WESTCHESTER COUNTY CROTON WATERSHED
WATER QUALITY CONDITIONS REPORT

For Development of the
Comprehensive Croton System Water Quality Protection Plan
in Westchester County

Prepared by the Westchester County Department of Planning
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a cooperative effort among
the Town of Bedford, the Town of Cortlandt, the Town of Lewisboro, the Town/Village of
Mt. Kisco, the Town of New Castle, the Town of North Castle, the Town of North Salem,
the Town of Pound Ridge, the Town of Somers, the Town of Yorktown and Westchester
County
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SECTION I: OVERVIEW
1. PURPOSE STATEMENT

The *Westchester County Croton Watershed Water Quality Conditions Report*, (from here on referred to as the Croton Water Quality Report) is a component of the Comprehensive Croton System Water Quality Protection Plan (Croton Plan) (Task 7: Water Resource Condition). The purpose of this report is to analyze and account for existing water quality conditions in Westchester County’s Croton Watershed area. This report is based on current water quality data and information. The information has been used to describe the existing water quality condition of the seven subwatershed areas, located, at least in part, in the Croton Watershed. Each subwatershed is further examined through discussion of minor watershed basins and evaluated based on a synthesis of available water quality information. The information contained within this report is limited to what was available during the information collection phase. The available information has been categorized in accordance with minor basin boundaries consistent with the New York City Department of Environmental Protection hydrologic unit.

The Croton Water Quality Report is intended to create a water quality baseline for the Croton Watershed. Ultimately, the Croton Water Quality Report will be used to develop water resource goals and objectives, prioritize water quality improvement strategies and will serve as a continual resource throughout the Croton Planning process. The information contained within this report will assist Westchester County and the ten Croton Watershed municipalities with identifying implementation strategies for recommendations that will be contained within the Croton Plan. Recommendations may relate to streambank/wetland stabilization projects, enhanced monitoring opportunities, creation of stormwater/drainage controls, and other means to improve water quality as identified through the various components of the Croton Plan.

The information contained within this report is divided into four sections. Section I discusses the methodology used to collect existing water quality information, describes the regulatory framework within which water quality is monitored and defines the various parameters that measure water quality. Section II provides general information about and a general description of the Croton Watershed. Section III provides detailed water quality information for each of the 7 subwatershed areas and minor basins of the Croton Watershed. Section IV contains the entire collection of subwatershed maps referred to in Section III.

2. METHODOLOGY

Water quality information was gathered from an array of sources. An inventory was undertaken to identify existing data reports and other documented information regarding water quality in the Croton Watershed. Information collected for the report was an ongoing effort between Westchester County, the New York City Department of Environmental Protection (NYCDEP), the New York State Department of Environmental Conservation (NYSDEC), the watershed municipalities and many other individuals, groups and organizations between September 1999 and July 2000.

In an effort to gather all pertinent information, an information request was sent to all watershed parties involved in the development of the Croton Plan, in March of 2000. In addition, the
Westchester County Department of Planning has met with the New York City Department of Environmental Protection throughout this process for information clarification and exchange. April/May 2000 meetings with the Croton Watershed Municipal Action Teams provided an additional effort to obtain information regarding the water quality of each subwatershed area.

3. INFORMATION SOURCES

Several sources have been identified and used as “primary sources” of water quality information and data. These sources are referred to throughout this report and have provided the basis for evaluation of the subwatersheds and minor basins within the Croton Watershed. These sources are listed and described briefly below:

- **Assessment of Water Quality of Streams in the New York City Watershed Based on Analysis of Invertebrate Tissues and Invertebrate Communities: April, 1999.** NYSDEC: For this assessment, 42 sites were sampled, 15 tributary to 6 reservoirs east of the Hudson. The resident invertebrate communities of these streams was used to characterize any impacts affecting them, and analysis of their tissues can detect elevated body burdens of contaminants. Based on data, stream impact was evaluated.

- **Croton Watershed Wastewater Diversion Study; December, 1998:** This study examined the technical and financial feasibility of diverting wastewater from inside the New York City Watershed to a location outside of the New York City Watershed Area. The study identified 30 wastewater treatment plants and 31 "focus areas" with the potential to be diverted. A focus area is an area currently not sewered or served by a wastewater treatment plant but because of suspected problems and/or the density of development should be considered for diversion.

- **Determination of Unacceptable Water Quality using the protocols of the NYSDEC/NYCDEP MOU; Addendum E April '98:** This document comes out every 6 months. It describes a series of methods to examine routine stream sampling data collected by NYCDEP’s Watershed Hydrology Unit. Each report lists the sites that do not meet the acceptable water quality standard.

- **NYCDEP 1999 List of Nominations to the New York State Priority Waterbodies List:** NYCDEP nominations to the NYSDEC Priority Waterbodies List.

- **NYS 1998 303(d) List:** Identifies waterbodies that are targeted for Total Maximum Daily Load (TMDL) development.

- **Phase II Phosphorus Total Maximum Daily Loads for Reservoirs in the New York City Water Supply Watershed (NYSDEC, June 2000):** Total maximum daily load submittal to the USEPA. These recommendations were developed in conjunction with the NYCDEP.

- **NYSDEC Priority Waterbodies List:** A listing of waterbodies that are not meeting their classified standard.
Additional sources of water quality information collected through community groups or sources of isolated information were also utilized. These remaining sources are listed in the References section.

4. **REGULATORY FRAMEWORK**

The New York City drinking water supply system serves as a water supply for eight million New York City Residents and approximately one million upstate residents. In Westchester County approximately 85% of total County residents obtain their drinking water from the Croton Watershed. In total, the New York City water supply system consists of three watershed systems, the Catskill watershed, Delaware watershed and the Croton system. These systems are located both east and west of the Hudson River. The Croton Watershed (located east of the Hudson River) can supply up to 30% of New York City’s drinking water supply system. Under normal operation, the Croton system supplies up to 10% of New York City’s drinking water supply. In 1997 the historic Memorandum of Agreement to protect New York City’s Drinking Water Supply (MOA) was signed by the United States Environmental Protection Agency, New York State agencies, select environmental groups, the New York City Department of Environmental Protection and the majority of the counties and municipalities with land area in the watershed of the water supply system. The MOA includes watershed protection programs and Watershed Rules and Regulations (Rules and Regulations) to protect and preserve the New York City Drinking Water Supply.

In Westchester County, municipal signators to the MOA include Bedford, Cortlandt, Harrison, Lewisboro, Mount Pleasant, Mt, Kisco, New Castle, North Castle, North Salem, Pound Ridge, Somers, and Yorktown. Each municipality agreed to implement the watershed programs and follow the Rules and Regulations for the Protection from Contamination, Degradation and Pollution of the New York City Water Supply and Its Sources (Watershed Rules and Regulations). The Watershed Rules and Regulations allow the New York City Department of Environmental Protection certain approval authority for activities taking place within the New York City drinking water supply watersheds.

Watersheds that comprise the New York City Drinking water supply are protected by many government entities, on the Federal, State, and local levels. Their roles, and relevant laws and regulations are discussed below.

4.1 **United States Environmental Protection Agency**

The U.S. Environmental Protection Agency (EPA) was established in 1970. Their primary mission is to protect human health and the environment. The EPA works in partnerships with the states and local communities, to implement laws that protect our drinking water, including the Clean Water Act and the Safe Drinking Water Act.
- **Clean Water Act:** The Clean Water Act is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. The Clean Water Act (CWA) is the primary federal law that protects our nation’s waters, including lakes, rivers, aquifers and coastal areas. The Clean Water Act's primary objective is to restore and maintain the integrity of the nation's waters. This objective translates into two fundamental national goals: (1) eliminate the discharge of pollutants into the nation's waters and (2) achieve water quality levels that are fishable and swimmable.¹

- **Safe Drinking Water Act:** The Safe Drinking Water Act (SDWA) was established in 1974 to protect the quality of drinking water in the U.S. Under this law, the EPA is required to establish maximum contaminant levels for any drinking water pollutants that may have adverse effects on human health.² This law focuses on all waters actually or potentially designated for drinking use, whether from above ground or underground sources. The Act authorized EPA to establish safe drinking water standards of purity and required all owners or operators of public water systems to comply with these health-related standards.³

- **Surface Water Treatment Rule:** To ensure adequate treatment of water systems, the Surface Water Treatment Rule (SWTR), which is part of the Safe Drinking Water Act, requires that all municipal surface water supplies with open reservoir systems be filtered. If, however, the operators of the system can meet strict criteria for water quality and, at the same time, demonstrate control of watershed activities to ensure future water quality, the EPA may grant a filtration avoidance waiver for a specified period of time.⁴ The Surface Water Treatment Rule provides protection against disease causing organisms (pathogens) in drinking water. In 1994, the law was amended to provide additional protection. Several features of the law identify and regulate the presence of Cryptosporidium; setting a maximum contamination level goal at zero. Cryptosporidium is a waterborne disease causing pathogen. The SWTR applies to all drinking water supply systems that serve over 10,000 people.⁵

The EPA retains oversight responsibilities for the CWA, SDWA and SWTR; however, the laws are often enforced by each of the states.

### 4.2 New York State Department of Environmental Conservation
The New York State Department of Environmental Conservation (DEC) was created on July 1, 1970 to bring together in a single agency all state programs directed toward protecting and

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⁵ United States Environmental Protection Agency. “Long Term 1 Enhanced Surface Water Treatment and Filter Backwash Proposed Rule.” http://www.epa.gov/safewater/mbdp/lt1fbr.html (Last updated 5/30/01)
enhancing the environment. Its mission is to, “conserve, improve, and protect its natural resources and environment, and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well being.”6 In regard to water quality, their responsibilities include: monitoring environmental conditions and testing for contaminants as well as promoting the wise use of water resources. The Division of water is specifically charged to protect water quality in lakes, rivers, aquifers and coastal areas by regulating wastewater discharges, monitoring waterbodies and controlling surface runoff. This responsibility translates to the enforcement of several state programs including the SPDES, TMDL, and PWL programs (discussed below). Many of these programs are extensions or the direct enforcement of responsibilities dictated by the EPA.

- **State Pollutant Discharge Elimination System:** The State Pollutant Discharge Elimination System (SPDES) program is designed to eliminate pollution of New York’s waters and to maintain the highest quality of water possible consistent with: public health, public enjoyment of the resource, protection and propagation of fish and wildlife, and industrial development in the state.

The program is implemented through a system of SPDES permits. A SPDES permit is required for (1) constructing or using an outlet or discharge pipe (referred to as a "point source") that discharges wastewater into the surface waters or ground waters of the state; (2) constructing or operating a disposal system such as a sewage treatment plant and (3) discharge of storm water.7

- **Waterbody Classification:** The NYSDEC categorizes all waterbodies in New York State according to two systems: classification and standard. Waterbody classification is the arrangement of waterbodies according to their best use, for example, the best use for waterbodies classified as AA are: *a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival.*8 The classification system lists waterbodies as AA, A, B, C, D. Generally, the best use of waterbodies classified as A is for drinking water; B for primary and secondary contact recreation and fishing; C for fishing and fish propagation and D for fishing.

A waterbody standard is a requirement associated with trout presence and the environmental conditions conducive to trout spawning. This standard effects the effluent discharge flowing into a waterbody. Trout waters are designated with a (T) following the rating; trout spawning water are designated with a (TS). A stream rated C (TS) would be classified as a C stream, and would be required to meet the (TS) standard.

NYSDEC classification for many of the waterbodies in the Croton Watershed varies depending upon their designated use. All of the waters located on New York City owned

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8 NYSDEC Water Quality Classification System Title VI Environmental Conservation Law 701.5
lands are classified as AA or A, for drinking water. However, several streams that are not located on NYC owned lands vary in rating between “C”, “B”, and “A”.

The NYSDEC has classified the source water reservoirs (source waters are “the last stop” prior to water coming out of the tap) in the Croton Watershed as “Class AA” or “Class A” fresh surface waters. The basic distinction between these two classifications is the necessity of filtration; a Class AA waterbody is to be of sufficient quality to serve as a source of unfiltered drinking water, while the Class A waterbody is one that will supply safe drinking water after its water has been subjected to filtration.

Classification/Standard codes associated with waterbodies listed in the Water Quality Conditions Report have been determined based on The Official Compilation Codes Rules and Regulations of the State of New York (1993). NYSDEC Officials from the Statewide Waters Assessment Section reviewed water bodies originally listed with a “D” rating and updated their status based on The Lower Hudson River Drainage Basin Reclassification proposal (which becomes effective Nov. 14, 2001).

- **Priority Waterbodies List:** The Priority Waterbodies List (PWL) is a listing of waterbodies that do not meet their waterbody classification designated “usage” as defined by the NYSDEC (see section above). In addition, this listing also includes waterbodies that fail to meet their use (impaired) and waterbodies that currently meet their use but may not in the future (threatened). Each waterbody listing includes information regarding the current condition and suspected causes of water quality degradation.

- **Total Maximum Daily Load:** A Total Maximum Daily Load (TMDL) for a pollutant is a tool to assess a waterbody’s capacity to handle a pollutant. Through the TMDL, point source waste load allocations (WLA) and nonpoint source load allocations (LA) are calculated. A margin of safety (MOS) is also factored into the calculation to account for any uncertainty in the relationship between the pollutant loads and the waterbody’s water quality. The TMDL is compared to current loading of the pollutant under examination. The difference between the TMDL and the current load will determine whether or not load reductions for the pollutant will be required. Under the CWA, the EPA requires states to identify waterbodies that do not meet water quality standards with technology-based controls alone as “water quality limited”. Waterbodies that do not meet their designated use or water quality standards are placed on the 305b list. If technology-based controls will be sufficient then a TMDL is not required and the waterbody is not considered “water quality limited”. If technology-based controls are not sufficient, the TMDL serves as a means to assist states with establishing water quality guidelines to achieve water quality standards. The NYSDEC has identified the New York City Watershed reservoirs as priority waterbodies for phosphorus TMDL development.

### 4.3 New York City Department of Environmental Protection

The New York City Department of Environmental Protection (NYCDEP) operates the water supply system that delivers water to City and upstate residents. The NYCDEP, along with many watershed stakeholders, are responsible for the health of the NYC drinking water supply system. NYCDEP officially announced new Watershed Rules and Regulations (as part of the 1997 MOA) to protect the NYC drinking water supply system. NYCDEP monitors the water supply system for microbiological, chemical and physical measures of quality.

- **Watershed Rules and Regulations**: The Watershed Rules and Regulations (Rules and Regulations) provide land use oversight and approval authority to the NYCDEP. The Rules and Regulations prohibit specific actions that could potentially impair water quality throughout the New York City Drinking Water Supply Watershed. The Rules and Regulations contain provisions related to water quality buffers, hazardous waste, application of road sand and salt, creation of impervious surfaces, etc. For example, the Rules and Regulations establish water quality buffers around wetlands, reservoirs and streams throughout the watershed. Specific activities, as outlined in the Rules and Regulations, are prohibited within these water quality buffers.

- **Monitoring Programs**: Most NYCDEP programs have a routine monitoring component. The routine programs that NYCDEP currently monitors include: meteorology, groundwater, streams, SWTR compliance, reservoirs, wastewater treatment plants and pathogens. Many information sources utilized in preparation of this report are based on data gathered from the NYCDEP’s stream, SWTR compliance, pathogen and reservoir monitoring programs. As such, inquiries regarding NYCDEP water quality monitoring data or monitoring locations should be made directly to the NYCDEP. The monitoring site locations for the above programs are based on NYCDEP Geographic Information System (GIS) coverage and are included in each respective subwatershed section.

- **Role in TMDL Development**: EPA, as well as numerous stakeholders, noted that the State guidance value for phosphorus was derived to protect aesthetic and recreational uses of the water body, not for the designated use of the reservoirs as a public water supply. Therefore EPA, in the Phase I TMDL decision letter dated April 2,1997 charged the TMDL workgroup with evaluating whether this value was adequate to protect a public water supply. NYCDEP, in the role of providing technical assistance to the TMDL program, was then charged with developing a site-specific (i.e. NYC watershed) guidance value based on monitoring data.

4.4 Westchester County

The goal of the Memorandum of Agreement (MOA) is to protect the New York City water supply system while also preserving the community character and economic viability of upstate watershed communities. Under this agreement, Westchester County works with the 12 Westchester County watershed municipalities that signed the MOA and facilitates the watershed protection and partnership programs outlined in the MOA. These programs include, among others, the Sewage Diversion Study, the East of Hudson Water Quality Investment Program and the development of the Croton Plan. In addition, the Westchester County

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11 Correspondence Kimberlee Kane to Natara Feller “WQ Questions” (July 19, 2001)
Department of Planning (WCDP) facilitates the Northern Westchester Watershed Committee (NWWC), which is composed of supervisors from the 12 watershed communities. The function of the NWWC is to oversee the implementation of the MOA and discuss related watershed issues.

The Watershed Rules and Regulations call for the development of the Comprehensive Croton Watershed Water Quality Protection Plan (the Croton Plan). This planning process, facilitated by the WCDP, involves 10 of the 12 New York City watershed communities. The Croton Plan is required to do the following:

- Identify significant sources of pollution to the Croton Watershed system;
- Recommend measures to be taken by the Northern Westchester watershed municipalities, Westchester County and the New York City Department of Environmental Protection (NYCDEP) which, in conjunction with other water quality protection programs (local, state and federal), will prevent degradation to, and improve water quality in the Croton Watershed; and
- Recommend measures to be taken to protect the character and special needs of communities located within the Croton Watershed.

4.5 Local (Municipal) Level
The ten local municipalities within the Croton Watershed have primary responsibility for determining how land within their political jurisdiction is developed and preserved. Each of the ten municipalities operates under their own set of land use controls. Development standards and design criteria can differ from municipality to municipality. Examples of some of the land use controls employed by these municipalities include zoning provisions, land development provisions, environmental protection controls and master plans.

5. WATER QUALITY PARAMETERS

Water quality is monitored using a set of parameters that measure the physical, biological and chemical characteristics of water, including naturally occurring constituents and introduced nutrients and pollutants. The expected values and acceptable ranges of these parameters vary with the type of waterbody (stream, lake, wetland) and with the waterbody’s intended use (i.e. drinking water, trout spawning streams, recreation) or classification.

The NYCDEP has a listing of acceptable ranges for parameters that measure both streams and reservoirs in the New York City drinking water supply system (where applicable, these ranges are listed). When water quality deviates from the acceptable ranges, human use and ecological functions can be adversely affected. This in turn may degrade the ecosystem’s value as a drinking water supply, fish and wildlife habitat and recreation area.

Water quality parameters are flow dependent and can vary considerably with storm events. Some of the commonly monitored parameters, their functions, concentrations and the effects of excess levels are described below.12

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• **Conductivity:** Conductivity measures the ability of water to pass an electrical current and can be used as a general index of water chemistry. Low conductivity usually signifies little human contact. High conductivity is usually associated with the presence of alkalinity and inorganic dissolved solids such as chloride, sodium and sulfate. These solids can be introduced by road salts or by outflow from septic systems. Freshwater aquatic species survive best in waters where conductivity measures between 150 and 500 uS/cm (micro Siemens per centimeter).

• **Temperature:** Water temperature affects a wide variety of biological and chemical processes. It affects the oxygen content of the water, the rate of photosynthesis by aquatic plants, the metabolic rates of aquatic organisms and the sensitivity of organisms to toxic wastes, parasites and diseases. Brook Trout require cold water temperatures (48°-55° F). In a watershed several activities cause temperature change, including removal of shading streambank vegetation, stormwater runoff and seasonal weather fluctuations.

• **pH:** pH is the measurement of the acidity of a water body. A pH of 7 is neutral, below 7 is acidic and above 7 is basic. A pH range of 6.5-8.2 is considered best for most aquatic species. pH outside of this range stresses the physiological systems of most organisms and can reduce species reproduction. Low pH can also mobilize toxic elements such as aluminum from soils, producing water quality conditions that are toxic to aquatic life. Wastewater discharge and acid rain can cause changes in pH.

• **Dissolved Oxygen and Biochemical Oxygen Demand:** Dissolved oxygen is a measure of the amount of oxygen dissolved in water. Aquatic animals such as insects and fish breathe oxygen in water through their gills; if oxygen levels are reduced, sensitive animals may move away, weaken or die. Biochemical Oxygen Demand is a related parameter that measures the amount of oxygen consumed by living organisms. It is used to set discharge levels for wastewater treatment plants and other sources of effluent, which add organic matter into freshwater systems. Decomposition, particularly following die-off of algae stimulated by excess nutrients, consumes dissolved oxygen and thereby lowers dissolved oxygen levels. In addition, cold water contains more dissolved oxygen, so conditions that cause higher temperatures indirectly cause lower oxygen levels. State regulations require oxygen levels to be at least 7.0 mg/l for trout spawning waters and at least 4.0 mg/l for drinking water; levels below 3.0 mg/l will stress many aquatic species.

• **Chloride:** Chloride can be introduced by road salt storage facilities, application of highway de-icing materials, waste salt discharge from water softeners, septic waste disposal systems and livestock waste. High chloride levels, even in localized areas, harm native species of plants and increase the potential for invasive species such as the common reed (*Phragmites Australis*) to take over. State regulation requires that chloride concentrations in drinking water not exceed 250 mg/l.

• **Nitrogen Compounds (ammonia, nitrite, nitrate):** Nitrogen is an essential and naturally occurring plant nutrient. In excess quantities, it can be extremely harmful and may cause reduced dissolved oxygen levels, accelerate eutrophication, cause undesirable increases in aquatic plant growth and change the types of plants and animals that survive in the aquatic
system. Major sources of excessive nitrogen compounds include: residential septic systems, discharge from sewage treatment plants, and fertilizers from lawns and golf courses. NYS regulations require that nitrate-nitrite concentrations in drinking water not exceed 10 mg/l.

• **Phosphorus:** Like nitrogen, phosphorus is a naturally occurring plant nutrient, but too much is harmful. A small increase in phosphorus can start a chain of undesirable changes including algae blooms, decreased dissolved oxygen and the subsequent die-off of some fish and other aquatic species. Sources of phosphorus include, but are not limited to, failing septic systems, fertilizer runoff and wastewater treatment plants. The NYSDEC TMDLs are based on a phosphorus concentration of 15 ug/l for all source water reservoirs and 20ug/l for all upstream reservoirs.

• **Turbidity**\(^\text{13}\): Turbidity is a measure of the relative clarity of water: the murkier the water, the greater the turbidity. Soil erosion, waste discharge, urban runoff, algae growth or abundant bottom feeding fish (such as carp) that stir up bottom sediments may cause high turbidity. High turbidity can lead to decreased dissolved oxygen levels if the particles causing the turbidity use up oxygen. Water becomes warmer as suspended particles absorb heat from sunlight. High turbidity can also cause decreased sunlight penetration, which leads to a decrease in photosynthesis, causing further reduction of oxygen levels. The combination of warm water, less light and oxygen depletion makes it impossible for some forms of aquatic life to survive. Suspended solids can clog fish gills and cause difficulty for macroinvertebrates to reproduce, as suspended solids may smother eggs and habitat. Turbidity can be measured using a turbidimeter. **NYCDEP does not have an internal standard for Secchi disk depth, nor is there a state or federal standard. Turbidity is regulated at keypoints (aqueduct sampling points at the terminal reservoirs) under the Safe Drinking Water Act.**\(^\text{14}\)

• **Chlorophyll a:** Algae levels in lakes are usually approximated by a measurement of chlorophyll *a*, the primary photosynthetic pigment found in all algae and most photosynthetic organisms. It constitutes approximately 1.5% (by dry weight) of the algal biomass. Chlorophyll *a* is often used to determine the trophic state of a waterbody (extent of eutritification). Lakes with excessive algae are often characterized by chlorophyll *a* levels greater than 10ug/l.

Note: There is often a strong correlation between total phosphorus, chlorophyll *a*, and secchi disk transparency.\(^\text{15}\) There is not a state or federal water quality standard for chlorophyll *a*. NYCDEP suggests a target of 7ug/l in the Phase II TMDL Guidance Value Report (1999).

• **Fecal Coliform:** Presence of fecal coliform may signify the presence of disease causing bacteria, viruses or protozoans. Sources of fecal coliform include animal waste, failing septic systems and runoff. State regulations require that fecal coliform concentrations in

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\(^{13}\) Information for turbidity is based on findings found in *The Field Manual for Water Quality Monitoring*, p. 53.

\(^{14}\) Correspondence Kimberlee Kane to Natara Feller “WQ Questions” (July 19, 2001)

drinking waters, as measured by the monthly geometric mean from at least five examinations, shall not exceed 200 cfu/100ml. It is also worth noting that this ambient water quality standard may change pending proximity to disinfection in drinking water supplies.

- **Macroinvertebrates:** Benthic Macroinvertebrates (BMIs) are animals that do not possess a backbone, are visible with the naked eye, and that live on the bottom of a stream, brook or river. Most freshwater BMIs are larvae of insects, but they also include aquatic worms, mollusks (clams and mussels) and crustaceans (crayfish). These creatures are an important food source for fish and have important ecological significance in terms of assessing the health of a stream or river. The presence of pollution-intolerant species, such as stoneflies, mayflies and caddisflies are an indication of good water quality, whereas the presence of many pollution tolerant species (e.g aquatic worms and fly larva) are an indication of fair to poor water quality. BMIs are good water quality indicators because these animals are present during all weather conditions and events, whereas chemical testing reveals a snapshot in time of water quality. There are several different methodologies of determining water quality by measuring macroinvertebrates. Typically, a qualitative measure is used to yield a determination of non-impacted, slightly impacted, moderately impacted or severely impacted waterbodies.

6. **WATER QUALITY MONITORING INFORMATION SOURCES**

Water quality parameters and standards for monitoring reservoirs and watershed systems, as compared to parameters and standards used for determining whether or not the water coming out of a faucet is ready to drink, vary. The information contained within this report reflects monitoring standards for reservoirs and the watershed system only. The water quality data for the Croton Watershed is derived from water quality information collected at various monitoring sites throughout the watershed. The water quality information listed below and contained within this report is not inclusive of water quality monitoring for “tap ready” water. Below is a list of organizations and the parameters they monitor for:

- **NYCDEP Biomonitoring Program:** The NYCDEP Stream Benthic Biomonitoring program was initiated in 1993. The primary objective of this program is to assess the water quality of watershed streams and rivers for the purpose of supporting aquatic life, through the sampling and identification of benthic macroinvertebrates (aquatic insects). Using sampling methods developed by the NYSDEC’s Biomonitoring Unit, sites are assessed as non-impaired, slightly impaired moderately impaired or severely impaired.¹⁶

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Through the end of the 1998 field season, 23 sites were tested in the Croton Watershed. In 1999, 6 sites were added. Sites are normally sampled for two consecutive years, although that period may be extended if circumstances warrant. Six sites in the Croton Watershed have been selected as routine.

- **NYCDEP Stream Monitoring**: In September, 1997, the NYSDEC and NYCDEP finalized a Memorandum of Understanding (MOU) governing several aspects of enforcement protocols in the NYC Water supply system watersheds. Addendum E of the MOU describes a series of methods to examine routine steam sampling data collected by NYCDEP. Fecal and total coliform bacteria, pH, total phosphorus, dissolved oxygen, total ammonia, and nitrate are the parameters routinely tested. Stream Monitoring consists of East of Hudson Hydrology sampling 41 stream and release sites in the Croton watershed for bacterial analysis twice a month. Stream and reservoir samples are collected at least twice a month at 42 sites in the Croton Watershed for physical, chemical and biological analyses.

- **NYCDEP Reservoir Monitoring**: NYCDEP currently samples terminal reservoirs twice a month (excluding times of ice cover), and the remaining reservoirs monthly. Each reservoir is sampled at the dam, mid-lake and at any major inflows or aqueducts. Additional samples may be taken depending on the size of the water body. Samples from at least two depths are collected at each site; a surface water sample and a bottom water sample. 46 sites are tested routinely in the Croton Watershed.

- **NYSDEC**: The NYSDEC has conducted several biological stream assessment projects within the Westchester portion of the Croton Watershed. Reports which utilize the stream biological data are listed in the References section.

- **Volunteer Water Quality Monitoring**: Community and school groups monitor physical, biological and chemical parameters on a routine basis. Information collected by volunteers is not recognized at the same legal caliber as regulatory agency monitoring. However, many of these organizations follow monitoring methods designed by the NYSDEC. The NYSDEC has been working with Hudson Basin River Watch (HBRW) toward the

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17 Ibid. p. 6-7.
21 New York City Department of Environmental Protection. Reservoir Monitoring Data Summary. (1999)
22 NYCDEP. Water Quality Surveillance Monitoring. (November, 1997) p. 47; Appendix 2.8a
development of standardized volunteer water quality monitoring protocols. HBRW is a network of volunteer monitors throughout the Hudson Valley. Many of the volunteer monitoring groups in Westchester County have been trained to follow HBRW protocols.
SECTION II: STUDY AREA DESCRIPTION AND GENERAL INFORMATION
1. CROTON WATERSHED PHYSICAL DESCRIPTION

The Croton Watershed encompasses all or parts of ten municipalities in Westchester County (the towns of Bedford, Cortlandt, Lewisboro, Mt. Kisco, North Castle, New Castle, North Salem, Pound Ridge, Somers and Yorktown). The watershed consists of a total of 113,265 acres (177 square miles) that represent 39 percent of Westchester County’s total land area. In total, there are 416.65 stream miles within the Westchester County portion of the Croton Watershed. The Croton Watershed generally contributes ten percent of New York City’s drinking water; under drought conditions, the reservoir may serve upwards of 25 percent of New York City’s water supply.23

In many unfiltered water supplies, there is either no human access to the watershed area or an extremely low population allowed to inhabit the area. However, the Croton Watershed is fairly populated in Westchester County. Approximately 107,451 people inhabit the area (according to 2000 Census estimates). In addition, several major transportation routes run throughout the Croton Watershed, making the watershed area extremely accessible to the public.

Two additional Westchester municipalities, the Town/Village of Harrison and Town of Mount Pleasant, lie within the boundaries of the Kensico Watershed, also part of the New York City watershed system. The Kensico watershed is being studied under other programs through the NYCDEP. (Refer to Map 1: Croton and Kensico Watersheds, New York City Drinking Water Supply System) This report specifically focuses on Westchester County’s portion of the Croton Watershed.

1.1 Geographic Breakdown

The Croton Watershed in Westchester County is comprised of subwatersheds of seven New York City reservoirs: Amawalk, Croton Falls, Cross River, East Branch, Muscoot, New Croton and Titicus (see Map 2: Westchester County Croton System Subwatersheds and Minor Basins). Only the New Croton Reservoir subwatershed is located entirely within Westchester County; portions of the other reservoir subwatersheds extend into Putnam County, New York and Fairfield County, Connecticut. Table 1 below refers to the breakdown of each of the seven subwatersheds by municipality. For example, 32% of the Amawalk Subwatershed is located in Somers. The remaining portion is located outside of Westchester County.

Table 1: Breakdown of Westchester County’s Portion of the Seven Croton Subwatersheds

<table>
<thead>
<tr>
<th>Subwatershed</th>
<th>Size (Acreage)*</th>
<th>Municipalities (followed by % of Subwatershed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amawalk</td>
<td>4071.61</td>
<td>Somers (32%)</td>
</tr>
<tr>
<td>Cross River</td>
<td>17313.61</td>
<td>North Salem (.6%), Lewisboro (49%), Bedford (24%), Pound Ridge (17%)</td>
</tr>
<tr>
<td>Croton Falls</td>
<td>220.27</td>
<td>Somers (2%)</td>
</tr>
<tr>
<td>East Branch</td>
<td>644.8</td>
<td>North Salem (1%)</td>
</tr>
<tr>
<td>Muscoot</td>
<td>43552.52</td>
<td>North Salem (9%), Somers (29%), Yorktown (12%), Lewisboro (8%), Bedford (26%), Pound Ridge (6%)</td>
</tr>
<tr>
<td>New Croton</td>
<td>37155.44</td>
<td>Somers (5.5%), Yorktown (41%), Cortlandt (10%), Bedford (12%), North Castle (.5%), Mount Kisco (5%), New Castle (26%)</td>
</tr>
<tr>
<td>Titicus</td>
<td>10387.02</td>
<td>North Salem (61%), Lewisboro (5.5%)</td>
</tr>
</tbody>
</table>

*Westchester Portion

These seven reservoir subwatersheds have been further divided into forty minor basins. These minor basins, ranging in size from 691 acres (~1 square mile) to 11,162 acres (~17 square miles), are a critical geographical reference for watershed planning and for “land based” water quality enhancement and protection initiatives. Delineation of subwatersheds are based on topographic/hydrologic mapping information and is consistent with NYCDEP’s drainage delineations. (Refer to Map 2). Throughout this report, the term “subwatershed” refers to the seven reservoir subwatersheds and the term “basin” refers to the forty minor basins. Geographic area and other pertinent water quality information for each minor basin is discussed in Section III of this report.

1.2 Water Flow Patterns

The seven subwatershed areas within the Croton Watershed are interconnected through a network of streams, ponds and reservoirs. Each reservoir acts as a catchment for all of the streams within its subwatershed and drains into a downstream reservoir. The arrows found on Map 3: Upstream/Source Connection of the East of Hudson Croton Watershed indicate the direction of flow between the upstream and downstream reservoirs. The seven Westchester County subwatersheds fall into four reservoir categories: headwater, upstream, source water and terminal. Headwater reservoirs are reservoirs that do not have any upstream reservoirs feeding into them. An upstream reservoir derives most of its water from precipitation, and flows into another reservoir. Upstream reservoirs drain into “source water reservoirs” which are the “last stop before the water comes out of the tap.” Source water reservoirs are capable of receiving surface runoff, and are located just prior to initial disinfection. The terminal reservoir is the last (or most downstream) reservoir in a system of reservoirs.
MAP 2. WESTCHESTER COUNTY CROTON WATERSHED
SUBWATERSHEDS AND MINOR BASINS

Sub-Basin Location Key

1. HUNTER BROOK
2. TOWN LAKES
3. L. NEW CROTON RESERVOIR
4. EASTOWN LAKE
5. S. NEW CROTON RESERVOIR
6. FORNALL BROOK
7. GEDNEY BROOK
8. CHAPPAQUA BROOK
9. MECO LAKE
10. HOWLANDER LAKES
11. LAKE SHEDROCK
12. MUSCOOT RIVER
13. AMARLA | RESERVOIR
14. UPWATER CREEK RESERVOIR
15. SPARKLE LAKE
16. CRUM FORD
17. MALLOCHS MILL BROOK
18. FLIN BROOK
19. ANGLE FLY BROOK
20. MUSCOOT RESERVOIR

HOLLY STREAM
21. THE BRANCH CROTON-RIVER
22. CROTON RIVER
23. UPPER MUSCOOT
24. LAKE RATHWELL
25. STONE MILL RIVER
26. BROAD BROOK
27. PEACHTREE LAKE
28. WOODBROOK
29. TITUS RIVER
30. TITUS RESERVOIR
31. CROOK BROOK
32. TROY LAKES
33. LAKE MACABE
34. MUSCOOT RESERVOIR
35. HADLEY LAKE
36. LAKE MACHABE
37. CROSS RIVER RESERVOIR
38. CROSS RIVER
39. LAKE NICHOLAN
40. CROTON FALLS RESERVOIR

Locator Map

Department of Planning
Michaelian Office Building
148 Mamaroneck Avenue
White Plains, New York
10601
The New Croton Reservoir is the only terminal reservoir within the Croton system. The New Croton Reservoir is also a source water reservoir. However, because of the NYCDEP’s ability to divert water directly from the Cross River and Croton Falls reservoirs, these reservoirs can also be considered to be source water reservoirs. Water enters the New Croton Reservoir via a spillway from the Muscoot Reservoir. Water enters the Muscoot Reservoir from the Croton Falls Reservoir, which receives water from three Putnam County (upstate) reservoirs: Diverting, Middle Branch and West Branch. The remaining four reservoirs in Westchester’s Croton Watershed, Cross River, East Branch, Titicus and Amawalk are “headwater reservoirs” and all of the water leaving these reservoirs flows directly into the Muscoot Reservoir. As a result of this hydrologic connection, the condition of the downstream reservoirs is a reflection of the water quality in the upstream reservoirs. Stormwater runoff from local land uses (roads, parking lots, etc.) also affects water quality.

2. EXISTING WATER QUALITY CONDITIONS

The NYSDEC has in large part classified the New Croton Reservoir as AA from the portion extending from the New Croton Dam to a point one mile upstream, or east of the New Croton Gatehouse (this portion includes the reservoir intakes). The remaining portions of the watershed are classified as A. As a drinking water source, it must also comply with federal standards as denoted in the Safe Drinking Water Act (SDWA) and the Surface Water Treatment Rule (SWTR). (See section 1 for more information.) The Croton System currently meets the SDWA standards, as well as SWTR standards, with the exception of watershed control. The water quality of the Croton Reservoir System is currently being monitored by the NYSDEC and the NYCDEP.

2.1 Meeting National Drinking Water Quality Standards

The NYCDEP has named three “causative conditions” for water quality problems in the Croton System: eutrophication, anoxia, and Total Organic Carbon. The New Croton Reservoir, as well as all of the other reservoirs in Westchester County, is over enriched with nutrients such as phosphorus. This results in excessive plant growth in the form of algae blooms. The New Croton Reservoir suffers from an anoxic condition, which threatens fish and other aquatic life and results in releases of iron, manganese and phosphorus from the sediment. Total Organic Carbon (TOC) is a measure of organic carbon. The carbon source can be due to plant or animal matter. Elevated levels of TOC have been detected within the New Croton Reservoir, coming from the upstream Muscoot Reservoir and reservoirs tributary to it, as well as from the surrounding Croton Watershed area.

24 Correspondence Kimberlee Kane to Natara Feller “Re:2 Quick Questions” (October 16, 2001)
26 The US Environmental Protection Agency has generally interpreted "watershed control" as total land-ownership or at a minimum land ownership of watershed areas by a state agency.
28 Ibid.
2.2 Water Quality Degradation

The primary causes of water quality degradation in the Croton Watershed have been identified through the research gathered in this report. Four primary problems: Fecal and Total Coliform, High Phosphorus, Sedimentation and Wastewater Treatment Plant effluent have been cited as the major causes of water quality degradation. Table 2: Indication of Water Quality Degradation lists the 40 minor basins and the major problems associated with each. These problems are discussed in general below and in detail within each subwatershed discussion of Section III.

- **Fecal and Total Coliform:** High fecal and total coliform counts are caused by animal waste, including human. This is a cause for concern because fecal coliform bacteria exist under the same conditions as certain disease-causing organisms such as streptococcus and salmonella. Elevated levels of coliform raise concern about human contact with a waterbody, particularly after a rain event where contact or ingestion of untreated water is possible.  
  Ten minor basins have been identified in the Westchester County portion of the Croton Watershed with high fecal and total coliform counts.

- **Phosphorus:** The adverse impact of excessive phosphorus on the water quality of the New Croton Reservoir serves as a warning for the entire Watershed. Most of the reservoirs in the Croton Watershed are “phosphorus limited”, meaning that they are suffering from poor water quality as a direct result of high phosphorus counts. Each year during the summer and fall, phosphorus in the New Croton Reservoir sets off a biological chain reaction. It promotes algae blooms that result in poor water taste, odor and color. Phosphorus-induced algae blooms also reduce dissolved oxygen in the bottom waters, cause increased levels of the heavy metal pollutants iron and manganese, and increase levels of organic carbon. The New York State Department of Environmental Conservation (NYSDEC) has listed all reservoirs within the Croton watershed as “stressed”, threatened”, or “impaired” by phosphorus on NYSDEC’s 1998 list of impaired waterbodies prepared pursuant to the Clean Water Act 303(d) list and submitted it to the United States Environmental Protection Agency (USEPA). Twelve minor basins have been identified in the Westchester County portion of the Croton Watershed with high phosphorus counts.

<table>
<thead>
<tr>
<th>Minor Basin Name</th>
<th>Fecal &amp; Total Coliform Counts</th>
<th>High Phosphorus Counts</th>
<th>Sedimentation</th>
<th>Wastewater Treatment Plants</th>
<th>Other</th>
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<tr>
<td>Hunter Brook</td>
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<td>Twin Lakes (Cortlandt)</td>
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<td>W. New Croton Reservoir</td>
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<td>Cornell Brook</td>
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<td>Gedney Brook</td>
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<td><strong>Amawalk Subwatershed</strong></td>
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<td>Lake Shenorock</td>
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<td>Muscoot River</td>
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<td>Amawalk Reservoir</td>
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<td>Upper Arm Crom Pond</td>
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<td>Truesdale Lake</td>
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</tbody>
</table>

*Summary of data based on monitoring data collected by the NYSDEC, NYCDEP and volunteers, TMDL reports and information contained within the PWL.
• **Sedimentation:** The main source of sediment in the Croton Watershed is urban runoff. Sedimentation causes a decrease in water clarity and light transmission through the water column, which causes a decrease in aquatic plant production and interferes with fish behaviors, such as mating activity. Sedimentation also inhibits feeding and respiration of macroinvertebrates. In addition, sediment acts as a substrate for organic pollutants, including pesticides.\(^{32}\) Trout Unlimited concluded in their *Study of Storm Water Conveyances as Point Sources of Pollution in the East of Hudson Watershed, New York City Drinking Water Supply* (July, 2000), that sediment concentrations increase dramatically on rain days, compared to dry days. Six minor basins have been identified in the Westchester County portion of the Croton Watershed with sedimentation problems.

• **Wastewater Treatment Plants:** Wastewater Treatment Plants (WWTP) are used to treat sewage from residential and commercial establishments. A WWTP treats sewage by removing most of the pollutants before discharging the water back into a waterbody. The effluent (the discharge from a WWTP) may contain higher levels of pollutants than the waterbody it is flowing into. In six of the seven subwatershed basins (all but the Titicus), WWTPs contribute to the phosphorus levels in the reservoirs.

### 3. ATMOSPHERIC DEPOSITION

Atmospheric deposition may be a source of pollution in a given waterbody. 1996 EPA data indicated that nitrogen deposition from nitrate and ammonium was greater than 7 kilograms/hectare per year over the entire New York City Watershed (both East and West of Hudson).\(^{33}\) This figure is an estimate of total atmospheric nitrogen deposition using the National Atmospheric Deposition Program/National Trends Network. Atmospheric deposition is often one of the major sources of nitrogen. For example, it has been identified as the major source in the Chesapeake Bay.\(^{34}\) However, at this time there is no information that draws relationships between atmospheric deposition of nutrients and surface water quality in the Croton Watershed.

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34 *ibid.*
SECTION III: SUBWATERSHED REPORTS
1. **AMAWALK SUBWATERSHED**

1.1. **Background Information**

**Geographic Description**

The Amawalk subwatershed is located in southern Putnam and northern Westchester Counties. The Westchester County portion contains 19.65 miles$^2$ (42.2 km$^2$) and 10.91 stream miles$^{35}$. The northern two-thirds of the Amawalk subwatershed are located in Putnam County in the towns of Carmel and Putnam Valley. The southern portion of the Amawalk subwatershed is located entirely within the Town of Somers in Westchester County. The population of the Westchester County portion of the Amawalk subwatershed is 4,860 people according to 2000 Census data estimates. The Amawalk subwatershed is made up of six minor basins, three of which are located in Westchester County: the Amawalk Reservoir, the Muscoot River and Lake Shenorock. (See Map 4: Amawalk Subwatershed in Section IV.)

**Land Use Description**

Most of the water in the waterbodies in the Amawalk subwatershed originates from precipitation and overland flow; therefore, land use has a tremendous impact on water quality in the subwatershed area. Chart A below outlines the various land uses. Generally, the land is forested and has open space characteristics, as 42% is categorized as very low density, (very low density translates into two dwelling units per acre). 26% of the land is undeveloped, and 23% of the land is waterbody/water supply. Approximately 4.4% of the land use is categorized as transportation, commercial, industrial or manufacturing.

**Chart A: Amawalk Subwatershed Land Use**

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$^{35}$ Stream miles are reflective of information contained within the Westchester County GIS database and may be an underestimate of stream miles.
**Water Body Classification**

The New York State Department of Environmental Conservation (NYSDEC) classifies waterbodies located in the Amawalk subwatershed as noted in Table 3 below. The primary use of the waterbodies in this subwatershed is for the New York City drinking water supply and therefore is classified as “A”. Refer to Section I for an explanation of waterbody classifications and standards.

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<thead>
<tr>
<th>Waterbody</th>
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<th>Standard</th>
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<tr>
<td>Lake Shenorock</td>
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<td>A</td>
</tr>
<tr>
<td>Muscoot River and tributaries</td>
<td>C/A*</td>
<td>C/A(TS)/A(T)*</td>
</tr>
</tbody>
</table>

*Depending on location in the stream system

**Subwatershed Monitoring and Point Source Discharges**

A list of sites monitored for water quality and point source discharges within the Amawalk Subwatershed is found in Tables 4 and 5 below. Each site is associated with a map reference number found on Map 4: Amawalk Subwatershed. For more information regarding the monitoring programs, refer to Section I.

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<thead>
<tr>
<th>Map Reference #</th>
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<td>Biomonitoring</td>
<td>NYCDEP</td>
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<td>H21</td>
<td>MUSCOOT10</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
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<td>L14</td>
<td>LIMNOM 3CA</td>
<td>Reservoir (Limnology)</td>
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<td>LIMNOM 1CA</td>
<td>Reservoir (Limnology)</td>
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<table>
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<th>Map Reference #</th>
<th>Site Name</th>
<th>Site Name</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>S35</td>
<td>SPDES 208027</td>
<td>Amawalk Filtration Plant</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S37</td>
<td>SPDES 235105</td>
<td>Rex Realty of Connecticut</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W26</td>
<td>SPDES 67741</td>
<td>Baldwin Place Shopping Center</td>
<td>NYSDEC</td>
</tr>
</tbody>
</table>
1.2 Subwatershed Water Quality Condition

Research for this report concludes that the main problems affecting the Amawalk subwatershed are high phosphorus loads and high fecal and total coliform counts. Some research provided by Trout Unlimited also indicates eroded conditions caused by failed stormwater drainage systems in the Town of Somers.36

There are currently eight wastewater treatment plants (WWTPs) in the Amawalk subwatershed. These WWTPs, in conjunction with the existing land uses, contribute to the overall phosphorus load of the subwatershed. The current phosphorus load in the subwatershed is 1,318 kg/yr.37 The NYCDEP, through their calculations for the phosphorus TMDL, determined that the available phosphorus allocation for this subwatershed is 1,196 kg/yr.38

According to the NYSDEC the Amawalk exceeds the available phosphorus allocation by 122 kg/yr. As such, the NYCDEP and the NYSDEC have recommended that nonpoint source phosphorus loads in this subwatershed be reduced by approximately 25%. The NYSDEC anticipates that the 25% reduction will be accomplished through the implementation of Phase II Stormwater Regulations throughout the Amawalk subwatershed.39

These problems are discussed in relation to the three minor basins of the Amawalk subwatershed below.

Reservoir Basin
The Amawalk Reservoir was placed in service in 1897 and is one of 12 reservoirs within the Croton Watershed. The Amawalk Reservoir Basin is located in north central Somers. The basin area encompasses the land immediately surrounding the Amawalk Reservoir. (Refer to Map 4) Several small tributaries enter the Amawalk Reservoir, four from the north, two from the south and two from the east. The Amawalk Reservoir is a headwater reservoir. Most of the water flows into the reservoir through two main tributaries, Lake Shenorock and the Muscoot River or by means of surface runoff (overland flow). Water leaves by way of a stream release at a dam and spillway structure located in the Town of Somers along Route 35. The outflow of the Amawalk Reservoir flows into the Muscoot Reservoir, an area outside of the Amawalk Subwatershed.40 The only direct withdrawal from the reservoir is by Westchester County Water District No. 2; the water is treated and distributed to the town of Yorktown.

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36 Trout Unlimited Croton Watershed Chapter – Trout Unlimited Photographs, May 1999
37 For TMDL methodology and calculation information refer to NYCDEP Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999).
38 Kane, Kimberlee, Proposed Phase II Phosphorus TMDL Calculations for Amawalk Reservoir (March, 1999), p.29.
40 Kane, Kimberlee, Proposed Phase II Phosphorus TMDL Calculations for Amawalk Reservoir (March, 1999), p.11.
Based on available data, there are concerns regarding the water quality of the Amawalk Reservoir. The Amawalk Reservoir is listed on the 1999 Priority Waterbodies List (PWL) due to high phosphorus loads. The PWL is a listing of waterbodies that do not meet their waterbody classification designated “usage” as defined by the NYSDEC. See Section I for more information. The Amawalk Reservoir was also listed on the 1996 Priority Waterbodies List, for similar problems.41

NYCDEP water quality research has concluded that relative to the other reservoirs in the Croton System, the Amawalk reservoir has average water quality.42 The list below outlines specific water quality findings:

- Secchi depth, a measure of water transparency is average for the period tested (1992-96).
- Water turbidity, a measure of light scattering, was measured to be lower than average when compared to other Croton reservoirs for the period tested (1992-96).
- The reservoir has average concentrations of chlorophyll $a$ for the Croton System.
- The reservoir is generally classified as eutrophic.43

**Minor Basin Condition**

Refer to Map 4 for geographic and monitoring site information in relation to the minor basins described below.

- **Muscoot River Basin:** The Muscoot River is the main tributary to the Amawalk Reservoir. Its headwaters are located in the Town of Carmel in Putnam County and terminate as it enters the Amawalk Reservoir in the Town of Somers in Westchester County. The Muscoot River itself is impaired. Monitoring data has indicated high fecal and total coliform counts. Coliform bacteria are tested as indicators of other bacteria; if they are found, it means that the water supply may be contaminated. The *Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU; Addendum E New York City Water Supply* reports that the H21 monitoring station from 1/1/97-6/30/98 had coliform samples exceeding the spike threshold of fecal coliform and total coliform on each of three data recordings.44 The most likely cause for these high coliform counts is urban runoff and wildlife bacteria sources. Data collected from the period of 7/1/97-12/31/97 listed total phosphorus counts in violation of the <50 ug/L benchmark currently used. Levels ranged between 22-68 ug/L for the indicated time period.45

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42 Kane, Kimberlee, *Proposed Phase II Phosphorus TMDL Calculations for Amawalk Reservoir*, (March, 1999), p.14
45 *ibid.*
The section of the Muscoot River from the source at Lake Mahopac to the Amawalk Reservoir is listed on the 1999 PWL as the “Muscoot River, Upper.”\textsuperscript{46} The PWL listing indicates water quality impairments related to pathogens and high nutrient levels. The NYCDP has reported unacceptably high average values of phosphorus and high values of fecal and total coliform. In addition, biomonitoring data for the Muscoot River has characterized the water body as slightly impacted, indicating possible stress on the fish in the river.\textsuperscript{47} This area is indicated on Map 4 as an “Area of Interest”.

The Baldwin Place Shopping Center, located in the northern section of the Muscoot River basin is listed on the 2001 NYSDEC Inactive Hazardous Waste Disposal Sites Report (April 2001). This site is indicated on Map 4 as an “Area of Interest.” Wells tested in this area indicated that the groundwater was contaminated with TrichloroE and TetrachloroE (PCE).\textsuperscript{48} High levels of these contaminants were found at the shopping center. It is believed that the source of this contamination originated with a dry cleaner located in the shopping center. As of April 2001 the remedial action to remedy the groundwater contamination had been completed and the site is currently being monitored.\textsuperscript{49}

* Lake Shenorock Basin: The Lake Shenorock Basin extends from north central Somers northward into the town of Carmel in Putnam County. Water flows south from Lake Shenorock through a small tributary and wetland into the Amawalk Reservoir. One small tributary enters Lake Shenorock from the east.

The Diversion Study and members of the Somers Municipal Action Team (MAT) have identified the area surrounding Lake Shenorock as an “area of interest” (indicated on Map 4).\textsuperscript{50} It is believed that there are septic problems contributing to the deterioration of the lake’s water quality. If these problems exist, they may be contributing to Lake Shenorock’s eutrophic condition. Septic problems are common to older lake communities in Westchester County. Many homes were often developed as summer lake cottages and have since become occupied year round. As such, many septic systems have not been updated to accommodate year round usage and are suspect for adding increased nutrients into waterbodies.

\textsuperscript{47} Ibid.
\textsuperscript{49} Ibid.
\textsuperscript{50} Savin Engineers, P.C. (as prepared for the Westchester County Department of Planning and Department of Public Works) *Croton Watershed Wastewater Diversion Study: Executive Summary*, (December, 1998) p. ES-4
1.3 Data Summary

Research for this report concludes that the main problems affecting the Amawalk subwatershed are high phosphorus loads and high fecal and total coliform counts. This conclusion is drawn based on data cited from the following sources:

- Kane, Kimberlee, Proposed Phase II Phosphorus TMDL Calculations for Amawalk Reservoir (March, 1999)
- Lawrence, Tracy, NYCDEP 1999 Priority Waterbody Nominations, (July, 1999)
- New York City Department of Environmental Protection, Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999).
- New York City Department of Environmental Protection. Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply, (April 1998; May, 1999)
- New York State Department of Environmental Conservation. Registry of Inactive Hazardous Waste Disposal Sites in New York State (April, 2001)
- New York State Department of Environmental Conservation, Phase II Phosphorus Total Maximum Daily Loads for Reservoirs in the New York City Supply Watershed. (June 2000)
- New York State Department of Environmental Conservation. The 1999 Lower Hudson River Basin Waterbody Inventory and Priority Waterbodies List, (June, 2000)
- Savin Engineers, P.C. (as prepared for the Westchester County Department of Planning and Department of Public Works) Croton Watershed Wastewater Diversion Study: Executive Summary, (December, 1998)
- Trout Unlimited Croton Watershed Chapter – Trout Unlimited Photographs, May 1999
2. CROSS RIVER SUBWATERSHED

2.1 Background Information

Geographic Description
The Cross River subwatershed covers northeastern Westchester County and a small portion of western Connecticut. The Westchester County portion contains 30 miles$^2$ (77.2 km$^2$) and contains 64.29 stream miles. The subwatershed extends through three municipalities in Westchester: Lewisboro, Pound Ridge, and Bedford and the Town of Ridgefield in Connecticut. The population of the Westchester County portion of the Cross River Subwatershed is 8,074 people according to 2000 Census data estimates. The Cross River Subwatershed is made up of seven minor basins, four of which are lakes (Twin Lakes, Lake Waccabuc, Truesdale Lake and Lake Kitchawan), the reservoir itself and two rivers (Cross River and Waccabuc River). Refer to Map 5: Cross River Subwatershed in Section IV and Table 6: Cross River Subwatershed by Town found below for the delineation of minor basins according to town:

Table 6: Cross River Subwatershed by Town

<table>
<thead>
<tr>
<th>Town</th>
<th>Minor Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedford</td>
<td>Cross River Reservoir</td>
</tr>
<tr>
<td>Pound Ridge</td>
<td>Cross River Reservoir</td>
</tr>
<tr>
<td></td>
<td>Lake Kitchawan</td>
</tr>
<tr>
<td></td>
<td>Cross River</td>
</tr>
<tr>
<td>Lewisboro</td>
<td>Twin Lakes</td>
</tr>
<tr>
<td></td>
<td>Lake Waccabuc</td>
</tr>
<tr>
<td></td>
<td>Truesdale Lake</td>
</tr>
<tr>
<td></td>
<td>Waccabuc River</td>
</tr>
<tr>
<td></td>
<td>Cross River Reservoir</td>
</tr>
<tr>
<td></td>
<td>Lake Kitchawan</td>
</tr>
<tr>
<td></td>
<td>Cross River</td>
</tr>
</tbody>
</table>


Land Use Description
Most of the water in the waterbodies in the Cross River subwatershed originates from precipitation and overland flow; therefore, land use has a tremendous impact on water quality in the subwatershed area. The subwatershed is primarily forested (low density residential land uses) and encompasses the Ward Pound Ridge Reservation. Chart B below outlines the various land uses based on Westchester County’s portion of the Cross River subwatershed. Generally, the land has open space characteristics, as 19% of the land is undeveloped, 24% is Park/Private Recreation/Nature Preserve/Cemetery and 43% is categorized as very low density. Less than 4% of the land area is categorized as transportation, commercial, industrial or manufacturing.

Chart B: Cross River Subwatershed Land Use

Water Body Classification
The New York State Department of Environmental Conservation (NYSDEC) classifies waterbodies located in the Cross River subwatershed as provided in Table 7 below. The primary use of waterbodies in this subwatershed is for the New York City drinking water supply and therefore are classified as “A”. Refer to Section I for an explanation of waterbody classifications and standards.
Table 7: Cross River Subwatershed Waterbody Classification

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Classification</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross River</td>
<td>A</td>
<td>A(T)</td>
</tr>
<tr>
<td>Cross River Reservoir</td>
<td>AA/A</td>
<td>AA(T)/A(T)</td>
</tr>
<tr>
<td>Lake Kitchawan</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Lake Waccabuc</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Truesdale Lake</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Twin Lakes (known locally as Lake Oscaleta and Lake Rippawam)</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Waccabuc River</td>
<td>A</td>
<td>A(T)</td>
</tr>
</tbody>
</table>

Subwatershed Monitoring and Point Source Discharges

A list of water quality monitoring sites and point source discharges within the Cross River Subwatershed is found in Tables 8 and 9 below. Each site is associated with a map reference number found on Map 5: Cross River Subwatershed. For more information regarding the monitoring programs, refer to Section 1.

Table 8: Cross River Subwatershed Monitoring Sites

<table>
<thead>
<tr>
<th>Map Reference #</th>
<th>Site Name</th>
<th>Monitoring Program</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>B15</td>
<td>Biomon 123</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>L16</td>
<td>LIMNOM 1CCR</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>L17</td>
<td>LIMNOM 2CCR</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>L18</td>
<td>LIMNOM 3CCR</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>H22</td>
<td>Cross2</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
</tr>
</tbody>
</table>

Table 9: Cross River Subwatershed Point Source Discharges

<table>
<thead>
<tr>
<th>Map Reference #</th>
<th>Site Number</th>
<th>Site Name</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>W34</td>
<td>WWTP SPDES 99520</td>
<td>Meadows at Cross River Condominium</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W35</td>
<td>WWTP SPDES 36684</td>
<td>Lewisboro Elementary School</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W33</td>
<td>WWTP SPDES 214841</td>
<td>Michelle Estates</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W36</td>
<td>WWTP SPDES 105708</td>
<td>Waccabuc County Club</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S43</td>
<td>SPDES 219762</td>
<td>Mobil Oil Service Station</td>
<td>NYSDEC</td>
</tr>
</tbody>
</table>
2.2. Subwatershed Water Quality Condition

Data collected for this report indicates the primary problems associated with the Cross River subwatershed are high phosphorus and unacceptable levels of fecal and total coliform. These problems are indicated on Map 5 and are discussed in relation to the seven minor basins of the Cross River subwatershed.

There are four wastewater treatment plants (WWTPs) in the Cross River subwatershed. These WWTPs, in conjunction with the existing land uses, contribute to the overall phosphorus load of the subwatershed. The current phosphorus load in the subwatershed is 717 kg/yr.\(^{51}\) The NYCDEP, through their calculations for the phosphorus TMDL, determined that the available phosphorus allocation for this subwatershed is 1,007 kg/yr.\(^{52}\)

According to the NYSDEC the current phosphorus load of the Cross River subwatershed is well below the available load. However, there will be benefits to implementing Phase II Stormwater Regulations, which will assist with downstream phosphorus reduction needs.\(^{53}\)

Reservoir Condition

The Cross River Reservoir was placed in service in 1908 and is one of 12 reservoirs within the Croton Watershed. The Cross River Reservoir is located mostly in Bedford with a small section extending eastward into Pound Ridge and Lewisboro. Most of the water flows into the reservoir by means of one major tributary (the Cross River) or by means of surface runoff (overland flow). The Cross River Reservoir is a headwater reservoir (i.e. it does not have any reservoirs located upstream or that drain into it. Water leaves the reservoir by way of a stream release at the dam, through a spillway and a pump station connected to the Delaware Aqueduct. The pump station is only used to augment New York City’s water supply during drought conditions.\(^{54}\) The outflow of the Cross River Reservoir flows into the Muscoot Reservoir, an area outside of the Cross River subwatershed.

Based on available data, the water quality condition of the Cross River Reservoir is determined to be relatively good. The Cross River Reservoir, while having high phosphorus levels, is the only reservoir in Westchester County whose use is not limited based on current phosphorus levels. The Cross River Reservoir is listed on the 1999 Priority Waterbodies List (PWL) due to high nutrient loads (nitrates and phosphates) and sedimentation. The sources of these pollutants are urban runoff, road-bank erosion,

\(^{51}\) For TMDL methodology and calculation information refer to NYCDEP Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999).
\(^{52}\) Kane, Kimberlee, Proposed Phase II Phosphorus TMDL Calculations for Cross River Reservoir, (March, 1999), p.29.
\(^{54}\) Kane, Kimberlee, Proposed Phase II Phosphorus TMDL Calculations for Cross River Reservoir, (March, 1999), p.11.
construction activity, storm sewers and on site septic systems. The Cross River Reservoir is indicated as an “Area of Interest” on Map 5.

Relative to other subwatersheds in the Croton system, the Cross River reservoir has variable water quality. The list below outlines specific water quality findings:

- Secchi depth, a measure of water transparency is varied for the time period tested (1992-96).
- Water turbidity, a measure of light scattering varies over this time period. There was an apparent increase in turbidity during 1995-6.
- The reservoir has average concentrations of chlorophyll $a$ for the Croton System.
- The reservoir is generally classified as mesotrophic.

**Minor Basin Condition**

The condition of the Cross River Reservoir is a reflection of the waterbodies contributing to it. Refer to Map 5 for geographic and monitoring site information on the minor basins discussed below. A summary of their water quality condition is listed below:

- **Cross River Basin**: The Cross River Basin is located in southern Lewisboro and northern Pound Ridge. Its headwaters are located in northeastern Pound Ridge. Cross River empties into the Cross River Reservoir in Lewisboro. Five smaller tributaries join the Cross River, two from the north and three from the south.

  The Cross River is the main tributary to the Cross River Reservoir. Monitoring data has indicated high fecal and total coliform counts. Unacceptable levels of fecal and total coliform bacteria were found by the NYSDEC monitoring station H22 (See Map 5 for site location). The *Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU: Addendum E New York City Water Supply* reports that the Cross monitoring station from 1/1/97-6/30/98 featured coliform samples exceeding the spike threshold of fecal coliform and total coliform on each of five data recordings. However, averages for both total and fecal coliform over the same time period were within the standard range. The peaks noted above may indicate storm events. The most likely cause for the high coliform counts is urban runoff and wildlife bacteria sources.

- **Lake Kitchawan Basin**: The Lake Kitchawan basin is located in southern Lewisboro. Four tributaries located entirely within the delineated basin boundary flow toward Lake Kitchawan, one from the north, one from the south, one from the east and one from the west. The outflow of the lake flows westward toward the Cross River.

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57 *ibid*, p 14-15.
Lake Kitchawan is also listed on the 1999 PWL for high nutrient loads. The cause for its listing was cited as onsite septic systems. The use of Lake Kitchawan is limited by algal blooms and excessive aquatic vegetation in the lake. Failing and/or inadequate on-site septic systems serving homes along the lakeshore and other runoff from urban/suburban development in the watershed are considered to be likely sources of Lake Kitchawan’s impairment as contributors to high phosphorus levels.\textsuperscript{59} It was also listed on the NYS 303D list in 1998.\textsuperscript{60} The 303D list is a program under the Clean Water Act that identifies waterbodies that are targeted for TMDL development for phosphorus. Lake Kitchawan was also listed on the 1996 PWL for similar reasons.\textsuperscript{61} Lake Kitchawan is indicated on Map 5 as an “Area of Interest.”

- **Lake Waccabuc:** Lake Waccabuc is located in northeast Lewisboro. There are seven tributaries entering Lake Waccabuc, three from the north, one from the east and three from the south. The outflow of Lake Waccabuc flows south toward the Waccabuc River.

Recently, the town installed storm drains around Lakes Waccabuc, Oscaleta, and Rippawam. (Lakes Oscaleta and Rippawam are known as the “Twin Lakes”; see below for more information) A high school student researched the impact that the newly installed storm drains could have on coliform counts. Research indicated a severe increase in coliform counts after significant precipitation at sites closest to newly installed storm drains.\textsuperscript{62}

- **Twin Lakes Basins:** The Twin Lakes are located in northeast Lewisboro. The Twin Lakes are known locally as Lake Oscaleta and Lake Rippawam. Their basin extends eastward into Ridgefield, Connecticut. There are six tributaries that empty into the Twin Lakes, one from the north, one from the east, one from the south and two from the west. There is one tributary that joins the Twin Lakes and connects them with Lake Waccabuc.

As mentioned above, research conducted by a high school student has found that the Twin Lakes has high coliform counts, possibly caused by recently installed storm drains.

- **Truesdale Lake Basin:** The Truesdale Lake Basin straddles between eastern Lewisboro and western Ridgefield, Connecticut. Water from Truesdale Lake flows into the Waccabuc River. A major tributary flows westward into Lake Truesdale.

\textsuperscript{60} NYSDEC. *New York State 1998 303(d) List of Nominations by NYSDEC for the Clean Water Act for TMDL Development*.
\textsuperscript{62} Treyz, Henrietta. *Determining the Cause for Increased Coliform Counts at the Three Lakes: Waccabuc, Oscaleta and Rippowam*, (April, 2000).
Truesdale Lake is listed on the 1999 PWL primarily due to high nutrient loads and sedimentation and secondarily, due to pesticide runoff. Truesdale Lake is a shallow man-made lake, which has experienced many problems associated with cultural eutrophication. Nutrient enriched water and sediment loading has necessitated chemical treatment in the past to allow the lake to continue its use as a bathing resource. Currently, the recreational use and aesthetics in Truesdale Lake are thought to be limited by algal blooms, excessive aquatic vegetation and eutrophication.\textsuperscript{63} The contribution of pollution from failing septic systems and urban runoff from residential/commercial development in the watershed is considered likely sources of pollution.\textsuperscript{64} Lake Truesdale is indicated on Map 5 as an “Area of Interest.”

- **Waccabuc River Basin:** The Waccabuc River Basin is located almost entirely within the Town of Lewisboro, a small section covers the northeast corner of the town of Pound Ridge. The source of the Waccabuc River is Lake Waccabuc, and the mouth is the Cross River. Seven small tributaries join the Waccabuc River, three from the north, one from the east and three from the south.

At this time, research did not lead to any water quality analysis for the Waccabuc River Basin.

### 2.3 Data Summary

The primary problems associated with the Cross River subwatershed are high phosphorus and unacceptable levels of fecal and total coliform. This conclusion is drawn based on data cited from the following sources:

- Kane, Kimberlee, *Proposed Phase II Phosphorus TMDL Calculations for Cross River Reservoir* (March, 1999)
- New York City Department of Environmental Protection. *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply*, (April 1998; May, 1999)
- New York City Department of Environmental Protection. *Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs* (March, 1999).


\textsuperscript{64} ibid.
3. CROTON FALLS SUBWATERSHED

3.1. Background Information

Geographic Description
Most of the Croton Falls subwatershed is located in Putnam County. A small portion of the Croton Falls subwatershed extends into the Town of Somers in Westchester County. The portion is .34 miles$^2$ (.89 km$^2$) and contains 1.02 stream miles. The total population of the Westchester County portion of the Croton Falls subwatershed is 990 people according to estimates based on 2000 Census data. (Refer to Map 6: Croton Falls Subwatershed in Section IV).

Land Use Description
Land use of Westchester’s portion of the Croton Falls subwatershed is broken down in Chart C below. Generally, the land is forested and has open space characteristics as approximately 39% of the land is classified as “private recreation”. Private recreation includes lands used for privately owned campgrounds, racetracks and playgrounds. 17% of the land is undeveloped and 19% is categorized as medium density residential (medium density translates to 2-6 dwelling units per acre).

Chart C: Croton Falls Subwatershed Land Use

- Private Recreation (39.3%)
- Low/Very Low Density (13.8%)
- Residential Medium Density (19.3%)
- Water Supply (6.6%)
- Transportation Utility (4.3%)
- Undeveloped (16.7%)
- No Data Available (<.1%)
**Water Body Classification**

The New York State Department of Environmental Conservation (NYSDEC) classification of waterbodies located in the Croton Falls subwatershed is provided in Table 10 below.

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Classification</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croton Falls Reservoir</td>
<td>AA</td>
<td>AA(T)</td>
</tr>
</tbody>
</table>

**Subwatershed Monitoring and Point Source Discharges**

*There is neither monitoring nor point source discharges found within Westchester County’s portion of the Croton Falls subwatershed.*

### 3.2 Subwatershed Water Quality Condition

Research for this report concludes that the primary problem associated with Westchester’s portion of the Croton Falls subwatershed is high phosphorus levels. The principal phosphorus sources in the Croton Falls subwatershed are wastewater treatment plants and upstream reservoirs. However, there are no wastewater treatment plants within Westchester County’s portion of the subwatershed.

The current phosphorus load in the subwatershed is 5,010 kg/yr.\(^65\) The NYCDEP, through their calculations for the phosphorus TMDL, determined that the available phosphorus allocation for this subwatershed is 3,565 kg/yr.\(^66\)

According to the NYSDEC the Croton Falls subwatershed exceeds the available phosphorus allocation by 885 kg/yr. As such, the NYCDEP and the NYSDEC have recommended that nonpoint source phosphorus loads in this subwatershed be reduced. The NYSDEC anticipates that nonpoint source reduction will be accomplished through the implementation of Phase II Stormwater Regulations and other nonpoint source water quality management strategies throughout the subwatershed. Point source reduction of phosphorus will occur through implementation of advanced technologies by the NYCDEP at each of the upstream WWTPs.\(^67\)

**Reservoir Condition**

The Croton Falls Reservoir, placed in service in 1910, is one of the 12 reservoirs within the Croton Watershed. The Croton Falls Reservoir receives most of its waters from upstream reservoirs, with minor contributions from its own watershed.\(^68\) Water enters the

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\(^65\) For TMDL methodology and calculation information refer to NYCDEP *Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs* (March, 1999).

\(^66\) Kane, Kimberlee. *Proposed Phase II Phosphorus TMDL Calculations for Croton Falls Reservoir*, (March, 1999), p. 29.


\(^68\) Kane, Kimberlee. *Proposed Phase II Phosphorus TMDL Calculations for Croton Falls Reservoir*, (March, 1999), p. 11.
reservoir primarily from the West Branch and Middle Branch Reservoirs (in Putnam County, NY), with a small contribution from the Diverting Reservoir (also in Putnam County) by way of a connecting channel. The outflow of the Croton Falls Reservoir flows downstream to the Muscoot Reservoir.\textsuperscript{69} (Refer to Map 3.)

The Croton Falls Reservoir does not meet the phosphorus water quality standard required of the New York City drinking water supply system. The Croton Falls Reservoir was nominated to the New York State Department of Environmental Conservation’s (NYSDEC) 1999 Priority Waterbodies List by the New York City Department of Environmental Protection (NYCDEP) due to high phosphorus loads, which exceed the value established by the NYSDEC. The Croton Falls Reservoir was consequently listed for reasons cited above.\textsuperscript{70} The Croton Falls Reservoir was also listed on the 1996 Priority Waterbodies List, for similar problems.\textsuperscript{71} This finding is consistent with other research and documentation including the Total Maximum Daily Load (TMDL) calculations by the NYCDEP and NYSDEC.

Relative to other reservoirs in the Croton system, the Croton Falls reservoir has below average water quality. This is due to the water quality of the reservoirs contributing to it and the water quality condition of the subwatershed itself.

\begin{itemize}
\item Secchi depth, a measure of water transparency is average for the time period tested (1992-96).
\item The reservoir has higher than average concentrations of chlorophyll $a$ for the Croton System generally
\item Water turbidity, a measure of light scattering, was measured to be higher than average when compared to other Croton reservoirs.
\item The reservoir is classified as eutrophic.\textsuperscript{72}
\end{itemize}

**Minor Basin Condition**

\textit{Except for the Croton Falls Reservoir basin (discussed above), there are no minor basins in Westchester County’s portion of the Croton Falls subwatershed.}

### 3.3 Data Summary

Research for this report concludes that the primary problem associated with Westchester’s portion of the Croton Falls subwatershed is high phosphorus levels. This conclusion is drawn based on data cited from the following sources:

\begin{itemize}
\item Kane, Kimberlee, \textit{Proposed Phase II Phosphorus TMDL Calculations for Croton Falls Reservoir} (March, 1999)
\end{itemize}

\textsuperscript{69} \textit{Ibid.}
\textsuperscript{70} New York State Department of Environmental Conservation. \textit{The 1999 Lower Hudson River Basin Waterbody Inventory and Priority Waterbodies List}, (June, 2000) p. 75.
• New York City Department of Environmental Protection. *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply*, (April 1998; May, 1999)


• NYCDEP Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999).
4. EAST BRANCH SUBWATERSHED

4.1. Background Information

Geographic Description
The East Branch subwatershed originates in Dutchess County, runs through Putnam County, and terminates in Westchester County in the Town of North Salem. A small portion extends into Connecticut. The Westchester County portion contains 1.01 miles\(^2\) (2.61 km\(^2\)) and 1.48 stream miles. The East Branch subwatershed consists of ten minor basins. Peach Lake is the only minor basin partly within the boundaries of Westchester County. Information contained within this section is limited to Westchester County’s portion of the Peach Lake basin (Refer to Map 7: East Branch Subwatershed in Section IV). The population of the Westchester County portion of the East Branch subwatershed is 714 people according to 2000 Census data estimates.

Land Use Description
The land use of Westchester’s portion of the East Branch subwatershed is broken down in Chart D below. Generally the land is forested and has open space characteristics, as 41% of the land is undeveloped and 17% is waterbody. “Undeveloped Land” is undeveloped, currently vacant lots owed either publicly or privately. 32% of the land is categorized as very low density residential (very low density translates to 2 dwelling units or less per acre).

Chart D: East Branch Subwatershed Land Use

![Chart D: East Branch Subwatershed Land Use](image-url)
Waterbody Classification
The New York State Department of Environmental Conservation (NYSDEC) classifies waterbodies located in Westchester County’s portion of the East Branch subwatershed as B. The best use of class B waters, such as Peach Lake, is primary and secondary contact recreation and fishing (i.e. - swimming, boating). Class B waterbodies should also be suitable for fish propagation and survival.73

Subwatershed Monitoring and Point Source Discharges
A list of sites monitored for water quality within the East Branch subwatershed is found in Table 11 below. Each site is associated with a map reference number found on Map 7. For more information regarding the monitoring programs, refer to Section I.

Table 11: East Branch Subwatershed Monitoring Sites

<table>
<thead>
<tr>
<th>Map Reference #</th>
<th>Site Name</th>
<th>Monitoring Program</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>P6</td>
<td>TRITT</td>
<td>Sitepath</td>
<td>NYCDEP</td>
</tr>
</tbody>
</table>

4.2 Subwatershed Water Quality Condition

Research for this report concludes that the primary problem associated with Westchester’s portion of the East Branch subwatershed is high phosphorus counts. For an overview see Map 7. This problem is discussed in detail below.

There are eleven wastewater treatment plants (WWTP) in the East Branch subwatershed. These WWTPs, in conjunction with the existing land uses, contribute to the overall phosphorus load of the subwatershed. The current phosphorus load in the subwatershed is 3,462 kg/yr.74 The NYCDEP, through their calculations for the phosphorus TMDL, determined that the available phosphorus allocation for this subwatershed is 2,822 kg/yr.75

73 ibid
74 For TMDL methodology and calculation information refer to NYCDEP Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999).
75 Kane, Kimberlee. Proposed Phase II Phosphorus TMDL Calculation for East Branch Reservoir, (March 1999), p.29.
According to the NYSDEC the East Branch subwatershed exceeds the available nonpoint source phosphorus allocation by 993 kg/yr. As such, the NYCDEP and the NYSDEC have recommended that significant reductions in urban and upstream basin (Peach Lake and Putnam Lake minor basins) phosphorus loads would have to occur. The NYSDEC anticipates that this reduction can be accomplished through the implementation of Phase II Stormwater Regulations and other nonpoint source water quality controls throughout the subwatershed.76

**Reservoir Condition**
The East Branch Reservoir, placed in service in 1892, is one of 12 reservoirs within the Croton Watershed however, the reservoir it outside of Westchester County. Water enters the reservoir primarily from the East Branch of the Croton River. Water leaves the reservoir in one of three ways: a stream release at the dam, a spillway structure when the reservoir is full and a tunnel to Bog Brook Reservoir. The outflow of the East Branch Reservoir flows downstream to the Diverting Reservoir (this reservoir is located outside of Westchester County).77 (Refer to Map 3.) Most of the water flows into the reservoir by means of surface runoff (overland flow). As such, land use practices in the East Branch subwatershed have a tremendous impact on the water quality of the streams, lakes, rivers and the reservoir itself.

The East Branch is listed on the 1999 Priority Waterbodies List (PWL) due to high phosphorus loads and the resulting eutrophication in the reservoir.78 The PWL is a listing of waterbodies that do not meet their waterbody classification designated “use” as defined by the NYSDEC. The East Branch Reservoir was also listed on the 1996 Priority Waterbodies List, for similar problems.79

Relative to other reservoirs in the Croton System, the East Branch Reservoir has below average water quality.
- The reservoir has average concentrations of chlorophyll $a$ for the Croton System.
- Secchi depth, a measure of water transparency, is shallower than average for the time period tested (1992-96).
- The turbidity values are higher than average compared to other Croton Reservoirs.
- The reservoir generally classified as eutrophic.80

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77 Kane, Kimberlee. *Proposed Phase II Phosphorus TMDL Calculation for East Branch Reservoir,* (March 1999), p.11.
Minor Basin Condition

Peach Lake is the only minor basin located in Westchester County.

- **Peach Lake Basin:** The Peach Lake basin virtually straddles itself evenly between the Town of North Salem in Westchester County and the Town of Southeast in Putnam County. Several small tributaries within the Peach Lake basin empty into Peach Lake, one from the north, one from the east and one from the west. The outflow of Peach Lake flows north via a tributary to the East Branch Reservoir in Putnam County (refer to Map 7).

Peach Lake is impaired due to excess nutrients (particularly high phosphorus levels) and coliform counts. It was listed on the NYS 303D list in 1998.\(^8^1\) Peach Lake was listed on the 1999 NYSDEC Priority Waterbodies List for excess nutrients and high coliform counts.\(^8^2\) High coliform counts force beach closings each summer, impairing the use of the lake for bathing. Algal blooms and an increase in aquatic vegetation in the lake are a result of excess nutrient loading (phosphorus). Heavy weed growth impairs boating, fish survival and fishing activity. The cause of water quality problems in Peach Lake were cited as onsite septic systems, and urban runoff (including waterfowl and residential/commercial construction).\(^8^3\) Peach Lake was listed on the 1996 PWL for similar circumstances.\(^8^4\) Peach Lake is indicated on Map 7 as an “Area of Interest.”

Most of the families that reside in the Peach Lake basin live there year round, but most of the homes were developed as summer lake cottages. As such, many septic systems have not been updated to accommodate year round usage.

The Peach Lake Environmental Committee (PLEC) is a Peach Lake community based organization focused on restoring the environmental integrity of the Lake. PLEC participates in the Citizens Statewide Lake Assessment Program (CSLAP). CSLAP is a volunteer lake monitoring program coordinated by the NYSDEC and the NYS Federation of Lake Associations.\(^8^5\) 1999 data suggests, “Peach Lake exhibits water quality characteristics slightly less productive but also slightly less “favorable” than other nearby and comparably sized lakes- this discrepancy may be due to the extent of weed growth in the lake.” The report also revealed that pH readings at Peach Lake exceeded the higher water quality standard (= 8.5) on four occasions in 1999 (50% of all samples). To date, there has been no evaluation of pH impacts on aquatic life and since pH often changes somewhat in transit from field to lab, it cannot yet be presumed that this is an issue of concern. However, pH levels should be watched closely and evaluated over the next few years. Total phosphorus concentrations exceeded the state guidance value during all but one sampling.

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\(^8^1\) NYSDEC. *New York State 1998 303(d) List of Nominations by NYSDEC for the Clean Water Act for TMDL Development.*


\(^8^3\) *ibid*


\(^8^5\) Kishbaugh & Hohenstein. *New York State Wide Lake Assessment Program Interpretive Summary* (NYSDEC, April 2000) p. 2.
PLEC has submitted a proposal to the NYSDEC to stock the lake with triploid grass carp to control aquatic vegetation.

### 4.3 Data Summary

Research for this report concludes that the primary problem associated with Westchester’s portion of the East Branch subwatershed is high phosphorus counts. This conclusion is drawn based on data cited from the following sources:

- Kane, Kimberlee, *Proposed Phase II Phosphorus TMDL Calculations for Croton Falls Reservoir* (March, 1999)
- Kishbaugh & Hohenstein. *New York State Wide Lake Assessment Program Interpretive Summary* (NYSDEC, April 2000)
- New York City Department of Environmental Protection. *Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs* (March, 1999).
- New York State Department of Environmental Conservation. *New York State 1998 303(d) List of Nominations by NYSDEC for the Clean Water Act for TMDL Development*

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5. **MUSCOOT SUBWATERSHED**

5.1. **Background Information**

**Geographic Description**
The Muscoot subwatershed spans over north central Westchester County, and a small portion of Putnam County. The Westchester portion contains 73.77 miles² (193.7 km²) and 166.12 stream miles. The Muscoot subwatershed spans over the Towns of Yorktown, Bedford, Somers, Pound Ridge, Lewisboro and North Salem in Westchester County and the Towns of Carmel and Southeast in Putnam County. The population of the Westchester County potion of the Muscoot subwatershed is 49,131 people according to 2000 Census data estimates. The Muscoot subwatershed is made up of 14 minor basins (listed below in Table 12). For more information, refer to Maps 8, 9 and 10 in Section IV.

<table>
<thead>
<tr>
<th>Town</th>
<th>Minor Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lewisboro</td>
<td>Muscoot Reservoir</td>
</tr>
<tr>
<td></td>
<td>Croton River</td>
</tr>
<tr>
<td></td>
<td>Upper Muscoot</td>
</tr>
<tr>
<td></td>
<td>Lake Katonah</td>
</tr>
<tr>
<td>Yorktown</td>
<td>Upper Arm Crompond</td>
</tr>
<tr>
<td></td>
<td>Sparkle Lake</td>
</tr>
<tr>
<td></td>
<td>Crom Pond</td>
</tr>
<tr>
<td></td>
<td>Hallocks Mill Brook</td>
</tr>
<tr>
<td>Somers</td>
<td>Upper Arm Crom Pond</td>
</tr>
<tr>
<td></td>
<td>Hallocks Mill Brook</td>
</tr>
<tr>
<td></td>
<td>Plum Brook</td>
</tr>
<tr>
<td></td>
<td>Angle Fly Brook</td>
</tr>
<tr>
<td></td>
<td>Muscoot Reservoir</td>
</tr>
<tr>
<td></td>
<td>East Branch Croton River</td>
</tr>
<tr>
<td></td>
<td>Croton River</td>
</tr>
<tr>
<td>North Salem</td>
<td>Holly Stream</td>
</tr>
<tr>
<td></td>
<td>East Branch</td>
</tr>
<tr>
<td></td>
<td>Croton River</td>
</tr>
<tr>
<td></td>
<td>Upper Muscoot</td>
</tr>
<tr>
<td>Pound Ridge</td>
<td>Stone Hill River</td>
</tr>
<tr>
<td>Bedford</td>
<td>Muscoot Reservoir</td>
</tr>
<tr>
<td></td>
<td>Stone Hill River</td>
</tr>
<tr>
<td></td>
<td>Broad Brook</td>
</tr>
</tbody>
</table>
**Land Use Description**

Most of the water in the waterbodies in the Muscoot subwatershed originate from precipitation and overland flow; therefore, land use has a tremendous impact on water quality in the subwatershed area. The land use of Westchester’s portion of the Muscoot subwatershed is broken down in Chart E below. Generally, the land is forested and has open space characteristics, as 43% is characterized as low density residential (translates to <2 dwelling units per acre) and 25% is undeveloped. Approximately 11% of the land area in this subwatershed in Westchester County is categorized as transportation, commercial, office, institutional or manufacturing.

**Chart E: Muscoot Land Use**

![Chart E: Muscoot Land Use](chart)

**Water Body Classification**

The New York State Department of Environmental Conservation (NYSDEC) classifies waterbodies located in the Muscoot subwatershed as provided in the table below. The primary use of the waterbodies in this subwatershed are for the New York City drinking water supply and therefore are classified as A.
Table 13: Muscoot Subwatershed Waterbody Classification

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Classification</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone Hill River</td>
<td>A/B/C</td>
<td>A(ts)/B/C</td>
</tr>
<tr>
<td>Broad Brook</td>
<td>Could not find</td>
<td>C</td>
</tr>
<tr>
<td>Plum Brook</td>
<td>B/C/*</td>
<td>B(T)/C(T)/C*</td>
</tr>
<tr>
<td>Angle Fly Brook</td>
<td>C</td>
<td>C(ts)</td>
</tr>
<tr>
<td>Muscoot Reservoir</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Hallocks Mill Brook</td>
<td>A/C*</td>
<td>A(T)/C(T)/C*</td>
</tr>
<tr>
<td>Crom Pond</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Sparkle Lake</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Upper Arm Crom Pond</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Croton River</td>
<td>C/B/A*</td>
<td>C/B/A(T)*</td>
</tr>
<tr>
<td>East Branch Croton River</td>
<td>A/C</td>
<td>A(T)/C(T)</td>
</tr>
<tr>
<td>Lake Katonah</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Upper Muscoot</td>
<td>A</td>
<td>A(TS)/A(T)</td>
</tr>
<tr>
<td>Holly Stream</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

*Depending on where located

Subwatershed Monitoring and Point Source Discharges

A list of sites monitored for water quality and point source discharges within the Muscoot Subwatershed is found in Tables 14 and 15 below. Each site is associated with a map reference number found on Maps 8, 9 and 10. For more information regarding the monitoring programs, refer to Section I.

Table 14: Muscoot Subwatershed Monitoring Sites

<table>
<thead>
<tr>
<th>Map Reference #</th>
<th>Site Name</th>
<th>Monitoring Program</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>B5</td>
<td>Biomon 102</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B6</td>
<td>Biomon 104</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B7</td>
<td>Biomon 105</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B8</td>
<td>Biomon 106</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B9</td>
<td>Biomon 127</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B10</td>
<td>Biomon 125</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B11</td>
<td>Biomon 126</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B12</td>
<td>Biomon 129</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B13</td>
<td>Biomon 120</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>L9</td>
<td>LIMNOM 6CM</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>L10</td>
<td>LIMNOM 2CM</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>L11</td>
<td>LIMNOM 4CM</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>L12</td>
<td>LIMNOM 1CM</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>H10</td>
<td>Plum2</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>H11</td>
<td>Stone5</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>H13</td>
<td>Titiicusr</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>H14</td>
<td>Amawalkr</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>H15</td>
<td>Hmill4</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
</tr>
</tbody>
</table>
### Table 15: Muscoot Subwatershed Point Source Discharges

<table>
<thead>
<tr>
<th>Map Reference #</th>
<th>Site Number</th>
<th>Site Name</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>S9</td>
<td>SPDES 147249</td>
<td>Klas Adas Kashau</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S15</td>
<td>SPDES 105651</td>
<td>Bedford Central School District</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S16</td>
<td>SPDES 105724</td>
<td>St. Mary of the Assumption</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S19</td>
<td>SPDES 110230</td>
<td>NYSDOT Residency (subsurface discharging facility)</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S22</td>
<td>SPDES 234097</td>
<td>Lincolndale Garage Remediation Project</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S23</td>
<td>SPDES 234605</td>
<td>Gulf Service Station Remediation Project</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S25</td>
<td>SPDES 250830</td>
<td>Amawalk Filtration Plant</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S26</td>
<td>SPDES 259403</td>
<td>Rt. 22 Office Building</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S27</td>
<td>SPDES 259861</td>
<td>Katonah Lewisboro School District</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S30</td>
<td>SPDES 34591</td>
<td>Somers Intermediate School</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W6</td>
<td>WWTP SPDES 36994</td>
<td>Lincoln Hall Sewage Treatment Plant</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W8</td>
<td>WWTP SPDES 33596</td>
<td>Bedford Park Apartments at Westchester</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W9</td>
<td>WWTP SPDES 101885</td>
<td>NYS Department of Correctional Facilities</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W10</td>
<td>WWTP SPDES 26891</td>
<td>Heritage Hills Pollution Control Plant</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W11</td>
<td>WWTP SPDES 36692</td>
<td>Increase Miller Elementary School</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W12</td>
<td>WWTP SPDES 65706</td>
<td>Wild Oaks Sewer District</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W14</td>
<td>WWTP SPDES 102877</td>
<td>Somers Manor Nursing Home</td>
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</tr>
<tr>
<td>W16</td>
<td>WWTP SPDES 29653</td>
<td>Waterview Hills Nursing Home</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W17</td>
<td>WWTP SPDES 026743</td>
<td>Yorktown Heights WWTP</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W19</td>
<td>WWTP SPDES 165498</td>
<td>Somers Office Building Complex</td>
<td>NYSDEC</td>
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<td>WWTP</td>
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<td>School Name</td>
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<td>---------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>W20</td>
<td>WWTP</td>
<td>35483</td>
<td>Somers High School</td>
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<td>SPDES</td>
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<td></td>
</tr>
<tr>
<td>W21</td>
<td>WWTP</td>
<td>105741</td>
<td>Bedford Middle School</td>
</tr>
<tr>
<td></td>
<td>SPDES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W22</td>
<td>WWTP</td>
<td>214540</td>
<td>Bedford Homes Elderly Housing</td>
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<tr>
<td></td>
<td>SPDES</td>
<td></td>
<td></td>
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<tr>
<td>W23</td>
<td>WWTP</td>
<td>105732</td>
<td>North Salem Middle School</td>
</tr>
<tr>
<td></td>
<td>SPDES</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.2 Subwatershed Water Quality Condition

The primary problem associated with the Muscoot subwatershed is high phosphorus and unacceptable levels of fecal and total coliform. These problems are discussed in detail below. For more information, refer to Maps 8, 9 and 10.

There are 22 wastewater treatment plants (WWTPs) in the Muscoot subwatershed. These WWTPs, in conjunction with the existing land uses, contribute to the overall phosphorus load of the subwatershed. The current phosphorus load in the subwatershed is 11,560 kg/yr. The NYCDEP, through their calculations for the phosphorus TMDL, determined that the available phosphorus allocation for this subwatershed is 9,397 kg/yr.

According to the NYSDEC the current phosphorus load of the Muscoot subwatershed exceeds the available phosphorus load and requires a nonpoint source reduction of 2,058 kg/yr. Implementation of the Phase II Stormwater Regulations in addition to nonpoint source reduction practices will be necessary. The balance of the phosphorus overage should be reduced through implementation of advanced technological controls, by the NYCDEP at each of the WWTPs.

Reservoir Condition

The Muscoot River acts as the boundary between several towns in Westchester County. The Muscoot Reservoir basin spans over Northwest Bedford, Southwest Lewisboro and Northwest North Salem. The major tributaries entering the Muscoot Reservoir are: Hallocks Mill Brook, Angel Fly Brook and Stone Hill River. The Muscoot Reservoir outflow flows into the New Croton Reservoir. The Muscoot Reservoir was placed in service in 1906 and is one of 12 reservoirs within the Croton Watershed. The majority of the water is derived from upstream reservoirs, with minor contributions from its own subwatershed. (Refer to Map 3.) Many of the upstream reservoirs are connected to the Muscoot Reservoir. Water enters the reservoir from several sources: the east and west branches of the Croton River (which flow from the Croton Falls and Diverting Reservoirs), the Muscoot River (which flows from the Amawalk Reservoir), the Cross River (which flows from the Cross River Reservoir) and the Titicus River (which flows from the Titicus Reservoir).

The Muscoot Reservoir currently does not meet the phosphorus water quality standard required of reservoirs in the New York City drinking water supply system. The Muscoot

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87 For TMDL methodology and calculation information refer to NYCDEP Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999).
90 Kane, Kimberlee. Proposed Phase II Phosphorus TMDL Calculation for Muscoot Reservoir, (March 1999), p.11.
Reservoir is listed on the 1999 Priority Waterbodies List for high phosphorus loads.\(^91\) The Muscoot Reservoir was also listed on the 1996 Priority Waterbodies List, for similar problems.\(^92\) This finding is consistent with other research and documents including the Total Maximum Daily Load (TMDL) calculations by the NYCDEP and NYSDEC.

The “Lower Muscoot River” (the section between the Amawalk Reservoir and the Muscoot Reservoir indicated as an “Area of Interest” on Map 9) has been nominated to the 1999 Priority Waterbodies list due to high fecal and total coliform counts and biomonitoring data has characterized the water body as slightly impaired. The most likely cause of these impairments are urban runoff and wildlife bacteria sources.\(^93\) It is also worth noting that the section of the Muscoot River below the Amawalk Dam is a NYSDEC special regulation trout stream.

The Katonah Municipal Well is currently listed on the 2001 Registry of Inactive Hazardous Waste Disposal Sites as “remediation action completed”.\(^94\) The site was formally listed as a Superfund site [also referred to as a National Priority Site (NPS)]. As of March 20, 2000 the remediation was complete and the site was “deleted” (process by which a site is no longer considered harmful and is removed from the Superfund list) from the NPS.\(^95\) The Katonah Municipal Well is located on a peninsula that extends into the Muscoot Reservoir and is indicated as an “Area of Interest” on Map 10. The Westchester County Health Department first discovered contaminants in the Katonah Municipal Well in 1978, at which time it was taken out of service. By 1979, the possible sources of the contamination were traced to four nearby dry cleaning establishments discharging process liquids to septic systems. The primary contaminant of concern to the groundwater feeding the municipal well is the volatile organic compound tetrachloroethene. The primary potential human health impact at this site would be through ingestion of the contaminated groundwater.\(^96\)

Relative to other reservoirs in the Croton system and as mentioned above, the water quality of the Muscoot Reservoir is poor. The poor water quality in the Muscoot can be attributed to the condition of the subwatershed itself as well as by the water quality of the five reservoirs contributing to it (refer to Map 3). The contributing reservoirs vary in water quality; the Croton Falls and Diverting Reservoirs are below average, the Amawalk Reservoir is above average, the Titicus Reservoir is above average and the Cross River

\(^95\) United States Environmental Protection Agency. *National Priority Site Fact Sheet: Katonah Municipal Well*. (Revised 6/15/00): [http://www.epa.gov/region02/superfund/site_sum/0202269c.htm](http://www.epa.gov/region02/superfund/site_sum/0202269c.htm)
\(^96\) United States Environmental Protection Agency. *National Priority Site Fact Sheet: Katonah Municipal Well*. (Revised 6/15/00): [http://www.epa.gov/region02/superfund/site_sum/0202269c.htm](http://www.epa.gov/region02/superfund/site_sum/0202269c.htm)
Reservoir is variable. The list below outlines specific water quality findings of the Muscoot Reservoir:

- The reservoir has higher than average concentrations of chlorophyll \(a\) for the Croton System.
- Secchi depth, a measure of water transparency, is shallower than average.
- Water turbidity, a measure of light scattering, was measured to be higher than average when compared to the other Croton reservoirs.
- The reservoir is generally classified as eutrophic.

**Minor Basins Condition**

The condition of the Muscoot Reservoir is a reflection of the waterbodies contributing to it. A summary of their water quality condition is listed below. Refer to Maps 8, 9 and 10 for geographic and specific monitoring site information.

- **Angle Fly Brook Basin:** The Angle Fly Brook Basin is located in central Somers. Several tributaries join the main stem of the brook prior to spilling into the Muscoot Reservoir from the north. Many of the tributaries entering Angle Fly Brook are surrounded by wetlands. Refer to Map 10 for more information.

  Angle Fly Brook is one of the healthiest streams in the entire Croton System. Biomonitoring data collected by the NYCDEP from 1994-1998 found Angle Fly Brook to be one of six streams to be assessed as non-impaired in at least one year of sampling between 1994 and 1998. Despite its proximity to significant residential development and the upstream construction of a golf course, Angle Fly Brook (Site B5) was assessed as non-impaired in every year sampled from 1994-1998 and had the highest water quality ratings of any site in the Croton System. In a similar study conducted by the NYSDEC in 1998, the DEC Stream Biomonitoring unit assessed Angle Fly Brook as non-impacted. A rating of non-impacted implies that the waterbody is in good condition and can support a diverse ecological community.

- **Broad Brook Basin:** The Broad Brook basin is located in central Bedford. The brook flows north and joins Stone Hill River prior to entering the Muscoot Reservoir. There are several tributaries that join the mainstem. Refer to Map 8 for more information.

  At this time, research did not lead to any water quality analysis for the Broad Brook Basin.

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97 All reservoir information is contained within their respective “Proposed Phase II Phosphorus TMDL Calculation Report,” (March 1999). Refer to References section for specific information.
100 Bode, Robert, et al. *Assessment of Water Quality of Streams in the New York City Watershed Based on Analysis of Invertebrate Tissues and Invertebrate Communities*, (April, 1999) p.3.
• **Crom Pond Basin:** The Crom Pond basin is located in central Yorktown. The pond itself is divided in two by a wetland. Three tributaries enter the pond, two from the north, and one from the south. The outflow of the pond flows eastward towards Hallocks Mill Brook. Refer to Map 9 for more information.

At this time, research did not lead to any water quality analysis for the Crom Pond Basin.

• **Croton River Basin:** The Croton River is the east-west boundary between the towns of North Salem and Somers. The Croton River basin extends westward into northern Somers and eastward into northern North Salem. This portion of the Muscoot subwatershed is delineated as the Croton River. The Croton River flows south into the Muscoot Reservoir. There are three minor tributaries entering the Croton River from the west. Outflow from the Titicus River enters the Croton River from the west. Refer to Map 10 for more information.

At this time, research did not lead to any water quality analysis for the Croton River Basin.

• **East Branch Croton River Basin:** The East Branch Croton River Basin is located in southern Southeast in Putnam County, New York and in north-central North Salem in Westchester County. Water flows southwest to the Muscoot Reservoir via the East Branch Croton River. Water enters the East Branch Croton River from Holly Stream. There is one small tributary within the delineated border that enters the River from the east. Refer to Map 10 for more information.

At this time, research did not lead to any water quality analysis for the East Branch Croton River Basin.

• **Hallocks Mill Brook Basin:** The Hallocks Mill Brook Basin spans over central-eastern Yorktown and central-western Somers. Hallocks Mill Brook has three identified sources, Upper Arm Crom Pond, Sparkle Lake and Crom Pond. More information on these sources is discussed within this section of the report. There are very few wetlands in the Hallocks Mill Brook basin. Hallocks Mill Brook flows eastward and empties into the Muscoot Reservoir. Refer to Map 9 for more information.

Two sections of Hallocks Mill Brook are listed on the 1999 Priority Waterbodies List (PWL). These sites are indicated on Map 9 as an “Area of Interest.” Section 1 of Hallocks Mill Brook originates from the stream’s mouth at the Muscoot River to 1.4 miles upstream (listed on the 1999 Priority Waterbodies List as “lower section”). This section is monitored by the NYCDEP at sampling site H15. The sampling site is just below the Yorktown Heights Wastewater Treatment Plant. NYCDEP’s “Determination of Water Quality Using Protocols of the NYSDEC/NYCDEP MOU; Addendum E”, indicated unacceptable average counts of fecal coliform, total phosphorus and ammonia. In addition, 13 fecal coliform, 10 total coliform, one total
phosphorus, and one ammonia spike values were detected. Unacceptable levels of fecal and total coliform bacteria were found by the Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU: Addendum E New York City Water Supply at monitoring stations H15 and H16. Identified samples exceed the spike threshold of fecal coliform 13 times and total coliform 10 times from 7/1/97-6/30/98. The peaks noted above may indicate storm water events. The most likely cause for these high coliform counts is the Yorktown Heights Wastewater Treatment Plant and urban runoff. NYCDEP data also indicates that ammonia counts were particularly high in the stream. Over this time period, one total phosphorus and one ammonia spike were also detected. The WWTP does not have an ammonia limit; therefore it is not a violation that is required to remedy. While the Yorktown WWTP SPDES permit does not have an ammonia limit, the effluent ammonia concentrations lead to chronic violations of ambient water quality standards downstream. Therefore, the plant is violating the Clean Water Act, and is, strictly speaking, liable for a remedy. In addition, biomonitoring data collected by the NYCDEP at site 105 characterized the brook as severely impaired. This is the lowest rating of any site monitored by the NYCDEP Biomonitoring Program in the NYC Watershed.

The effluent from the Yorktown Heights WWTP is only one of the sources of pollution in this stream. In addition, urban runoff and erosion/siltation are the other main sources of water quality problems.

The Upper Section of Hallocks Mill Brook (noted as “Section 2” in 1999 PWL), is 1.4 miles upstream of the mouth of the Muscoot River to tributary 6, which drains Sparkle Lake. This section is listed on the NYSDEC Priority Waterbodies List due to high fecal total coliform counts and of a biomonitoring rating of “slightly impaired”.

- **Holly Stream Basin**: The Holly Stream Basin is primarily located in the town of Southeast in Putnam County, NY. The basin extends southward into north-central North Salem. There are many wetlands located in the basin. Holly Stream flows westward and joins the East Branch of the Croton River in Putnam County. Refer to Map 10 for more information.

At this time, research did not lead to any water quality analysis for the Holly Stream Basin.

- **Lake Katonah Basin**: The Lake Katonah Basin is located in western Lewisboro and extends southward towards the northeast section of Bedford. Lake Katonah flows

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102 NYCDEP. Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply, (April, 1998) p.6; (May, 1999) p.6
103 ibid.
104 ibid.
northward toward an unnamed tributary within its delineated basin. The unnamed tributary flows into the Muscoot Reservoir on its eastern side. Refer to Map 10 for more information.

At this time, research did not lead to any water quality analysis for the Lake Katonah Basin.

- **Plum Brook Basin**: The Plum Brook basin is located in southern Carmel in Putnam County and north-central Somers. Two main tributaries join together in Somers and continue flowing southward, emptying into the Muscoot Reservoir. A wetland runs along the waterway. Refer to Map 10 for more information.

  At this time, research did not lead to any water quality analysis for the Plum Brook Basin.

- **Sparkle Lake Basin**: Sparkle Lake is located in northern Yorktown. The basin extends into northeast Yorktown. Sparkle Lake drains to a tributary that empties into Hallocks Mill Brook. Refer to Map 9 for more information.

  Water from the Sparkle Lake basin may be contributing to high fecal and total coliform counts found in Section 2 of Hallocks Mill Brook. Section 2 of Hallocks Mill Brook has been nominated to the 1999 Priority Waterbodies List for this reason, and begins where Sparkle Lake drains into Hallocks Mill Brook.

  At this time, research did not lead to any water quality analysis for the Sparkle Lake Basin.

- **Stone Hill River (also known as Beaver Dam Brook) Basin**: The Stone Hill River basin extends over central Pound Ridge and central Bedford. Numerous tributaries join the main stem of the Stone Hill River as it flows north to the Muscoot Reservoir. Refer to Map 8 for more information.

  Data on the Stone Hill River (Beaver Dam Brook) varies from poor to very good. The section of the brook near site H11 from the Bedford Center to the mouth is listed on the Priority Waterbodies List (PWL) due to high fecal and total coliform counts in addition to a biomonitoring rating of slightly impaired.\textsuperscript{107} This section is indicated on Map 8 as an “Area of Interest.” This section of Stone Hill River is listed on the 1999 NYS Priority Waterbodies List primarily due to high nutrient levels and pathogens. The suspected sources of pollution at this location are urban runoff, wildlife sources and the WWTP from the upstream correctional facility.\textsuperscript{108} Unacceptable levels of fecal and total coliform bacteria were found by the Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU: Addendum E New York City


Water Supply at monitoring station H11. Identified samples exceed the spike threshold of fecal coliform two times and total coliform two times from 7/1/97-12/31/98.\textsuperscript{109} The peaks noted above may indicate storm water events.

Research conducted by Trout Unlimited in the Stone Hill River basin identified eroded streamside conditions (symptomatic of failed stormwater drainage systems) leading to considerable deposition of silt and other pollutants in the stream.\textsuperscript{110}

Biomonitoring in the Stone Hill River basin over 1997-1998 by the NYCDEP indicated good water quality. Biomonitoring site B13 received a rating of “non impacted” in 1998 and slightly impacted in 1997. The non-impacted value was one of only six sites in the entire Croton Watershed that received that rating throughout the four year monitoring program.\textsuperscript{111}

The Westchester Colprovia Corporation, located on Harris Road in the Town of Bedford is approximately 9.2 acres in size. Stone Hill River borders the site along the northern portion of the property (indicated as an “Area of Interest” on Map 8). This site is listed on the 2001 NYSDEC Inactive Hazardous Waste Disposal Report (April, 2001). In 1986, trichloroethene (TCE) was discovered in a monitoring well installed on the Colonial Sand and Gravel property (located southwest of the Colprovia Corporation). It was believed that pollution was coming from the Colprovia Corporation. The NYSDEC took measures to further investigate and clean up the site. The groundwater monitoring data confirms the contamination has been significantly reduced.\textsuperscript{112} Routine monitoring of the reservoir has not revealed any further contamination. The April 2001 Registry of Inactive Hazardous Waste Sites indicates that the remedial action is complete.\textsuperscript{113}

\begin{itemize}
  \item **Upper Arm Crom Pond Basin:** The Upper Arm Crom Pond basin straddles northeast Yorktown and northwest Somers. There are many wetlands located in the basin. Four tributaries join the mainstem of the primary unnamed tributary of the Upper Arm Crom Pond Basin and flow southward through a large wetland. The tributary empties into Hallocks Mill Brook. Refer to Map 9 for more information.

  At this time, research did not lead to any water quality analysis for the Upper Arm Crom Pond Basin.

  \item **Upper Muscoot Basin:** The Upper Muscoot basin is located in southwest North Salem and northern Lewisboro. There is a major wetland in the headwaters of the
\end{itemize}

\textsuperscript{109} NYCDEP. *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply*, (April, 1998) p. 5.


\textsuperscript{112} NYSDEC. *Registry of Inactive Hazardous Waste Disposal Sites in New York State* (April, 2001), p. 211

\textsuperscript{113} ibid.
Upper Muscoot tributary. The Upper Muscoot flows westward and joins an unnamed tributary of the Croton River. Refer to Map 10 for more information.

At this time, research did not lead to any water quality analysis for the Upper Muscoot Basin.

5.3 Data Summary

The primary problem associated with the Muscoot subwatershed is high phosphorus and unacceptable levels of fecal and total coliform. This conclusion is drawn based on data cited from the following sources:

- Bode, Robert, et al. Assessment of Water Quality of Streams in the New York City Watershed Based on Analysis of Invertebrate Tissues and Invertebrate Communities, (April, 1999)
- Kane, Kimberlee. Proposed Phase II Phosphorus TMDL Calculation for Muscoot Reservoir, (March 1999)
- Kane, Kimberlee. Proposed Phase II Phosphorus TMDL Calculation for Cross River Reservoir, (March 1999)
- Lawrence, Tracy, New York State Department of Environmental Protection 1999 Priority Waterbody Nominations, (July, 1999)
- New York State Department of Environmental Protection. Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999)
- New York State Department of Environmental Protection. Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply, (April, 1998; May, 1999)
- New York State Department of Environmental Conservation, Phase II Phosphorus Total Maximum Daily Loads for Reservoirs in the New York City Supply Watershed. (June 2000)
- New York State Department of Environmental Conservation. The 1999 Lower Hudson River Basin Waterbody Inventory and Priority Waterbodies List, (June, 2000)
  http://www.epa.gov/region02/superfund/site_sum/0202269c.htm
6. NEW CROTON SUBWATERSHED

6.1 Background Information

Geographical Description
The New Croton subwatershed spans over northeastern and central Westchester County through the towns of Yorktown, Cortlandt, Somers, New Castle, North Castle, Bedford and the village of Mt. Kisco. The Westchester County portion contains 59.95 miles\(^2\) (153.6 km\(^2\)) and contains 135.93 stream miles The population of Westchester County’s portion of the New Croton Subwatershed is 40,412 people according to 2000 Census data. Ten minor basins (including the reservoir basin itself) drain into the reservoir. The basins are listed in the table below by town (refer to Maps 11 and 12 in Section IV).

<table>
<thead>
<tr>
<th>Town</th>
<th>Minor Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortlandt</td>
<td>Hunter Brook, Twin Lakes, West New Croton Reservoir, Teatown Lake</td>
</tr>
<tr>
<td>Yorktown</td>
<td>Hunter Brook, Twin Lakes, West New Croton Reservoir, East New Croton Reservoir, Teatown Lake, Cornell Brook, Gedney Brook, Kisco River</td>
</tr>
<tr>
<td>Mt. Kisco</td>
<td>Kisco River, Howlands Lake</td>
</tr>
<tr>
<td>Bedford</td>
<td>E. New Croton Reservoir, Kisco River, Howlands Lake</td>
</tr>
<tr>
<td>New Castle</td>
<td>Teatown Lake, East New Croton Reservoir, Cornell Brook, Gedney Brook, Chappaqua Brook, Kisco River, Howlands Lake</td>
</tr>
<tr>
<td>North Castle</td>
<td>Howlands Lake</td>
</tr>
<tr>
<td>Somers</td>
<td>E. New Croton Reservoir</td>
</tr>
</tbody>
</table>
**Land Use Description**

Most of the water in the waterbodies in the New Croton subwatershed originate from precipitation and overland flow. Therefore, land use has a tremendous impact on water quality in the subwatershed area. Chart F below outlines the various land uses based on Westchester County’s portion of the New Croton subwatershed. Generally, the land is forested and has open space characteristics, as 26% of the land is undeveloped and 38.1% is categorized as very low density residential (<2 dwelling units per acre). Less than 8% of the land area is categorized as transportation, commercial, industrial, office or manufacturing.

**Chart F: New Croton Land Use**

![Pie chart showing land use distribution]

- 38% Undeveloped
- 16% Waterbody/Water Supply
- 11% Commercial/Institutional/Manufacturing/Office
- 6% Residential High/Medium Density
- 2% Transportation Utility
- 1% Mixed Use
- 2% Park/Private Recreation/Nature Preserve/Cemetery
- 1% Other

**Water Body Classification**

The New York State Department of Environmental Conservation (NYSDEC) classifies waterbodies located in the New Croton subwatershed as provided in Table 17 below. The primary use of waterbodies in this subwatershed are for the New York City drinking water supply and therefore are classified as A.
Table 17: New Croton Subwatershed Waterbody Classification

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Classification</th>
<th>Standard</th>
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</thead>
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<tr>
<td>Hunter Brook</td>
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<td>B(TS)/C(TS)/C</td>
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<tr>
<td>Twin Lakes</td>
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<td>West New Croton Reservoir</td>
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<td>AA/A</td>
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<td>B</td>
</tr>
<tr>
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<td>Gedney Brook</td>
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<tr>
<td>Chappaqua Brook</td>
<td>C</td>
<td>C</td>
</tr>
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<td>Kisco River</td>
<td>B/C</td>
<td>B(TS)/C(TS)</td>
</tr>
<tr>
<td>East New Croton Reservoir</td>
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<td>AA/A</td>
</tr>
</tbody>
</table>

Subwatershed Monitoring and Point Source Discharges

A list of sites monitored for water quality and point source discharges within the Muscoot Subwatershed is found in Tables 18 and 19 below. Each site is associated with a map reference number found on Maps 11 and 12. For more information regarding monitoring programs, refer to Section I.

Table 18: New Croton Subwatershed Monitoring Sites

<table>
<thead>
<tr>
<th>Map Reference #</th>
<th>Site Name</th>
<th>Monitoring Program</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Pest28</td>
<td>Pest</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>P1</td>
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<td>NYCDEP</td>
</tr>
<tr>
<td>P2</td>
<td>Muscootr</td>
<td>Pathogen</td>
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<td>Biomon 107</td>
<td>Biomonitoring</td>
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<td>NYCDEP</td>
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<td>Reservoir</td>
<td>NYCDEP</td>
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<td>NYCDEP</td>
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<td></td>
<td>(Limnology)</td>
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<td>LIMNOM 7CNC</td>
<td>Reservoir</td>
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Table 18 cont.

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Table 19: New Croton Subwatershed Point Source Discharges

<table>
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<th>Site Name</th>
<th>Monitoring Program</th>
<th>Monitoring Agency</th>
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<tr>
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<td>NYSDEC</td>
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<td>SPDES 251151</td>
<td>Letchworth DOSO</td>
<td>NYSDEC</td>
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<td>S4</td>
<td>SPDES 259705</td>
<td>Universal Voltronics</td>
<td>NYSDEC</td>
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<td>S6</td>
<td>SPDES 100293</td>
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<td>SPDES 149195</td>
<td>Croton Harmon School District Bus Garage</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>S12</td>
<td>SPDES 207331</td>
<td>Cornell Wood Development</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W1</td>
<td>WWTP SPDES 26727</td>
<td>Yorktown Lakeside Village Sewage (subsequently disconnected and diverted off of watershed)</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W2</td>
<td>WWTP SPDES 35017</td>
<td>Walter Panas High School</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W3</td>
<td>WWTP SPDES 147247</td>
<td>Khal Adas Kashau</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W4</td>
<td>WWTP SPDES 165425</td>
<td>Fox Hollow Sewer Co.</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>W5</td>
<td>WWTP SPDES 147087</td>
<td>Yeshivath Kehilath Yakov</td>
<td>NYSDEC</td>
</tr>
</tbody>
</table>
6.2 Subwatershed Water Quality Condition

Research for this report indicates that the primary problems associated with the New Croton subwatershed are high phosphorus and unacceptable levels of fecal and total coliform. The New Croton Reservoir currently does not meet the phosphorus water quality standard required of reservoirs in the New York City drinking water supply system.

There are six wastewater treatment plants in the subwatershed. These WWTPs, in conjunction with the existing land uses, contribute to the overall phosphorus load of the subwatershed. The current phosphorus load in the subwatershed is 11,189 kg/yr. The NYCDEP, through their calculations for the phosphorus TMDL, determined that the available phosphorus allocation for this subwatershed is 9,731 kg/yr.

According to the NYSDEC the current phosphorus load of the New Croton subwatershed exceeds the available phosphorus load and requires a nonpoint source reduction of 1,356 kg/yr. NYCDEP is currently reducing phosphorus levels at WWTPs through technological controls. The balance of the phosphorus reduction will then come from nonpoint source reductions.

Reservoir Basin

The New Croton Reservoir basin is located in the towns of New Castle, Cortlandt, Mount Kisco and Yorktown. The major tributaries entering the New Croton Reservoir include: the Kisco River, Cornell Brook, Gedney Brook and outflow from the Twin Lakes (refer to Maps 11 and 12). The New Croton Reservoir is one of twelve reservoirs in the Croton System and was placed in service in 1842, beginning with the Old Croton Aqueduct. The New Croton Reservoir is the terminal reservoir for the Croton System, meaning that it is the last stop prior to delivery to New York City and the water quality is affected by the water quality of the upstream reservoirs contributing to it. The Muscoot Reservoir is the primary contributor with below average water quality, impacting the quality of the New Croton Reservoir basin. (refer to Map 3 and the Muscoot Subwatershed Section for more detail).

The New Croton Reservoir is listed on the 1999 Priority Waterbodies List due to high nutrient loads and siltation. This area is indicated as an “Area of Interest” on both Maps 11 and 12. The major sources of pollution are urban runoff, storm sewers, road-bank erosion, construction, septic systems and wastewater treatment plants. The New

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114 For TMDL methodology and calculation information refer to NYCDEP Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs (March, 1999).
115 Kane, Kimberlee. Proposed Phase II Phosphorus TMDL Calculations for New Croton Reservoir (March, 1999), p.27.
118 ibid.
Croton Reservoir was also listed on the 1996 PWL under similar conditions. Two minor basins have significant water quality problems: the Kisco River and the Hunter Brook. These problems are discussed in their respective sections below.

NYCDEP water quality research has concluded that relative to other reservoirs in the Croton System, the New Croton has average water quality. The list below outlines specific water quality findings.

- The reservoir has average concentrations of chlorophyll a for the Croton System
- Secchi depth, a measure of water transparency, is average.
- Water turbidity, a measure of light scattering, was measured to be lower when compared to the other Croton Reservoirs.
- The reservoir generally straddles the border between a mesotrophic and a eutrophic state.

### Minor Basins Condition

Data collected for this report reflects that the condition of the subwatershed varies considerably between minor basins. Refer to Maps 11 and 12 for geographic and monitoring site information on the minor basins described below.

- **Chappaqua Brook Basin:** The Chappaqua Brook basin is located in central New Castle. Both the Saw Mill River Parkway and the Metro North Railroad run through a wetland along Chappaqua Brook. Chappaqua Brook empties into the Kisco River in Mt. Kisco. Refer to Map 12 for more information.

  At this time, research did not lead to any water quality analysis for the Chappaqua Brook Basin.

- **Cornell Brook Basin:** The Cornell Brook Basin is located in northern New Castle and spans north into Yorktown. Two major tributaries join together prior to entering the Croton Reservoir from the South. Route 100 runs along the main tributary of Cornell Brook, and may contribute water quality pollution in the form of stormwater runoff.

  At this time, research did not lead to any water quality analysis for the Cornell Brook Basin. Refer to Map 12 for more information.

- **Gedney Brook Basin:** The Gedney Brook basin is located in central New Castle and southern Yorktown. The Brook starts in New Castle and flows northward to the southern side of the New Croton Reservoir. Refer to Map 12 for more information.

  At this time, research did not lead to any water quality analysis for the Gedney Brook Basin.

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121 *ibid.*
• **Howlands Lake Basin:** The Howlands Lake basin spans through Mount Kisco, New Castle, and Bedford. Howlands Lake is located in Bedford. A major tributary enters the Lake from the south in Bedford. The outflow of the Lake flows west toward the Kisco River. Refer to Map 12 for more information.

The Marx Residence, located in the southwestern corner of the Howlands Lake Basin along Route 128, just north of the New Castle town line, is listed in the 2001 NYSDEC Inactive Hazardous Waste Disposal Report (April 2001). This area is indicated as an “Area of Interest” on Map 12. Sometime during the two year period between September 1987-1989, organic chemicals were disposed into the septic system of this residence. Soil sampling found that the soil in the sewage disposal area on the Marx property was contaminated with tetrachloroethene, acetone, methyl ethyl ketone and toluene. As of April 2001 the remedial action has been complete. However, there are possible effects on surface waters and sediment along drainage paths at the confluence of Wampus Pond.\(^\text{122}\)

At this time, research did not lead to any water quality analysis for the Howlands Lake Basin.

• **Hunter Brook Basin:** The Hunter Brook basin is located in northwest Yorktown and northeast Cortlandt. Two main tributaries join together at Mill Pond. Hunter Brook continues southward and empties into the New Croton Reservoir. Route 202/35 runs along a portion of the stream corridor and may be a suspect contributor to some water quality problems. Refer to Map 11 for more information.

Hunter Brook is one of the main tributaries to the New Croton Reservoir. Two sections of the stream are listed on the Priority Waterbodies List (PWL). Portion 1 (referred to as Section 1 by NYCDEP) of Hunter Brook, the reach downstream of Mill Pond (indicated as an “Area of Interest” on Map 11) is listed on the 1999 Priority Waterbodies List due to fecal/total coliform and thermal changes.\(^\text{123}\) The water quality in this section of Hunter Brook is affected by high fecal coliform counts indicated by sampling data and a biomonitoring rating of “slightly impaired”.\(^\text{124}\) Unacceptable levels of fecal and total coliform bacteria were found in the Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU: Addendum E New York City Water Supply at monitoring station H2, located just below the pond identified samples exceed the spike threshold of fecal coliform six times and total coliform eight times from 7/1/97-6/30/98.\(^\text{125}\) The peaks noted

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\(^\text{122}\) NYSDEC. *Registry of Inactive Hazardous Waste Disposal Sites in New York State* (April, 2001), p. 219
above may indicate storm water events. The most likely cause for the high coliform counts is urban runoff and wildlife bacteria sources. Additional documentation by a Yorktown student monitoring group has indicated that the water quality of Hunter Brook is impaired according to biomonitoring data taken at sites upstream and downstream of Mill Pond.

Portion 2 (referred to as Section 2 by NYCDEP) of the Hunter Brook is located from the source to Mill Pond. This section of the Brook faces similar water quality issues as the portion of Hunter Brook above Mill Pond. Portion 2 of Hunter Brook is listed on the 1999 Priority Waterbodies List due to fecal/total coliform counts, nutrients and silt/sediment runoff. The likely source of pollution is runoff. The water quality in this section of Hunter Brook is affected by high fecal coliform counts indicated by sampling data and a biomonitoring rating of “slightly impaired”. Unacceptable levels of fecal and total coliform bacteria were found by the Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU: Addendum E New York City Water Supply at monitoring station H1. Identified samples exceed the spike threshold of fecal coliform eight times and total coliform 11 times from 7/1/97-6/30/98.

• **Kisco River Basin:** The Kisco River starts in New Castle, runs north through Mount Kisco toward the Croton Reservoir. The Kisco River basin includes portions of the towns of Bedford, Mt. Kisco, New Castle, Yorktown and North Castle. Chappaqua Brook and the outflow from Howlands Lake join the Kisco River in Mt. Kisco. Refer to Map 11 for more information.

The water quality of the Kisco River varies throughout its course. Water quality is poorest where the water passes under Route 133 (Main Street) in Mt. Kisco. However, the water quality of the Kisco River recovers a short distance away and is good as it enters the New Croton Reservoir. Two sections of the Kisco River and one tributary are listed on the 1999 PWL. These sites are indicated as “Area of Interest” on Map 11.

The “lower” section of the Kisco River (referred to as Section 1 by NYCDEP), from the Reservoir to tributary 5 demonstrates poor water quality as a result of high

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126 NYCDEP. *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply*, (May, 1999) p.4
127 Mildred E. Strang Middle School Water Quality Data, Spring 1998
nutrient levels and sedimentation entering the River from urban runoff.\textsuperscript{132} In addition, NYCDEP biomonitoring data at site B4 has characterized the river as “slightly impaired”. A rating of “slightly impaired” means that there is documented proof that the water quality condition is compromised.

The Kisco River (referred to as Section 2 by NYCDEP), from tributary 5 to Howlands Lake, flows through the village of Mt. Kisco. It was originally nominated by the NYCDEP to the PWL due to unacceptable average values of fecal and total coliform and total phosphorus.\textsuperscript{133} The fishery in this portion of the Kisco River is considered impaired by pathogens and nutrient input to the stream and other pollutants from urban/suburban runoff.\textsuperscript{134} Unacceptable levels of fecal and total coliform bacteria were found by the Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU: Addendum E New York City Water Supply at monitoring station H7. Identified samples exceed the spike threshold of fecal coliform 15 times and total coliform 15 times from 7/1/97-6/30/98.\textsuperscript{135} The peaks noted above may indicate storm water events. The most likely cause for the high coliform counts is urban runoff and wildlife bacteria sources.\textsuperscript{136} Through June 1998, the phosphorus levels at times exceeded the 50 ug/l guideline and reached 77 ug/l.\textsuperscript{137} In addition, Biomonitoring data collected by the NYCDEP at B1 characterized the river as “moderately impaired”.\textsuperscript{138}

The Kisco River is one of three streams that were assessed as moderately impacted in the New Croton subwatershed. The Kisco River was assessed as moderately impacted, but the “worst” rating went to Hallocks Mill Brook below the Yorktown WWTP which was correctly reported as being severely impacted earlier in this report. Ratings range from non-impacted to severely impacted, depending on species biodiversity. Approximately 1.5 miles of the Kisco River is considered to have poor water quality. Biomonitoring data has indicated that the water quality of the Kisco River is poor. In addition, unacceptable levels of fecal and total coliform counts were found at two monitoring locations H5 and H7.\textsuperscript{139}

Tributary 10 of the Kisco River is listed on the 1999 Priority Waterbodies List. The 10th tributary is located just upstream of Chappaqua Brook, between the village of Mount Kisco and the hamlet of Chappaqua. Water quality is poor due to high levels


\textsuperscript{133} Lawrence, Tracy, \textit{NYCDEP 1999 Priority Waterbody Nominations}, (July, 1999) p.11.

\textsuperscript{134} New York State Department of Environmental Conservation. \textit{The 1999 Lower Hudson River Basin Waterbody Inventory and Priority Waterbodies List}, (June, 2000) p. 106.

\textsuperscript{135} NYCDEP. \textit{Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply}, (April, 1998) p. 6; (May, 1999) p. 5.

\textsuperscript{136} ibid.

\textsuperscript{137} ibid.

\textsuperscript{138} Lawrence, Tracy, \textit{NYCDEP 1999 Priority Waterbody Nominations}, (July, 1999) p. 11.

of nutrients (phosphorus), pathogens and ammonia. The most likely cause of this pollution is wildlife bacteria and fertilizer from a nearby golf course. This stream is monitored by the NYCDEP at sample site H4. Water quality samples collected at this site exceed the spike threshold of fecal coliform eight times and total coliform 12 times and Ammonia one time from 7/1/97-6/30/98

- **Teatown Lake Basin:** The Teatown Lake basin is contained within the towns of Yorktown, New Castle and Cortlandt. The Lake itself is located in Yorktown. Two tributaries enter Teatown Lake, one from the east and one from the south. There are several small, unnamed lakes within the delineated basin. The outflow of the lake flows northward and empties into the New Croton Reservoir. Teatown Lake is located on the Teatown Lake Reservation. Refer to Map 11 for more information.

At this time, research did not lead to any water quality analysis for the Teatown Lake Basin.

- **Twin Lakes Basin:** The Twin Lake basin is located in east-central Cortlandt. There is one tributary that runs through the eastern lake emptying into the New Croton Reservoir. The eastern and western lakes appear to be joined by a wetland. Refer to Map 11 for more information.

At this time, research did not lead to any water quality analysis for the Twin Lakes Basin.

### 6.3 Data Summary

Research for this report indicates that the primary problems associated with the New Croton subwatershed are high phosphorus and unacceptable levels of fecal and total coliform. This conclusion is drawn based on data cited in the following sources:

- **Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply,** (April, 1998)
- Kane, Kimberlee. *Proposed Phase II Phosphorus TMDL Calculations for New Croton Reservoir* (March, 1999)
- Lawrence, Tracy, *NYCDEP 1999 Priority Waterbody Nominations,* (July, 1999)
- *Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs* (March, 1999)
- Mildred E. Strang Middle School Water Quality Data, Spring 1998
- New York City Department of Environmental Protection. *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply,* (April, 1998; May, 1999)

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• New York State Department of Environmental Conservation. *Registry of Inactive Hazardous Waste Disposal Sites in New York State* (April, 2001)
• New York State Department of Environmental Conservation, *Kisco River Biological Assessment*, (1999)
7. TITICUS SUBWATERSHED

7.1 Background Information

Geographic Description
The Titicus subwatershed covers northeast Westchester County and Connecticut. The Westchester County portion is 24.34 miles\(^2\) (62.2 km\(^2\)) and contains 36.9 stream miles. The Titicus subwatershed is located in the northeast corner of Westchester County, primarily within the town of North Salem and partially in the north-central portion of Lewisboro. The subwatershed extends eastward into Ridgefield, Connecticut. Six minor basins drain into the reservoir, four of which are in Westchester County; Titicus River, Titicus Reservoir, Mopus Brook and Crook Brook. Lake Mamanasco and Lake Naraneka are located in Connecticut. (Refer to Map 13: Titicus Subwatershed in Section IV.) The population of Westchester County’s portion of the Titicus subwatershed is 3270 people according to 2000 Census data estimates.

Land Use Description
Most of the water in the waterbodies originates through precipitation. Therefore, land use in the subwatershed has a tremendous impact on water quality. Chart G below outlines various land uses based on Westchester County’s portion of the New Croton subwatershed. Generally, the land is forested and has open space characteristics, as 50% of the land is undeveloped and 23% is categorized as very low density residential (<2 dwelling units per acre). Less than 3% of the land area is categorized as transportation, or commercial. No land is categorized as industrial or manufacturing.

Chart G: Titicus Subwatershed Land Use
Waterbody Classification

The New York State Department of Environmental Conservation (NYSDEC) classifies waterbodies located in the Titicus subwatershed as provided in the table below. The primary use of waterbodies in this subwatershed are for the New York City drinking water supply and therefore are classified as A.

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Classification</th>
<th>Standard</th>
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<tr>
<td>Titicus River</td>
<td>A/C</td>
<td>A(T)/C(TS)</td>
</tr>
<tr>
<td>Crook Brook</td>
<td>C</td>
<td>C(T)</td>
</tr>
<tr>
<td>Mopus Brook</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Titicus Reservoir</td>
<td>AA/A</td>
<td>AA/A</td>
</tr>
</tbody>
</table>

Subwatershed Monitoring and Point Source Discharges

A list of sites monitored for water quality and point source discharges within the Titicus Subwatershed is found in Table 21 below. There are no SPDES (pollution discharge sites) located in the Titicus Subwatershed. Each site is associated with a map reference number found on Map 13. For more information regarding the monitoring programs, refer to Section I.

<table>
<thead>
<tr>
<th>Map Reference #</th>
<th>Site Name</th>
<th>Monitoring Program</th>
<th>Monitoring Agency</th>
</tr>
</thead>
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<td>B16</td>
<td>Biomon 113</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B17</td>
<td>Biomon 22222</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>B18</td>
<td>Biomon 122</td>
<td>Biomonitoring</td>
<td>NYCDEP</td>
</tr>
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<td>H23</td>
<td>Titicus1</td>
<td>Hydrologic</td>
<td>NYCDEP</td>
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<td>L19</td>
<td>LIMNOM 2CT</td>
<td>Reservoir (Limnology)</td>
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</tr>
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<td>NYCDEP</td>
</tr>
<tr>
<td>L21</td>
<td>LIMNOM 1CT</td>
<td>Reservoir (Limnology)</td>
<td>NYCDEP</td>
</tr>
</tbody>
</table>

7.2 Subwatershed Water Quality Condition

Research for this report has concluded that the primary problems associated with the Titicus subwatershed are high phosphorus and unacceptable levels of fecal and total coliform. These problems are discussed in detail below. For an overview of the water quality condition of the Titicus subwatershed, refer to Map 13.
There are no wastewater treatment plants (WWTPs) in the Titicus subwatershed. In the New Croton Reservoir System, WWTPs are one of the primary contributors to the phosphorus load entering the reservoirs. However, there are no documented point sources of pollution in the Titicus subwatershed. As such, it appears that water quality degradation is caused by nonpoint source pollution runoff. The current phosphorus load in the subwatershed is 1,124 kg/yr. The NYCDEP, through their calculations for the phosphorus TMDL, determined that the available phosphorus allocation for this subwatershed is 984 kg/yr.

According to the NYSDEC the current phosphorus load of the Titicus subwatershed exceeds the available phosphorus load and requires a nonpoint source reduction of 140 kg/yr. Implementation of the Phase II Stormwater Regulations in addition to nonpoint source reduction practices will be necessary.

**Reservoir Basin**

The Titicus Reservoir is one of the twelve Croton Watershed reservoirs and was placed in service in 1895. The Titicus Reservoir is a headwater reservoir. Most of the water it receives is from surface runoff. The Titicus Reservoir basin is located in central North Salem. Water enters the Titicus Reservoir primarily from the Titicus River and seven small tributaries (six from the north and one from the south). There is one lake located in the northwest section of the basin. Water flows out the Titicus Reservoir either over the spillway or through the stream release at the dam. The outflow of the Titicus Reservoir flows into the Muscoot reservoir, an area outside of the Titicus river basin.

The Titicus Reservoir currently does not meet the phosphorus water quality standard required of reservoirs in the New York City drinking water supply system. The Titicus Reservoir is listed on the 1999 Priority Waterbodies List due to high nutrient loads and siltation. The major sources of pollutants are urban runoff, storm sewers, road-bank erosion, construction, and septic systems. The Titicus Reservoir was also listed on the 1996 Priority Waterbodies List for similar reasons.

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143 For TMDL methodology and calculation information refer to NYCDEP *Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs* (March, 1999).
144 Kane, Kimberlee. *Proposed Phase II Phosphorus TMDL Calculations for Titicus Reservoir* (March, 1999), p.27.
146 ibid.
NYCDEP water quality research has concluded that relative to the other reservoirs in the New York City watershed, the Titicus Reservoir has above average water quality.\textsuperscript{149} The list below outlines specific water quality findings.

- The reservoir has lower than average concentrations of chlorophyll a for the Croton System.
- Secchi depth, a measure of water transparency, is deeper than average.
- Water turbidity, a measure of light scattering, was measured to be average when compared to the other Croton Reservoirs.
- The reservoir is generally classified as mesotrophic.\textsuperscript{150}

**Minor Basins Condition**

Data collected for this report reflects that the condition of the subwatershed varies considerably between minor basins. Refer to Map 13 for geographic and monitoring site information on the minor basins described below.

- **Titicus River Basin:** The Titicus River basin spans between Ridgefield, Connecticut and the Town of North Salem. All of the minor tributary basins join the Titicus River. The Titicus River empties into the Titicus Reservoir.

  The Titicus River is the main tributary to the Titicus reservoir. The section of the Titicus River between the reservoir and the Connecticut State line is listed on the 1999 Priority Waterbodies List (PWL). The water quality of the Titicus River is affected by the high fecal coliform counts indicated by sampling data and a biomonitoring rating of “slightly impaired”.\textsuperscript{151} Unacceptable levels of fecal and total coliform bacteria were found by the Determination of Unacceptable Water Quality using the Protocols of the DEC/DEP MOU: Addendum E New York City Water Supply at monitoring station H23 (refer Map 13 for more information). Identified samples exceed the spike threshold of fecal coliform seven times and total coliform four times from 1/1/97-6/30/98.\textsuperscript{152} The peaks noted above may indicate storm water events. The most likely cause for high coliform counts is urban runoff and wildlife bacteria sources.\textsuperscript{153}

  The Titicus River is currently listed on the 1999 PWL due to high nutrient levels, pathogens. This area is indicated as an “Area of Interest” on Map 13. One of the


\textsuperscript{152} NYCDEP. *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply*, (April, 1998) p. 7; (May, 1999) p. 5.

\textsuperscript{153} NYCDEP. *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply*, (May, 1999) p.5.
causal factors may be improperly stored manure. Details of the 1999 PWL listing describe the Titicus River is stressed by nutrient and coliform runoff from improperly stored manure in the subwatershed. These findings are consistent with water quality data collected by the Westchester Land Trust (WLT). The WLT Volunteer Project monitored water quality of the Titicus River subwatershed (including all other minor basins) over a 10-month project in 1997.

- **Crook Brook Basin:** Crook Brook originates in the town of Lewisboro in the Mountain Lakes Camp region and flows past a few homes and through mostly undeveloped open space. According to data collected between 1997 and 1998 by the Westchester Land trust, this tributary proved to have very good water quality, although high coliform counts were detected. A horse trail passes by the area near the sampling sites and may contribute to the elevated coliform levels.

At this time, research did not lead to any water quality analysis for the Crook Brook Basin.

- **Mopus Brook Basin:** The Mopus Brook basin originates in the northeastern corner of North Salem and primarily flows through Connecticut where it joins the Titicus River. Data collected by the WLT as a part of their study on the water quality of the Titicus River Subwatershed found the water quality of Mopus Brook to be good. However, during high water episodes high coliform bacteria counts were found.

### 7.3 Data Summary

Research for this report has concluded that the primary problems associated with the Titicus subwatershed are high phosphorus and unacceptable levels of fecal and total coliform. This conclusion is drawn based on data cited from the following sources:

- *Determination of Unacceptable Water Quality Using the Protocols of the DEC/DEP Memorandum of Agreement; Addendum E New York City Water Supply*, (April, 1998; May, 1999)
- *Kane, Kimberlee, Proposed Phase II Phosphorus TMDL Calculations for Titicus Reservoir* (March, 1999)
- *New York City Department of Environmental Protection, Methodology for Calculating Phase II TMDLs of Phosphorus for New York City Drinking Water Reservoirs* (March, 1999)
- *New York State Department of Environmental Conservation, Phase II Phosphorus Total Maximum Daily Loads for Reservoirs in the New York City Supply Watershed* (June 2000)

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155 Ibid.

SECTION IV: SUBWATERSHED MAPS
This map is for general reference purposes only. Monitoring and point source discharge data was obtained from New York City Department of Environmental Protection (NYCDEP). Point data in Putnam County is for display purposes only, and is not referred to in the Water Quality Report. Geographic locations of monitoring and point source data are subject to verification by NYCDEP.

Map Produced by WCDP: 1/2002

Legend
- SPDES Permits
- Wastewater Treatment Plants
- Limnological Monitoring Sites
- Hydrologic Monitoring Sites
- Biomonitoring Sites
- USGS Monitoring Sites
- Pesticide Application Sites
- Pathogen Monitoring Sites

Area of Interest
- NYSDEC Wetlands
- Major Drainage Basins
- Minor Drainage Basins

Map 4. Amawalk Subwatershed

Andrew J. Spano
Westchester County Executive

Department of Planning
432 Michaelian Office Building
148 Martine Avenue
White Plains, New York
10601
This map is for general reference purposes only. Monitoring and point source discharge data was obtained from New York City Department of Environmental Protection (NYCDEP). Point data in Putnam County is for display purposes only, and is not referred to in the Water Quality Report. Geographic locations of monitoring and point source data are subject to verification by NYCDEP.

Legend:
- SPDES Permits
- Wastewater Treatment Plants
- Limnological Monitoring Sites
- Hydrologic Monitoring Sites
- Biomonitoring Sites
- USGS Monitoring Sites
- Pesticide Application Sites
- Pathogen Monitoring Sites
- Area of Interest
- NYSDEC Wetlands
- Major Drainage Basins
- Minor Drainage Basins

Map Produced by WCDP: 1/2002

Department of Planning
432 Michaelian Office Building
148 Marline Avenue
White Plains, New York
10601

MAP 12. EAST NEW CROTON SUBWATERSHED

Andrew J. Spano
Westchester County Executive
This map is for general reference purposes only. Monitoring and point source discharge data was obtained from New York City Department of Environmental Protection (NYCDEP). Point data in Putnam County is for display purposes only, and is not referred to in the Water Quality Report. Geographic locations of monitoring and point source data are subject to verification by NYCDEP.
This map is for general reference purposes only. Monitoring and point source discharge data was obtained from New York City Department of Environmental Protection (NYCDEP). Point data in Putnam County is for display purposes only, and is not referred to in the Water Quality Report. Geographic locations of monitoring and point source data are subject to verification by NYCDEP.

Legend

+ SPDES Permits
\( \text{\textbullet} \) Wastewater Treatment Plants
\( \text{\textbullet} \) Limnological Monitoring Sites
\( \text{\textbullet} \) Hydrologic Monitoring Sites
\( \text{\textbullet} \) Biomonitoring Sites
\( \text{\textbullet} \) USGS Monitoring Sites
\( \text{\textbullet} \) Pesticide Application Sites
\( \text{\textbullet} \) Pathogen Monitoring Sites

Area of Interest

NYSDCF Wetlands
Major Drainage Basins
Minor Drainage Basins

MAP 9. WEST MUSCOOT SUBWATERSHED

Department of Planning
432 Mianus Avenue
White Plains, New York 10603

Andrew J. Spano
Westchester County Executive

Map Produced by WCDP: 1/2002
This map is for general reference purposes only. Monitoring and point source discharge data was obtained from New York City Department of Environmental Protection (NYCDEP). Point data in Putnam County is for display purposes only, and is not referred to in the Water Quality Report. Geographic locations of monitoring and point source data are subject to verification by NYCDEP.

Legend
- SPDES Permits
- Wastewater Treatment Plants
- Limnological Monitoring Sites
- Hydrologic Monitoring Sites
- Biomonitoring Sites
- USGS Monitoring Sites
- Pesticide Application Sites
- Pathogen Monitoring Sites
- Area of Interest
- NYSDEC Wetlands
- Major Drainage Basins
- Minor Drainage Basins

Map Produced by WCDP: 1/2002

Andrew J. Spano
Westchester County Executive

Department of Planning
402 Michaelian Office Building
148 Martine Avenue
White Plains, New York 10601

1,750 0 1,750 3,500 5,250 7,000
Feet
MAP 7. EAST BRANCH SUBWATERSHED

Legend

- SPDES Permits
- Wastewater Treatment Plants
- Limnological Monitoring Sites
- Hydrologic Monitoring Sites
- Biomonitoring Sites
- USGS Monitoring Sites
- Pesticide Application Sites
- Pathogen Monitoring Sites
- Area of Interest
- NYSDEC Wetlands
- Major Drainage Basins
- Minor Drainage Basins

This map is for general reference purposes only. Monitoring and point source discharge data was obtained from New York City Department of Environmental Protection (NYCDEP). Point data in Putnam County is for display purposes only, and is not referred to in the Water Quality Report. Geographic locations of monitoring and point source data are subject to verification by NYCDEP.

Map Produced by WCDP: 1/2002

Miles

0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5

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SECTION V: REFERENCES
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