the sole permitted point source within the watershed, and has been identified as a contributing source of P (CTDEEP 2011).
- **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. TSS sampling may include visual assessment of bed sediments and water clarity as well as grab samples to determine TSS concentrations. Modeling results indicate "hotspots" in subwatersheds 7, 9, 11, 12, and 14.
- **Bacteria**: As an indicator organism, *E. coli* is useful in predicting the level of fecal contamination in a water body. For Class B water bodies designated for All Other Recreational Uses, the CTDEEP standard is a geometric mean for *E. coli* of less than 126 cfu per 100ml, and a single-sample maximum less than 576cfu/100ml (CTDEP 2011, Water Quality Standards). One (1) 303(d) listed bacterial impairment was identified in the Five Mile River Watershed, from the Old Norwalk Road crossing upstream to the confluence with the New Canaan POTW outfall. Modeling results, which use fecal coliform rather than *E. coli* as the indicator of contamination, indicate "hotspots" in subwatersheds 2, 3, 4, 101, and 103. 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.
- **Dissolved oxygen**: Dissolved oxygen is critical to the survival of all in-stream animals, but is particularly critical 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 Five Mile River Watershed. Warm-weather, low-flow sampling is recommended in areas

with suspected nutrient and temperature problems, as these will be the most likely reaches 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 is good but macroinvertebrate populations have been impacted, water quality may be an issue. These variables 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.

Fish communities can represent quality as well as connectivity of habitat. Fish species are generally mobile, for example resident fish may exist in stable populations in a reach enclosed at both ends by barriers while the presence of anadromous individuals (that is, species which migrate between fresh and salt water) indicates that lower barriers are passable. In addition, the species composition of a sample population can be a good indicator of water temperature, dissolved oxygen, and viable habitat.

Macroinvertebrates are less mobile than fish, and as such are more representative of specific local 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) 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 (often mud, sand, gravel, cobble, or boulders) 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.
- **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 content. 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 PLAN

The monitoring plan includes the following components (Table 22):

- **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. Frequency and duration of sampling varies depending on what type of data is collected (see Table 22).

Habitat and stream stability assessment

Building on the partial existing conditions assessment conducted in July 2010 by AKRF, additional habitat assessments should be conducted within representative reaches using a similar scoring and rating approach (see Appendix C). Conducting habitat assessments for every stream reach within the watershed will likely be cost prohibitive, representative reaches should be selected within several subwatersheds (Table 22). 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 (Chapter 2) 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 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, and upstream and downstream of the New Canaan POTW outfall (Table 22). 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 22, and include TP, orthophosphate, TSS, *E. coli*, TKN, $N0_3$, $N0_2$ (nitrite), and NH_4 (ammonium). An initial baseline monitoring program during years 1–5 of the monitoring plan implementation is recommended, consistent with the idea of a "pilot" phase of implementation.

Table 22. Monitoring Plan Overview

Monitoring Type	Location	Frequency	Duration	Variables
Routine				
Habitat Quality and Channel Stability	Representative reaches within subwatersheds 1, 4, 8, 11, 14, and 103	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	Outlets of subwatersheds 1, 102, 103, and 101above the salt line	Once per five years	Periodically throughout implementation period.	TKN; NH_4; $NO_{2/3}$; TP; dissolved orthophosphate; TSS; *E. coli*
Bio-indicators	Representative reaches within subwatersheds 1, 4, 8, 12, 14, and 103; above and below New Canaan POTW outfall	Semi-annually	Year 1: baseline conditions, Years 2-20: routine monitoring	Macroinvertebrate communities
Dry Weather Water Quality	Representative reaches within subwatersheds 1, 4, 8, 12, 14, and 103; above and below New Canaan POTW outfall	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	Selected headwater reaches within subwatersheds 8, 11, 12, 13, 14	Bi-annually	On-going through implementation period	Changes in grade or patterns of erosion, 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 structural BMPs	Annually or bi-annually	On-going throughout implementation period	Vegetation type, structural condition, accumulation of sediment/debris, and condition of downstream outfalls; downstream water quality (TKN; NH_4; $NO_{2/3}$; TP; dissolved orthophosphate; TSS; *E. coli*)

Wet Weather Water Quality Monitoring

Characterization of wet weather pollutant loading would ideally be conducted at years five, 10, 15, and 20 of Plan implementation, funding permitting, in order to determine how much pollution is carried by stormwater runoff. Typically the overwhelming portion of total pollutant loading tends to occur during storm events. These events can be sampled using an automatic sampler at representative locations (Table 22). Trained volunteers can be helpful in performing a variety of tasks including monitoring weather conditions, turning on the autosampler prior to use, and collecting and transporting water samples.

Wet weather monitoring stations should be established at multiple representative locations (Table 22). Suggested parameters for wet weather monitoring include TP, orthophosphate, TSS, *E. Coli*, TKN, $N0_3$, $N0_2$, and NH_4. Typically, flow-weighted composite water samples are collected using automated water samplers. Samplers are typically housed in wooden enclosures which can be locked between events. Prior to sample collection, a flow rating curve is established to relate 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 subwatersheds 8, 11, 12, 13, and 14. Monitoring should be conducted at least semi-annually and the results communicated to municipal officials.

Structural Best Management Practice Monitoring

Multiple stormwater management basins and swales were observed within the watershed. Additional new basins and basin retrofits are proposed, as well as riparian buffers, rain gardens, and other structural practices. These structures 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 because it reduces the volume of stormwater captured through infiltration and uptake while filtering out nutrients and creating an aesthetic amenity. Native plant species are typically more 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 true for riparian buffers, which can pass 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 no structural damage is 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 in or out. Structures should be inspected twice per year.

Sediment/Debris

Depending in the total drainage area to the structural BMP and the nearby soil and development conditions, 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, 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 practice, and should be established on a case-by-case basis.

Downstream Outfalls

Basin outfalls may simply tie into the storm sewer, in which case the only monitoring required is to assure that water is passing through as designed. However where basins outlet directly into wooded areas or streams, serious erosion can occur if the outlet is not designed correctly. Down-slope erosion is a common symptom of unprotected outfalls where water flows freely out of the pipe onto a natural surface. These can be prevented by stabilizing the outfall with stone and cobble for several feet along the flow path, and by avoiding areas with significant grade (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 load reduction function 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.

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[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.

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[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. This data was available for both Connecticut and New York.

APPENDIX A. SITE-SPECIFIC STRUCTURAL BEST MANAGEMENT PRACTICES

BMP A. Colonial Village; Norwalk Housing Authority (NHA)

Scribner Ave. & West Cedar St., Norwalk, CT

Five Mile River Watershed

BMP Type: Naturalized surface storage basin
Subwatershed: 1 (Keeler's Brook)
Construction Cost Estimate: $22,000
Potential Benefits: Water quality, flood control, channel protection
Permitting: Municipal Construction, Water Diversion, and 401 Water Quality Certification; and USACOE Clean Water Act
Site Access: Easy road access
Ownership: Public
Other Constraints: Portions of the park are currently in use several times a year for high school football practice/games.

Existing Conditions

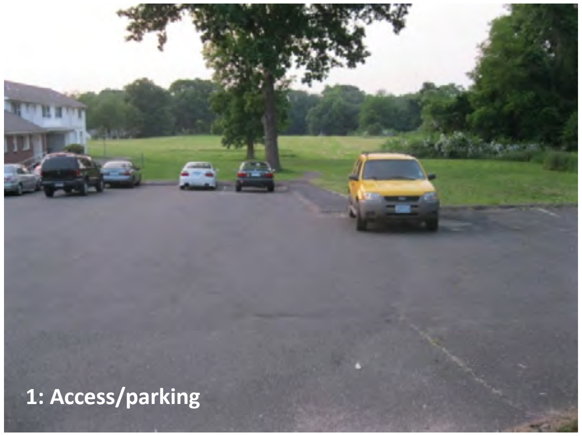
Regionally, Colonial Village is located in the upper midsection of Keeler's Brook, a high priority subwatershed identified by stakeholders. The park is located down-slope of several housing developments along Taylor Ave.; preliminary investigation indicates that the street drainage from these residential areas is centrally piped along West Cedar St. to a low point near the park.

The proposed BMP area is an open field which appears to be mowed regularly but is not in active use (photo 2). The parcel is adjacent to a residential housing unit and a small parking lot, both of which drain to grassed areas. A small tributary to Keeler's Brook runs north within the tree line at the east edge of the property. The channel is incised with minimal base flow. Some storm flow from the existing parking lot (photo 1) appears to be flowing overland into the field. A raised parking lot held back by a retaining wall at the eastern property boundary may be contributing overland flow, and the wall itself appears undermined.

Proposed BMP

Approximately 1.5 ac. of impervious street area could be diverted into a naturalized surface storage basin in the Colonial Village open space. Runoff from the adjacent property appears to drain directly to the existing field. The contributing drainage area would include portions of Cedar Crest Place and West Cedar St. If the commercial and residential properties draining to these streets are included in the estimate, the basin could capture as much as 3.5 ac. of impervious area assuming that none of the properties discharge to local outfalls or manage stormwater onsite.

In order to provide a full suite of ecological benefits, the proposed basin should be sized for channel protection, water quality, and flood control. Based on field reconnaissance of the drainage area and proposed BMP area, there appears to be adequate space available to provide these benefits. Conveyance structures would most likely be diverting stormwater flows from existing infrastructure along West Cedar St. and overflowing to the tributary.



1: Access/parking

2: Proposed storage site

BMP B. Kendall Elementary School

57 Fillow St, Norwalk, CT

Five Mile River Watershed

BMP Type: Subsurface infiltration
Subwatershed: 1 (Keeler's Brook)
Construction Cost Estimate: $1,035,000
Potential Benefits: Flood control and channel protection
Permitting: Municipal construction and Water Diversion
Site Access: Easy road access
Ownership: Public
Other Constraints: Available open space limited on this site, restricting the use of surface stormwater management practices.

Existing Conditions

Kendall Elementary is located in the far northeastern headwaters of Keeler's Brook, in a low point on Fillow St. The school's roof and parking lots are the largest impervious areas in the neighborhood. Several residential streets drain to this part of Fillow St., including portions of Carlisle, Van Ness, Petton, Shamrock, and Lower Fillow. Although no mapped streams cross the property, a low wooded area that runs along the western edge of the property appears to collect some drainage. The channel is incised with minimal base flow.

Conveyance structures appear to run underground through the large open space, carrying stormwater from the upstream neighborhoods toward an outfall on the stream. Two monitoring wells were observed between the tennis courts and the rear of the school building. A large manhole was observed uphill adjacent to the ball field, in the grass near the low point of the parking lot.

Proposed BMP

Due to site constraints, subsurface practices are recommended for this BMP. A combination of storage and infiltration installed beneath the ball field could be used for the maximum water quality and flood control benefit. An estimated 7 ac. of onsite and local street impervious area could be captured by diverting from existing infrastructure; another acre could be added if the neighborhood roofs and driveways drain directly to streets.

As noted above, the presence of monitoring wells on the school property may suggest that some stormwater is already being managed onsite; however the total volume and the function of the system (water quality, flood control) would have to be determined before moving forward with a design.

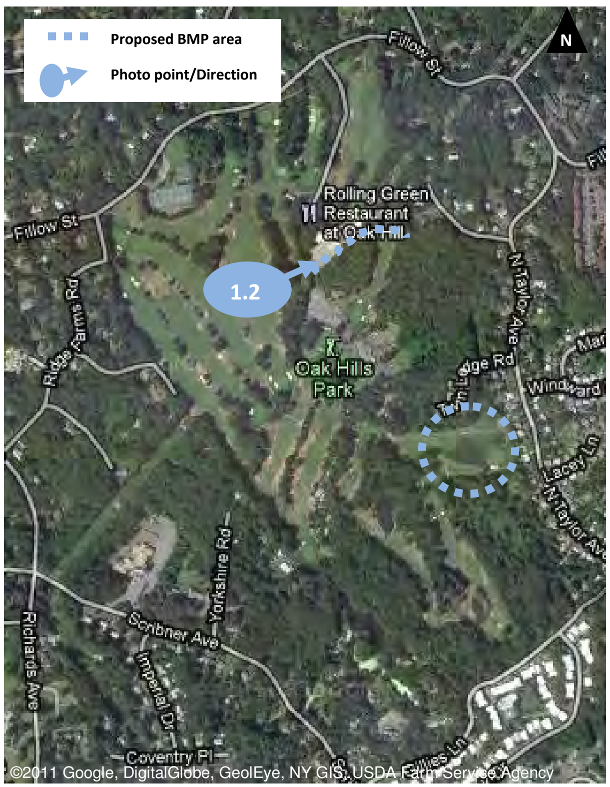

1: Main parking & inlet


2: Proposed BMP area

BMP C. Oak Hills Park

Charles Marshall Drive off Fillow St., Norwalk, CT — Five Mile River Watershed

BMP Type: Stream restoration with pocket wetlands, riparian buffer
Subwatershed: 1 (Keeler's Brook)
Construction Cost Estimate: $436,000
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: Easy road access
Ownership: Public
Other Constraints: Utility lines; golf course line of sight (buffers)



Existing Conditions

Headwaters of Keeler's Brook originate in Oak Hills Park, a public golf course for the City of Norwalk. Several ponds at the south end of the course drain to a channel which feeds the streams running through the Ledgebrook Condos on Gillies Ln., a priority area identified by stakeholders. The northernmost of these ponds, just off Taylor Ave., is poorly buffered and displays significant algal growth.

Down slope from the restaurant and adjacent to a maintenance area, parking lot and golf course runoff feed a stagnant ditch (photo 2) in the power line right-of-way which forms the headwater stream that is visible along Chipping Ln. Adjacent to this ditch is the grounds maintenance facility including outbuildings and a parking lot where uncovered mulch and sand are piled (photo 1). There may be a subsurface stormwater unit behind the restaurant—a Vortex unit manhole cover was observed in the field behind the building's parking lot.

Proposed BMP

A three-tiered approach is recommended for this sensitive area in order to manage existing stormwater, repair damage to headwater streams, and minimize nutrient loading from lawn fertilizers. About 33,000 ft^2. of riparian buffer should be added around the pond along Taylor Ave. and the tributary receiving runoff from the golf course and restaurant (assume 30' meadow-type buffer). The stagnant ditch drains the parking lot and a portion of the golf course and should be restored using mainly a soft stabilization approach (about 700 ft. of restoration). Such an approach would include the use of grading and vegetative elements, and avoid rock and log placement where possible. As part of the ditch restoration, stormwater storage could be created in pocket wetlands along the restored channel in order to provide water quality benefits and reduce erosion and incision. The drainage area to the ditch is roughly 4 ac. and consists of approximately 1.5 ac. of impervious area with the remainder low-cut turf grass.

The proposed pocket wetlands might require tree removal or demolition of a portion of the adjacent lot. Since space constraints may be an issue, the pocket wetlands should be sized first for water quality, and expanded for flood control and channel protection if possible.

Just north of this area, the Norwalk Parks Authority has proposed a restoration on a reach of stream very nearby. These opportunities may pair well together.

1: Grounds maintenance facility


2: Ditch adjacent to facility

BMP D. Ledgebrook Condominiums

Gillies Ln., Norwalk, CT

Five Mile River Watershed

BMP Type: Riparian buffer
Subwatershed: 1 (Keeler's Brook)
Construction Cost Estimate: $5,000
Potential Benefits: Water quality, habitat creation
Permitting: Municipal construction
Site Access: Easy road access
Ownership: Private
Other Constraints: Several small ponds upstream; incoming water quantity may vary as ponds fill with sediment and are dredged.

Existing Conditions

Streams enter this large condominium complex near the complex's northeast corner and near the intersection of Gillies Ln. and Ledgebrook Dr. Several large pipes, which appear to drain the adjacent neighborhoods, also enter the property at Gillies and Ledgebrook, where they outfall to a ditch that runs along the parking lot and feeds a small poor-quality wetland complex lining the northwestern edge of the property. Cloudy, stagnant water and a large stand of Multiflora Rose (*Rosa multiflora*) were observed here.

At the center of the property, a pond runs between two rows of housing units and joins the Main Stem of Keeler's brook. This central stream is well buffered with naturalistic plantings, and banks appeared fairly stable. Since housing units are built directly up to the stream corridor, no available space was found for additional buffering or storage.

A ditch running the length of Ledgebrook Rd. is completely unbuffered (photo 2). Water is almost completely stagnant and the channel is clogged with sediment. Upstream from its culvert outlet under Scribner Ave., fine sediment and debris have collected. The adjacent roadway drains directly to the ditch via regularly placed curb cuts, and active erosion can be seen in the lawn at each outlet point (photo 1). Roof and yard drains also outlet to this ditch via PVC pipes.

Proposed BMP

Restoration should focus on limiting nutrient and sediment contributions from eroded ditches. Approximately 6,000 $ft.^2$ of buffer should be installed along the ditch at Ledgebrook Rd. (assume 5' meadow-type buffer). Where space allows, buffer width should be increased. Small rain gardens and bioretention areas could potentially be installed in several areas where roof and yard drain outlets discharge into the lawn/bank area several ft. back from the active channel (not included in BMP cost). Approximately 1,000 $ft.^2$ of riparian buffer should also be considered along the private property adjacent to the tributary originating in Oak Hills Park.

The ditches along Gillies Ln. are moderately well buffered, and cannot be expanded or restored due to space constraints from parking on one side and wetlands on the other. On the parking lot side, native vegetation might be restored to create some habitat benefit. However additional storage does not appear to be feasible due to lack of available space.


1: Eroded curb cut


2: Proposed buffer restoration

BMP E. Costco

779 Connecticut Ave., Norwalk/Darien, CT

Five Mile River Watershed

BMP Type: Retrofit existing stormwater basin
Subwatershed: 101 (Lower Main Stem)
Construction Cost Estimate: $115,000
Potential Benefits: Water quality
Permitting: Municipal construction and Water Diversion—no impacts to wetlands or waterways
Site Access: Limited—accessible through gate at rear of Costco parking lot
Ownership: Private
Other Constraints: Unclear what drainage area it was built to capture

Existing Conditions

The existing basin behind the Costco and DoubleTree Inn properties is approximately 150 ft. by 80 ft. in size, with 4 ft. high walls. Two outfalls were observed at the far end of the basin, near an approximately 2 ft. high riprap overflow that drains directly to the stream. Near the inflow pipes is a sediment forebay which appears to be regularly cleaned, and the basin overall appears to be maintained on a regular basis. No outlet control structure was observed, indicating that the basin was constructed for flood control rather than water quality. Drainage area to the basin was not clear, although based on the size of the inflow pipes it may be fairly large.

Proposed BMP

A simple restriction of the outlet structure to provide retention/ponding of small storms could add water quality and channel protection benefits to the existing flood control. Depending on the exact drainage area to the basin, storage volume might have to be increased by excavating the bottom. Measures should be taken to mimic the existing native plant community, as it appears to be thriving in this location.

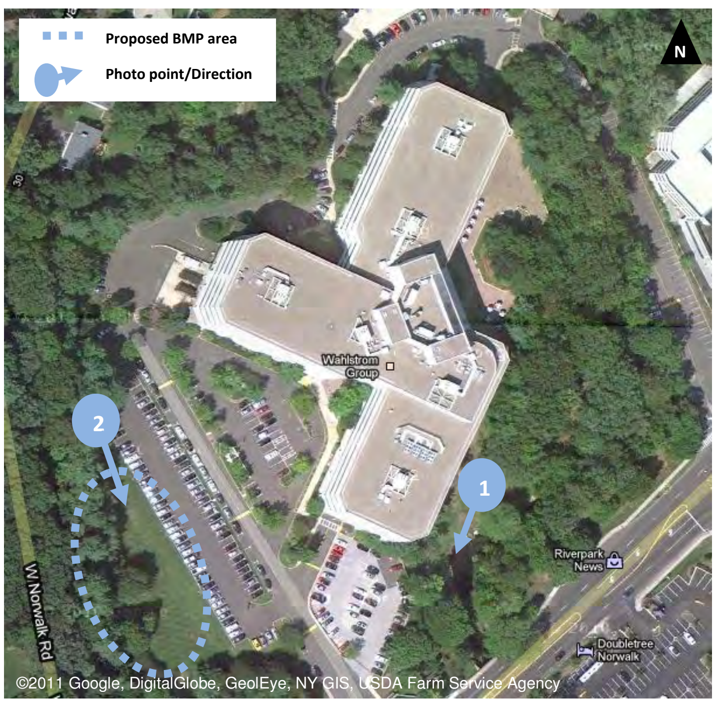

1: Existing basin


2: Inflow pipe

BMP F. River Park

800 Connecticut Avenue | Five Mile River Watershed

BMP Type: Swale retrofit
Subwatershed: 101 (Lower Main Stem)
Construction Cost Estimate: $38,000
Potential Benefits: Water quality, flood control, channel protection, habitat
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: Easy street access
Ownership: Private commercial
Other Constraints: During construction, the parking lot might become temporarily inaccessible.



Existing Conditions

River Park is located on the banks of the Main Stem Five Mile River, in the Route 1 commercial corridor. Adjacent to The Wahlstrom Group's property the stream crosses Route 1 and receives a large input of stormwater via several outfalls. A small lunch area lines the banks on the corporate campus, with picnic tables and easy access to the river. The riparian buffer is limited across the property, with no buffer at all near the picnic area. The banks have been stabilized with boulders and a wall. Evidence of slumping can be seen near the main driveway where an outfall is set back from the active channel (photo 1).

Numerous catch basins in the parking lot all appear to either drain directly to the stream, or enter a pipe in Route 1 briefly before outfalling downstream. An existing swale (photo 2) of approximately 150 ft. by 15 ft. is located on the western side of the main parking lot. The swale appears to be managing parking lot runoff and does not appear to have been designed for water quality treatment.

Proposed BMP

Banks along the picnic area should be vegetated to prevent nutrient entry from lawn fertilizers and to help stabilize slumping banks. A careful planting and mowing plan would have to be devised in order to still allow lines of sight from the picnic area to the water's edge.

The existing swale could easily be retrofitted to create additional storage and water quality benefits. About 200 ft. by 35 ft. of free lawn space could be excavated between the parking lot and woods at the opposite edge. The outlet structure should be modified for water quality, and a meadow-type planting plan should be developed to slow flows and enhance nutrient uptake. Assuming half of the main building and the adjacent parking lot could be easily diverted to the swale, there appears to be enough space to size the new swale for water quality, flood control, and channel protection.


1: Banks near picnic area


2: Existing swale

BMP G. Norwalk Community College

188 Richards Avenue, Norwalk, CT

Five Mile River Watershed

BMP Type: Naturalized surface storage basin
Subwatershed: 101 (Lower Main Stem)
Construction Cost Estimate: $60,000
Potential Benefits: Water quality, flood control
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; and USACOE Clean Water Act
Site Access: Easy access from college parking area
Ownership: Public
Other Constraints: None

Existing Conditions

Norwalk Community College is located just below the outlet of subwatershed #2 in the east bank of the Main Stem. The east half of the college all drains through a central pipe that crosses Richards Ave. and outfalls directly to a large pond on the Main Stem of the Five Mile River (Richards Ave. itself drains to the municipal system and is not included in this BMP area). There is a large open area (photo 1) at the low end of the entire property, adjacent to the western edge. The area is currently under construction and it is unclear if this will remain open space. The south half of the property also drains westward and eventually outfalls into the river, but there is no flat open space available to manage this portion of the property.

Proposed BMP

Because onsite drainage is mostly centralized, a single large surface basin would offer a great deal of benefit at a reasonable cost. Drainage from the east half of the property could easily be accessed and treated in a large basin in the open space at the bottom of the large parking lot near the stream. A new basin built to treat the approximately 9 ac. of impervious area draining to it would have a footprint of ½ acre and a depth of approximately 3 ft.—almost exactly the area available. Due to this size constraint, no attempt should be made to convey drainage from the southern portion of the campus into the basin. The parking lot at the southeastern corner of the property drains to West Cedar St. and into subwatershed #1.


1: BMP area, northeast view


2: BMP area, southeast view

BMP H. Saint John's Cemetery

204 Richards Ave., Norwalk, CT

Five Mile River Watershed

BMP Type: Naturalized surface storage basin
Subwatershed: 101 (Lower Main Stem)
Construction Cost Estimate: $791,000
Potential Benefits: Water quality, flood control, channel protection
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, and Water Diversion; and USACOE Clean Water Act
Site Access: Easy street access
Ownership: Private institutional
Other Constraints: Proposed BMP area is located within an active cemetery facility

Existing Conditions

Saint John's Cemetery straddles the drainage divide between subwatershed #2 and the Lower Main Stem direct drainage area. The stream runs alongside Richards Ave. before entering a pond on the cemetery property. The outlet of the pond drains directly into a pipe, which appears to flow underground through the cemetery. Runoff from Richards Ave. and Priscilla Rd. discharge via three pipes to a headwall structure (photo 1), which may be functioning as an overflow during storm events. However, no obvious signs of flooding or erosion were observed. An outflow pipe from the headwall apparently joins the piped stream before the stream daylights at a tributary to the Main Stem. At its northern edge, this property is bordered by the Hebrew Cemetery., and its western edge abuts a portion of the Main Stem. Both upstream and downstream locations on the Main Stem have been indicated by stakeholders as flooding problems.

Proposed BMP

Restoration should focus on managing the stormwater from the adjacent roads that passes through the property. Stormwater that is piped to the headwall structure could be diverted to the large open space beyond the structure (photo 2). A naturalized storage basin should be constructed to treat road runoff from Richards Rd. and Priscilla Rd. before overflowing back to the existing pipe, which joins the subsurface stream.

There appears to be enough room in the open areas to manage the approximately 2.5 ac. of impervious drainage area for flood control, water quality, and channel protection. If a detailed design indicates that space may be a constraint, flood control functions should take precedence over water quality and channel protection. Before this BMP is designed, soil and groundwater should be tested for leaching contaminants. Testing should also be conducted to determine depth to water table (not included in cost estimate).

Opportunities to daylight a portion of the piped stream could also be investigated. If possible, day-lighting the stream would create habitat and enhance connectivity within the stream network. This possibility is not included in the cost estimate.

1: Headwall/overflow structure

2: Proposed surface storage

BMP I. Fireside Ct. Cul-de-Sac

End of Fireside Ct., Norwalk, CT — Five Mile River Watershed

BMP Type: Bioretention
Subwatershed: 4
Construction Cost Estimate: $141,000
Potential Benefits: Flood control
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: Easy road access
Ownership: Public right-of-way
Other Constraints: Limited space in right-of-way

Existing Conditions

Fireside Ct. is a residential neighborhood located uphill from the Main Stem of the Five Mile River north of Nursery Rd. Nearly the entire road drains downhill toward the cul-de-sac. Three (3) inlets near the cul-de-sac connect to a pipe running the length of the entire drainage area (approximately 2 ac. of impervious area). All inlets are sufficiently shallow to allow diversion to a cul-de-sac practice. A single outlet drains the three (3) bottom inlets into the woods abutting the river. The cul-de-sac area is approximately 1,000-square ft. and vegetated by turf and a single tree of <6-in. diameter.

Proposed BMP

The available open space in the cul-de-sac is not enough to manage the approximately 2.0 ac. of contributing impervious area for flood control, water quality, and channel protection. A small naturalized surface practice (i.e., a rain garden) could be constructed to filter most storm events, but would have to overflow back into the drainage system during larger storms. Some additional storage could be created by expanding the central grassy ring slightly farther out into the road. Several nearby homes have tall meadow-type vegetation in their front lawns and could potentially manage small portions of the street runoff on private property.


1: Typical inlet


2: Existing cul-de-sac

BMP J. Fox Run Elementary School

228 Fillow St., Norwalk, CT

Five Mile River Watershed

BMP Type: 2-3 naturalized surface storage basins or bioretention
Subwatershed: 2 & 4
Construction Cost Estimate: $32,000
Potential Benefits: Flood control, habitat, water quality, channel protection
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: Easy road access
Ownership: Public institutional
Other Constraints: Subsurface utilities; tree removal

Existing Conditions

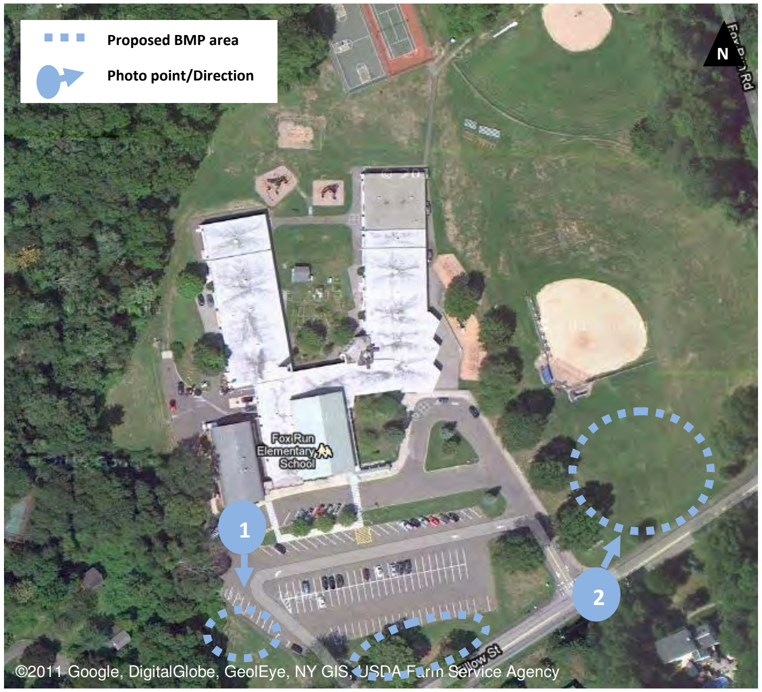
Fox Run Elementary School straddles the drainage divide between subwatersheds 2 and 4. In number 2, runoff from the school property flows southeast into a small headwater stream. In number 4, runoff flows southwest, eventually entering a mapped tributary that has been implicated in several flooding reports. The BMP site is located just west of the intersection of Fox Run Rd. and Fillow St. Both these streets drain downhill toward the school in centralized pipes beneath the street, offering the potential for regional storage.

The school buildings and parking lot appear to drain south toward the street. All parking lot inlets appear to drain east into subwatershed number 2. Inlets on the property are all sufficiently shallow to divert stormwater to surface practices. Two large baseball fields are located to the east at the property's low point near the intersection of Fillow St. and Fox Run Rd. A large utility structure is located in front of the first ball field near the edge of Fillow St.

Proposed BMP

There is more than enough room on this property to manage as much stormwater as can be easily conveyed to the property. Furthermore, there should be enough room for the new basins to be sized for flood control, channel protection, and water quality control of the approximately 4.5 impervious ac. in the contributing drainage area. Road runoff can be captured by tapping into inlets in Fillow St. Parking lot and roof runoff can be captured by diverting from inlets in the front parking lot and driveway, and by creating curb cuts at the low point of the parking lot. Overflows would be conveyed back to the existing street infrastructure.

The optimal location for a naturalized basin is the open space just south of the ball fields (photo 2). Because this area is adjacent to utilities, some space constraints may exist. Naturalized basins to manage the roof and parking lot could also be located uphill of the ball fields in the grassy area south of the parking lots, and drainage may be conveyed via curb cuts. It should be noted that if these front practices are designed to overflow to the road, this water will be pitched into subwatershed number 4 rather than number 2.




1: Proposed basin location at southwest of property


2: Proposed basin location adjacent to ball fields

BMP K. Kiwanis Park

77 Old Norwalk Rd., New Canaan, CT — Five Mile River Watershed

BMP Type: Naturalized surface storage basin
Subwatershed: 102 (New Canaan Center)
Construction Cost Estimate: $27,000
Potential Benefits: Flood control, habitat, water quality, channel protection
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; and USACOE Clean Water Act
Site Access: Easy road access
Ownership: Public institutional
Other Constraints: Constrained conveyance over long distance required; parts of site may be needed for storage and/or overflow parking

Existing Conditions

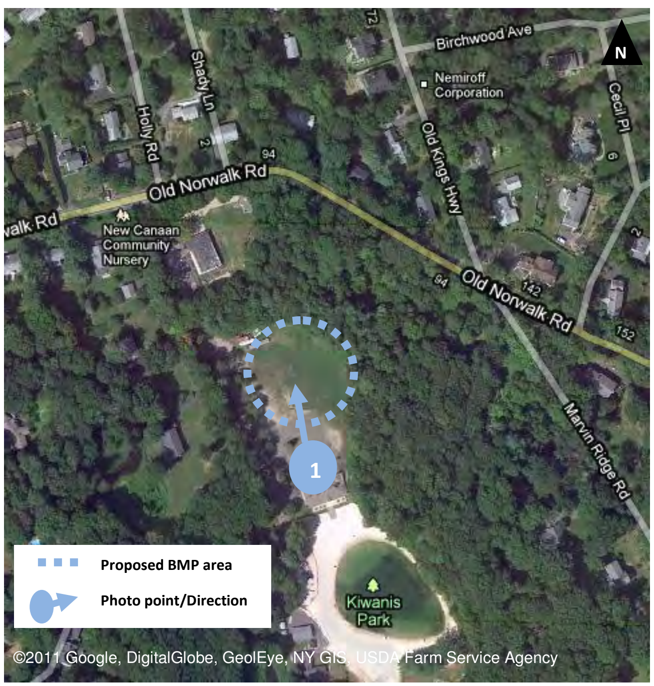
Kiwanis Park is located on the Main Stem of the Five Mile River. Just downstream, beyond the Merritt Parkway, is Meeting Grove Ln., an area where neighbors have complained of significant flooding. The portion of the Main Stem between Kiwanis Park and Meeting Grove shows signs of bank erosion and a perched floodplain. Locally, Old Norwalk Rd. and several side streets (e.g., Holly Rd.) drain downhill towards the park conveyed in central pipes below the street. Just west of the park where Old Norwalk crosses the Main Stem, several large culverts discharge directly into the river.

The park contains a large open field (photo below) in the area outside the recreation center. The field is mowed but does not appear to be used regularly for recreation. Some trucks and heavy equipment are being stored there currently. An adjacent gravel area may be used for overflow parking.

Proposed BMP

Due to its specific location up-slope of serious flooding, a stormwater management approach on this property should focus first on attenuation of storm flows into the municipal sewer system, and second on water quality and downstream channel protection measures.

Stormwater runoff from approximately 1.6 ac. of impervious area from Old Norwalk and other roads could be captured and stored in a naturalized surface storage basin in the open space at Kiwanis Park. Water would be conveyed from the existing street infrastructure about 400 ft. along the park driveway and into the proposed basin. Safe overflow conveyance back to the stream over approximately 150 ft. would be required. Assuming that the open space is not in use, there appears to be enough room to size the basin for flood control, water quality and channel protection.



1: Proposed BMP area

BMP L. New Canaan YMCA

564 South Ave., New Canaan, CT

Five Mile River Watershed

BMP Type: Naturalized surface storage basin
Subwatershed: 102 (New Canaan Center)
Construction Cost Estimate: $49,000
Potential Benefits: Flood control, water quality, channel protection, habitat
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: East road access
Ownership: Private institutional
Other Constraints: Site is used for active recreation; utilities border the available open space

Existing Conditions

The New Canaan YMCA property is located at the far western edge of the Five Mile River Watershed. The onsite impervious area equals approximately 3 ac., and appears to drain entirely toward the rear of the property where it outlets to the storm sewer along Putnam Rd. Severe flooding has been reported at many properties below this area, making the YMCA a prime target for onsite stormwater detention.

Behind the YMCA facility is an open field which appears to be used at least in part for recreation (photo 1). The field is flat and the main drainage pipe is assumed to run directly underneath it. Several utility conflicts were noted, including gas, water, and sanitary sewer. In addition, the far property boundary borders a power line right–of-way (photo 2).

Proposed BMP

Due to its specific location up-slope of serious flooding, a stormwater management approach on this property should focus first on attenuation of storm flows into the municipal sewer system, and second on water quality and downstream channel protection measures.

The field at the rear of the YMCA property appears to be large enough to manage the stormwater exiting the property, but not without sacrifice—some of the landscaped or recreational areas would have to be repurposed for surface stormwater management. Alternately, a combined approach using surface and subsurface practices would be more expensive, but would allow for all of the current uses to continue unchanged.

Whether the BMP uses a naturalized surface basin or an underground infiltration gallery, care should be taken to avoid the existing utilities running on a diagonal from the rear of the parking lot out to the road. The outlet of the new BMP may have to cross the power line right-of-way (pictured below). Practices should be sized first for flood control, then for channel protection, and lastly for water quality based on the property's location in the watershed and the downstream uses and values identified by stakeholders.

1: Proposed BMP area

2: Overflow & power lines below BMP area

BMP M. Saxe Middle School

468 South Ave., New Canaan, CT

Five Mile River Watershed

BMP Type: Naturalized surface storage
Subwatershed: 102 (New Canaan Center)
Construction Cost Estimate: $197,000
Potential Benefits: Flood control, habitat, water quality
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion
Site Access: 2 sites accessible from the road or from the school's ball fields
Ownership: Public institutional
Other Constraints: Limited open space where pipes are easily accessible and limited pipe access near existing flood control basin.

Existing Conditions

The Saxe Middle School property is located at the far western edge of the Five Mile River Watershed. The onsite impervious area equals nearly 13 ac., making it one of the largest singly-owned impervious areas in the New Canaan Center subwatershed (102). It appears to drain directly into pipes along Farm Rd., which continue down a steep slope to eventually discharge into the river. Severe flooding has been reported at many properties below this area, making the school a prime target for onsite or near-site stormwater detention.

An existing flood control basin can be seen from the edge of the woods along the adjacent YMCA property. It appears that only the athletic fields are being managed by this basin.

Proposed BMP

Due to its specific location up-slope of serious flooding, a stormwater management approach on this property should focus first on attenuation of storm flows into the municipal sewer system, and second on water quality and downstream channel protection measures. Stormwater from the southern parking lots could be diverted to the existing depression area below the athletic fields. The basin would need to be excavated and planted with native vegetation, and an outlet control, overflowing to existing manholes, would need to be installed (for this reason, costs were developed as if for a new basin rather than a retrofit). Conveyance to the basin would require replacing or retrofitting numerous inlet structures and piping over 200 ft..

BMP N. Avalon Apartments

100 Avalon Dr. East, New Canaan, CT

Five Mile River Watershed

BMP Type: Retrofit surface storage basin
Subwatershed: 102 (New Canaan Center)
Construction Cost Estimate: $19,000
Potential Benefits: Flood control, habitat, water quality
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; and USACOE Clean Water Act
Site Access: 2 sites accessible from the road or from the school's ball fields
Ownership: Public institutional
Other Constraints: Space and location in floodplain

Existing Conditions

The Avalon Apartment complex is located on the Main Stem of the Five Mile River, downstream of Mill Pond and upstream of the New Canaan Waste Management facility. Severe flooding has been reported at many properties just downstream of this area.

An existing basin is located between the river's edge and the westernmost housing unit. Field inspection indicates that the basin may have been sized for water quality, but the exact drainage area is not clear. The basin appears to be managing only the lower half of the Avalon complex, with the upper half draining into the woods uphill of Mill Pond. Basin walls are steep (approximately 1:1 or greater), and approximately 7 ft. high. The east side is bounded by a stone retaining wall. Accumulated silt was observed on the basin floor. The outlet structure (photo 1) has a grate-covered top and includes a small low flow orifice at ground elevation and a v-notch weir. Overflow passes directly into the stream. The vegetation is a mix of native wetland and invasive plant species.

Proposed BMP

A review of existing design plans should be conducted first to determine what area is draining to this basin and whether water quality treatment has been provided. There may be an opportunity to add some volume to the basin and expand the drainage area to include the uphill units; however based on the space available and the existing slopes, this could be difficult. More likely the outlet structure could be modified to provide better water quality treatment, although this retrofit should also be carefully considered. As with other BMPs in this subwatershed, flood control should remain the top priority, and water quality retrofits should only be conducted if they will not decrease the overall flood control benefits.

1: Control structure

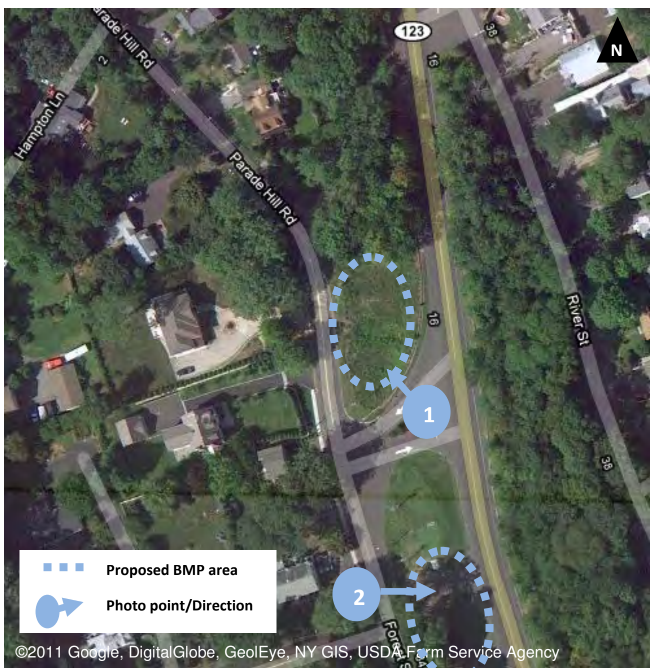
1: Basin floor and east wall

BMP O. Smith Ridge Rd. Median

Near 16 Smith Ridge Rd., New Canaan, CT

Five Mile River Watershed

BMP Type: Naturalized surface storage basin
Subwatershed: 102 (New Canaan Center)
Construction Cost Estimate: $595,000
Potential Benefits: Flood control, water quality, channel protection
Permitting: Municipal Construction, 401 Water Quality Certification, and Water Diversion; and USACOE Clean Water Act
Site Access: Easy road access
Ownership: Public right-of-way
Other Constraints: Above ground utility wires are hung along the west side of the proposed BMP area; available space is limited



Existing Conditions

The proposed BMP area at the intersection of Smith Ridge Rd. (Rt 123), Parade Hill Rd., and Forest St. is located across the street and uphill from the Main Stem of the Five Mile River, near River St. where residents have complained of flooding. The median (photo 1) is lower than the road and receives inflow from two storm pipes with a drainage area of approximately 3 ac.. The area outlets to a large diameter pipe under Smith Ridge Rd., which appears to outfall directly to the river. A gully up to one foot depth has formed in the space between the outfalls and the outlet structure.

Surface utility wires hang along the west side of the proposed BMP area. Approximately 50 ft. by 150 ft. of open space is available outside of utility boundaries.

Another median area just south of the proposed BMP area shows evidence of high storm flows from Forest St. running over a residential yard toward a blocked outlet pipe (photo 2). The drainage area to this blocked outlet is approximately 1 acre. A large electric utility unit is located along the north margin of the median, leaving approximately 30 ft. by 100 ft. of open turf area.

Proposed BMP

A BMP here should address flood control for the two large pipes that outfall into the northern median. Excavation to a minimum of approximately 3 ft. would be required. The outlet structure should be modified and stabilization will be required for the incoming flows to prevent channel formation in the basin bed. The basin should be planted with native vegetation. If possible given the space constraints, the basin should also be designed for channel protection and water quality.

Measures should also be taken to address the gully/erosion at the 84 Forest St. residence. The clogged outlet appears to be holding water in the grassy depression; the area could be redesigned as a small naturalized basin to provide flood control, channel protection and water quality benefits and to decrease flooding risk to the adjacent properties.


1: Proposed basin location


2: Gully/erosion

BMP P. East Elementary School

54 Little Brook Rd., New Canaan, CT

Five Mile River Watershed

BMP Type: Naturalized surface storage basin & bioretention
Subwatershed: 8
Construction Cost Estimate: $270,000
Potential Benefits: Flood control, habitat, water quality, channel protection
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, Stream Channel Encroachment, and Water Diversion; and USACOE Clean Water Act
Site Access: Easy road access
Ownership: Public institutional
Other Constraints: Water utility lines

Existing Conditions

East School is located near the outlet of subwatershed number 8, just upstream of Mill Pond. Upstream of the school several housing developments have resulted in denuded riparian buffers and unstable reaches of headwater streams.

The school property contains enough open space to easily manage the onsite impervious area for flood control, channel protection, and water quality. Furthermore, a significant portion of Little Brook Rd. currently drains to an outfall on the school property. The outfall drains directly to the stream, which at this point is stagnant and has accumulated sediment in the channel and onto the floodplain. Inlets in the road and on the school property are all sufficiently shallow for diversion to surface stormwater practices. A single large manhole was observed in the center of the main field.

Proposed BMP

Runoff from the road and parking lot can be conveyed to the large open field at the north end of the property using a combination of curb cuts and diversions from existing inlets. A large naturalized surface storage basin can easily be sized for flood control, channel protection, and water quality. Concurrently, several small bioretention practices along the east edge of the property could manage a portion of the storm flows. Overflow would be safely conveyed to the tributary at the north of the property. Approximately 4 ac. of impervious area drain toward this location, assuming the roofs can all be conveyed.

Some subsurface storage may already have been installed behind the main building near the playground. Site plans should be reviewed before moving ahead with a design plan.

Most roof runoff appears to be draining toward the rear of the property, and might have to be treated in a separate basin at the western end of the field to avoid additional conveyance.

Improving stormwater management may rehabilitate the tributary over time. In the future, stream restoration may also be considered to restore geomorphic stability and improve habitat, but significant tree removal would be required.


1: Proposed basin location at east edge of property


2: Proposed basin location at north of property

BMP Q. Mill Pond Park

Intersection of East Ave. & Millport Ave., New Canaan, Connecticut

Five Mile River Watershed

BMP Type: Wetland restoration
Subwatershed: 102 (Main Stem)
Construction Cost Estimate: N/A
Potential Benefits: Flood control, channel protection, habitat, water quality
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, and Water Diversion
Ownership: Public
Other Constraints: Major construction and permitting; dam removal; significant alteration of downstream flows

Existing Conditions

Mill Pond is located at the confluence of subwatershed 8 with the Main Stem Five Mile River, just south of New Canaan town center. The stream above the pond is stable with a connected floodplain, and the banks and substrate appear to be in good condition. Significant bank erosion and signs of flooding were observed downstream, as well as thick algae mats below the New Canaan POTW outfall.

The pond itself is shallow (approximately 2-3 ft. deep). Sediment accumulation was observed where the river enters the pond. A trail loop circles the pond and a small park has been recently constructed at its north end (photo 1). Banks are not well buffered in the park area. The pond outlet is controlled by an approximately 4 ft. dam (photo 2).

The direct drainage area to the pond is approximately seven (7) ac. of impervious area. Just upstream in subwatershed 8, approximately four (4) ac. of impervious area could be managed by the East School BMP recommended in this report. Ideally these BMPs should be completed jointly.

Proposed BMP

Mill Pond represents a break in observed stream quality, where directly upstream conditions are good and downstream conditions are fair to poor. A large-scale restoration is recommended here in order to alleviate flooding downstream and to improve the aesthetic and environmental conditions at the site.

The proposed restoration would first require removal of the dam to drain the pond and open up instream habitat. A channel could then be created in the existing flow path, and pocket wetlands could be added along the channel to divert storm flow and encourage connection to a restored floodplain. At a minimum this series of wetlands should be designed to manage the 7-ac direct drainage area. Additionally, desktop analysis indicates that some or most of downtown New Canaan may be draining regionally to this location. Further analysis is required to determine the potential for a large-scale regional management BMP in this location.

As part of any stormwater effort, the public park should be redesigned to encourage recreation on the trail and to feature signage and interpretive areas for local schools and neighborhoods.


1: Pond & public park


2: Outlet dam

BMP R. South Salem Community Park

442 Smith Ridge Rd., South Salem, NY

Five Mile River Watershed

BMP Type: Bioretention
Subwatershed: 13 (Headwaters)
Construction Cost Estimate: $25,000
Potential Benefits: Water quality
Permitting: Municipal Construction, Inland Wetlands and Watercourses, 401 Water Quality Certification, and Water Diversion
Ownership: Public
Other Constraints: Slope of BMP area, limited space

Existing Conditions

This small community park is located near the intersection of Smith Ridge Rd. and East St. in the farthest north headwater (#13), at the eastern edge of the watershed boundary. The majority of the property is located outside of the Five Mile Watershed. However the parking lot (photo 2) drains into subwatershed 13 via sheet flow to its northwestern side, where water enters a shallow parking lot inlet connected to a municipal stormwater pipe. Across Smith Ridge Rd. the pipe outfalls into a wetland.

The park's open space (photo 1) includes a baseball field that straddles the drainage divide and a strip of meadow along Smith Ridge Rd.

Proposed BMP

The parking lot's approximately 0.8 ac. of impervious area could be easily managed in the adjacent lawn area at the corner of Smith Ridge and East St. Due to the limited BMP area and contributing drainage, benefits will be mainly water quality rather than flood control. The area is flat near the parking lot, but slopes steeply downward over approximately 15 ft. to the road on both sides. Even given the slope constraints, there appears to be enough flat area to manage the drainage from the parking lot.

Conveyance to the new basin will be easy due to the simple overland drainage pattern. The existing inlet in the parking lot should be replaced with a curb cut, and the overflow from the basin should outfall into the municipal pipe running along East St.


1: Proposed BMP area


2: Parking lot

BMP S. Estate at Puddin Hill Road

Intersection of Puddin Hill Road and Scenic Drive, Lewisboro, NY

Five Mile River Watershed

BMP Type: Riparian buffer
Subwatershed: 14
Construction Cost Estimate: $4,000
Potential Benefits: Water quality
Permitting: None
Ownership: Private
Other Constraints: None

Existing Conditions

Just across the CT/NY State line on the Connecticut side, the stream passes through fields on a large private estate. Three ponds are drained by a single tributary at the east side of the property, behind residences facing Smith Ridge Road. The stream is bordered by a forested buffer in some places, but runs unbuffered through meadow in some areas.

Proposed BMP

Approximately 11,000 ft.^{2} of meadow-type buffer should be added along this portion of stream, assuming a buffer depth of approximately 10 ft. 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 verified due to access constraints on private property.

NO PHOTO AVAILABLE

APPENDIX B. FUNDING OPPORTUNITIES

Funding Source	Maximum Dollar amount	Minimum Dollar amount	Required match	Applications Open	Deadline
DEEP 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.					
DEP 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					
DEEP 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					
DEP 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
DEEP 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.					
DEEP 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 DEEP'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 DEEP 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**
1	Michigan Road west of Summersweet Lane	14	good	pasture, residential, forested	3'	moderate	riffle-pool	boulder	9	8	10	8	10	9	5	7	7	8	**8.1**	**good**	Tricoptera; Plecoptera	boulders; leaf packs; wood; riffles; pools	wetlands adjacent; evidence of minor incision and widening, probably in past; bed armored
2	Michigan Road near Summersweet Lane	11	good	pasture, residential, forested	3'	moderate	riffle-pool	cobble	4	6	5	8	10	8	5	5	3	5	**5.9**	**poor**	not sampled	riffles; boulders; submerged aquatic vegetation; wood	sediment accumulation/embedded substrate; algal growth; boulder/cobble bank stabilization; flows to a pond
3	Country Club Road	103 (Father Peter's Brook)	fair	residential, forested	10'	moderate	riffle-pool	cobble	9	10	7	7	10	7	5	7	6	7	**7.5**	**good**	Tricoptera; Plecoptera	riffles; boulders; wood; leaf packs	well connected to floodplain but minor bank erosion where lawn extends to stream; algae present
4	Nursery Road	101 (Lower main stem)	poor	residential	15'	low	plane-bed	sand	5	7	6	7	7	6	10	1	0	3	**5.2**	**poor**	not sampled	undercut banks; overhanging vegetation	sediment accumulation/mid-channel bar forming; bank erosion adjacent to lawns extending to stream; geese; cloudy water; algae
5	Fillow Road near Little Fox Lane	4	poor	residential	2'	moderate	plane-bed	concrete	1	1	3	3	7	7	1	1	1	2	**2.7**	**poor**	not sampled	none observed	channelized; multiple small ponds; boulder-lined or concrete rectangular channel
6	Flax Hill road near Primrose Lane	1	poor	residential	7'	moderate	riffle-pool	cobble	1	1	3	5	7	7	3	3	1	3	**3.4**	**poor**	not sampled	riffles; boulders	severe bank erosion with recent stabilization; channelized downstream of Primrose; algae abundant
7	Flax Hill Road near Shadybrook Lane	101 (Lower main stem)	poor	residential, commercial	25'	moderate	riffle-pool	boulder	6	7	7	8	8	7	10	5	7	3	**6.8**	**fair**	not sampled	pools; riffles; overhanging vegetation; leaf packs	sections of bank stabilized; some fine sediment accumulation/point bar in back water; lawn to river on one side; substrate 30% embedded; algae
8	Rowayton Avenue	1 (Keeler's Brook)	poor	residential, commercial	12'	moderate	riffle-pool	cobble	2	3	1	5	3	2	5	1	1	1	**2.4**	**poor**	not sampled	boulders; riffles; pools; overhanging vegetation	boulder stabilized banks; lawn up to stream edge; commercial development very close to stream
9	Rt. 1 bridge	101 (Lower main stem)	poor	residential, commercial	25'	low	plane-bed	sand	7	7	3	5	8	9	10	5	7	5	**6.6**	**fair**	not sampled	overhanging vegetation; boulders; riffles; leaf packs	point bar and backwater downstream of bridge

***Impervious Cover (IC) Scores equate to the following expected stream condition:**
Poor (IC score = 3 or 4)
Fair (IC score = 1 or 2)
Good (IC score = 0)
****Stream Visual Assessment (SVA) Scores are the average of the parameter scores and equate to the following observed stream conditions (SVA Category):**
≤6.0 = Poor
6.1-7.4 = Fair
7.5-8.9 = Good
≥9.0 = Excellent