

Bronx River Watershed Baseline Assessment

Prepared for:

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April 2006

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Section 1. Introduction

1.1 Introduction to the Project

The Bronx River and its tributaries drain approximately 48 square miles of urbanized land in Westchester County before flowing through the Bronx Borough to the East River, and ultimately, the Long Island Sound. The Westchester County Department of Planning is spearheading the development of a comprehensive watershed management plan for the Bronx River. As part of this effort, the County has contracted with the Center for Watershed Protection (the Center) and Biohabitats, Inc., to develop a *Bronx River Watershed Assessment and Management Report*.

The *Watershed Assessment and Management Report* will specify priority actions and identify candidate stormwater retrofit and watershed restoration project locations. The *Report* will cover the whole watershed, however, detailed recommendations and strategies will be limited to five subwatersheds. The *Report* will provide a framework for the County to pursue additional investigations and build upon the management plan for those subwatersheds not assessed by the Center and Biohabitats. Ultimately, the *Report* will serve as a technical support document to the watershed plan being developed by Westchester County and others.

1.2 Scope of Work

The scope of work for the Center and Biohabitats consists of four major tasks, described below.

- *Task 1. Performing a Baseline Watershed Assessment.* The Center will develop a baseline watershed assessment for the Bronx River Watershed within Westchester County. Subtasks include:
 - Subtask 1.1 Database Screening to Find Potential Hot Spot Sites
 - Subtask 1.2 Comparative Subwatershed Analysis
 - Subtask 1.3 Stakeholder Meeting
 - Subtask 1.4 Baseline Watershed Assessment
- *Task 2. Identifying Stream Restoration, Pollution Prevention, and Retrofit Opportunities.* The Center and Biohabitats will identify stream restoration, pollution prevention, and retrofit opportunities in the stream corridor and upland portions of the subwatershed areas selected for assessment. Subtasks include:
 - Subtask 2.1 Physical Stream Assessment
 - Subtask 2.2 Upland Subwatershed Site Reconnaissance
 - Subtask 2.3 Riparian Corridor Restoration and Retrofit Inventory
 - Subtask 2.4 Uplands Stormwater Retrofit Inventory
- *Task 3. Crafting a Watershed Assessment and Management Report.* The Center and Biohabitats will develop a Watershed Assessment and Management Report that specifies priority actions, provides planning budgets and schedules, and identifies potential financial and technical partners for restoration implementation. Additionally, the Watershed Assessment and Management Report will contain subwatershed maps that

identify candidate and priority project locations, stream conditions, monitoring locations, conservation areas, land use, and other pertinent information. Subtasks include:

- Subtask 3.1 Project Evaluation and Ranking
 - Subtask 3.2 Subwatershed Treatment Analysis
 - Subtask 3.3 Draft Watershed Assessment and Management Report
 - Subtask 3.4 Final Watershed Assessment and Management Report
 - Subtask 3.5 Public Information Sessions
- *Task 4. Coordinating Project Activities.* The Center will attend a kickoff meeting, attend up to four project coordination meetings, and coordinate partner communication.

1.3 Introduction to the Baseline Assessment

This report serves as the deliverable under Task 1: *Performing a Baseline Watershed Assessment*. Over the past six months, the Center has:

- Reviewed existing watershed data, studies, and reports;
- Analyzed extensive watershed Geographical Information System (GIS) data;
- Conducted database screening of generating sites to identify potential watershed hotspots¹;
- Assessed jurisdictional watershed-related codes and ordinances;
- Developed a baseline Watershed Treatment Model for existing and future watershed conditions; and
- Conducted a Comparative Subwatershed Analysis.

This *Baseline Assessment* documents the results of this work. The *Baseline Assessment* does not outline specific watershed restoration recommendations. Instead, the *Baseline Assessment* is intended to be an objective document that outlines current watershed conditions and may be used as a watershed reference at later stages in the project.

The remaining sections in this *Baseline Assessment* include:

- Section 2. Natural Features – describes basic watershed features and reviews hydrology, geomorphology, water quality, and other watershed data.
- Section 3. Community Features – discusses historical, community, and jurisdictional characteristics of the watershed.
- Section 4. Land Use and Land Cover – summarizes current land use and impervious cover.
- Section 5. Local Government Code and Ordinance Review – summarizes the County’s code and ordinance review.
- Section 6. Subwatershed Prioritization – presents results of the Watershed Treatment Model and describes a ranking process by which subwatersheds are compared using a number of derived metrics.

¹ The results of the generating sites database screening will be discussed in the technical memorandum to be submitted under Task 2.

Section 2. Natural Features

2.1 Introduction to the Bronx River Watershed

The Bronx River Watershed drains approximately 48.3 square miles of urbanized land in Westchester County (see map A-1: Bronx River Watershed Subwatersheds in Appendix A). The Kensico Reservoir is located at the headwaters of the Bronx River, and is one of many components in the New York City water supply system. The Kensico Reservoir has a capacity of 30.6 billion gallons, stores water from the Catskill and Delaware aqueducts, and supplies 85% of Westchester County residents and New York City with drinking water.

Prior to the construction of the Kensico Dam in 1915, the headwaters of the Bronx River were located in the southern portion of New Castle in central Westchester County. The section of channel in the Kensico Reservoir subwatershed is still called the Bronx River, and flows six miles from New Castle into the Kensico Reservoir. According to Malcolm Pimie, 1975, there is no hydraulic connection between the Kensico Reservoir and the downstream section of the Bronx River. There is, however, a connection between the reservoir and Davis Brook, a tributary to the Bronx River. Also, the large fountain pools in front of the Kensico Dam, when in operation, are filled with water drained from the Kensico Reservoir. This water circulates through the fountain pools and is discharged directly into the Bronx River (Doscher, 2005). A series of wetlands on the Davis Brook in Valhalla is now identified as the headwaters of the Bronx River. From this location the Bronx River continues for approximately 23 miles to the East River, at Hunts Point, and then into Long Island Sound (USACE, 2004).

A basic profile of the watershed is provided in Table 2-1. Sections 2, 3, and 4 of this report provide more detailed information on the natural features, community features, and land use and land cover of the watershed. The Center reviewed a number of documents while developing this Baseline; a complete listing of all Bronx River related documents obtained and reviewed is provided in Appendix B, along with a list of all GIS data sources used to create maps.

Factor	Factoid
Area in Westchester County	<ul style="list-style-type: none"> 48.3 square miles (30,932 acres)
Stream Length	<ul style="list-style-type: none"> Approx. 53.5 miles
Land Use	<ul style="list-style-type: none"> Residential (44.9%) Non-Residential (21.5%) Water (16.2%) Open Space (12.6%) Undeveloped (3.3%) Mixed (1.5%)
Subwatersheds	<ul style="list-style-type: none"> 15 subwatersheds
Jurisdictions	<ul style="list-style-type: none"> 14 cities, towns, and villages
Water Quality	<ul style="list-style-type: none"> 2004 303(d) list for high dissolved oxygen demand and pathogens
Current Impervious Cover	<ul style="list-style-type: none"> 20.3% imperviousness (per WCDP, 2005a)
Subwatersheds Selected for Detailed Assessment	<ul style="list-style-type: none"> Fulton Brook Grassy Sprain Brook Hartsdale Brook Manhattan Park Brook Bronx River Middle Direct Drainage
Major Transportation Routes	<ul style="list-style-type: none"> Bronx River Parkway, Sprain Brook Parkway, and Cross County Parkway Cross Westchester Expressway (I-287) New York State Thruway (I-87) Harlem Line of the Metro North Railroad System
Significant Natural and Historic Features	<ul style="list-style-type: none"> Kensico Reservoir White Plains Reservoirs Bronx River Parkway Reservation

2.2 Hydrology

The natural hydrologic function of the Bronx River has been modified as a result of urbanization, channel relocation, and the construction of impoundments that divert water from the river. The Kensico Dam was constructed in Mount Pleasant on the Bronx River in 1915, reducing the total stream flow by approximately one quarter. The Bronx River basin has three major impoundments below Kensico Dam: White Plains Reservoirs and Grassy Sprain Reservoir, which control approximately 5.3 square miles of Bronx River drainage area (Malcom Pirnie, 1975).

The USGS historically maintained a stream gage on the Bronx River at Bronxville starting in November 1943, though it is currently no longer in operation. Recorded flood flows for the period of operation show a correlation between increasing flood magnitudes and urbanization in the watershed (Malcom Pirnie, 1975). The highest recorded flood on the Bronx River occurred on June 15, 1969, with an estimated flow of 1,580 cfs and a flood stage of 81.1 feet above mean sea level. The U.S. Army Corps of Engineers (USACE) is currently creating a HEC-HMS model of the Bronx River based on current land use conditions.

During the construction of the Bronx River Parkway (Parkway) the hydrology of the Bronx River was modified to create ponds, lakes, and other water features deemed to enhance scenic and recreational amenities. The three most significant of these are Bronxville Lake, Scarsdale Lake, and Crestwood Lake, which were created as siltation ponds, and now have accumulated sediment and provide marsh habitat. Crestwood Lake and Bronxville Lake have been identified by Westchester County as in need of periodic dredging to maintain sediment removal efficiencies (Westchester County, 1999).

2.3 Subwatersheds in the Bronx River Watershed

The Bronx River watershed has 15 subwatersheds (see Table 2-2 and map A-1: Bronx River Watershed Subwatersheds in Appendix A), as delineated by the Center. The Center used the following sets of data to define the Bronx River subwatersheds:

- Subwatershed delineations provided by the County, which defined the Kensico Reservoir, the Grassy Sprain, and Bronx River drainages.
- Subwatershed delineations completed by the USACE and provided to the Center as a hard copy drawn onto a USGS topographical map of the area.

The Center refined the subwatershed boundaries based on the following decisions:

- Used the County's overall watershed delineation for the Bronx River Watershed, which differed from the delineation completed by the USACE.
- Used the three subwatershed boundaries (Kensico Reservoir, Grassy Sprain, and Bronx River) provided by the County.
- Identified significant tributaries to the Bronx River.
- Reviewed land use and drainage patterns to define subwatershed boundaries within the County's overall Bronx River Watershed delineation.

- Field verified suspected diversions not apparent from topographic mapping.²

Table 2-2: Bronx River Subwatersheds in Westchester County			
Subwatershed	Acronym	Area (acres)	Area (square miles)
Bronx River Lower Direct Drainage	BRL	2,084	3.3
Bronx River Middle Direct Drainage	BRM	3,252	5.1
Bronx River Upper Direct Drainage	BRU	3,213	5.0
Clove Brook	CB	848	1.3
Davis Brook	DB	1,373	2.1
Fox Meadow Brook	FMB	928	1.4
Fulton Brook	FB	628	1.0
Grassy Sprain Brook	GSB	3,120	4.9
Grassy Sprain Brook Direct Drainage	GSD	1,263	2.0
Hartsdale Brook	HB	772	1.2
Kensico Reservoir	KR	7,948	12.4
Manhattan Park Brook	MP	2,118	3.3
Sprain Brook	SB	1,088	1.7
Troublesome Brook	TB	1,725	2.7
White Plains Reservoirs	WPR	576	0.9
Bronx River Watershed		30,932	48.3

2.4 Geomorphology

The form of a river, its channel, banks, and floodplain is the result of an evolving series of processes influenced by climate, natural events, and humans. Before the last ice age it is believed the Bronx River flowed similar to its present day course, with headwaters in upstate New York and terminating in Long Island Sound. The glacier that occupied the Bronx River valley during the last ice age obstructed a portion of the channel, altering the rivers course to its present day alignment (BRA, 2005).

Studies conducted along the Bronx River show that starting before the construction of the Parkway in 1925, the pressures of development filled, rerouted, and altered the course of the original stream channel (Pfizer-Jahnig, 1994). Development influences prior to the Parkway included railroad construction, factories, mills, sewer lines, and houses built along the river. To accommodate the construction of the Parkway, the natural sinuosity and associated meander bends of the Bronx River at some locations were straightened, deepened or backfilled.

² During October 2005 fieldwork, Biohabitats staff noted that the headwaters of the Sprain Brook subwatershed, as delineated by the USACE, actually drain to Grassy Sprain Brook. The final subwatershed areas and delineations reflect this change.

2.5 Climate

The Bronx River watershed is located in an area with a temperate and humid climate. Based on historical climate information available from a weather station in White Plains, New York, precipitation is generally well distributed throughout the year with the wettest conditions in April and May and driest in February (worldclimate.com for White Plains, Westchester County). In White Plains, the mean annual precipitation over a 29-year period of record is 48.9 inches, and the 24-hour average temperature ranges from a high of 73.2°F in July to a low of 27.3°F in January.

2.6 Water Quality

Water quality in the Bronx River has been degraded, similar to other urban streams, primarily due to the conversion of forested lands to development and impervious surfaces. Pollution enters the Bronx River from non-point and point sources, which include discharges from sewage outfalls. NY State classifies the Bronx River as a Class “C” fresh surface water, “suitable for fishing and fish propagation”. The New York State Water Quality Section 305b Report (NYS DEC, 2004) classifies the Bronx River in Westchester County as having impaired segments and the Kensico Reservoir as possibly threatened. The Bronx River in Westchester County is on New York State’s 2004 303(d) list of impaired waters for high dissolved oxygen demand and for pathogens (EPA, 2004). Possible pollution sources include effluent from publicly owned treatment works, sanitary sewer breaks, overflows, and illegal connections or discharges along with urban stormwater runoff.

The Bronx River water quality is generally characterized as moderately to severely impacted based on chemical and biological monitoring efforts (WCDP, 2000). Macroinvertebrate sampling conducted for various studies along the Bronx River have revealed low diversity and occurrences of pollution tolerant species, resulting in a characterization of slightly impacted water quality in the Bronx River near Valhalla to moderately impacted water quality conditions near White Plains, continuing towards New York City (Hudsonia, 1994; NYS DEC, 1998). Floating debris is the most noticeable pollutant in the river, which is primarily originating from street litter washed into storm drains and illegal dumping (WCDP, 2000). A more recent analysis conducted by the USACE in the Bronx River concludes that water quality parameters such as temperature, dissolved oxygen, specific conductivity, salinity, turbidity, pH and redox “fall well within acceptable biological thresholds for supporting aquatic life” (USACE, 2005).

The New York State Department of Environmental Conservation (NYS DEC) has issued Stormwater Phase II permits to 44 communities with Municipal Separate Stormwater Sewer Systems (MS4s) within Westchester County, 13 of which are in the Bronx River watershed. Among the permit requirements the communities must develop a Stormwater Management Plan (SMP), which lists BMPs that will be implemented to reduce stormwater pollution. Ideally, the implementation of SMPs will reduce stormwater pollutant loads entering the Bronx River, improve water quality or prevent further water quality degradation. It has been determined that improving water quality in the Bronx River will also indirectly improve the water quality of Long Island Sound, to which it eventually flows.

2.7 Habitat

Habitat in the Bronx River watershed exists primarily in conjunction with urban open spaces, athletic fields, cemeteries, and residential communities. These habitats can consist of ornamental lawns and grasses and upland canopy trees with understory canopy layers. The habitat corridor along the Bronx River and its tributaries is fragmented due to the Parkway, railroad, and adjacent land uses, which inhibit movement and increase the wildlife mortality rate. Wildlife can access the Bronx River Parkway Reservation (Reservation) via its north/south axis, though east/west axis is limited due to urban development.

Within the Reservation, habitat types include deep emergent marsh, successional shrubland, floodplain forest, red maple-hardwood swamp, rich mesophytic forest, and phragmites/purple loosestrife marsh (WCPD, 2000). The remnant forest areas in the Reservation provide habitat for migratory birds.

2.8 Wetlands

The Bronx River watershed contains palustrine wetlands, which are primarily broad-leaf deciduous forests. Plant species identified in the Bronx River watershed and common to palustrine wetlands are cattails (*Typha spp.*), common reed (*Phragmites australis*), and spike grass (*Distichlis spicata*).

The Center obtained and reviewed three wetlands-related GIS files from Westchester County: National Wetland Inventory, Hydric Soil Wetlands, and New York State Designated Freshwater Wetlands. According to these data, approximately 7.2% of the Bronx River watershed is wetlands and/or hydric soils, as displayed in map A-2: Bronx River Watershed Wetlands and Hydric Soils in Appendix A. Table 2-3 displays wetlands and hydric soils coverage by subwatershed.

Subwatershed Name	Wetlands Area (acres)	Percent of Subwatershed (%)
Bronx River Lower Direct Drainage	115	5.5%
Bronx River Middle Direct Drainage	312	9.6%
Bronx River Upper Direct Drainage	301	9.4%
Clove Brook	111	13.1%
Davis Brook	119	8.7%
Fox Meadow Brook	72	7.8%
Fulton Brook	59	9.5%
Grassy Sprain Brook	299	9.6%
Grassy Sprain Brook Direct Drainage	32	2.5%
Hartsdale Brook	57	7.4%
Kensico Reservoir	416	5.2%
Manhattan Park Brook	137	6.5%
Sprain Brook	125	11.4%
Troublesome Brook	24	1.4%
White Plains Reservoirs	42	7.3%
Bronx River Watershed	2,221	7.2%

2.9 Forest

Due to the effects of urbanization in the Bronx River watershed, relatively few wooded areas remain. Of those, Garth and Butler Woods in Scarsdale are relatively untouched and represent forested areas that once blanketed the Bronx River basin. These stands include oak and tulip trees, though the hemlock and native flowering dogwoods have been lost due to a wooly adelgid insect infestation. Cranberry Lake Preserve, a 165-acre county park in the Kensico Reservoir subwatershed, is another significant forested area within the Bronx River watershed.

The Center for Land Use Education and Research (CLEAR) at the University of Connecticut, in partnership with Nonpoint Education for Municipal Officials (NEMO), developed satellite imagery based land cover classifications, circa 2002, for the Long Island Sound basin. The 11 land cover categories depicted include: developed; turf and grass; other grasses and agriculture; deciduous forest; coniferous forest; water; non-forested wetland; forested wetland; tidal wetland; barren land; and utility right-of-ways. These data provide an overview of deciduous and coniferous forest cover across the Bronx River watershed, as displayed in map A-3: Bronx River Watershed Forest Cover in Appendix A. According to these data, approximately 9,120 acres, or about 29% of the watershed, is forested.

2.10 Flora and Fauna

A study conducted in the vicinity of White Plains, investigating the restoration of the Woodland Viaduct, identified and described riparian wetland and floodplain communities along the Bronx River (Pfizer-Jahnig, 1994). Riparian wetlands are predominantly forested with ash-leaved maple and box elder species. Floodplain communities consist of canopy, vine, shrub, and herbaceous layers with a combination of native and non-native species. Red maple, American elm, and speckled alder are common species identified in the floodplain canopy. Common vines in the floodplain include wild grape, Japanese honeysuckle, poison ivy, and Asiatic bittersweet. The two most common shrub species identified in the floodplain are invasive species, the multiflora rose and Morrow's honeysuckle. Common herbaceous layer species include jewelweed, skunk cabbage, common reed, purple loosestrife, mugwort, false hellebore, and lesser celandine. The most commonly reported invasive plant species along the Bronx River include the Asiatic bittersweet vine that chokes wooded areas, purple loosestrife (an invasive non-native wetland plant), and Tree of Heaven and Norway maple, both of which displace native forest species.

The USACE Draft Scoping Document for the Bronx River basin (USACE, 2004) details a comprehensive list of mammal, avian, reptile, and waterfowl and waterbird species identified in the Bronx River watershed based upon studies by the US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration. Identified mammal species include eastern gray squirrel, eastern cottontail, house mouse, muskrat, Norway rat, raccoon, and white-tailed deer. Common avian species include red-winged blackbird, blue jay, American robin, marsh wren, house sparrow, American goldfinch, American crow, and mourning dove. Wooded areas and wetlands in the watershed provide habitat for reptilian species such as the eastern painted turtle, common garter snake, common snapping turtle, and red-eared slider. Observed waterfowl and waterbirds include mallard, black duck, herring gull, and snowy egret. Generally wildlife is

limited to available habitat in the urbanized watershed and the diversity of species is low. Additional species identified along the Bronx River during a 2005 survey include meadow vole and white-footed mouse mammal species, and Canada goose, gray catbird, black-capped chickadee, great blue heron, white throated sparrow, and rock dove avian species (USACE, 2005).

During a June 1994 sampling event in White Plains, six species of fish were identified in the Bronx River: blacknose dace, white sucker, mummichog, redbreast sunfish, pumpkinseed, and tessellated darter (Hudsonia, 1994). With the exception of the blacknose dace, which was caught in low numbers, all are considered pollution tolerant species. Of the sampled fish, numerous specimens had parasitic and/or bacterial infections. The results of the sampling revealed degraded diversity and density, which was attributed to poor water quality. A sampling event conducted in September 1998 identified many of the same species as well as fathead minnow and bluegill (NYS DEC, 1998). A more recent study in the Bronx River revealed a very low diversity of fish species at all sampled sites, though based on observed site and water quality conditions the study concludes “there may be as many as several dozen fish species that could be candidates for the fish fauna of the Bronx River” (USACE, 2005).

2.11 Rare, Threatened, or Endangered (RTE) Species

Numerous avian, mammal, plant, reptile and amphibian species listed by Federal, State or County jurisdictions as threatened or endangered are known to occur in Westchester County, though their occurrence in the Bronx River watershed has not been confirmed. Of those, the bog turtle and bald eagle are two federally listed threatened or endangered species identified within Westchester County, whose occurrence in the Bronx River watershed is uncertain (USACE, 2004).

Section 3. Community Features

3.1 History of the Area

Starting before the arrival of Europeans in the 1600s, the Bronx River provided Native Americans who lived along the river a source of food, water, and spiritual inspiration. Tribes that were known to have lived in the area include Mohegan, Weckquasgeek, and Siwanoy. The Siwanoy Indians called the river valley “Laaphawachking” or “Place of Stringing Lakes” because of the multiple beaver dams and ponds built along it, while the Mohegan Indians called the river “Aquehung” or “River of High Bluffs.”

The bountiful beaver populations along the river first attracted European traders in the 1600’s. A Swedish settler by the name of Jonas Bronck purchased 500 acres of land from the Mohegan Indians in 1639, and over the next 100 years the power of the “Bronck’s River” was utilized by as many as 12 mills to produce commodities such as tapestries, pottery, flour, paper, snuff and barrels.

In 1776, The Bronx River basin was the location of the Revolutionary War Battle of White Plains. During the battle, and for some time following, General George Washington’s military headquarters were located in the Jacob Purdy House in Northern White Plains. The Jacob Purdy House and monuments to the battle have been preserved in and around White Plains.

Well into the 1800’s the river remained thickly forested and was even considered as a potential water source for New York City. Conditions in the Bronx River precipitously deteriorated over the next 75 years as construction of the New York Central Railroad in the 1840’s created an industrial corridor along the Bronx River, leading one official to describe the river as an “open sewer.”

In 1905, Westchester County initiated the construction of the Bronx River Valley Sewer District to control the major sewer sources entering the river. The Sewer District did not solve all the pollution problems, so the Bronx River Parkway Commission began consolidating properties along the river to create a buffer from burgeoning development and pollution sources, establishing what is today the 807-acre Reservation. Another component in this effort involved the construction of the Parkway, within the Reservation, which was completed in 1925.

The Parkway was the first roadway in the country designed to integrate the landscape and offer a scenic recreational driving experience for city residents. The Parkway was based on designs made popular by Fredrick Law Olmstead and Calvert Vaux in New York’s Central Park and in Boston, Massachusetts, which were originally modeled after the tree-lined boulevards in Paris and Berlin. The Bronx River Parkway Commission coordinated a collaborative design effort led by Jay Downer, the Commission’s Chief Engineer, Arthur G. Hayden, the Design Engineer, and Hermann Merkel, the Chief Landscape Architect. Elements of the design required channelization of the Bronx River, reforestation of the riverbanks and surrounding Reservation areas, and the future management of the river, roadway, and parkland as one cohesive unit.

3.2 Watershed Jurisdictions

The Bronx River watershed is almost entirely contained within Westchester County and the Bronx Borough of New York City. Within Westchester County, 14 jurisdictions – three cities, six towns, and five villages – encompass the watershed (Table 3-1). Almost half of the watershed falls within two jurisdictions – Greenburgh and Yonkers.

Only three subwatersheds are entirely contained within a single jurisdiction – Clove Brook (in Mount Pleasant), Grassy Sprain Brook Direct Drainage (in Yonkers), and Hartsdale Brook (in Greenburgh). The remaining subwatersheds cross multiple jurisdictional boundaries, with the most (seven jurisdictions) being in the Bronx River Middle Direct Drainage. Table 3-2 displays the jurisdictions the subwatersheds are in.

Jurisdiction	Area within the Watershed (square miles)	Percent of Watershed
Town of Greenburgh	10.8	22.3%
City of Yonkers	9.8	20.3%
Town of North Castle	8.2	16.9%
Town of Mount Pleasant	6.8	14.1%
City of White Plains	3.2	6.7%
Village of Scarsdale	2.7	5.7%
Town of Harrison	1.4	2.9%
Town of Eastchester	1.2	2.5%
City of Mount Vernon	1.2	2.5%
Village of Bronxville	0.9	1.8%
Village of Ardsley	0.6	1.2%
Town of New Castle	0.6	1.2%
Village of Tuckahoe	0.6	1.2%
Village of Elmsford	0.4	0.8%
Bronx River Watershed	48.3	100%

Subwatershed	Jurisdiction	Area (square miles)	Percent of Subwatershed
Bronx River Lower Direct Drainage	Mount Vernon	0.6	19.5%
	Yonkers	2.6	80.5%
Bronx River Middle Direct Drainage	Bronxville	0.9	16.8%
	Eastchester	1.2	23.4%
	Greenburgh	0.4	7.0%
	Mount Vernon	0.6	11.4%
	Scarsdale	0.6	12.3%
	Tuckahoe	0.6	11.5%
	Yonkers	0.9	17.7%

Table 3-2: Bronx River Subwatersheds and Jurisdictions			
Bronx River Upper Direct Drainage	Greenburgh	1.1	22.7%
	Mount Pleasant	0.2	4.4%
	North Castle	0.6	12.6%
	Scarsdale	0.8	15.9%
	White Plains	2.2	44.4%
Clove Brook	Mount Pleasant	1.3	100.0%
Davis Brook	Greenburgh	0.0	1.0%
	Mount Pleasant	2.1	99.0%
Fox Meadow Brook	Scarsdale	1.3	91.4%
	White Plains	0.1	8.6%
Fulton Brook	Greenburgh	0.8	76.8%
	White Plains	0.2	23.2%
Grassy Sprain Brook	Ardsley	0.6	11.8%
	Greenburgh	2.8	57.4%
	Yonkers	1.5	30.8%
Grassy Sprain Brook Direct Drainage	Yonkers	2.0	100.0%
Hartsdale Brook	Greenburgh	1.2	100.0%
Kensico Reservoir	Harrison	1.2	9.9%
	Mount Pleasant	3.2	25.4%
	New Castle	0.6	4.6%
	North Castle	7.4	59.9%
	White Plains	0.0	0.1%
Manhattan Park Brook	Elmsford	0.4	12.1%
	Greenburgh	2.9	87.6%
	Mount Pleasant	0.0	0.3%
Sprain Brook	Greenburgh	0.5	29.3%
	Yonkers	1.2	70.7%
Troublesome Brook	Greenburgh	1.1	40.8%
	Yonkers	1.6	59.2%
White Plains Reservoirs	Harrison	0.2	16.7%
	North Castle	0.1	11.4%
	White Plains	0.7	72.0%

3.3 Community Features

The communities of people who live, work, or play in the Bronx River watershed fill an important role as advocates for restoring and protecting the rivers valuable resources. In 1974, prompted by degraded conditions in the Bronx River, local residents formed the Bronx River Restoration Project, Inc., which succeeded in numerous stream clean ups and community outreach efforts. The Bronx River Alliance was formed in 2001 to continue and expand upon these efforts by partnering with local and regional stakeholders in the Bronx River watershed.

The Reservation was designed to provide numerous recreational opportunities, starting with the scenic drive along the Bronx River Parkway to the ball fields and Boy Scout facilities that continue to attract the community. The most prominent of these facilities include the Westchester County Center and the Kensico Dam Plaza and Park. Unfortunately, some of the community access to the Bronx River has led to compacted soils, litter, and localized areas of bank erosion.

The most common recreation activities along the Bronx River are canoeing, kayaking, and fishing, though water quality conditions in the river generally prevent primary contact recreation such as swimming. Concurrent with the construction of the Parkway, the Bronx River Pathway was created within the Reservation, which allows walkers to access and enjoy the river. Another popular activity that occurs during the spring and autumn are Bike & Skate Sundays. On these Sundays a portion of the Parkway closes to vehicular traffic and is open to pedestrians, bicycles and skaters.

3.4 Transportation Corridors

Two-thirds of the Bronx River Parkway is listed on the National Register of Historic Places, and is valued for its small roadway size, its contained views, and modest speed limits. It has been estimated that traffic-related alterations have destroyed the historic integrity of the remaining one-third of the Parkway (Pfizer-Jahnig, 1994). Not only does the Parkway fulfill its original purpose as a scenic highway, as the population of Westchester County has grown, it also serves as an important transportation corridor into New York City and for local destinations.

Other important transportation corridors that cross or parallel the Bronx River watershed include the Cross Westchester Expressway (I-287), NY State Thruway (I-87), Sprain Brook Parkway and Cross County Parkway. The Harlem line of the Metro North Railroad System is also located in the Bronx River watershed with stations in Mt. Vernon, Tuckahoe, Crestwood, Scarsdale, Hartsdale, White Plains, and North White Plains. Major transportation corridors in the watershed are displayed in map A-4: Bronx River Watershed Transportation Corridors in Appendix A.

3.5 Utilities

One of the reasons the Reservation was initially conceived, as early as 1885, was due to uncontrolled sewage discharges entering the river. The Bronx Valley Sewer District was constructed in 1907 and includes a sanitary sewer trunk line that parallels, and in some locations crosses, the Bronx River servicing an area of approximately 21,980 acres. The Bronx Valley Sewer District did not stop all pollution from entering the river, since dumping from riverbanks remained unrestricted, and private landowners were not required to connect to the new sewer.

Utility companies consider the Reservation a desirable location for utility lines for many reasons, including minimal disruption of local roads, low relative cost to restore parkland as opposed to roadways, easy access for repairs particularly when located in unpaved area, and minimal disruption to nearby property owners (WCPD, 2000). The most significant utility operators include Consolidated Edison (Con Edison) Gas Company (subsurface gas electric and gas lines), Tennessee Gas Transmission Company (natural gas), and UA Columbia Cablevision (cable line).

Section 4. Land Use and Land Cover

4.1 Current Land Use

In the summer of 2005, Westchester County staff analyzed and confirmed current land use in the watershed using 2000 aerial photos. County staff created a new GIS layer (WCDP, 2005b) that identified three categories of current land use: *Level I Land Use*, *Level II Land Use*, and *Environmental Function*. These land use codes are summarized in Table 4-1.

It should be noted that, once the GIS layer was developed, it did not align with the County’s Bronx River watershed boundary. This is due to the slight variations in GIS data from different sources. County staff shifted the land use GIS layer by hand so that it aligned with the watershed boundary.

Table 4-1: Categorization of Land Use Codes (Source: WCDP, 2005c)

Residential	Non-Residential cont.	Open Space cont.
RHD Residential High Density	MIXED Mixed Use	PR Public Recreation
<i>Residential High Density</i>	<i>Mixed Use</i>	<i>Camp</i>
RLD Residential Low Density	OFF Office	<i>Club/Center</i>
<i>Residential Low Density</i>	<i>Office</i>	<i>Conservation Land</i>
RMD Residential Medium Density	TCU Transportation Utility	<i>Golf</i>
<i>Residential Medium Density</i>	<i>Transportation General</i>	<i>Historic</i>
RVLD Residential Very Low Density	<i>R.O.W. Easements</i>	<i>Homeowners Assoc.</i>
<i>Residential Very Low Density</i>	<i>Utilities</i>	<i>Marina</i>
Non-Residential	STP Sewage Treatment Plant	<i>Open Space General</i>
AGR Agriculture	<i>Sewage Treatment Plant</i>	<i>Park</i>
<i>Farm</i>	Open Space	<i>Private Recreation General</i>
<i>Live Stock / Stables</i>	NATPR Nature Preserve	PUB Public Non-Park Land
<i>Nursery</i>	<i>Preserve</i>	<i>Conservation Land</i>
<i>Other</i>	PPA Public Park Active	<i>R.O.W. Easements</i>
CEM Cemetery	<i>Beach</i>	<i>Landfill</i>
<i>Cemetery</i>	<i>Club/Center</i>	<i>Marina</i>
CR Commercial	<i>Open Space General</i>	<i>Non-Park Lands General</i>
<i>Commercial General</i>	<i>R.O.W. Easements</i>	PUR Public Recreation
<i>Hotels, Motels and Resorts</i>	<i>Historic</i>	<i>Golf</i>
<i>Motor Vehicle Services</i>	<i>Marina</i>	<i>Club/Center</i>
IPA Institutional	<i>Park</i>	Undeveloped
<i>Institutions</i>	PPP Public Park Passive	U Undeveloped
MIW Manufacturing	<i>Open Space General</i>	<i>Undeveloped</i>
<i>Manufacturing/Warehouse</i>	<i>R.O.W. Easements</i>	Water
MIN Mining and Quarrying	<i>Marina</i>	IWB Waterbody
<i>Mining and Quarrying</i>	<i>Park</i>	<i>Waterbody</i>
	<i>Camp</i>	W-SUP Water Supply
		<i>Water Supply</i>

Level I Land Use Codes: highlighted in gray
Level II Land Use Codes: bold faced
Environmental Function: italicized

Land use in the watershed, identified by the Level I Land Use categories, is displayed in Table 4-2. Residential land use is the dominant land use in the watershed, covering about 45% of the watershed. This is followed by non-residential land use at 21.5%, open water at 16.2%, and open space at 12.6%. The most significant open space parcel in the Bronx River watershed is the 807-acre Reservation. The watershed is largely built-out, with only 3.3% identified as undeveloped.

Level II Land Use and land use categorized by Environmental Function can be found in Appendix C. Land use maps for each subwatershed are provided in Appendix D.

Level I Land Use	Area (square miles)	Percent of Watershed
Residential	21.7	44.9%
Non-Residential	10.4	21.5%
Water	7.8	16.2%
Open Space	6.1	12.6%
Undeveloped	1.6	3.3%
Mixed	0.7	1.5%
Bronx River Watershed	48.3	100.0%

4.2 Impervious Cover

In 2005, Westchester County staff conducted an impervious surface analysis of the Bronx River watershed (WCDP, 2005a). Impervious surfaces were defined as structures (buildings, tanks, train stations, train platforms, and miscellaneous structures) and transportation features (paved roads, paved alleys, driveways, sidewalks, and paved parking). Staff utilized existing structure and transportation datasets from the County’s 2000 Base Mapping Project and confirmed questionable features using orthophotos. A complete description of the methodology and datasets used are provided in Appendix E.

Based on this data, the watershed has a current impervious cover of 20.3% (Table 4-3). Imperviousness of the subwatersheds ranges from 43.7% in the Bronx River Lower Direct Drainage subwatershed, to 1.7% in the White Plains Reservoirs subwatershed. Impervious cover generally decreases moving from south to north in the watershed. The imperviousness of all subwatersheds is displayed in Table 4-3 and in map A-5: Bronx River Watershed Subwatershed Imperviousness in Appendix A. In addition, subwatershed impervious cover maps are provided in Appendix F.

Subwatershed imperviousness is a valuable indicator of the impacts of urbanization on streams. When evaluating the direct impact of urbanization on streams, researchers have emphasized hydrologic, physical, and biological indicators to define urban stream quality. In recent years, impervious cover has emerged as a key paradigm to explain and sometimes predict how severely these stream quality indicators change in response to different levels of watershed development. The Center has integrated these research findings into a general watershed-planning model, known as the impervious cover model (ICM). The ICM predicts that most stream quality indicators decline when watershed impervious cover exceeds 10%, with severe degradation expected beyond 25% impervious cover.

Table 4-3: Bronx River Subwatersheds Impervious Cover		
Subwatershed Name	Impervious Area (acres)	Imperviousness (%)
Bronx River Lower Direct Drainage	912	43.7%
Grassy Sprain Brook Direct Drainage	437	34.6%
Fulton Brook	205	32.7%
Bronx River Upper Direct Drainage	959	29.8%
Troublesome Brook	511	29.6%
Bronx River Middle Direct Drainage	956	29.4%
Sprain Brook	240	22.0%
Manhattan Park Brook	459	21.7%
Hartsdale Brook	155	20.1%
Fox Meadow Brook	184	19.9%
Clove Brook	133	15.7%
Grassy Sprain Brook	455	14.6%
Davis Brook	184	13.4%
Kensico Reservoir	479	6.0%
White Plains Reservoirs	10	1.7%
Bronx River Watershed	6,279	20.3%

4.3 Future Growth

The potential for future development was not reviewed extensively as part of this project. As noted above, only 3.3% of the watershed is currently classified as “undeveloped,” implying that any significant development activities in the future will most likely occur as infill or redevelopment.

With the exception of Sprain Brook, subwatershed undeveloped area generally increases moving south to north in the watershed. The Kensico Reservoir, Clove Brook, and Davis Brook subwatersheds contain more than two-thirds of the undeveloped lands in the watershed. Undeveloped land use by subwatershed is displayed in Table 4-4.

Table 4-4: Undeveloped Land Use by Subwatershed			
Subwatershed	Undeveloped Area (acres)	Percent of Subwatershed	Percent of Watershed
Kensico Reservoir	282.1	3.5%	0.9%
Clove Brook	226.5	26.7%	0.7%
Davis Brook	190.7	13.9%	0.6%
Sprain Brook	115.8	10.6%	0.4%
White Plains Reservoirs	69.2	12.0%	0.2%
Bronx River Upper Direct Drainage	44.6	1.4%	0.1%
Grassy Sprain Brook	30.7	1.0%	0.1%
Manhattan Park Brook	22.9	1.1%	0.1%
Grassy Sprain Brook Direct Drainage	16.9	1.3%	0.1%
Bronx River Middle Direct Drainage	12.0	0.4%	0.0%
Troublesome Brook	7.8	0.5%	0.0%
Fox Meadow Brook	0.8	0.1%	0.0%
Hartsdale Brook	0.7	0.1%	0.0%
Bronx River Lower Direct Drainage	0.2	0.0%	0.0%
Fulton Brook	0.1	0.0%	0.0%
Total	1,020.8		3.3%

Section 5. Local Government Code and Ordinance Review

In January 2005, Westchester County staff submitted a review of watershed-related codes and ordinances to the 14 villages, towns, and cities in the Bronx River watershed. This document, *Municipal Land Use Regulatory Review for the Bronx River Watershed, Westchester County, NY*, (hereafter, *Regulatory Review*) was reviewed in detail by the Center, and comments were submitted to Westchester County in a memorandum dated June 7, 2005.

The Regulatory Review audited codes and ordinances of the 14 jurisdictions as related to:

- Drinking Water (Aquifers and Reservoirs) Protection
- Wetlands/Watercourse Protection
- Erosion and Sediment Control
- Stormwater Management
- Vegetation Conservation and Replacement
- Refuse Management
- Site Design

Major findings of the Regulatory Review are highlighted in the box below.

Overall, the *Regulatory Review* is a thorough and complete summary of the watershed-related codes and ordinances for the 14 Westchester County towns, villages, and cities in the Bronx River watershed. The Department of Planning staff will find it a useful reference tool as well as a benchmark for where the towns are now. The Center suggests an additional review in the future (maybe at the end of the first cycle of NPDES Phase II permits) to measure progress in implementation by each town.

Major Findings of the Regulatory Review (Excerpted from WCDP, 2004)

Drinking Water Protection

- Four of the fourteen municipalities (City of White Plains and the Towns of Mount Pleasant, North Castle and the Village of Harrison) have residences that use well water within the Bronx River Watershed area of their municipality.
- Three of the fourteen municipalities (Town of Mount Pleasant and North Castle and the Village of Harrison) have a drinking water reservoir.
- None of the fourteen municipalities has a drinking water ordinance.

Wetland and Water Course Protection

- All of the fourteen municipalities in the Bronx River Watershed have State or Federal designated wetlands within the Watershed.
- Nine of the fourteen municipalities (Towns of Eastchester, Greenburgh, Mount Pleasant, New Castle and North Castle and the Villages of Elmsford, Harrison and Scarsdale) in the Bronx River Watershed have local freshwater wetlands regulations.

Erosion and Sediment Control

- Three of the fourteen municipalities (Town of New Castle and the Villages of Harrison and Scarsdale) have an erosion and sediment control ordinance.
- Two of the fourteen municipalities (Town of Greenburgh and New Castle) have a steep slopes ordinance.
- Six of the fourteen municipalities (Towns of Greenburgh, Mount Pleasant and North Castle and the Villages of Ardsley, Elmsford and Harrison) have an excavation and filling ordinance.
- Erosion and sediment control, steep slope and excavation and filling ordinances can be combined to create one comprehensive erosion and sediment control ordinance.

Stormwater Management

- One municipality (Village of Scarsdale) in the Bronx River Watershed has a stormwater ordinance.

Refuse Management

- All of the municipalities in the Bronx River watershed have provisions for many of the different refuse management areas.

Tree and Vegetation Protection and Conservation

- Seven of the fourteen municipalities (Cities of White Plains and Yonkers, Towns of Greenburgh, Mount Pleasant, New Castle and North Castle and the Village of Harrison) in the [Bronx River]³ Croton Bay watershed have provisions for tree and vegetation protection and conservation.

Site Design

- All of the municipalities in the Bronx River Watershed have provisions for many of the key elements found in the site design recommendations. However, a majority of those regulations do not fulfill the recommended standards or thresholds.
- Many of the open space requirements relate only to cluster developments or higher density developments and not to all of the subdivisions.

³ In this bullet, the *Regulatory Review* referred to the Croton Bay watershed. It is assumed that this was a typo, and that it should have read Bronx River.

Section 6. Subwatershed Prioritization

6.1 Watershed Treatment Model

The Watershed Treatment Model (WTM) was used to estimate existing and future nutrient and total suspended solid loads within the Westchester County portion of the Bronx River watershed and its 15 subwatersheds. This information was used, in part, to target specific subwatersheds for more detailed and intensive field assessments.

The WTM, version 3.1 (Caraco, 2002), is a simple spreadsheet model used to:

- Estimate pollutant loading under current watershed conditions
- Determine the effects of current management practices
- Estimate load reductions associated with implementation of structural and non-structural management practices
- Evaluate the effects of future development

The model has two basic components: Pollutant Sources and Treatment Options. The *Pollutant Sources* component of the WTM estimates the load from primary land uses (i.e. residential, commercial, forest land) and secondary sources (i.e. active construction, managed turf, channel erosion, illicit connections) in a watershed without treatment measures in place. The *Treatment Options* component of the model estimates the potential reduction in this uncontrolled load if various treatment measures (both structural and nonstructural) are used. A more detailed description of the WTM can be found in Appendix G.

The following caveats should be considered while reviewing this portion of the subwatershed prioritization:

- The WTM is a planning level model primarily for urban/suburban applications. There are many simplifying assumptions made by the WTM, and the model results are not calibrated. Therefore, the results of the model simulations should be compared on a relative basis rather than used as absolute values.
- The application of existing treatment practices in the Bronx River watershed is based on limited GIS data⁴, best professional judgment, and default values associated with the WTM.
- A series of modeling assumptions were made on loading rates, existing and current practice application, and stormwater program implementation that may or may not be valid throughout the Bronx River watershed. These assumptions were reviewed by County staff for refinement where possible.

⁴ Although extensive GIS data was provided by the County to the Center, additional GIS data that would have been useful when developing the WTM include locations of existing stormwater treatment practices, septic systems, storm drains, and sanitary sewers.

A description of the assessment methods and the results of the WTM modeling for existing and future conditions in the Bronx River watershed, with no change to existing management practices, is provided below.

Pollutant Sources

The WTM land use primary source estimates are based on area calculations from Westchester County's land use layer. Impervious cover factors were assigned to each land use based on guidance derived and reported in "Impervious Cover and Land Use in the Chesapeake Bay Watershed" (Cappiella and Brown, 2001). The WTM impervious cover estimates were also compared to direct impervious cover calculations from Westchester County's impervious cover GIS layers. The WTM estimates were adjusted where reasonable, using best professional judgment, to align more closely with the directly measured values generated from the County impervious cover layers. Limited discrepancies exist between the two impervious cover values for some subwatersheds. This is explained, in part, by 1) factors from Cappiella and Brown are composites and taken from a different geographic region, and 2) County impervious cover layers don't include all forms of impervious cover such as sidewalks, shorter driveways, and small parking areas.

Additional assumptions for primary sources include:

- An annual average precipitation of 48.9 inches (worldclimate.com for White Plains, Westchester County).
- Half of rural TN load is from storm versus non-storm flow, 70% of TP and 90% of TSS, respectively.
- Planning horizon of 20 years.
- The Kensico Reservoir Basin subwatershed was not included as a primary source contributor to the entire Bronx River watershed because there is no longer a hydrologic connection between the Kensico Reservoir and the Bronx River.
- Pollutant contributions from open water were removed from the following subwatersheds: White Plains Reservoirs, Kensico Reservoir, Grassy Sprain and the Bronx River Lower Direct Drainage. This adjustment was made based on three factors: 1) each of these subwatersheds contain a large area of open water; 2) the pollutant assimilation or uptake capacity of these water bodies is unknown; and 3) removing the open water pollutant component allows all the Bronx River subwatersheds to be compared more evenly.

Secondary source loads are basically calculated as a product of flow and concentration. Refer to Caraco (2002) for detail on how loads are specifically calculated for each type of secondary source. Secondary sources that are present in the watershed and quantifiable based on existing data were considered. In most cases, this involved using GIS data provided to CWP by Westchester County or default values of the WTM. Table 6-1 describes input data and assumptions for secondary sources.

Table 6-1: Secondary Sources and Assumptions	
Secondary Source	Assumption
General Sewage Use Data	Based on information received from the County, and as defined in the Westchester County report entitled “Land Use Trends in Westchester County, 1988-1996” (Vasilakos, 2005), the residential land uses are defined as follows: Very low density: <1 du/acre, Low density: <2 du/acre, Medium density: 2-16 du/acre, High density: >16 du/acre. It was also assumed the area treated by septic systems in the watershed is minimal and negligible.
Active Construction	Across the entire watershed 75 total active construction sites exist, each with an area of 2.0 acres. Active construction is assumed to be occurring initially within currently undeveloped or rural land use areas. In subwatersheds where the amount of undeveloped or rural land use area was not great enough to support all the acres presumed to be in active construction, the remaining area was subtracted from the residential land use with the greatest area.
SSOs	Sanitary sewer length was estimated based on land use estimates from a previous study. For the ‘Potomac River Source Water Assessments of Maryland Plants’, sanitary sewer length was calculated for low (57 ft/acre) and high (118 ft/acre) density residential land uses where sanitary sewer data was available, and applied the resulting ratios to the remaining study area where data was unavailable. These land use estimates were applied to this investigation and interpolated to estimate medium density residential sanitary sewer lengths. For example, low and high density land use areas were assumed to be 57 and 118 ft of sanitary sewer line per acre respectively, and 88 ft of sanitary sewer line per acre for medium residential areas. High density estimates were used for industrial, commercial and institutional land uses.
CSOs	No estimates of existing CSOs were included in the WTM model.
Illicit Connections	0.1% of residential and 10% of business areas assumed to have illicit connections.
Channel Erosion	No estimates of channel erosion were included in the WTM model. This decision was made due to the complexity of the Bronx River watershed and the simplifying assumptions used by the WTM channel erosion estimator, coupled with initial field observations that in-stream sources do not appear to be a large sediment contributor. A more detailed investigation, beyond the capabilities of the WTM, is recommended to more accurately understand the channel erosion patterns in the watershed. This decision means the results of the WTM model focus on upland pollution sources and control programs.
Lawns (Subsurface Flow)	The county GIS soils layer was combined with Hydrologic Soil Group (HSG) information and used to estimate the percentage of HSG A, B, C, or D located within each subwatershed.
Hobby Farms / Livestock / Marinas	No hobby farms, livestock operations, or marinas are present in the Bronx River Watershed.
Road Sanding	Two road layers were used to estimate the total road length in each subwatershed, and where information is not available, it was assumed all roads have 2 lanes. Additionally, it was assumed all highway miles are sanded, approximately 75% of the non-highway roads are sanded and approximately 15% of all the roads in the watershed are open section. Based on information from the Maryland State Highway Administration and presented in the ‘Potomac River Source Water Assessments for Maryland Plants’ report, a road sand application rate of 1.66 tons/lane mile/year was applied.

Management Practices

The WTM models load reductions from primary and secondary sources associated with the application of treatment practices. Existing practices and future reductions associated with potential practice implementation can both be modeled. To date, only existing management practices have been included in the WTM model, based primarily on information provided by Westchester County and field observations made by CWP. Table 6-2 summarizes the assumptions used for applying the existing treatment practices.

Table 6-2: Existing Management Practices and Assumptions	
Input	Assumption
Lawn Care / Pet Waste Education	Although both Pet Waste and Lawn Care education programs exist in the watershed, it is assumed that these are not effective at reaching a large number of citizens. In addition, the existing Grass Roots Healthy Lawn program focuses on reduction of pesticide use on private property, as opposed to reduced nutrient application.
Erosion and Sediment Control	ESC programs exists throughout the watershed, with an approximate 70% program efficiency. A program efficiency of 70% is based on a sediment control program that emphasizes erosion control measures, including practices that limit clearing and grading or use of phased construction methods, and requires advanced erosion and sediment control measures to reduce the concentration of sediment in runoff leaving the site (Caraco, 2002). It is assumed approximately 50% of all construction sites have ESC permits. Additionally, it is assumed the programs have few inspectors, no pre-construction meetings, and some poor and ineffective practices are included in the guidance manuals.
Street Sweeping	Residential roadways, parking lots and other roadways are swept twice a year with a mechanical sweeper. Additionally, no parking restrictions or operator training are required or in place.
Impervious Cover Disconnection	25% of residential parcels and 10% of commercial parcels employ rooftop disconnection techniques.
Structural Stormwater Management Practices	Based on December 2005 field work, CWP is aware of at least one stormwater pond in the Davis Brook subwatershed, two in the Clove Brook subwatershed, and at least one in Manhattan Park Brook. These have been accounted for in the WTM. However, in general, the vast majority of developed sites do not appear to have structural stormwater management features, and the rest of the subwatersheds were modeled as such.
Riparian Buffers	No design guidance is provided and the buffer is a setback, with no restrictions on activities within the buffer. The riparian buffer length was calculated using the deciduous forest land cover estimate from the University of Connecticut. Riparian buffer width was estimated by averaging the buffer width at 10 random locations, where a riparian buffer had been identified, within each subwatershed.
Catch Basin Cleanouts	The acreage treated by catch basins in each subwatershed can be approximated by the roadway imperviousness in each subwatershed. Additionally, catch basins are cleaned annually and poor disposal practices are employed.

Future Development

Future land use was estimated using a GIS zoning layer for Westchester County in the Bronx River watershed. The descriptions in the zoning layer were matched with the categories used for the land use primary source estimates, and are summarized in Table 6-3. Additionally, areas where the land use was assumed not to change between existing and future conditions were

incorporated into the zoning information. The land use areas assumed not to change included public open space, areas adjacent to water supply water bodies, known roadways, and cemeteries.

Zoning Description	WTM Category
1 to 2 DU's	Low Density Residential
17 to 49.9 DU's	High Density Residential
50 and Over DU's	High Density Residential
9 to 16 DU's	Medium Density Residential
Business, Office, Commercial	Commercial
Campus, Office, Research, Ind. Park	Institutional
Less than 1 DU	Very Low Density Residential
Major Water Bodies	Open Water
Man., Ind., Warehouse, Stor., Pub. Util.	Industrial
Other Non-Res. Classifications	Office
Over 2 to 8.9 DU's	Medium Density Residential

The zoning descriptions used in the future loads analysis did not always align with existing land use categories. As a result, a random quality review of the data revealed that where zoning descriptions did not accurately align with the existing land use category the impervious cover for that parcel could be somewhat under or over estimated. However, inspection of the overall changes in impervious cover for each subwatershed are reasonable and within the expected shift.

The following are additional assumptions made for future development conditions:

- The Kensico Reservoir subwatershed was not included as a contributor of future pollutant loads to the entire Bronx River watershed because there is no hydrologic connection between the two.
- Pollutant contributions from open water were removed from the following subwatersheds: White Plains Reservoirs, Kensico Reservoir, Grassy Sprain, and Bronx River Lower Direct Drainage. This adjustment was made based on three factors, 1) each of these subwatersheds contain a large area of open water, 2) the pollutant assimilation or uptake capacity of these water bodies is unknown, and 3) removing the open water pollutant component allows all the Bronx River subwatersheds to be compared more evenly.

Table 6-4 summarizes the data and assumptions input into the WTM to model future conditions.

Input	Assumption
New Wastewater Treatment Customers	Additional future development in the watershed will not be treated by wastewater treatment plants discharging to the Bronx River or its tributaries.
New Construction	Estimate based on increased land use area between existing and future conditions divided by a planning horizon of 20 years to estimate the annual construction acreage.
Stormwater Controls on New Development	The controls on new development inputs were based on the current stormwater program, with an assumption that Best Management Practices (BMPs) would be required for stormwater quality. As currently modeled, pollutant loads for future conditions assume no change in existing management practices.

Results

Results are presented for nutrient and total suspended solid (TSS) loads for existing and future conditions, both based on existing management practices.

Nutrient and TSS loads for existing conditions are summarized for the Bronx River Watershed and each of the 15 subwatersheds in Table 6-5.

Table 6-5: Existing Load Estimates				
Name	Existing Imperviousness (%)	TN (lb/acre/year)	TP (lb/acre/year)	TSS (lb/acre/year)
Bronx River Lower Direct Drainage ¹	41.2	6.5	0.9	316.0
Bronx River Middle Direct Drainage	29.1	6.3	0.7	292.5
Bronx River Upper Direct Drainage	28.5	6.0	0.7	267.5
Clove Brook	19.4	6.0	0.7	180.8
Davis Brook	13.3	3.1	0.3	191.8
Fox Meadow Brook	18.5	5.9	0.6	227.9
Fulton Brook	35.8	7.6	1.0	309.6
Grassy Sprain Brook ¹	17.9	3.2	0.3	215.2
Grassy Sprain Brook Direct Drainage	36.2	5.0	0.6	273.1
Hartsdale Brook	19.2	6.0	0.6	231.2
Kensico Reservoir ¹	9.2	3.6	0.4	129.1
Manhattan Park Brook	25.0	5.3	0.6	217.0
Sprain Brook	27.8	3.4	0.3	192.4
Troublesome Brook	32.4	6.4	0.8	278.3
White Plains Reservoirs ¹	1.8	2.5	0.3	111.8
Bronx River Watershed	22.3	5.0 ²	0.6 ²	229.2 ²
Notes:				
1. Bronx River Lower Direct Drainage, Grassy Sprain Brook, Kensico River, and White Plains Reservoirs do not include load estimates from atmospheric deposition into open water bodies.				
2. Load estimates for Bronx River Watershed do not include the Kensico River Basin, which is not hydrologically connected to the Bronx River.				

Nutrient and TSS loads for future conditions are summarized for the Bronx River Watershed and each of the 15 subwatersheds in Table 6-6. Table 6-7 summarizes the net increase in imperviousness and the percent increase in pollutant loads from existing to future land use conditions.

Table 6-6: Future Load Estimates				
Name	Future Imperviousness (%)	TN (lb/acre/year)	TP (lb/acre/year)	TSS (lb/acre/year)
Bronx River Lower Direct Drainage ¹	42.0	6.7	1.0	374.9
Bronx River Middle Direct Drainage	30.9	6.6	0.9	369.5
Bronx River Upper Direct Drainage	31.4	6.6	0.8	342.7
Clove Brook	25.4	6.7	0.9	279.1
Davis Brook	18.3	3.9	0.5	283.0
Fox Meadow Brook	26.1	7.2	0.9	361.8
Fulton Brook	40.0	8.8	1.3	430.0
Grassy Sprain Brook ¹	20.4	3.3	0.4	282.4
Grassy Sprain Brook Direct Drainage	42.0	6.0	0.7	331.2
Hartsdale Brook	26.5	7.3	0.9	338.0
Kensico Reservoir ¹	9.1	3.8	0.4	151.6
Manhattan Park Brook	31.2	6.9	0.9	333.2
Sprain Brook	28.4	3.6	0.4	228.0
Troublesome Brook	36.6	7.2	1.0	351.9
White Plains Reservoirs ¹	5.2	3.1	0.4	157.4
Bronx River Watershed	24.5	5.6 ²	0.7 ²	295.8 ²

Notes:

1. Bronx River Lower Direct Drainage, Grassy Sprain Brook, Kensico River, and White Plains Reservoirs do not include load estimates from atmospheric deposition into open water bodies.
2. Load estimates for Bronx River Watershed do not include the Kensico River Basin, which is not hydrologically connected to the Bronx River.

Table 6-7: Summary of Increases from Existing to Future Land Use Conditions				
Name	Net Increase in Imperviousness (%)	% Increase in TN (lb/year)	% Increase in TP (lb/year)	% Increase in TSS (lb/year)
Bronx River Lower Direct Drainage ¹	0.8	3.6%	9.9%	18.7%
Bronx River Middle Direct Drainage	1.8	4.7%	18.4%	26.3%
Bronx River Upper Direct Drainage	2.9	9.4%	21.3%	28.1%
Clove Brook	6.1	10.8%	18.5%	54.4%
Davis Brook	5.0	26.2%	52.9%	47.5%
Fox Meadow Brook	7.6	22.6%	46.7%	58.8%
Fulton Brook	4.2	15.2%	25.4%	38.9%
Grassy Sprain Brook ¹	2.5	26.7%	56.8%	36.0%
Grassy Sprain Brook Direct Drainage	5.8	20.5%	28.8%	21.3%
Hartsdale Brook	7.2	21.4%	37.4%	46.2%
Kensico Reservoir ¹	-0.1	6.2%	8.9%	17.5%
Manhattan Park Brook	6.3	29.1%	43.2%	53.5%
Sprain Brook	0.6	7.1%	16.6%	18.5%
Troublesome Brook	4.2	12.4%	21.1%	26.4%
White Plains Reservoirs ¹	3.4	22.9%	24.7%	40.7%
Bronx River Watershed	2.2	12.2% ²	21.9% ²	29.1% ²

Notes:

1. Bronx River Lower Direct Drainage, Grassy Sprain Brook, Kensico River, and White Plains Reservoirs do not include load estimates from atmospheric deposition into open water bodies.
2. Load estimates for Bronx River Watershed do not include the Kensico River Basin, which is not hydrologically connected to the Bronx River.

6.2 Comparative Subwatershed Analysis

The Comparative Subwatershed Analysis (CSA) screens subwatersheds within a watershed to identify the ones with the greatest restoration potential. Subwatershed “metrics” are used to conduct this analysis. Metrics are single numeric values that characterize the relative restoration potential of a subwatershed.

The CSA involves a simple spreadsheet analysis of selected subwatershed metrics that are derived by analyzing available GIS layers and other subwatershed data sources. Subwatersheds with the highest aggregate score become priorities of subsequent field investigations for actual restoration potential. This enables watershed planners to allocate limited resources on subwatersheds where restoration has the greatest chance of success.

Many different subwatershed metrics can be used for screening purposes. The basic method to conduct a CSA consists of four general tasks:

1. Delineate subwatershed boundaries and review available metric data
2. Choose and compute metrics that best describe restoration potential
3. Develop weighting and scoring rules to assign points to each metric
4. Compute aggregate scores and develop initial subwatershed ranking

The Center completed a CSA for the Bronx River watershed. First, the Center completed a review of all existing watershed data provided by Westchester County, including GIS data. Based on this review, the Center proposed 15 metrics that could be used in the CSA:

- | | |
|--------------------------------|---|
| 1. Current Impervious Cover | 9. Stormwater Hotspot Density |
| 2. Future Impervious Cover | 10. Subwatershed Stream Density |
| 3. Publicly-Owned Land | 11. Stream Corridor Forest Cover |
| 4. Subwatershed Forest Cover | 12. Public Ownership of Corridor |
| 5. Subwatershed Wetland Cover | 13. Road Crossings |
| 6. Subwatershed Conserved Land | 14. Special Designation / Special Resources |
| 7. Detached Residential Land | 15. Current Annual Total Pollutant Loading |
| 8. Industrial Land | |

Upon further review of available data, and after conversations with County staff, the Center selected 12 metrics to use in the Bronx River watershed CSA. The Center used GIS data provided by the County and NEMO to compute the value of each metric.

After the metrics were computed for each subwatershed, the Center developed a weighted scoring system. Table 6-8 provides more detailed information on each selected metric, including:

- *Metric* – The metric selected to measure restorability of the subwatershed.
- *How Metric is Measured* – Describes the units used to define the metrics.
- *Indicates Higher Restoration Potential When...* – Describes how this metric is used to determine “restorability” of a subwatershed.

- *Metric Points* – Provides an example of how points may be assigned to different metric values.

The results of the CSA for the Bronx River watershed, including metric scores and total scores, are summarized in Table 6-9. Actual metric values are provided in Appendix H.

Table 6-8: Summary of Subwatershed Metrics Proposed for the Bronx River Watershed			
Metric	How Metric is Measured	Indicates Higher Restoration Potential When...	Metric Points
Current Impervious Cover	% impervious cover in subwatershed	Current impervious cover is low	Less than 10% = 10 pts; 11 to 25% = 7 pts; 26 to 40% = 5 pts; 41 to 60% = 3 pts; >60% = 1 pt
Publicly-Owned Land	% of subwatershed that is publicly owned	Public land ownership is high	Award 1 pt for each 2.5% of subwatershed in public ownership
Subwatershed Forest Cover	% forest cover in subwatershed	Forest cover is low	Less than 10% = 10 pts; 11 to 25% = 7 pts; 26 to 40% = 5 pts; 41 to 60% = 3 pts; >60% = 1 pt
Subwatershed Wetland Cover	% of subwatershed that is wetlands	Wetlands cover is high	Award 1 pt for each 2% of subwatershed area
Subwatershed Conserved Land	% of subwatershed that is currently conserved	Conserved land is high	Award 1 pt for each 2% of subwatershed area
Detached Residential Land	% of subwatershed as detached residential	Detached residential land is high	Award 1 pt for each 10% of subwatershed in public ownership
Industrial Land	% of subwatershed as industrial	Industrial land is high	Award 1 pt for each 1% of subwatershed classified as industrial
Subwatershed Stream Density	stream miles / square mile	Stream density is high	Award 1 pt for each 5% increase in stream density from watershed average of 1.1 stream miles / square mile
Stream Corridor Forest Cover	% of stream corridor that is forested	Corridor forest cover is low	Add 1 pt for each 10% reduction in forest cover
Public Ownership of Corridor	% of stream corridor that is publicly owned	Public corridor ownership is high	Add 1 pt for each 10% of stream corridor in public ownership
Storm Water Hotspot Density	potential hotspots / square mile	Hotspot density is high	Less than 3 hotspots/sq mi = 1 pt; 3 to 6 = 3 pts; 6 to 9 = 5 pts; >9 = 7 pts
Municipalities	number of municipalities / subwatershed	Number of municipalities is low	Award 5 pts for 1 municipality; 3 pts for 2 municipalities; 1 pt for 3 or more municipalities

Table 6-9: Results of the Comparative Subwatershed Analysis for the Bronx River Watershed

Subwatershed	Score (points)												
	Current Impervious Cover	Publicly-Owned Land	Forest Cover	Wetland Cover	Conserved Land	Detached Residential Land	Industrial Land	Stream Density	Stream Corridor Forest Cover	Public Ownership of Corridor	Hotspot Density	Municipalities	Total
Hartsdale Brook	7	15	5	3	9	4	0	0	5	2	7	3	60
Bronx River Middle Direct Drainage	5	6	7	4	4	6	1	4	6	7	7	1	58
Bronx River Lower Direct Drainage	3	3	10	2	6	5	0	0	9	8	7	3	56
Sprain Brook	7	8	5	5	0	3	1	15	7	1	3	1	56
Grassy Sprain Brook	7	12	5	4	6	4	0	2	7	5	1	3	56
White Plains Reservoirs	10	3	1	3	32	0	0	0	2	2	1	1	55
Bronx River Upper Direct Drainage	5	6	7	4	5	5	1	1	6	6	5	1	52
Fox Meadow Brook	7	2	7	3	0	8	0	7	6	1	1	3	45
Manhattan Park Brook	7	6	5	3	0	3	0	4	7	1	5	1	42
Grassy Sprain Brook Direct Drainage	5	0	7	1	3	6	2	0	8	0	5	5	42
Davis Brook	7	2	5	4	3	1	0	7	6	0	3	3	41
Clove Brook	7	0	3	6	2	3	0	5	3	0	3	5	37
Fulton Brook	5	0	5	4	0	4	0	1	7	0	7	3	36
Troublesome Brook	5	1	7	0	0	7	0	0	9	1	3	3	36
Kensico Reservoir	10	2	3	2	11	2	0	0	3	0	1	1	35

6.3 Priority Subwatersheds for Restoration

As part of the CSA, the Center grouped the 15 subwatersheds into five categories based on similar conditions (e.g., land use, development patterns, drainage patterns, etc.):

- Subwatersheds that drain to water supply reservoirs
- Suburban / rural subwatersheds that drain to Bronx River tributaries
- Subwatersheds that drain to the mainstem of the Bronx River
- Subwatersheds that drain to Grassy Sprain, the largest Bronx River tributary
- Urbanized subwatersheds that drain to Bronx River tributaries

Subwatersheds with similar characteristics will also have comparable restoration strategies and recommendations. Watershed restoration is a costly and lengthy process – developing detailed restoration strategies for all 15 subwatersheds would be an extremely expensive undertaking. Instead, the Center will develop detailed plans for select subwatersheds that are considered “most restorable” per the CSA. Then, general, subwatershed-wide recommendations identified for these specific subwatersheds may be applied to other subwatersheds in the same grouping.

The subwatershed categorization is displayed in Table 6-10 and in map A-6: Bronx River Watershed Subwatershed Characterization in Appendix A. Based on the subwatershed

categorization, the results of the CSA, and the results of the WTM, the Center recommended five subwatersheds for detailed assessment and planning:

- Manhattan Park Brook
- Middle Bronx River Basin
- Grassy Sprain Brook
- Hartsdale Brook
- Fulton Brook

With the exception of Fulton Brook, these subwatersheds received the highest restorability scores on the CSA in their respective categories. Fulton Brook was also selected due to the highly developed nature of the subwatershed, the diversity of land use, and the high density of hotspots. A subwatershed in the “reservoirs” category was not selected due to the existing reservoir and land use management practices already in place in these subwatersheds.

Table 6-10: Bronx River Subwatersheds Categorization and CSA Results

Subwatershed Group	Subwatershed Group Characterization	Subwatershed	Subwatershed Area (sq mi)	CSA Score (points)
1	Subwatersheds drain to water supply reservoirs	White Plains Reservoirs	0.9	55
		Kensico Reservoir	12.4	35
2	Suburban / rural subwatersheds draining to Bronx River tributaries	Manhattan Park Brook	3.3	42
		Davis Brook	2.1	41
		Clove Brook	1.3	37
3	Subwatersheds drain to the mainstem of the Bronx River	Bronx River Middle Direct Drainage	5.1	58
		Bronx River Lower Direct Drainage	3.3	56
		Bronx River Upper Direct Drainage	5.0	52
4	Subwatersheds drain to Grassy Sprain, the largest Bronx River tributary	Sprain Brook	1.7	56
		Grassy Sprain Brook	4.9	56
		Grassy Sprain Brook Direct Drainage	2.0	42
5	Urbanized subwatersheds draining to Bronx River tributaries	Hartsdale Brook	1.2	60
		Fox Meadow Brook	1.4	45
		Fulton Brook	1.0	36
		Troublesome Brook	2.7	36

Note: Subwatersheds selected for detailed assessment and planning are highlighted in gray.

Section 7. Next Steps

This *Baseline Assessment* serves as the deliverable under Task 1: *Performing a Baseline Watershed Assessment*. There are several next steps in the project, as described below.

First, the Center and Biohabitats will submit a technical memorandum summarizing the results of the Unified Stream Assessment, the Upland Subwatershed and Site Reconnaissance, and the uplands stormwater retrofit inventory. Then, the Center and Biohabitats will participate in a stakeholder meeting. The goal of this stakeholder meeting will be to identify specific Bronx River watershed restoration goals, which may then be translated into a project prioritization scheme.

Once vegetations reappears in the spring of 2006, staff from Biohabitats will conduct a riparian corridor restoration and retrofit inventory while Center staff complete the uplands stormwater retrofit inventory. After all potential restoration projects have been identified, they will be evaluated and ranked, per the previously mentioned project prioritization scheme. Specific restoration projects and other watershed recommendations will be assimilated to create a proposed restoration strategy for the watershed. The Center will then conduct a subwatershed treatment analysis to examine the ability of the proposed restoration strategy to reduce pollutant loading in the subwatershed selected for detailed assessment and planning.

Once the draft restoration strategy has been developed and evaluated, the Center and Biohabitats will develop the draft *Watershed Assessment and Management Report*. Westchester County staff will have an opportunity to review the *Report*, and the Center and Biohabitats will participate in a stakeholder meeting to discuss the draft *Report*. A final *Report* will then be submitted. As the last task of this project, Center and Biohabitats staff will participate in a public information session to present the findings of the *Report*.

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