MianusPlan_ Inventory data.pdf

Byram River plan_ Inventory Data.pdf

Greenwich Open Space Plan (maps and resources).pdf

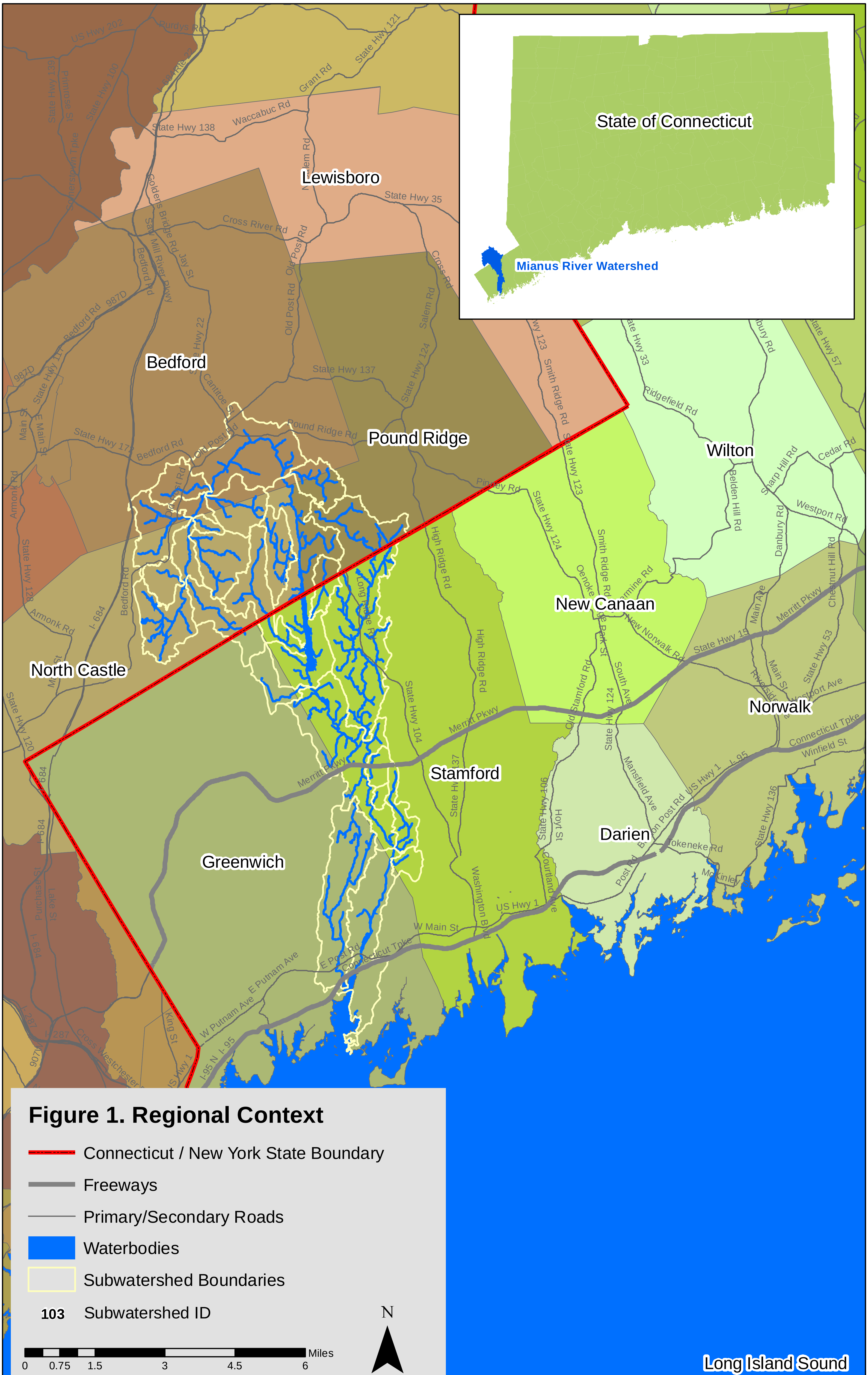


Figure 1. Regional Context

have modified the channel and riparian zone with small walls, dams, bridges, and landscaping. In the lower watershed, intense recreation in park areas has led to disputes over the need for better stewardship and responsible use. In some areas, urban development has reached levels that often result in water and habitat quality impacts. These patterns have imperiled many of the resources that make the Mianus River Watershed a desirable place to live and play.

THE URBAN STREAM SYNDROME

When watersheds become urbanized, changes in the physical and chemical stream characteristics cause a systematic and predicable decline in the health and diversity of aquatic species. Nonpoint source (NPS) pollutants, such as bacteria, sediment, nitrogen (N), and phosphorus (P) are delivered to streams in increasing quantities. And 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 and no longer contain 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.

The Mianus River lies somewhere in the middle on the spectrum of effects of urbanization. Aquatic monitoring and stream assessments reveal a patchwork of conditions, in some cases quite healthy and in others partially degraded. Regionally, the river has fared better than many of its neighbors, due mainly to land protection in the headwaters and a strong local community committed to protecting this resource.

The Mianus River Watershed Based Plan ("the Plan") outlines a targeted, science-based, and community-led effort to improve and protect conditions in the Mianus River Watershed through on-the-ground restoration and stormwater management, 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 waterbodies has been regulated through the National Pollution Discharge Elimination System (NPDES) program, which is geared toward large commercial, industrial, or public sites that discharge water to streams. Over the past several decades, this program has reduced levels of pollution and improved water quality throughout the country. NPDES has however been less effective at managing NPS pollution.

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

In the Mianus River Watershed, development in some areas is approaching threshold levels that are commonly associated with mild to moderate water quality and aquatic habitat degradation (see Chapter 2). Although sampling by the Connecticut Department of Energy and Environmental Protection (CTDEEP) has been very limited, the existing conditions assessment conducted in support of this Plan (Chapter 2) identifies multiple areas where water quality and habitat problems exist. Many of these problem areas are related to stormwater runoff from roads and parking lots, or residential landscaping and construction along the stream banks. If current land use practices are continued, stream conditions may worsen to a point where aquatic habitat is significantly impacted. In the absence of strong regulation to deal with this problem, and since the watershed spans municipal and land use boundaries, watershed based planning is a particularly important approach to dealing with these 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 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 in the long run will be more effectively implemented than one that 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 framework 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 protection and restoration. Central to its approach is the idea that the Plan will be most effectively implemented when municipalities and partner organizations work together to achieve pollution reduction targets and minimize future impacts. 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 criteria established by CTDEEP.

Westchester Counties. The river flows north from its headwaters in North Castle, New York, then curves east and south through the municipalities of Bedford and Pound Ridge before crossing the state boundary and flowing south through Stamford and Greenwich, Connecticut where it outlets to LIS. The watershed is bisected by the Metro-North Railroad and by two major highways, I-95 and the Merritt Parkway (CT-15). For the purposes of this Plan, the study area ends just below the confluence with Strickland Brook, at the point where the Metro-North Railroad crosses the estuary.

The Mianus River Watershed contains approximately 106 miles of stream, including tributaries. Major tributaries include the East Branch (seven miles long), Piping Brook (three miles long), and Strickland Brook (five miles long), and several smaller unnamed streams. The Main Stem of the Mianus River from below the S.J. Bargh Reservoir to the downstream extent of the study area is approximately nine miles long.

In its headwaters, the river is a relatively slow-moving lowland stream with a silty bottom; as it moves into the Mianus River Gorge, the stream speeds up through a series of pools and rocky outcrops (Aquatic Resources Consulting 2000). Multiple small dams and channel modifications are found throughout the watershed. Major dams are located at the S.J. Bargh Reservoir, Mianus Mill Pond, and Mianus Pond near the Route 1 crossing. Despite these modifications, the banks have not been extensively channelized, and most of the channel maintains a meandering pattern.

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 S.J. Bargh Reservoir, which provides drinking water to many residents living within and outside of the watershed. In addition to providing a source of drinking water, the Mianus River is also used for recreational fishing (bank fishing and fly fishing). Boaters row and paddle the multiple small ponds along the lower reaches of the Mianus River.

Given the diversity of uses that depend on high-quality water, 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 not been sufficient to indicate that any portion of the river fails to meet minimum standards; however studies have indicated problems related to bacteria in Strickland Brook (Milone & MacBroom 2004) and on the Main Stem (Aquatic Resources Consulting 2000). Since 2004, sewers have been installed in parts of Greenwich in the lower portion of the watershed, which may invalidate earlier bacteria data. Prior to development of the Plan it has been generally presumed that some reaches may fail to meet state standards for recreation or habitat, based on the assessments described above.

Stakeholders have suggested that bacterial problems within the watershed may be related to numerous malfunctioning or under-performing septic systems located on private property, but results of Aquarion Water Company's sanitary monitoring program suggest that failure rates of septic systems within the watershed are very low (B. Roach, pers. comm., 8.20.12). Aquarion conducts annual visual sanitary inspections at approximately 240 sites within the Mianus River Watershed in the communities of Bedford, Pound Ridge, North Castle, Greenwich, and Stamford (B. Roach, pers. comm., 8.20.12). During the past five years of monitoring, Aquarion performed over 1,000 sanitary inspections within the Mianus River Watershed and found no reportable septic system failures (B. Roach, pers. comm., 8.20.12). However, it should be noted that the Aquarion study was based on a visual inspection of septic system condition and did not include advanced techniques for identifying septic plumes.

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 Mianus River Watershed were largely related to farming, although parts of the Gorge were never farmed due to steep slopes and rocky soil. In the estuary, oyster farming was a major industry, peaking in the early 20th century. Since then, the land has been largely cleared and developed for suburban neighborhoods. Commercial corridors are found near the coast and in Bedford Town Center. 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 Mianus River Watershed is primarily residential (76 percent of the watershed area) (Table 1). The watershed assumes a more rural character in the upper watershed, while suburban residential communities dominate land use in the lower watershed (Figure 2). Approximately 22 percent of the watershed is preserved as open space. The remaining three percent of land use is designated for commercial, industrial, and institutional uses. Impervious cover is estimated to be 12 percent.

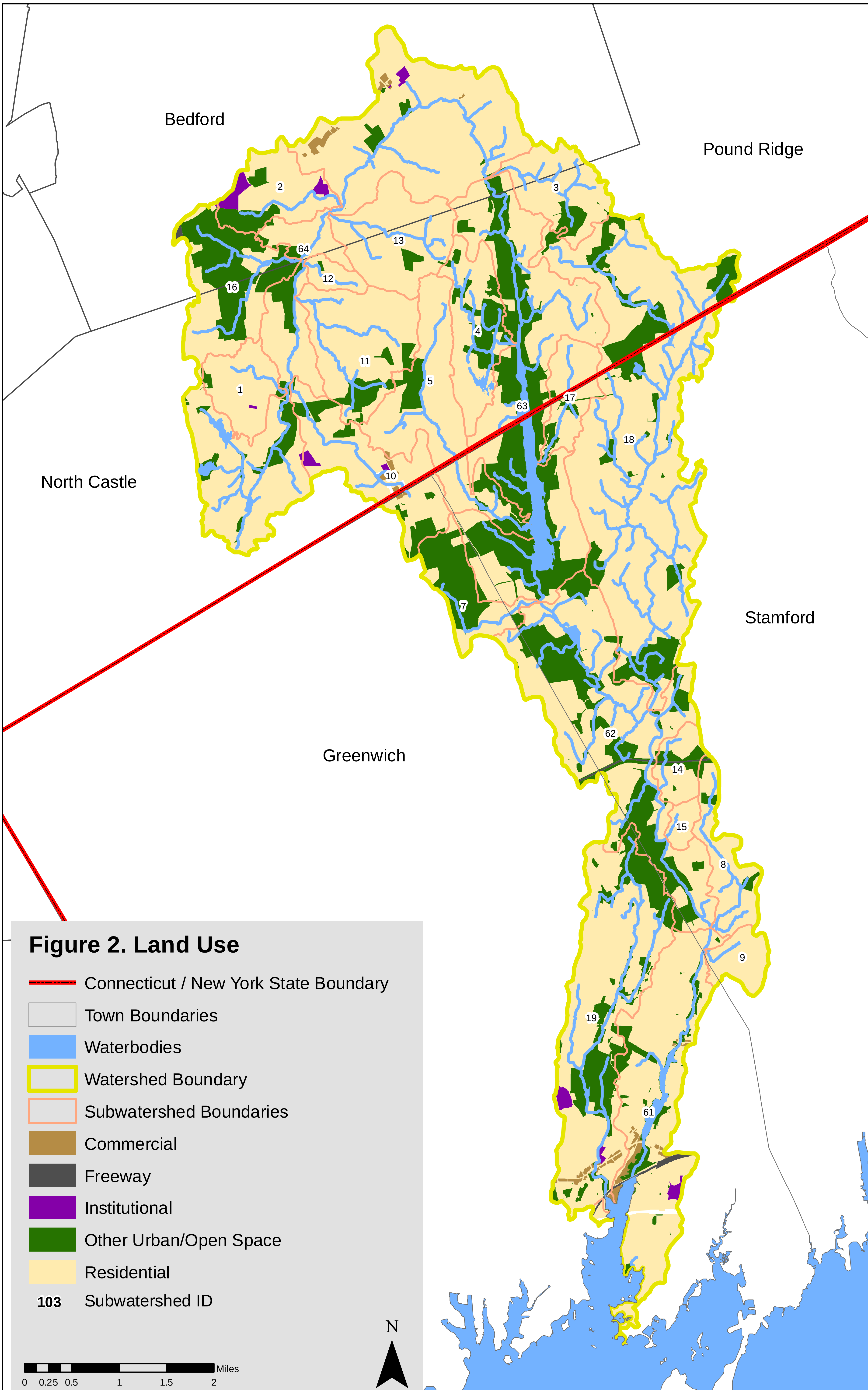
Table 1. Watershed Land Use

Land use	Percent of Watershed Area
Commercial	1
Freeway	<1
Industrial	<1
Institutional	1
Other Urban/Open Space	22
Residential	76

Vegetation and Wildlife

Vegetation and wildlife are closely tied to land use and soil type characteristics. In the Mianus 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



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.

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

The Mianus River Gorge, located at the heart of the watershed, contains some of the last stands of old-growth forest left in the region. Steep slopes and poor logging potential made this area unappealing to settlers, while much of the adjacent forest was cleared for pasture land in the 18th and 19th centuries. Today the Gorge is home to coyote, deer, bobcat, and a variety of birds, reptiles, and amphibians.

Below the gorge, most of the remaining forested land within the watershed has some history of disturbance, whether related to land development or farming. As is typical in the region, native forest species have given way in many areas to large stands of invasive species, including bamboo (*Bambusa vulgaris*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), and others. An overabundance of white-tailed deer has led to increasing pressure to hunt these animals as a forest management measure.

Soils and Geology

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

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).

Located along the eastern coastal plain, soils and geology within the Mianus River Watershed are generally representative of the region. Well-drained soils predominate overall, although conditions vary throughout (Table 2, Figure 3). The river follows a fairly low gradient from the low hills of North Castle, then steepens significantly through the Mianus Gorge, a periglacial feature created by blockage and rerouting of streams below the glacial front (USGS Geology of National Parks, 3D and Photographic Tours: accessed 5/23/12).

Table 2. Hydrologic Soil Group Percent of Total Area

Hydrologic Soil Group	Percent of Watershed Area
Groups A and B	55
Group C	22
Group D	19
Water	3

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

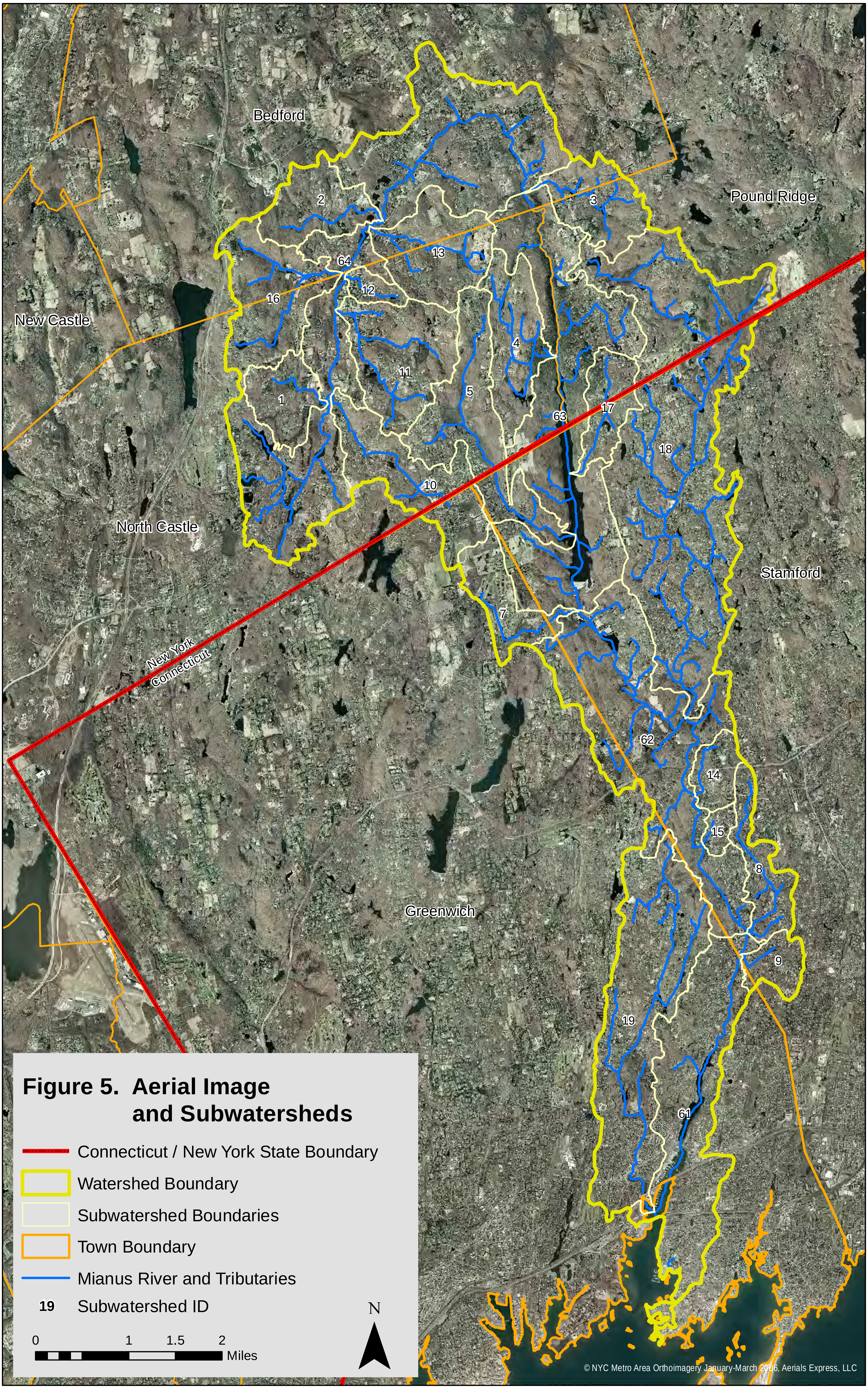


Figure 5. Aerial Image and Subwatersheds

north of the Mianus River Gorge Preserve. Observed conditions were better than predicted by the impervious cover analysis in subwatershed 62 (site 11) along the Main Stem. Channel characteristics may make the river more resistant to instability at this location.

Reaches in Strickland Brook, the East Branch, and the Upper Main Stem were in worse condition than predicted. The comparison of visual assessment and impervious cover analysis results in these locations suggest that in-stream conditions in the Mianus River Watershed are strongly influenced by both watershed-scale conditions (i.e., levels of overall imperviousness) and local-scale conditions such as poor riparian buffers and dams. In particular, large tracts of open space within these subwatersheds may have slightly improved the overall impervious cover score, although levels of development might be quite high in some areas. These local-scale conditions often resulted in stream conditions that were in worse condition than predicted by the ICM.

Local conditions responsible for poorer-than-expected conditions included dams, poor riparian buffers, channelization, and streamside development. Dams were often associated with shallow, stagnant pools, and were observed in all locations where conditions were more impaired than expected (visual assessment sites 10, 12, 15, 16, and 18). Also, recent ridge-crest developments coupled with steep valley walls likely contributed to the formation of gullies within some protected areas (e.g., Mianus River Gorge Preserve, etc.). Downstream of the Mianus River Gorge Preserve, multiple areas of channelization were observed on residential properties where the stream flowed through private backyards. In subwatershed 19, sample site 10 is located on an unstable reach of a small tributary to Strickland Brook where the stream is abutted by residential lawns and flows in culverts under driveways. In subwatershed 18, site 12 is located downstream of the Rockrimmon Golf Course, where an algae-rich pond and unstable banks were observed. In subwatershed 64, site 15 is located along the Main Stem just downstream of Miller's Mill. Degradation of this reach is likely due to the presence of a large dam; conditions within the upstream impoundment; and sediment delivery from adjacent roads and gullied tributaries. In subwatershed 4, conditions at site 16 were likely due to its location directly downstream of a low-head dam, in contrast to nearby site 17 which was not impounded and was in good condition. In subwatershed 64, site 18 is located below the Windmill Lakes development, where multiple instances of serious erosion in drainage ditches and first-order streams were observed.

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, which is a quantity of pollutant transported per unit time, from concentration, which is a quantity of pollutant per volume of water.

There are a few methods for estimating pollutant loading (i.e., the amount of pollutants entering the stream). Generally, these methods fall into two categories, computer simulation and direct measurements. Given the difficulty and expense of directly measuring pollutants, the Plan team decided to use computer simulation to estimate the quality of pollutants being introduced to the Mianus 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, and open spaces as well as various soil types. The source of these estimates comes from a series of nationwide studies of urban runoff.

In Chapter 3, the existing pollutant load estimate will be compared with pollutant load estimates for the Mianus River Watershed assuming urban development had not occurred (i.e., the entire watershed was forested). 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 bacteria. Of these, sediment, N, P, and bacteria are considered the most important NPS pollution parameters. WinSLAMM can simulate loading for each of these pollutants by estimating N modeling as nitrate (NO_3), P as particulate P (the portion of P that is associated with sediment particles), and using Total Suspended Solids (TSS) as an indicator of sediment loading. Finally, WinSLAMM uses fecal coliform as an indicator of pathogenic bacteria loading. The following sections provide a general overview of common NPS pollutants and their sources.

Nitrogen

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

Bacteria

Many different species of bacteria are carried into surface waters from 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 Mianus 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 NURP pollutant concentrations to different types of land cover based on

- 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.

Table 6. Pollutant Loading Analysis Results

Subwatershed (Headwaters to outlet)	Area (ac)	Avg TSS Load (lb/yr)	Avg TSS Load (lb/ac/yr)	Avg Particulate P Load (lb/yr)	Avg Particulate P Load (lb/ac/yr)	Avg NO_3 Load (lb/yr)	Avg NO_3 Load (lb/ac/yr)	Avg Indicator Bacteria Load (billion cfu/yr)	Avg Indicator Bacteria Load (billion cfu/ac/yr)
64 (Upper Main Stem)	2363.4	1,817,638	769	9,632	4.1	5,346	2.3	536,038	227
1	364.4	107,891	296	635	1.7	462	1.3	39,547	109
10	778.9	422,097	542	2,003	2.6	1,546	2.0	131,384	169
11	818.8	287,357	351	1,210	1.5	972	1.2	90,334	110
12	109.5	33,970	310	185	1.7	129	1.2	14,582	133
16	796.3	482,943	606	930	1.2	1,074	1.3	113,138	142
13	680.4	228,971	337	1,300	1.9	907	1.3	78,699	116
2	472.2	185,908	394	671	1.4	543	1.1	55,442	117
3	493.9	116,990	237	491	1.0	314	0.6	54,893	111
63 (Main Stem/Bargh Reservoir)	2074	989,600	477	4,494	2.2	2,804	1.4	254,415	123
4	582.9	137,268	235	484	0.8	355	0.6	57,780	99
17	337.8	229,833	680	1,322	3.9	755	2.2	61,492	182
5 (Piping Brook)	980.7	703,860	718	2,926	3.0	1,492	1.5	178,759	182
7	409	344,515	842	1,297	3.2	750	1.8	79,248	194
62 (Below Bargh Reservoir)	1576.6	1,479,094	938	6,237	4.0	22,908	14.5	838,305	532
18 (East Branch)	3466.1	1,255,906	362	6,899	2.0	13,005	3.8	636,277	184
14	215.1	145,416	676	618	2.9	442	2.1	40,358	188
15	87.5	23,168	265	136	1.6	94	1.1	9,190	105
8	385.8	307,209	796	1,614	4.2	940	2.4	78,568	204
61 (Lower Main Stem)	3162.4	909,405	288	4,866	1.5	36,479	11.5	1,332,936	421
9	206.3	159,344	772	947	4.6	527	2.6	42,053	204
19 (Strickland Brook)	1807.9	1,749,012	967	8,328	4.6	31,700	17.5	1,230,310	681
Mianus Watershed:	**22,169**	**12,117,395**	**547**	**57,225**	**2.6**	**123,544**	**5.6**	**5,953,748**	**269**

Most reaches in the Mianus River Watershed are designated Class AA streams (Figure 9), and as such are held to the strictest water quality standards. Strickland Brook is designated as a Class A stream. The Mianus River estuary is designated a Class SA waterbody, which means that human consumption of shellfish is permitted.

These use designations are associated with a series of quantitative and qualitative standards that define maximum concentrations for various pollutants above which a waterbody is no longer considered to meet its designated use. A waterbody that is found to fail minimum quality standards for its designated use is placed on the Connecticut IWL. In the Mianus River Watershed, no segments have been identified as failing water quality standards.

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 have been collected to support this conclusion. Since sampling in the Mianus 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. Throughout this document, the term "impairment" is used generally to refer to areas expected not to meet state standards.

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

As noted in the impervious cover analysis, SVA scores were commonly associated with predicted impervious cover scores based on existing land use conditions. Since field observations of tributary streams were similar to or worse than the predicted conditions based on impervious score, all tributary streams located in subwatersheds with fair impervious cover scores (subwatersheds 1, 8, 9, 10,11, 12, 13, 14, 15, 17) warrant further investigation to determine if impairments are present.

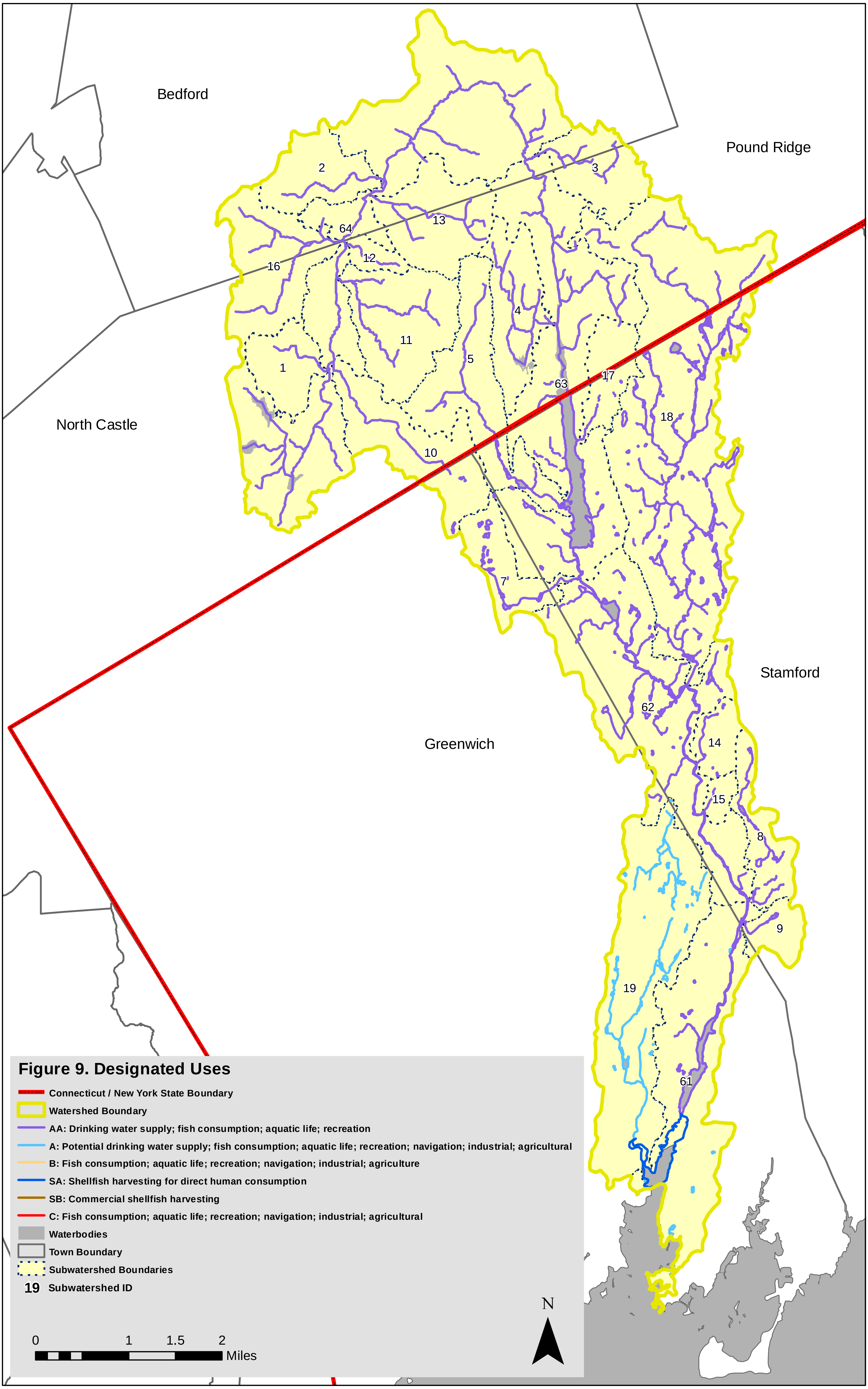


Figure 9. Designated Uses
Connecticut / New York State Boundary
Watershed Boundary
AA: Drinking water supply; fish consumption; aquatic life; recreation
A: Potential drinking water supply; fish consumption; aquatic life; recreation; navigation; industrial; agricultural
B: Fish consumption; aquatic life; recreation; navigation; industrial; agriculture
SA: Shellfish harvesting for direct human consumption
SB: Commercial shellfish harvesting
C: Fish consumption; aquatic life; recreation; navigation; industrial; agricultural
Waterbodies
Town Boundary
Subwatershed Boundaries
19 Subwatershed ID
0 1 1.5 2
Miles
N
Bedford
Pound Ridge
North Castle
Stamford
Greenwich
1
2
3
4
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63
64

As discussed in Chapter 1, 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 Mianus River and its tributaries. A key question moving forward is "how much do pollutant loads need to be reduced?"

There are many ways to approach the issue of pollutant load reduction. Ideally, the question of load reduction 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. The required load reduction would then be the one that lowers the pollutant concentrations from their current levels to acceptable levels. Using this approach, however, requires in-stream monitoring data that currently do not exist for the Mianus River. In addition, this approach requires the use of a standard for the acceptable maximum pollutant concentrations for each segment of the Mianus River and its tributaries. State numeric standards have not yet been established for N, P, or TSS concentrations. And although numeric standards exist for indicator bacteria, sampling data is insufficient to characterize in-stream concentrations of indicator bacteria throughout the Mianus River and its tributaries.

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

The following section establishes pollution reduction targets for the Mianus 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 the 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 Mianus 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 method similar to that used to develop existing conditions models (methods and results described in Chapter 2); here, however, the models assume that land use within the watershed is 100 percent forested. As described in the introduction to this chapter, the predevelopment load was subtracted from the existing conditions load to determine the total target pollutant load reduction for each subwatershed for each pollutant. The target was set to zero if the predevelopment load was greater than the existing conditions load (discussion of results follows). In the 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 HSG.

As noted above, the Plan acknowledges 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 9,304 lb/yr reduction in TSS (Table 7), a 998 lb/yr reduction in particulate P (Table 8), a 100,931 lb/yr reduction in NO_3 (Table 9), and a 3,550,136 billion cfu/yr reduction in indicator bacteria (Table 10). 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 7, 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 9 and 10). NO_3 load reduction targets range from 48 lb/yr to 34,721 lb/yr and the indicator bacteria reduction targets range from 4,243 billion cfu/yr to 1,146,062 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 7 and 8). 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 424 lb/yr in the eight subwatersheds where particulate P increased from predevelopment conditions. TSS load reduction targets were as large as 4,201 lb/yr in the three 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 TSS and P than other soil types. In these instances, increased impervious cover in the existing conditions model may have eliminated substantial sources of TSS and particulate P, thus reducing load estimates from the predevelopment to existing conditions scenario. For subwatersheds where TSS and/or particulate P loads decreased from existing conditions, no load reduction targets were developed for the respective constituent. For TSS, this fact may appear to contradict visual assessments, which have indicated that fine sediment is overabundant in the upper watershed and in Strickland Brook. These results do not imply that sediment is not a concern in the watershed; rather they indicate that TSS related to land use changes external to the stream channel may not be the primary cause of sedimentation. It is likely that a combination of channel modification (dams, culverts, etc.) and other characteristics such as steepness and soils within the greater watershed are the source of the observed sedimentation.

For the Mianus River Watershed, total pollution reduction targets require annual decreases of 0.1 (Table 7), 1.7 (Table 8), 81.7 (Table 9), and 59.6 percent (Table 10) for TSS, particulate P, NO_3, and indicator bacteria loads, respectively. Interim (60 percent) targets require decreases of 0.06, 1.0, 49.0, and 35.8 percent, for TSS, particulate P, and NO_3, and indicator bacteria, respectively. All pollutants are summarized in Table 11. Typical load reductions and efficiencies for the management actions recommended in the Plan are presented in Chapter 6.

Table 7. Total Suspended Solids Load Reduction Targets

Subwatershed (headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Total Load Reduction Target (lb/yr)	Percent Reduction (%)	Interim Load Reduction Target (lb/yr)
64 (Upper Main Stem)	1,817,638	1,889,796	0	0.0%	0
1	107,891	113,591	0	0.0%	0
10	422,097	429,703	0	0.0%	0
11	287,357	294,043	0	0.0%	0
12	33,970	32,426	1,544	4.5%	926
16	482,943	488,538	0	0.0%	0
13	228,971	238,830	0	0.0%	0
2	185,908	190,901	0	0.0%	0
3	116,990	112,789	4,201	3.6%	2,521
63 (Main Stem/Bargh Reservoir)	989,600	1,029,198	0	0.0%	0
4	137,268	133,709	3,559	2.6%	2,135
17	229,833	246,895	0	0.0%	0
5 (Piping Brook)	703,860	704,562	0	0.0%	0
7	344,515	351,644	0	0.0%	0
62 (Below Bargh Reservoir)	1,479,094	1,570,325	0	0.0%	0
18 (East Branch)	1,255,906	1,295,101	0	0.0%	0
14	145,416	152,536	0	0.0%	0
15	23,168	23,837	0	0.0%	0
8	307,209	326,054	0	0.0%	0
61 (Lower Main Stem)	909,405	1,012,182	0	0.0%	0
9	159,344	171,105	0	0.0%	0
19 (Strickland Brook)	1,749,012	1,992,828	0	0.0%	0
Watershed Total:	**12,117,395**	**12,800,593**	**9,304**	**0.1%**	**5,582**

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

Table 8. Particulate Phosphorus Load Reduction Targets

Sub-watershed (headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Total Load Reduction Target (lb/yr)	Percent Reduction (%)	Interim Load Reduction Target (lb/yr)
64 (Upper Main Stem)	9,632	9,449	183	1.9%	110
1	635	568	67	10.6%	40
10	2,003	2,148	0	0.0%	0
11	1,210	1,470	0	0.0%	0
12	185	162	23	12.4%	14
16	930	2,443	0	0.0%	0
13	1,300	1,194	106	8.2%	64
2	671	955	0	0.0%	0
3	491	564	0	0.0%	0
63 (Main Stem/Bargh Reservoir)	4,494	5,146	0	0.0%	0
4	484	669	0	0.0%	0
17	1,322	1,234	87	6.6%	52
5 (Piping Brook)	2,926	3,523	0	0.0%	0
7	1,297	1,758	0	0.0%	0
62 (Below Bargh Reservoir)	6,237	7,852	0	0.0%	0
18 (East Branch)	6,899	6,476	424	6.1%	254
14	618	763	0	0.0%	0
15	136	119	17	12.5%	10
8	1,614	1,626	0	0.0%	0
61 (Lower Main Stem)	4,866	5,061	0	0.0%	0
9	947	855	92	9.7%	55
19 (Strickland Brook)	8,328	9,964	0	0.0%	0
Watershed Total:	**57,225**	**63,998**	**998**	**1.7%**	**599**

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

Table 9. Nitrate Load Reduction Targets

Subwatershed (Headwaters to outlet)	Existing Load (lb/yr)	Predevelopment Load (lb/yr)	Total Load Reduction Target (lb/yr)	Percent Reduction (%)	Interim Load Reduction Target (lb/yr)
64 (Upper Main Stem)	5,346	3,333	2,013	37.7%	1,208
1	462	216	246	53.2%	148
10	1,546	765	781	50.5%	469
11	972	549	423	43.5%	254
12	129	62	66	51.2%	40
16	1,074	861	213	19.8%	128
13	907	448	459	50.6%	275
2	543	351	192	35.4%	115
3	314	226	88	28.0%	53
63 (Main Stem/Bargh Reservoir)	2,804	1,857	947	33.8%	568
4	355	268	87	24.5%	52
17	755	429	326	43.2%	196
5 (Piping Brook)	1,492	1,226	266	17.8%	160
7	750	605	146	19.5%	88
62 (Below Bargh Reservoir)	22,908	2,717	20,191	88.1%	12,115
18 (East Branch)	13,005	2,400	10,605	81.5%	6,363
14	442	266	176	39.8%	106
15	94	47	48	51.1%	29
8	940	561	379	40.3%	227
61 (Lower Main Stem)	36,479	1,758	34,721	95.2%	20,833
9	527	295	232	44.0%	139
19 (Strickland Brook)	31,700	3,372	28,328	89.4%	16,997
Watershed Total:	**123,544**	**22,613**	**100,931**	**81.7%**	**60,559**

Table 10. Indicator Bacteria Load Reduction Targets

Subwatershed (Headwaters to outlet)	Existing Load (billion cfu/yr)	Predevelopment Load (billion cfu/yr)	Total Load Reduction Target (billion cfu/yr)	Percent Reduction (%)	Interim Load Reduction Target (billion cfu/yr)
64 (Upper Main Stem)	536,038	354,296	181,742	33.9%	109,045
1	39,547	22,947	16,599	42.0%	9,959
10	131,384	81,325	50,060	38.1%	30,036
11	90,334	58,341	31,993	35.4%	19,196
12	14,582	6,613	7,969	54.6%	4,781
16	113,138	91,539	21,599	19.1%	12,959
13	78,699	47,613	31,086	39.5%	18,652
2	55,442	37,327	18,115	32.7%	10,869
3	54,893	24,021	30,871	56.2%	18,523
63 (Main Stem/Bargh Reservoir)	254,415	197,375	57,041	22.4%	34,225
4	57,780	28,484	29,296	50.7%	17,578
17	61,492	45,597	15,895	25.8%	9,537
5 (Piping Brook)	178,759	130,310	48,449	27.1%	29,069
7	79,248	64,284	14,964	18.9%	8,978
62 (Below Bargh Reservoir)	838,305	288,783	549,523	65.6%	329,714
18 (East Branch)	636,277	255,131	381,146	59.9%	228,688
14	40,358	28,294	12,064	29.9%	7,238
15	9,190	4,946	4,243	46.2%	2,546
8	78,568	59,654	18,914	24.1%	11,348
61 (Lower Main Stem)	1,332,936	186,874	1,146,062	86.0%	687,637
9	42,053	31,384	10,668	25.4%	6,401
19 (Strickland Brook)	1,230,310	358,473	871,838	70.9%	523,103
Watershed Total:	**5,953,748**	**2,403,612**	**3,550,136**	**59.6%**	**2,130,082**

Table 11. Pollutant Load Reduction Targets and Percent Reductions

Subwatershed (Headwaters to outlet)	NO_3			Particulate P			TSS			Indicator Bacteria		
	Total Target (lb/yr)	Interim Target (lb/yr)	Target as Percent of Total Watershed Target	Total Target (lb/yr)	Interim Target (lb/yr)	Total Target as Percent of Total Watershed Target	Total Target (lb/yr)	Interim Target (lb/yr)	Total Target as Percent of Total Watershed Target	Total Target (billion cfu/yr)	Interim Target (billion cfu/yr)	Total Target as Percent of Total Watershed Target
64 (Upper Main Stem)	2,013	1,208	2.0%	183	110	18.3%	0	0	0.0%	181,742	109,045	5.1%
1	246	148	0.2%	67	40	6.7%	0	0	0.0%	16,599	9,959	0.5%
10	781	469	0.8%	0	0	0.0%	0	0	0.0%	50,060	30,036	1.4%
11	423	254	0.4%	0	0	0.0%	0	0	0.0%	31,993	19,196	0.9%
12	66	40	0.1%	23	14	2.3%	1,544	926	16.6%	7,969	4,781	0.2%
16	213	128	0.2%	0	0	0.0%	0	0	0.0%	21,599	12,959	0.6%
13	459	275	0.5%	106	64	10.6%	0	0	0.0%	31,086	18,652	0.9%
2	192	115	0.2%	0	0	0.0%	0	0	0.0%	18,115	10,869	0.5%
3	88	53	0.1%	0	0	0.0%	4,201	2,521	45.2%	30,871	18,523	0.9%
63 (Main Stem/Bargh Reservoir)	947	568	0.9%	0	0	0.0%	0	0	0.0%	57,041	34,225	1.6%
4	87	52	0.1%	0	0	0.0%	3,559	2,135	38.3%	29,296	17,578	0.8%
17	326	196	0.3%	87	52	8.8%	0	0	0.0%	15,895	9,537	0.5%
5 (Piping Brook)	266	160	0.3%	0	0	0.0%	0	0	0.0%	48,449	29,069	1.4%
7	146	88	0.1%	0	0	0.0%	0	0	0.0%	14,964	8,978	0.4%
62 (Below Bargh Reservoir)	20,191	12,115	20.0%	0	0	0.0%	0	0	0.0%	549,523	329,714	15.5%
18 (East Branch)	10,605	6,363	10.5%	424	254	42.5%	0	0	0.0%	381,146	228,688	10.7%
14	176	106	0.2%	0	0	0.0%	0	0	0.0%	12,064	7,238	0.3%
15	48	29	0.1%	17	10	1.7%	0	0	0.0%	4,243	2,546	0.1%
8	379	227	0.4%	0	0	0.0%	0	0	0.0%	18,914	11,348	0.5%
61 (Lower Main Stem)	34,721	20,833	34.4%	0	0	0.0%	0	0	0.0%	1,146,062	687,637	32.3%
9	232	139	0.2%	92	55	9.2%	0	0	0.0%	10,668	6,401	0.3%
19 (Strickland Brook)	28,328	16,997	28.1%	0	0	0.0%	0	0	0.0%	871,838	523,103	24.6%
Total:	**100,931**	60,559	**100.0%**	**998**	599	**100.0%**	**9,304**	5,582	**100.0%**	**3,550,136**	2,130,082	**100.0%**

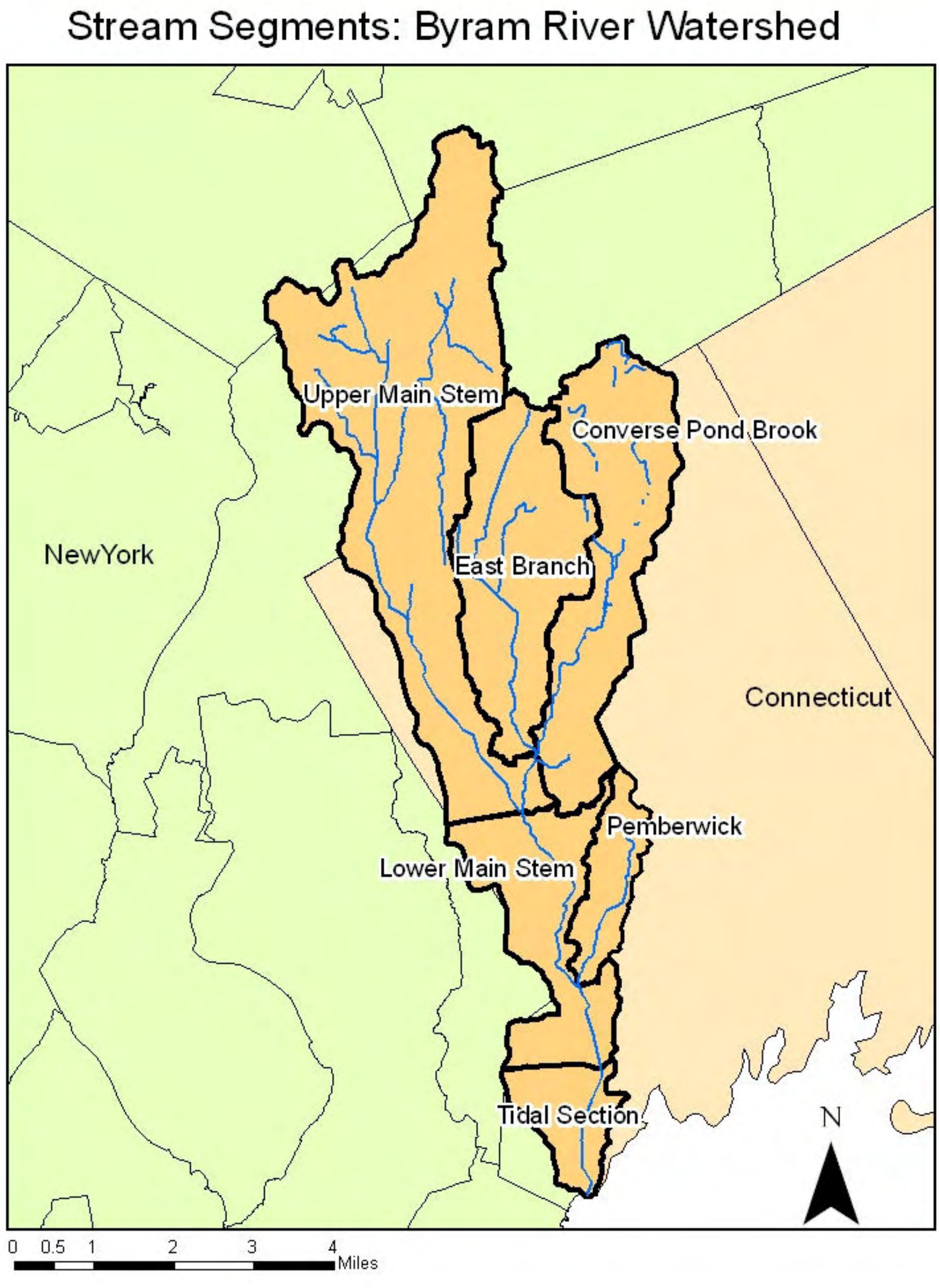


Figure 2. Stream Segments of Byram River Watershed.

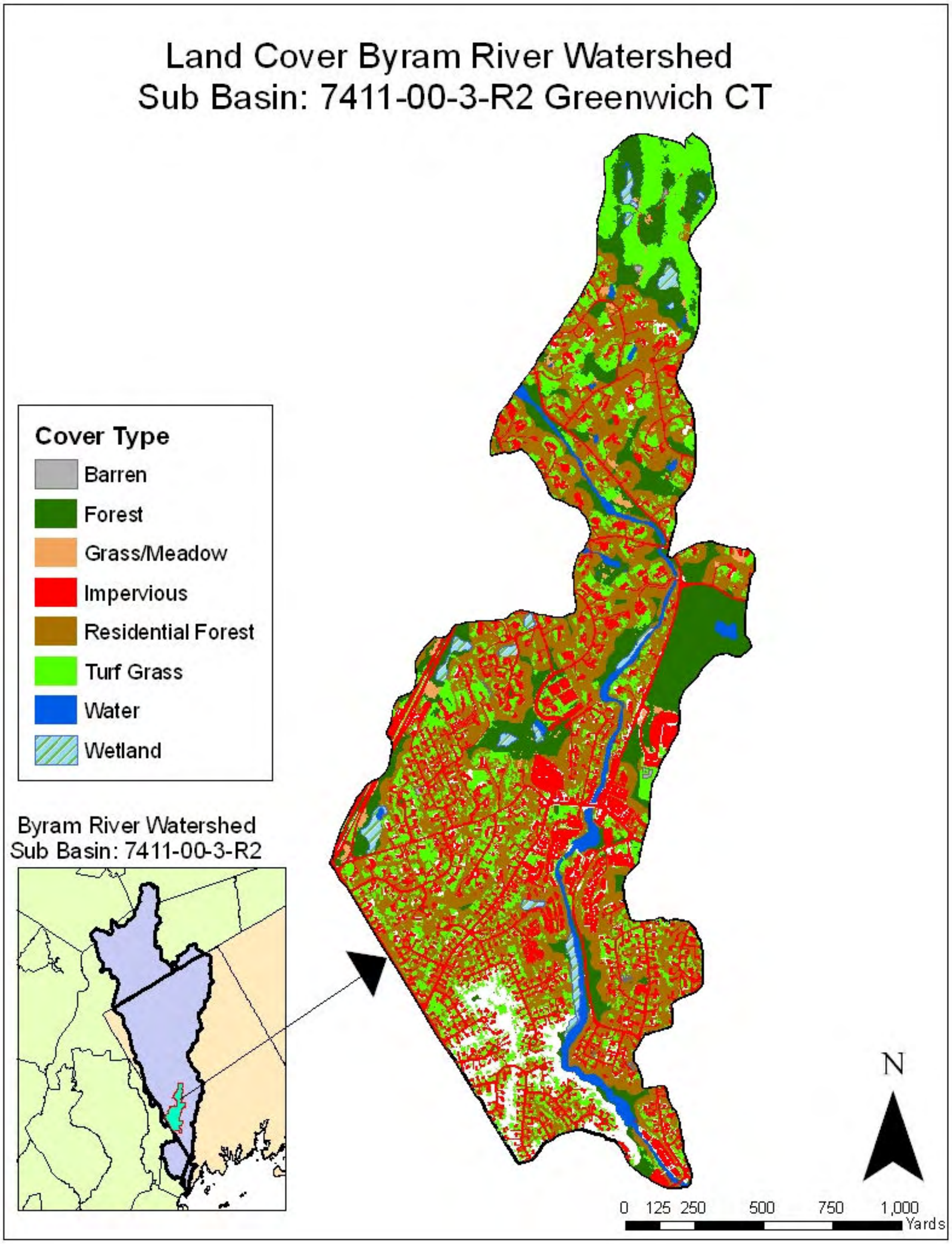


Figure 5. An example of one of the more developed regions of the Byram River Watershed. Note the amount of Impervious Cover, Turf Grass, and Residential Forest buffering the river.

3. NON-POINT POLLUTANT ASSESSMENT

3.1 Existing Data 2010

A review of existing data was conducted in the spring of 2010. The purpose of the review was to identify all relevant existing data sets and studies to date regarding nonpoint source pollutants and their causes. Datasets and studies were obtained from the following sources: Interstate Environmental Commission, US Environmental Protection Agency (Storet database), CT Department of Energy and Environmental Protection, NY State Department of Environmental Conservation, Greenwich Health Department, and Greenwich Conservation Department. The data was reviewed, summarized, and analyzed. Data gaps important to the understanding of the Byram were also identified. Individual Data Summaries are found in Appendix 1. Westchester County was not queried for data.

3.2 Assessment of Pollutants and Impairment 2010-2012

There are several ongoing efforts, which involve the collection and assessment of pollutant and impairment data. These projects will likely lead to future adjustments and refinements to the plan. A summary of these efforts are presented as follows:

1) Sampling, Analysis, and Load Model Calibration - The Interstate Environmental Commission in conjunction with Columbia University received funding under the American Recovery and Reinvestment Act in conjunction with a NYSDEC 604(b) grant to sample within a large length of the Byram River. The intent of the sampling and analysis is “to help design specific flow and water quality monitoring programs, to prioritize sub-basins that contribute significant nutrient and pathogen loads, and to identify infrastructure projects for funding recommendations”. The data will be used to model the river for water quality and quantity, and to support eventual calculation of Total Maximum Daily Loads (TMDLs) pursuant to NYSDEC criteria. Sampling, analysis, and model calibration commenced in the spring of 2010 and is expected to be completed by December 2011. The project plan specifies ten sampling locations distributed along the lower Byram River, the main stem of the river, East Branch, and West Branch. Three of the ten sampling locations are in NY (in the West Branch), in the town of North Castle. There are no sampling locations specified on the Converse Brook branch.

2) Sampling – the Greenwich Department of Health conducts routine sampling of the lower reaches of the Byram River. Their monitoring confirms the bacteriological problem in the impaired segments of the Byram River. See Appendix 1 for an explanation of the sampling protocol.

3) Stream Walk Assessments – The BWC is sponsoring volunteer streamwalk surveys. The program commenced during the late spring of 2010. CT office of the NRCS and the (CT) Southwest Conservation District furnished training to volunteers. Volunteers were

assigned to walk segments of the Byram and document potential water quality concerns and influences such as algae, aquatic plant life, substrate, erosion, buffer habitat, impoundments, culverts, trash, and discharge pipes. Additional training of new volunteers and fieldwork to evaluate additional stream segments began in the summer of 2011. Fieldwork is expected until the end of Fall 2011, followed up by data summarization and analysis. Additional fieldwork will likely be needed in 2012.

4) Fisheries Resource Assessments – The CT DEEP Inland Fisheries Division has an ongoing statewide fisheries resource assessment that includes survey locations within the Byram. To date, assessment has not included the West Branch of the river, but has included areas within the lower river, the main stem, East Branch, and Converse Pond Brook. There are historical records for alewives, blueblack herring, and gizzard shad, and at least one record for native brook trout in the upper reaches. American eels have been observed in the Byram. The first impoundment is the Pemberwick Dam. It is located 3.1 miles upstream from Long Island Sound. The second dam upstream is the Glenville Dam. It is about .75 miles upstream of the Pemberwick Dam. It is unclear if river herring migrate upstream to below the first impoundment. The majority of the species on the river are warm water and pond habitat species, a likely result of the impoundments and channel modifications within the river.

5) Illicit Sanitary Connection Elimination – In July 2009, EPA Region 2 issued an enforcement action (CWA-02-2009-3060) to the Village of Port Chester, NY regarding their stormwater management program and water quality in the lower portion of the Byram River and Byram Harbor. EPA ordered corrective measures to eliminate sources of pollution began September 1, 2010. This has resulted in increased effort by Port Chester in investigations of storm water outfalls to identify and correct bacteria and other pollutant problems caused by illicit sanitary connections. Routine sampling in storm drain catch basins, manholes, and the Byram River outfalls for total and fecal coliform, e-coli, ammonia, and surfactants is underway. Video inspections, smoke testing, and dye testing of sanitary sewers and storm drains are being conducted. (Greenwich Time November 29, 2010). In August 2010, EPA Region 2 issued a follow up enforcement action (CWA-02-2010-3048) requiring Port Chester to complete all work necessary to eliminate illicit sanitary connections to the Village of Port Chester's storm water system by July 2011 and complete outfall sampling to verify elimination of illicit sanitary connections to the storm sewer system by January 2012. The Village of Port Chester received a $725,000 grant from NYDEC in November 2010 to fund the illicit sanitary connection track down and repair project. Port Chester estimates that the total cost of the project to be twice that amount.

3.3 Additional Studies 2011

As a result of the data analysis conducted in 2010, further data refinement was conducted in 2011 by a consultant working in cooperation with Town of Greenwich Conservation Department staff. An impervious cover analysis was performed for the watershed and each sub basin using GIS data from Columbia University, the Town of Greenwich, and Westchester County. Long-term ambient water quality monitoring data was obtained from the CT DEP and analyzed for trends with regard to benthic assemblages. Preliminary data was obtained from the Interstate Environmental Commission (IEC) 2010 water quality assessment and analyzed for general trends in physical parameters. The findings from all three endeavors were applied to the previous 2010 findings to refine the available knowledge of pollutant impairments.

3.4 Analysis of Watershed Data

3.41 Project Results 2010

Based on the reporting from the 2010 data sources and understandings of the watershed, the major causes of pollution to the Byram are:

1) Bacteria (indicator species E. Coli, Enterococcus ,total coliform, and fecal coliform),
2) Nutrients (nitrates),
3) Floatables,
4) Sediment (turbidity).

Other pollutants documented in the river's sediments include:

5) Pesticides,
6) Heavy metals in the Byram (metals were found downstream in LIS),
7) PCBs (Reports by NY DEC and ATSDR)
8) PAHs

2010 Summary Of Existing Data For Byram Watershed

The causes and sources of pollution to the Byram, as reported in the above data sources are summarized in Table 1. Point sources were not included in this analysis as watershed planning efforts will be focused on nonpoint sources.

The specific terminology used to describe causes and sources was adopted directly from each of the data sources, and therefore reflect the scale that each study report addresses. For example, report data from the NYSDEC uses the terminology "pathogens" while the Greenwich Health Department separates pathogens into "Fecal Coliform", "Total Coliform", and "Enterococcus". Similarly, the IEC reports use the term "runoff" while the CT DEP uses the term "stormwater". Although this may pose some methodological problems in comparing the results, the table is qualitatively helpful in that it still portrays a broad survey of the problems within the river that need to be addressed.

Table 1. Summary of Existing Data for Byram Watershed*

Location (data)	Types of Pollutants	Sources	Affected Use
LIS (iec)	PCBs, Cadmium, Dioxin, Mercury (Hg), Lead (Pb)	Past chemical spills, contaminated sed/ resusp., atmospheric deposition.	Fish Consumption
LIS (iec)	Fecal Coliform, Total Coliform, Parasites	Runoff	Shellfish
LIS (iec)	Low Dissolved Oxygen, Nutrients, Organics	Runoff, atmospheric deposition	Aquatic Life
LIS (iec)	Elevated Bacteria	Rain, sewage, runoff	Primary Contact Recreation
LIS (ctdep)	Low Dissolved Oxygen, Total Nitrogen, Nutrient/Eutrophication, Fecal Coliform, Enterococcus	Stormwater, Highway/road/bridge, waterfowl, sanitary sewers, boats	Habitat, Shellfish, Recreation
Port Chester Harbor (nysdec)	Floatables, Pathogens	Urban/storm runoff, municipal	Primary & Secondary Contact Recreation & Fishing
Lower Byram River – Tidal Section (nysdec)	Pathogens	Urban, on-site water treatment systems	Fishing
Lower Byram River - Tidal Section (ctdep)	Fecal Coliform, Enterococcus	Stormwater, residential districts, sanitary sewers, illicit connections, boats, marinas	Shellfish, Recreation
Lower Byram River Tidal Section (ghd)	Total Coliform, Fecal Coliform, Nitrate	Unreported storm sewers - illicit connections	N/A
Lower Main Stem (ctdep)	Escherichia Coli	N/A	Recreation, Habitat
Lower Main Stem (gpz)	Fecal Coliform	Animals, septics, leaky sewers	N/A

*Note: Emphasis is on nonpoint sources and causes. Terminology regarding causes/sources directly adopted from the data sources, and redundancies reflect the differences in reporting scales.

iec = Interstate Environmental Commission; ctdep = CT Dept. of Energy and Environmental Protection; nysdec = NY State Dept. of Environmental Conservation; ghd = Greenwich Health Dept.; gpz = Greenwich Planning and Zoning

Sources of pollution

1) Major *bacterial* sources include sewage from leaky septics, illicit sanitary connections to stormwater pipes, waterfowl (geese), sewage from boats, marinas, and runoff from urban infrastructure such as roads, bridges, parking lots and other impervious surfaces.

2) Major *nutrient* sources include fertilizer runoff, leaky septics, horse farms, golf courses and other managed landscapes, and runoff from impervious surfaces.

3) Major *floatable* sources include bridges, roads, stormwater outflows, boats, individual littering and dumping, and impervious surfaces.

4) Major *sediment* sources include erosion from upstream construction, road/stream crossings, streambank erosion due to flooding and degraded vegetation, stormwater runoff, post construction land development, and impervious surfaces.

5) Although *pesticides* (including herbicides) were not reported within the cited data sources, it would be expected that there would be some amount of pesticide runoff within the watershed considering the level of development and land uses within the region. Major pesticide sources would include runoff from suburban and managed urban landscapes.

6) Similarly, even though *metals* were not reported as a major cause of impairment within the waters of the river, it would be expected that there would still be some presence of metals within the sediments. Major sources would be from polluted runoff from transportation related impervious surfaces, including parking lots, highways, roads, fleet and road maintenance yards and river crossings, as well as from local site contamination.

Data Gaps

Several data gaps and inherent methodological biases were identified during the course of the 2010 review. These gaps may affect the current understanding of any patterns of contamination within the Byram, and will require the collection of additional information. Collecting data and identifying gaps is part of an iterative data gathering process, as future data is collected and analyzed, there will be additional gaps identified as well that may need to be addressed.

The EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters (March 2008) suggests that there are three types of data gaps often encountered during the assessment process. *Informational data gaps* refer to whether the existing information is relevant to the types of information needed to assess the watersheds goals. *Temporal data gaps* refer to whether the existing information was collected within the appropriate time frames relevant to the analysis. *Spatial data gaps* refer to the spatial relevancy and over all spatial applicability of generalizations based upon the data. Although there were gaps in the data in all three categories, the significant data gaps were primarily *spatial* and *informational*.

Spatial Data Gaps

The majority of the data assessment points were located in the tidal portion of the Lower Byram and in the LIS. There are few data assessment points located within the lower main stem, the upper main branch, the East Branch, or Converse Pond Brook. Since the lower portion of the river likely aggregates pollutants that originate from both the upstream and the lower stream segments, the data still has value since it may indicate in a single snapshot some of the potential threats to the health of the river at that location. It would be important to know if there are pollutants that only impair the upstream. It would also be important to determine the proportion of contribution of any upstream pollutants to the downstream assessment points. The 2010-1011 study by the IEC will bring forth more data to begin to address this issue.

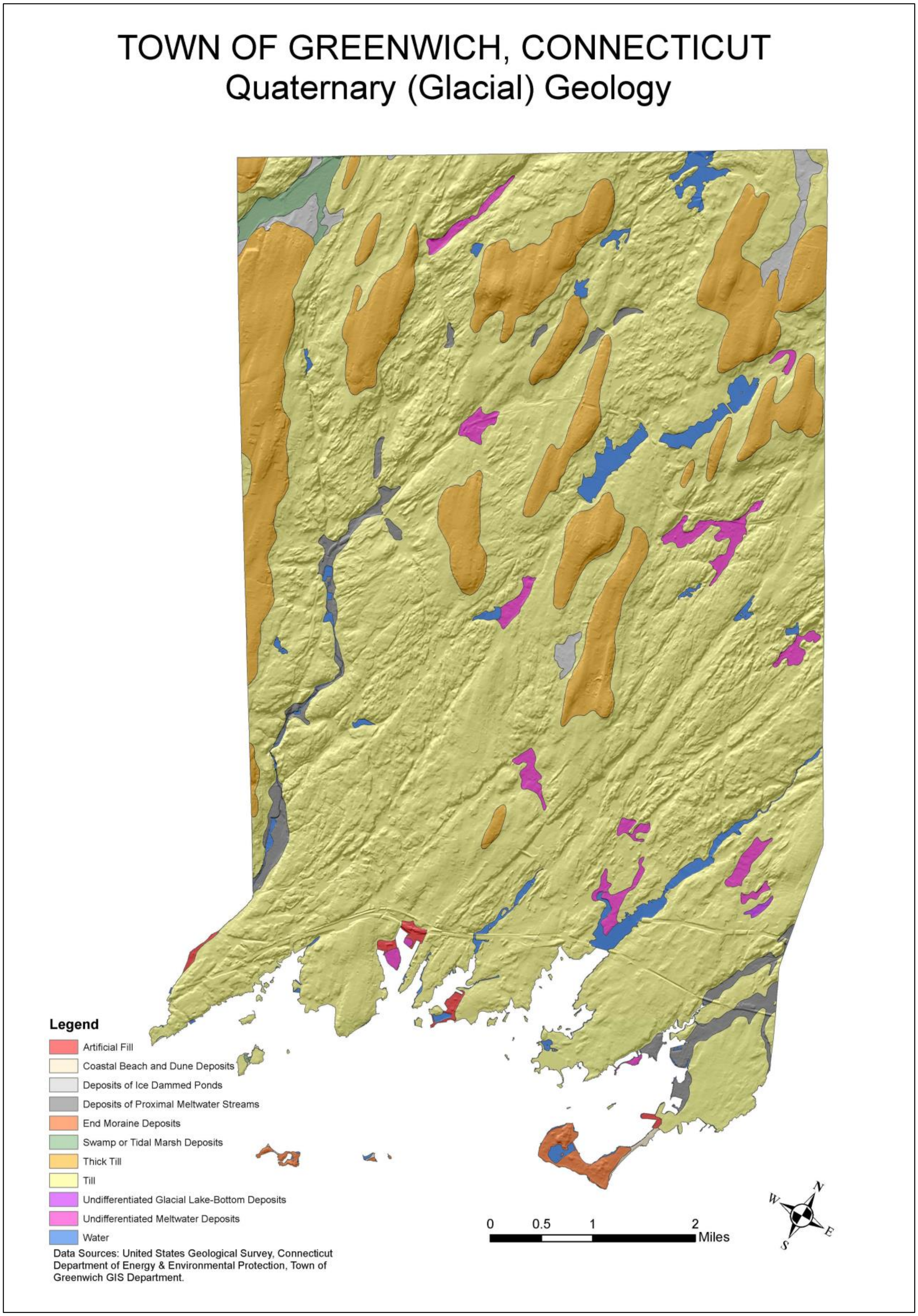
Informational Data Gaps

Pesticides and Heavy Metals: There was little mention in the above data sources of the role of pesticides and heavy metals within the river. Given the level of suburbanization and urbanization in the watershed, it is reasonable to expect some level of pollution by these agents. There may be a few reasons why these parameters were understated. The agents may not have been fully sampled for. The agents may be present at a level below the detectable or impairment level of the particular study. Local contamination upstream may be diluted downstream or locally bound to sediments or settled out during low flows and not mobile. Furthermore, the sampling sites might not constitute a representative sample, as previously discussed.

Other Pollutants: It should be noted that for each reported pollutant to be listed, it had to be present in amount relative to a threshold to trigger impairment relative to a specific use. It is conceivable that a pollutant could have been present at a base level, at a level sufficient to pose a concern to those interested in the health of the river, but not at a level high enough to trigger the impairment threshold for a designated use as specified by the regulatory agencies, and therefore not reported in their data.

3.42 Impervious Cover Analysis - 2011

The percent impervious cover (percent IC) for each of the fifty-five hydrologic subbasins (8-digit HUC subbasins) in the Byram watershed was calculated using Arc GIS mapping software. Impervious coverage was compiled from existing datasets from the Town of Greenwich GIS Department and the Westchester County GIS data warehouse. The individual subasins were then summarized by the watershed segments of the major tributaries. A detailed description of methods and tabulated results for individual sub basins is provided in Appendix 3.


TOWN OF GREENWICH, CONNECTICUT
Quaternary (Glacial) Geology
Legend
Artificial Fill
Coastal Beach and Dune Deposits
Deposits of Ice Dammed Ponds
Deposits of Proximal Meltwater Streams
End Moraine Deposits
Swamp or Tidal Marsh Deposits
Thick Till
Till
Undifferentiated Glacial Lake-Bottom Deposits
Undifferentiated Meltwater Deposits
Water
Data Sources: United States Geological Survey, Connecticut Department of Energy & Environmental Protection, Town of Greenwich GIS Department.
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to carry out their natural functions and they are often very difficult to restore once impaired, it is vital to protect and properly manage these important resources.

Water Resources

Long Island Sound

Forming the southern boundary of Greenwich, the Long Island Sound estuary is one of the Town's most significant and beautiful natural resources. An estuary is defined as a semi-enclosed coastal body of water, which has a free connection with the open sea and forms a transition zone between marine and freshwater environments.

Long Island Sound extends 110 miles east to west, separating Connecticut and Long Island. At its widest point, the Sound is 21 miles wide; off of Greenwich the width is approximately 7 miles. The US Environmental Protection Agency has designated Long Island Sound as an estuary of national significance, whose estuarine waters, natural ecosystems, and economic activities have been deemed by Congress to be critical to the environmental health and economic well-being of the nation.

Long Island Sound provides a diverse array of habitat types including beaches, dunes, rocky intertidal areas, deep and shallow open water habitats, eelgrass beds, and tidal wetlands. The wide variety of habitats support a diverse assemblage of plant and animal species and also provide a myriad of ecosystem services. One critically important and especially vulnerable habitat type is tidal wetlands, which are among the most productive ecosystems on earth. Tidal wetlands are wetlands that are periodically flooded and exposed by the rising and falling tides. Greenwich has approximately 44.5 acres of tidal wetlands as defined by their hydric soil type.

Tidal wetlands provide important foraging, nesting, and refuge areas for many species of birds, critical nursery habitat for fish species, as well as important habitat for many other organisms that inhabit the Long Island Sound coast. They also offer several other ecosystem services including trapping sediments and nutrients, reducing turbidity, filtering out heavy metals and other toxins, buffering against flooding, as well as reducing the impacts of storm and wave energy.

Long Island Sound is a tremendously productive estuary that supports a number of important commercial and recreational fisheries. More than 120 species of finfish inhabit the sound and it provides important spawning habitat for more than 50 of these species. Long Island Sound also supports more than 1,200 species of invertebrates, including several recreationally and commercially important species such as oysters, scallops, clams, lobster, and other shellfish. Greenwich's coastal waters support a variety of shellfish including oysters, hard and soft shell clams, and blue mussels, however poor water quality in Long Island Sound prompted the closure of these beds in 1960 by the CT Department of Agriculture. In 1986, 14 years after the passage of the federal Clean Water Act, the Greenwich Shellfish Commission was formed and began working to re-open the town's shellfish beds. Today, through careful management and improvements in water quality, the beds are open and support an important recreational shellfishery for town residents.

The natural beauty and diversity offered by Long Island Sound's coastline attracts many recreational boaters, beachgoers, and naturalists who, in turn, form an important component of the local economy. The Town of Greenwich owns and manages 8 coastal parks: Greenwich Point Park, Byram Beach, Grass Island, Island Beach, Great Captain's Island, Bruce Park, Roger Sherman Baldwin Park, and the newly restored Cos Cob Power Plant site. It also has 3 marinas: Greenwich Point Marina, Mianus River Marina, and the Grass Island Marina.

One of the biggest challenges Greenwich residents will face in the coming years is finding ways to deal with the rising sea levels and increased frequency of severe storms that are anticipated in association with global climate change. It is estimated that sea levels have risen about 0.8 feet over the past 100 years in Long Island Sound. This trend is expected to continue, and even low sea level rise projections of 1-2 feet by the end of this century would result in the loss of between 38 and 83 acres of Greenwich's current shoreline. This will impact the entire Greenwich coastline including all of our coastal parks and the recreational opportunities and ecosystems they support.

Rivers, Streams, and Watersheds

A watershed is an area of land where all of the water that falls on it or drains off of it flows out to a common waterbody. Most watersheds are drained by a river or stream, though some are drained by direct surface runoff or groundwater flow. All of the land in Greenwich is within the Long Island Sound Watershed. In Greenwich, the land area is further divided into six subregional watersheds with their associated streams, as well as an area of land that drains directly into Long Island Sound.

Byram River Watershed

The Byram River Watershed is approximately 30 square miles and is spread over portions of Greenwich and five other towns in Westchester County, New York. The headwaters of the Byram River are located in North Castle NY. The Byram River drains into Long Island Sound and serves as the boundary between Greenwich and Port Chester, NY. The Route 1 Bridge is considered to be the boundary between freshwater and estuarine sections of the river.

Water quality of the Byram River is generally fair and varies throughout the watershed. The mainstem Byram River received a surface water quality classification of B. The east branch of the Byram River as well as Pemberwick Brook received a classification of A, indicating higher quality. The tidal portion of the river is classified as SB indicating impairment.

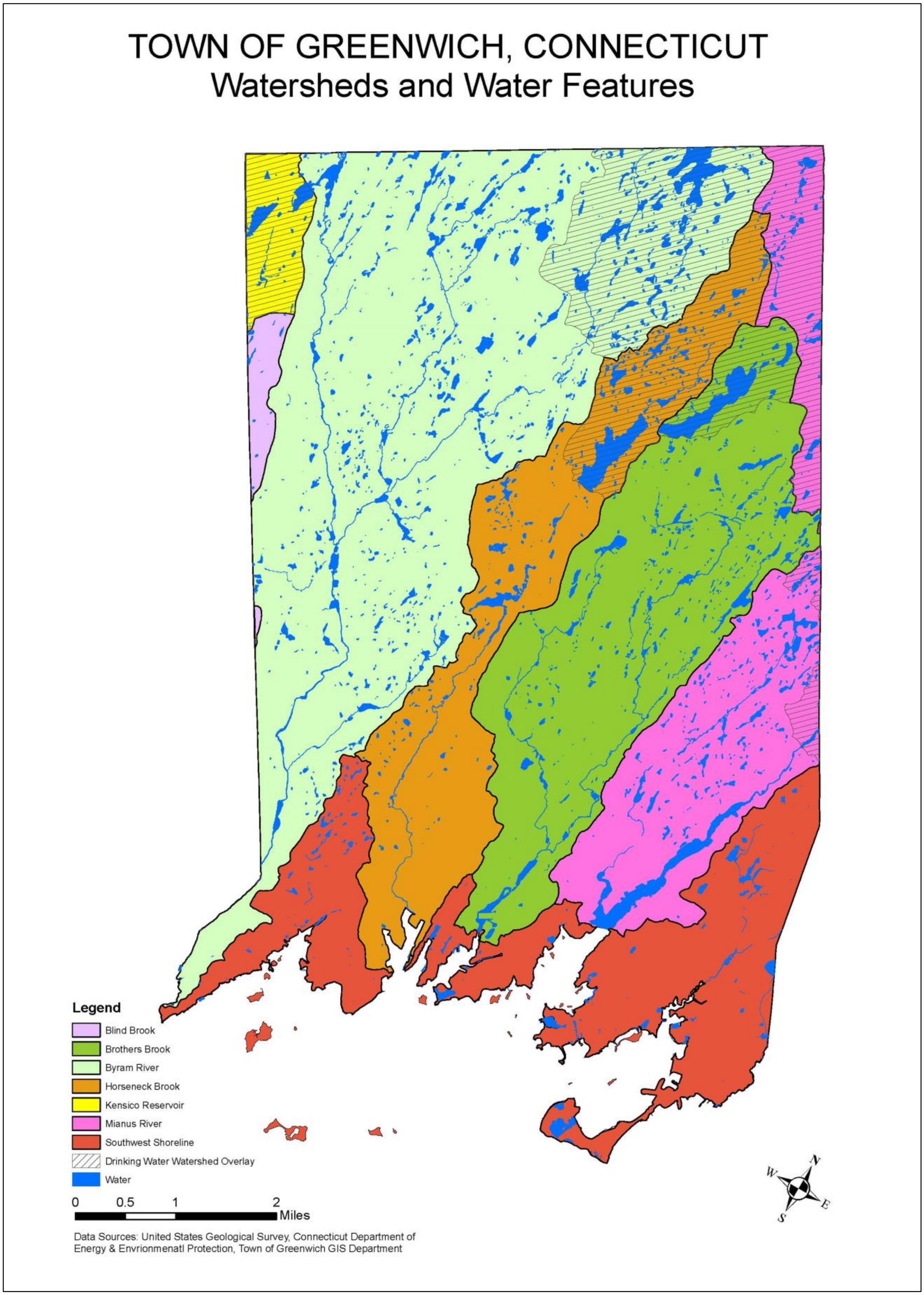
The hydrology of the Byram River watershed is heavily influenced by dams. Over 40 dams are present in the watershed today; most of these are historic mill dams that are relicts of the area's agricultural and industrial past. Despite the presence of these dams and other human alterations to the river channel, portions of the Byram River watershed still have functional floodplains that are subject to periodic riverine flooding.

The Byram River Watershed Coalition completed a watershed management plan for the Byram River in fall 2011. This plan provides a detailed evaluation of non-point pollution sources and offers advice

Connecticut Water Quality Classifications

Under Connecticut's Water Quality Standards, classifications have been established to provide guidance in the regulation of surface and ground waters such that water quality is maintained or improved. The classes as well as their associated designated uses are listed in the table below.

Class	Designated Uses
Inland Surface Waters	
AA	Existing or proposed drinking water supply, fish & wildlife habitat, recreation, agricultural & industrial water supply
A	Potential drinking water supply, fish & wildlife habitat, recreation, agricultural & industrial water supply, navigation
B	Fish & wildlife habitat, recreational use, agricultural & industrial water supply, navigation
Coastal & Marine Surface Waters	
SA	Marine fish, shellfish, & wildlife habitat, shell fish harvesting for direct human consumption, recreation, navigation
SB	Marine fish, shellfish, & wildlife habitat, shellfish harvesting for transfer to approved areas for purification prior to human consumption, recreation, navigation
Groundwater	
GAA	Existing or potential public supply of water suitable for drinking without treatment; baseflow for hydraulically connected surface water bodies
GA	Existing private and potential public or private supplies of water suitable for drinking without treatment; baseflow for hydraulically connected surface water bodies.
GB	Industrial process water and cooling waters; baseflow for hydraulically connected surface water bodies; presumed not suitable for human consumption without treatment
GC	Assimilation of discharge authorized by the Commissioner pursuant to Section 22a-430 of the General Statutes.


TOWN OF GREENWICH, CONNECTICUT
Watersheds and Water Features
Legend
Blind Brook
Brothers Brook
Byram River
Horseneck Brook
Kensico Reservoir
Mianus River
Southwest Shoreline
Drinking Water Watershed Overlay
Water
0
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2
Miles
Data Sources: United States Geological Survey, Connecticut Department of Energy & Envrionmenatl Protection, Town of Greenwich GIS Department
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on minimizing their impacts with good land management practices.

Mianus River Watershed

The Mianus River Watershed drains approximately 34 square miles and is the public drinking water supply for Greenwich and surrounding communities. The headwaters of the watershed are found in North Castle and Bedford, NY. The majority of the watershed is found in Stamford, CT, North Castle, Bedford, and Pound Ridge of Westchester County, NY.

The Mianus River watershed is fragmented by a number of dams that greatly influence the watershed's hydrology. Notable dams in the watershed are the Samuel Bargh Reservoir Dam in northern Stamford and the Mianus Mill Pond Dam in Greenwich, which serve as storage and diversion points for the Aquarion Water Company, as well as the Mianus Pond Dam, which forms a barrier between freshwater and marine environments. A fishway at the Mianus Pond Dam forms a critical link for many aquatic organisms between the Mianus River watershed and Long Island Sound. Strickland Brook is a major tributary that joins the Mianus River in the lower portion of the watershed and is subject to a combination of tidal and riverine flooding after rain events.

Water quality in the Mianus River is good to excellent, receiving the highest rating of AA. Under the direction of the Southwest Regional Planning Agency, and in coordination with the Town of Greenwich and the Mianus River Watershed Council, a watershed management plan was completed for the Mianus River in 2012.

Horseneck Brook Watershed

Horseneck Brook Watershed is approximately 6.52 square miles and is contained entirely within Greenwich. The watershed begins in northeastern Greenwich just above Upper Cross Road and extends southwest to where it drains into Long Island Sound in the vicinity of Shore Road. The public water supply reservoir Putnam Lake is found in the watershed just south of the Merritt

A small section of Horseneck Brook flowing through a high quality riparian area.

Parkway. Water quality in the Horseneck Brook watershed is good to excellent. Those waters that drain into Putnam Lake received a rating of AA, while those waters that flow from Putnam Lake received a rating of A.

Brother's Brook Watershed

Brother's Brook Watershed is approximately 8.89 square miles and is contained entirely in Greenwich. The watershed begins just north of Lower Cross Road and extends southwest to where it drains into Long Island Sound in the vicinity of Bruce Park. The public water supply reservoir Rockwood Lake is found in the upper portions of the watershed. Water quality in the Brother's Brook watershed is good to excellent. Those waters that drain into Rockwood Lake received a rating of AA, while those waters that flow from Rockwood Lake received a rating of A.

Southwest Shoreline Watershed

The Southwest Shoreline Watershed is composed of areas near the coast that tend to drain directly into Long Island Sound as surface runoff or as groundwater flow. Most of the Southwest Shoreline watershed is heavily developed and in close proximity to the coast. Streams in this watershed, such as Cider Mill Brook, area heavily influenced by tidal cycles and area especially prone to flooding. The portion of the Southwest Shoreline watershed located within Greenwich has an area of approximately 11 square miles.

Other Watersheds

There are small portions of the Blind Brook and Kensico Reservoir watersheds in the northwest corner of Greenwich. The Blind Brook watershed has an area of approximately 10 square miles, of which less than .5 square miles is in Greenwich. The Kensico Reservoir watershed has an area of approximately 13 square miles, of which approximately .9 square miles is in Greenwich that drains into the Kensico Reservoir system which is part of the drinking water supply for New York City residents.

Lakes, Ponds, and Reservoirs

Greenwich has an abundance of fresh water resources, including still waters that range in size from small ponds and to large public water supply reservoirs. Many of these lakes and ponds, however, were manmade by placing dams and creating impoundments of local streams. Most of these are small ponds on private properties created either as farm ponds or for aesthetics. Although they provide for open water habitat that is different from streams, they are subject to sedimentation and eutrophication.

The largest lakes in Greenwich are the public water supply reservoirs, Putnam and Rockwood lakes. Putnam Lake has an area of approximately 100 acres and Rockwood Lake has an area of approximately 105 acres. These lakes and much of the surrounding land area are private property owned and maintained by Aquarion Water Company. These lakes supply water to a number of Greenwich and NY residents. The 51-acre Mianus Pond is the only publicly owned pond of appreciable size. It supports an important pond habitat for alewife. Mianus Pond also provides recreational opportunities including fishing and kayaking.

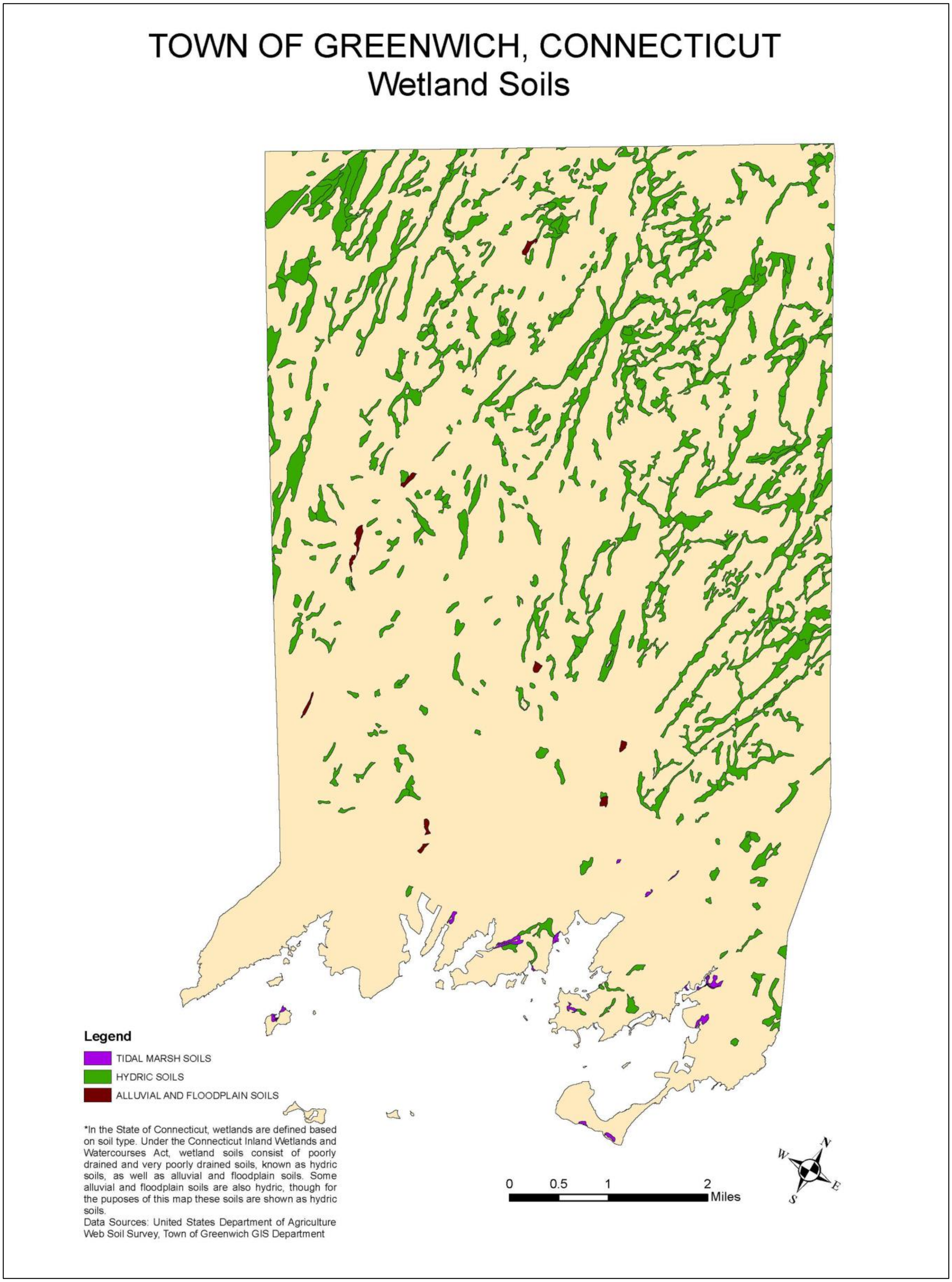
Inland Wetlands and Watercourses

Inland wetlands provide a multitude of ecosystem services and are an invaluable asset to the town. They help to maintain surface and groundwater supplies, control flooding, and mitigate pollutants. They also provide important habitat. In Connecticut, inland wetlands are defined by soil type, as outlined in the CT Inland Wetlands and Watercourses Act (IWWA). Using the Natural Resources Conservation Service (NRCS) soil classification system, wetland soils are those that are classified as poorly drained, very poorly drained, alluvial, and floodplain soils. There are approximately 3890.5 acres of inland wetland soils in Greenwich.

Many of the largest intact wetlands in Greenwich are found on open space properties. Notable wetland features in Greenwich include the approximately 300 acre Tamarack Swamp in the northwest corner of Town near Interstate 684. There are also an abundance of wetland features in the upper reaches of the Horseneck Brook watershed, including those found in the town-owned Babcock Preserve. The red maple swamp is the most prevalent type of wetland in Greenwich.

Vernal pools are a unique type of wetlands that are defined not only their hydrology but by the wildlife they support. Due to the natural topography and shallow to bedrock soils in Greenwich, vernal pools are scattered throughout the forested upland landscape. Examples of vernal pool habitat can be found on most of the Town owned open space parcels north of the post road including Babcock Preserve, Mianus River Park, and Montgomery Pinetum/Pomerance/Tuchman properties.

Vernal pools are temporary bodies of water that form in small depressions during the spring due to snowmelt, precipitation, and elevated water tables and do not support fish populations. They provide a unique habitat that supports obligate species that only vernal pool. In Connecticut these include Jefferson, blue spotted, marbled, and spotted salamanders, wood frogs, fairy shrimp, and, the State endangered eastern


TOWN OF GREENWICH, CONNECTICUT
Wetland Soils
Legend
TIDAL MARSH SOILS
HYDRIC SOILS
ALLUVIAL AND FLOODPLAIN SOILS
*In the State of Connecticut, wetlands are defined based on soil type. Under the Connecticut Inland Wetlands and Watercourses Act, wetland soils consist of poorly drained and very poorly drained soils, known as hydric soils, as well as alluvial and floodplain soils. Some alluvial and floodplain soils are also hydric, though for the puposes of this map these soils are shown as hydric soils.
Data Sources: United States Department of Agriculture Web Soil Survey, Town of Greenwich GIS Department
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