Identification of Potential Water-Resources-Monitoring Sites in the Croton Reservoir System, Southeastern New York

By Kristin S. Linsey, Stephen W. Wolcott, and Nancy B. Schoonmaker

U.S. GEOLOGICAL SURVEY
Open-File Report 97-638

Prepared in cooperation with the
New York City Department of
Environmental Protection

USGS
science for a changing world

Albany, New York
1999

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For addtional information write to:

District Chief
U.S. Geological Survey
425 Jordan Road
Troy, New York 12180

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225-0286

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS AND VERTICAL DATUM

For the convenience of readers who prefer metric (International System) units to the inch pound units used in this report, the following conversion factors may be used:

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
acre	0.407	hectare
	Flow	
gallon per minute (gal/min)	0.06309	liter per second
gallon per day (gal/d)	0.003785	cubic meter per day
million gallons per day (Mgal/d)	0.04381	cubic meters per second
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch per year(in/yr)	25.4	millimeter per year

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

IDENTIFICATION OF POTENTIAL WATER-RESOURCES-MONITORING SITES IN THE CROTON RESERVOIR SYSTEM, SOUTHEASTERN NEW YORK

By Kristin S. Linsey, Stephen W. Wolcott, and Nancy B. Schoonmaker

ABSTRACT

Urbanization has led to the deterioration of water quality within the Croton Reservoir system, a 374-square-mile watershed with 12 reservoirs in southeastern New York that supply 10 percent of New York City's water. Water-resources managers need hydrologic data to develop plans to protect and conserve the water resources of this watershed. In 1990, the U.S. Geological Survey in cooperation with New York City Department of Environmental Protection (NYCDEP) began a 2-year program to establish water-resources data-collection sites that, together, would provide managers with the information needed to monitor and evaluate the water resources of the Croton Reservoir System.

Sites for the water-resources monitoring network in the Croton Reservoir system were subjectively selected with the aid of a Geographic Information System (GIS). The site-selection process entailed (1) developing a GIS data base of long-term and current water-resources data, and (2) using the GIS data base to identify potential sites for (A) water sampling and (B) measurement of surface-water flow into and out of selected reservoirs and (C) monitoring ground-water levels. Use of a GIS to store the data collected for this study aided in the analysis of the data during the site-selection process and could be used in a similar manner to establish water-resources-monitoring networks in other watersheds.

The data base that was developed in this study contains 13 GIS coverages and 2 related tables. Data were obtained from the NYCDEP, the New York State Department of Environmental Conservation, and the U.S. Geological Survey (USGS) National Water Information System (NWIS) data bases. The scale of the source maps ranged from 1:24,000 to 1:250,000.

Three groups of potential monitoring sites were identified: (1) reservoir-outflow-monitoring sites, (2) reservoir-inflow-monitoring sites, and (3) ground-water-monitoring areas. Eight reservoir-outflow-monitoring sites were identified to obtain discharge and water-quality data for eight of the twelve reservoirs within the system and nine reservoir-inflow-monitoring sites were selected to provide data on streamflow characteristics and chemical quality of water flowing into these reservoirs. Sixteen ground-water monitoring areas were selected to provide an overview of ground-water levels and chemical quality of ground water in the Croton reservoir system.

INTRODUCTION

Urbanization and changes in land use can alter the quality and quantity of water that flows from a given watershed. Expanding urbanization in the 374-mi2 Croton River basin (fig. 1) in southeastern New York has led to the deterioration of water quality in the Croton Reservoir system, which is managed by the City of New York and supplies 10 percent of the City's water, but could supply as much as 25 percent during periods of drought (Goldin, 1989). The water does not require filtration at present, but if current trends in population growth (fig. 2) and in water-quality deterioration continue, filtration and other costly types of treatment may be required. Water-resources managers need data on reservoir storage, streamflow, ground-water levels, and the chemical quality of ground water and surface water to monitor these resources and to develop plans to protect and conserve them.

In 1990, the U.S. Geological Survey (USGS), in cooperation with the New York City Department of Environmental Protection (NYCDEP), began a 2-year study to identify appropriate data-collection sites for monitoring the water resources of the Croton Reservoir system. This water-resources monitoring network would consist of three categories of sites—reservoir-outflow-measurement sites, reservoir-inflow-measurement sites, and ground-water-monitoring areas. Water-quality data would be collected at all sites in each of the three categories.

The main objective of the study was to subjectively establish the optimum number and location of sites needed to adequately monitor streamflow, ground-water levels, and chemical quality of surface water and ground water in the basin. Other objectives were to document the approach used for site selection and to develop data bases, through Geographical Information System (GIS) technology, for use during the study and in the future. The type of GIS data bases developed in this study could be used to help establish water-resources-monitoring networks in other watersheds. A total of 13 GIS coverages and 2 data tables were developed.

Purpose and Scope

This report describes (1) the categories of data that were collected, (2) which types of data from each category were used in the subjective site selection, and (3) the potential sites that were selected as appropriate for the water-resources monitoring network. Selected data that were compiled during this study are depicted on 10 maps that were generated with a GIS. The appendix summarizes the type and sources of data, the map scale, and the procedures used in the development of the 13 coverages and the 2 related data tables for this study.

Approach

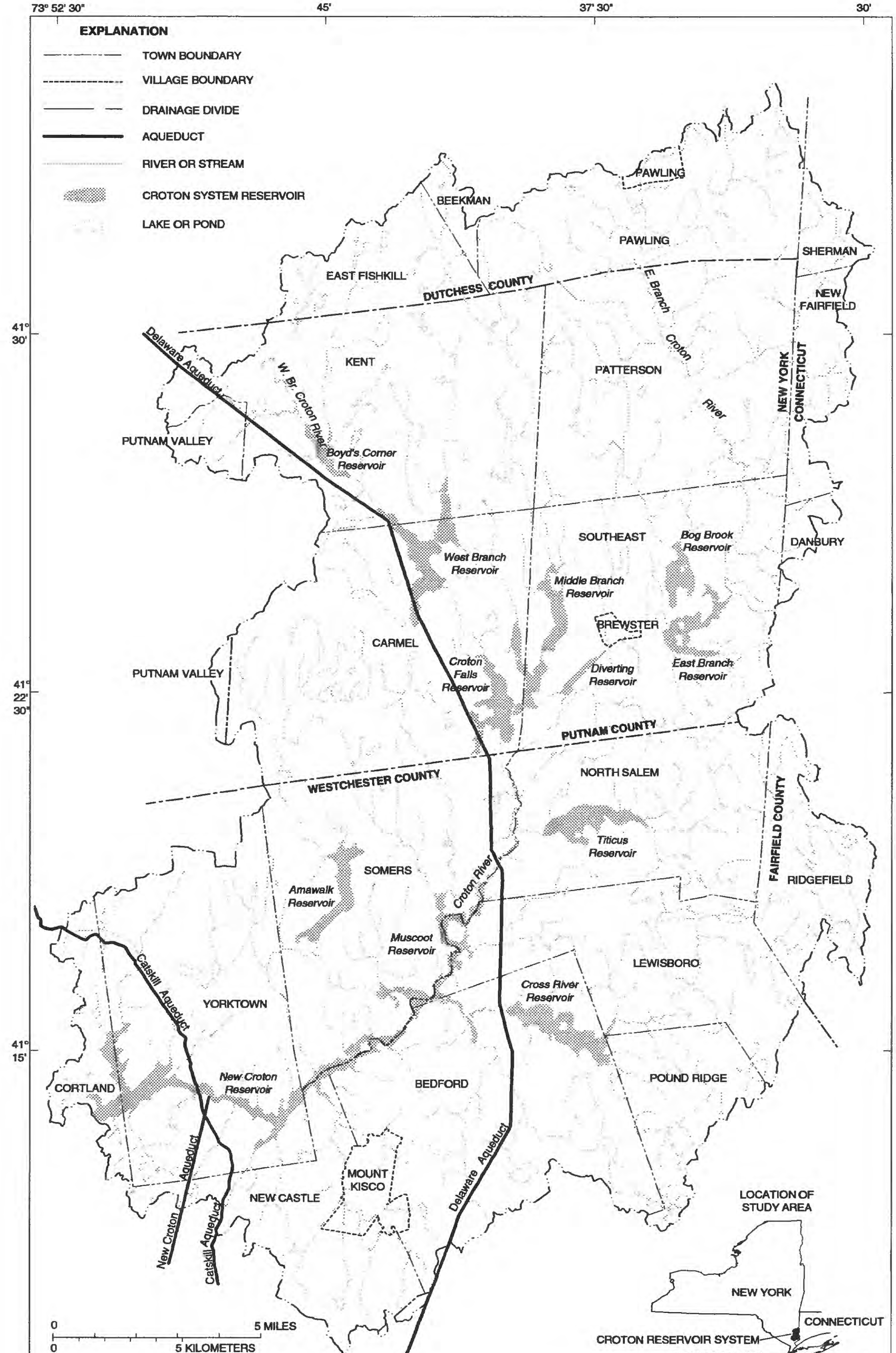
Development of plans to protect and conserve the water resources of the Croton Reservoir system will require a variety of hydrologic data, including lake or reservoir outflows and inflows, ground-water levels, and chemical quality of surface water and ground water within the basin. Reservoir-outflow and -inflow data enable monitoring of changes in the reservoir storage and detection of changes in the chemical quality of their water. Ground-water data allow calculation of the availability and quality of ground water that contributes to baseflow throughout the watershed. Thus the data-collection sites would be selected in locations that would provide those types of data; sites also would be selected in areas that represent unique characteristics related to land use or bedrock geology, or with characteristics that are similar to those in other parts of the watershed, so information would be transferable to those areas.

The study was conducted in two stages. The first stage entailed collection of long-term and current data on population, bedrock and surficial geology, streamflow, ground-water levels, chemical quality of surface water and ground water, and land use. Sources of data included the New York City Department of Environmental Protection, the New York State Department of Environmental Conservation (NYSDEC), county agencies, and U.S. Geological Survey National Water Information System (NWIS) data bases. The scale of the maps from which data were collected ranged from 1:24,000 to 1:250,000. The data were incorporated into a GIS data base; similar types of data were merged into a single data set or table.

The second stage of the study entailed using the GIS data bases to subjectively identify potential data-collection sites for the water-resource-monitoring network. The primary sources of data that were used to help select reservoir-outflow sites included the locations of dams maintained by New York City, subbasin drainage boundaries, and surface-water diversions. The reservoir-inflow sites were selected from data bases showing subbasin drainage boundaries and the land-use practices within the study area, and the ground-water-monitoring areas were selected from the previously determined reservoir-inflow subbasin drainage boundaries and from surficial and bedrock geologic maps.

Acknowledgments

The NYCDEP provided water-quality data, reservoir-stage data, and diversions into and out of the Croton Reservoir system. The authors thank Eliot Schneiderman of the NYCDEP and Sam Wear of the Westchester County Planning Department for providing land-use data for significant parts of the study area.



Base from U.S. Geological Survey digital data, 1:100,000, 1983

Figure 1. Location and major geographic features of the Croton Reservoir system

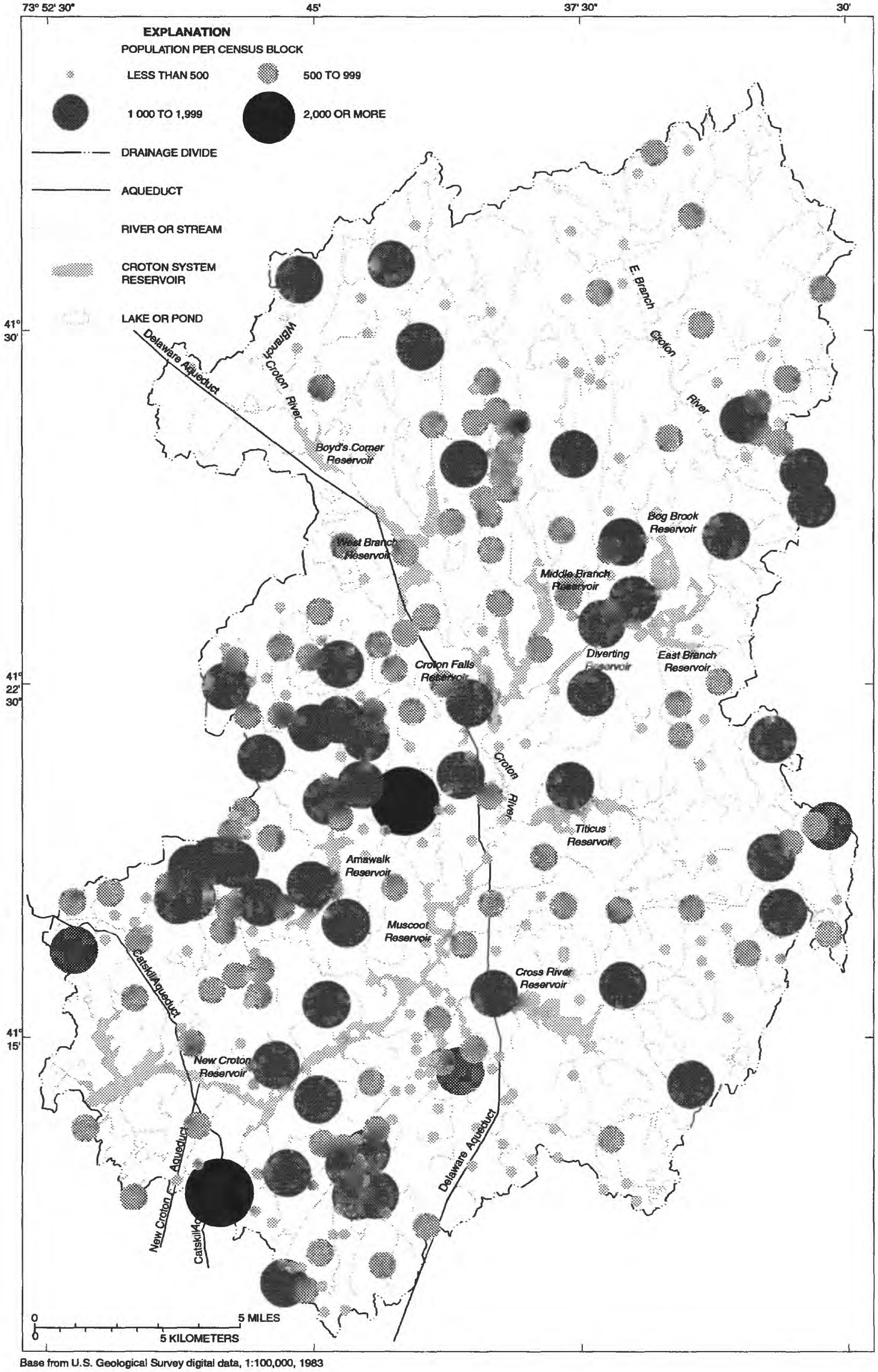


Figure 2. 1990 population within the Croton Reservoir system by census block. (Boundaries of census blocks not shown) (Data from U.S. Department of Comerce, 1990)

SITE SELECTION

The process of identifying potential water-resources-monitoring sites began with the collection of water-resources information on past and present monitoring sites for water-quality sampling and other data such as population and land-use. The results of the data were organized and compiled into data sets, which were used to subjectively identify potential monitoring sites. The objective of final site selection was to adequately represent the water resources of the Croton Reservoir system with an optimum number of sites.

The following sections describe (1) the sources from which site-selection data were obtained, and (2) the process used to identify sites that are potentially suitable for the monitoring network.

Data-Base Development

Water-resources data from USGS and NYCDEP data bases were developed into GIS data sets and(or) compilations of data through the ARC/INFO[1] GIS, and each GIS data set or data compilation was categorized into as one of four types—general information, surface-water data, ground-water data, or water-quality data.

The GIS data base consists of a set of data "layers" or "coverages" that can be displayed as a map representing a specific category of data for a given geographic area. All data stored in a coverage are categorized as points, lines (arcs), or polygons. For example, well locations are represented as points, roads as arcs, and areas with a predominant land use as polygons. Coverages can be easily compared or overlain to identify intersections of spatial or point data, as was done to subjectively identify locations potentially suitable for monitoring sites. Additionally, the coverages can be combined to create maps that depict the contents (or partial contents) of the coverages. All maps in this report were created in this manner from the coverages developed in this study, but not all coverages developed for this study were used in production of these maps.

The following sections describe how the GIS coverages used to make the maps in this report were developed. Site names, locations, and types of data collected are listed in tables 1 through 7. Descriptions of all 13 GIS coverages and the two related data compilations are given in the appendix, which includes the type of coverage or data compilation, the map scale and the source of data, and the procedures used in development of each coverage or data array.

General-Use Data

The general-use data category refers to three data sets—hydrography, roads, and population.

Hydrography (fig. 1).—This data set represents the major surface-water features in the Croton Reservoir system—rivers, streams, aqueducts, reservoirs, and lakes. The major rivers are the Croton River, with its West, Middle, and East Branches, and the Muscoot River, the Titicus River, the Cross River, and the Kisco River (the four smaller tributaries to the Croton River). The 12 reservoirs in the study area, all of which supply water to New York City, are: Boyd's Corner (the smallest), West Branch, Middle Branch, East Branch, Bog Brook, Diverting, Croton Falls, Titicus, Cross River, Amawalk, Muscoot, and New Croton (the largest). The study area contains three aqueducts—the Catskill Aqueduct (which originates west of the study area, and although it has a connection at the New Croton Reservoir, its water usually bypasses the Croton watershed); the Delaware Aqueduct (which also originates west of the study area, and has connections to the northwest and southern ends of the West Branch Reservoir and to the Cross River Reservoir); and the New Croton Aqueduct (which originates within the study area at the New Croton Reservoir and is the primary source of water release for the Croton Basin). The hydrography coverage was developed from 1:100,000-scale digital line graphs (DLG) obtained from the USGS. It was then enhanced by digitizing smaller streams from 1:24,000-scale USGS topographic maps. A wetland area is represented by a line through the center of the wetland area rather than by the boundary of the wetland area.

Roads (fig. 1).—This coverage includes the transportation routes in the study area, from all major highways to most town roads and streets. The major highways in the study area are Interstate 84 in the northeastern part of the study area, the Taconic State Parkway in the western part, Interstate 684 (which intersects Interstate 84 in the northeast and runs south toward New York City), and the Sawmill River Parkway (which runs northeast to southwest and connects Interstate 684 with

[1]The use of trade or product names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

the Taconic State Parkway). This data set was developed from Digital Line Graphs (DLGs) (scale 1:100,000) obtained from the USGS. The linework from the DLGs was enhanced by including smaller roads from 1:24,000-scale planimetric maps provided by the New York State Department of Transportation.

Population (fig. 2).—This coverage represents the 1990 population distribution within the Croton Reservoir system. The study area had a population of 175,708 in 1990 (U.S. Department of Commerce, 1990). The largest concentrations are along the major transportation routes—south and east of the New Croton Reservoir (along Interstate 684 and the Sawmill River Parkway), around the Amawalk Reservoir (along the Taconic Parkway), and between the Middle Branch and Bog Brook Reservoirs (along Interstate 84). The population map (fig. 2) was derived from data of the 1990 Census of Population and Housing (U.S. Department of Commerce, 1990) for the conterminous United States. Each point in this map represents the approximate geographical center of a "census block group;" a census block group is the next to smallest geographic area in the Bureau of the Census hierarchy of geographic presentation. Data for each census block include the total number of persons and housing units.

Surface-Water Data

The surface-water data include four data sets—basins, dams, surface-water diversions (deliveries and withdrawals), and surface-water gages.

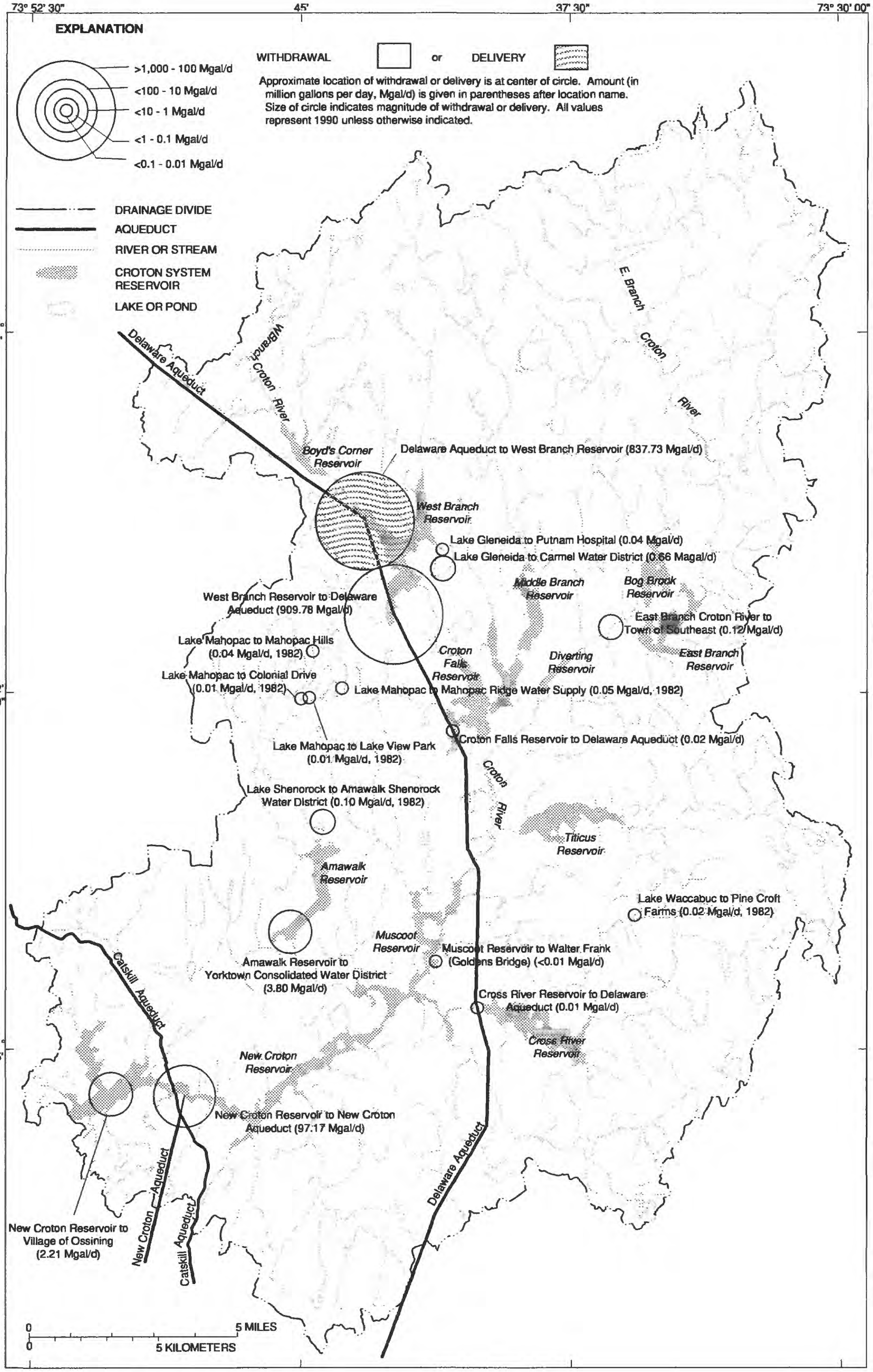
Basins (fig. 4).—This coverage includes the outline of the 374 mi^2 drainage basin and the boundaries of its 229 subbasins. The USGS drainage-area compilation for New York (Wagner, 1982) is continually updated, and, as part of this process, GIS coverages are being developed that contain the boundaries of all drainage basins and subbasins in New York. These boundaries are delineated by the USGS and checked by the Natural Resources Conservation Service.

Dams (Fig. 4).—This category contains information on dams on the streams and reservoirs in the Croton Reservoir system and includes the name of the owner of the dam and the body of water impounded by the dam (fig. 4). The information was obtained from a list of dams (July 1983) provided by NYSDEC from their Dam Safety Project data base. The study area contains 17 dams that are owned by New York City (these impound water in the 12 reservoirs in the study area) and 84 dams that are privately owned.

Deliveries and withdrawals.—This data compilation represents all deliveries and withdrawals from the Croton Reservoir system. The data, provided by the NYCDEP, included the losing or receiving body of water, the amount of water diverted, and the agency responsible for the diversion. Locations and amounts of 1990 deliveries and withdrawals are plotted in figure 3. The primary diversion (837.73 Mgal/d in 1990) into the Croton Reservoir system is from the Delaware Aqueduct into the northwestern end of the West Branch Reservoir (fig. 3); this water is generally diverted from the southern end of the West Branch Reservoir (909.78 Mgal/d in 1990), where it is pumped into the next section of the Delaware Aqueduct. Diversions in the Croton Reservoir system include withdrawals by municipal and private water suppliers (ranging from less than 0.01 Mgal/d to 3.80 Mgal/d in 1990) and the diversion from the New Croton Reservoir to the New Croton Aqueduct (97.17 Mgal/d in 1990).

Surface-water gages (fig. 4, table 1).—This coverage includes information on past and present USGS surface-water data-collection sites. The USGS currently has one active streamflow-gaging station in the study area—Croton River at New Croton Dam near Croton-on-Hudson (site 01375000, site 1 in fig. 4), which reported an annual average discharge of 680 ft^3/s for calendar year 1990. Historical streamflow data from two discontinued USGS gages were available—Croton River at Old Croton Dam near Croton Heights (site 01374990, site 3 in fig. 4), and Bird Brook near Croton (site 01375500, site 2 in fig. 4). The USGS has also measured streamflow at 78 other locations (including low-flow sites, peak-flow sites, crest-stage gages, and miscellaneous-measurement sites) within the study area. The NYCDEP collects reservoir-stage data on each of the 12 reservoirs in the Croton Reservoir system.

Data on surface-water data-collection sites were obtained from USGS data bases and publications. Active and inactive USGS streamflow-measurement locations were obtained through a retrieval from the USGS National Water Information System (NWIS) data base and from USGS publications. The GIS data sets were then created from the location data obtained from these sources. Information in this data set includes the name of each site, USGS station number, type of data collected, drainage area, number of measurements made during the period of record, and the period of record.



Base from U.S. Geological Survey digital data, 1:100,000, 1983

Figure 3. Annual 1990 withdrawal and delivery of surface water in the Croton Reservoir system

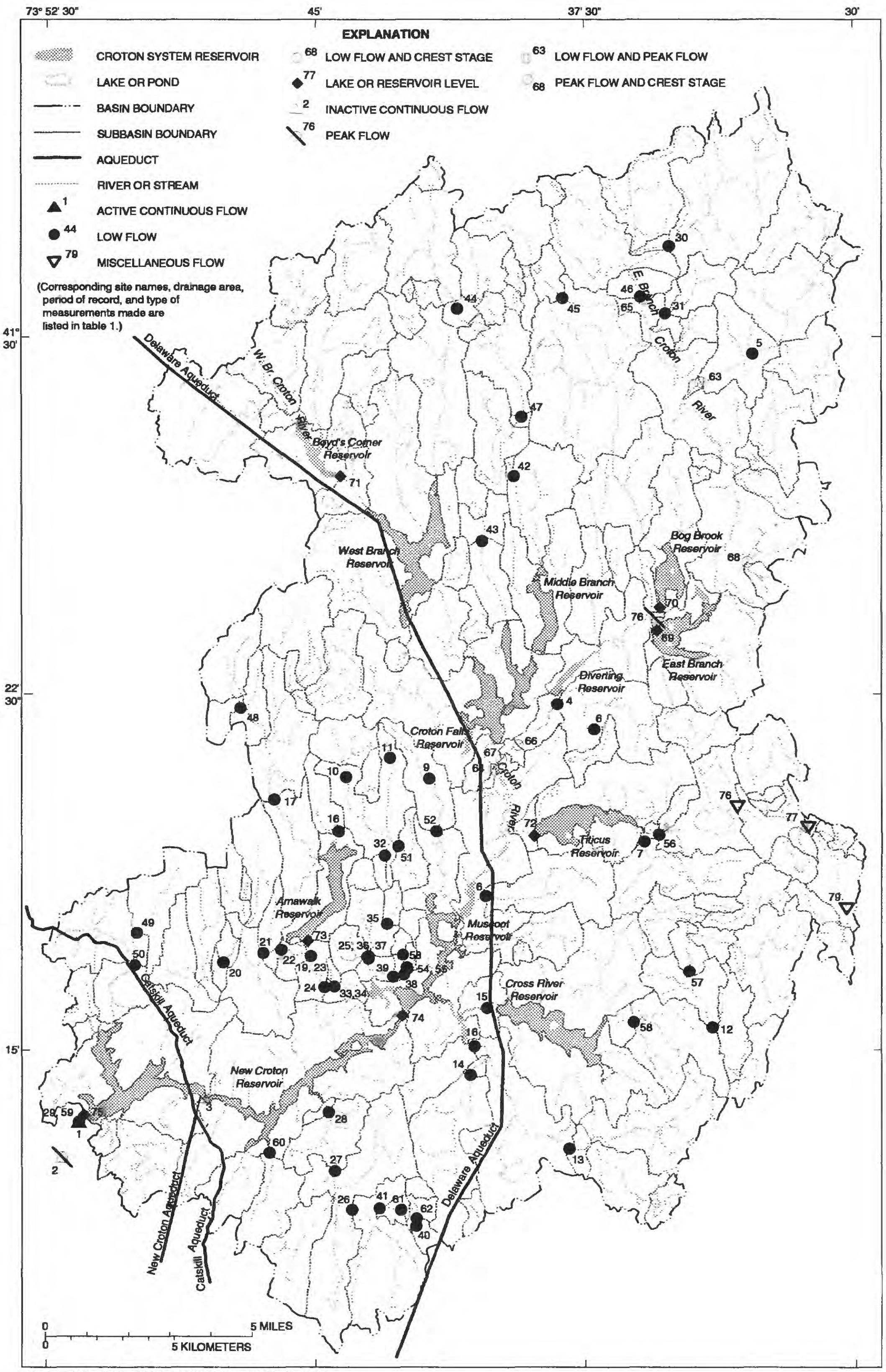


Figure 4. Drainage divides and surface-water flow, stage, or level sites established by the U.S. Geological Survey within the Croton Reservoir system

Table 1. Types of data collected at surface-water data-collection sites.

[Locations are shown in fig. 4. — indicates data undetermined or not applicable; LF = low flow,* PF = peak flow,† CS = crest stage,‡ LK = lake, MS = miscellaneous measurement, ASF = active continuous streamflow, ISF = inactive continuous streamflow.]

No. on Fig. 4	Site identification number	Site name	Type of mea-sure-ment	Drain-age area	No. of meas. for period	Period of record
1	0137500000	Croton River at New Croton Dam nr Croton-on-Hudson	ASF	378	758	7/33 to present
2	0137550000	Bird Brook near Croton-on-Hudson	PF,ISF	0.40	—	—
3	0137499000	Croton River at Old Croton Dam near Croton Heights	ISF	—	—	—
4	0137453500	Holly Stream near Salem Center	LF	—	1	08/15/74
5	—	Haviland Hollow Brook near Haviland Hollow	LF	10.10	2	03/25/54-09/29/54
6	0137454000	Holly Stream near Brewster	LF	4.82	8	07/10/62-09/28/73
7	0137478800	Crook Brook at Salem Center	LF	3.88	1	08/05/76
8	0137483000	Croton River Tributary at Goldens Bridge	LF	3.62	1	08/05/76
9	—	Watermelon Creek near Lincolndale	LF	1.06	1	03/24/54
10	—	Plum Brook at Lake Lincolndale	LF	1.67	2	03/24/54-09/29/54
11	—	Plum Brook Tributary at Lake Lincolndale	LF	0.27	2	03/24/54-09/29/54
12	0137488000	Waccabuc River at Boutonville	LF	10.62	2	07/07/76-08/04/76
13	0137490800	Stone Hill River at Bedford	LF	7.55	3	07/07/76-11/16/76
14	0137491500	Broad Brook at Bedford Hills	LF	5.11	1	08/15/74
15	0137491700	Broad Brook at Katonah	LF	5.30	1	08/05/76
16	0137491900	Stone Hill River at Katonah	LF	19.60	3	07/06/76-11/16/76
17	0137493000	Muscoot River at Baldwin Place	LF	13.50	5	03/24/54-11/16/76
18	0137493700	Lake Shenorock Outlet at Shenorock	LF	1.08	1	08/04/76
19	0137494200	Muscoot River at Amawalk	LF	19.90	3	07/06/76-07/21/76
20	0137494800	Crum Pond Outlet at Yorktown Heights	LF	3.88	1	08/04/76
21	0137496000	Hallocks Mill Brook at Yorktown	LF	10.40	3	07/06/76-07/21/76
22	0137496300	Hallocks Mill Brook at Amawalk	LF	11.40	2	07/19/76-07/21/76
23	0137496500	Hallocks Mill Brook at Mouth at Amawalk	LF	11.90	3	07/06/76-07/20/76
24	0137497000	Muscoot River near Amawalk	LF	32.60	3	07/06/76-07/21/76
25	0137497600	Angle Fly Brook at Whitehall Corners	LF	3.01	1	08/04/76
26	0137498300	Kisco River at Lexington Ave. at Mount Kisco	LF	6.06	4	08/16/74-11/16/76
27	0137498500	Kisco River at Mount Kisco	LF	—	1	08/16/74
28	0137498700	Kisco River Below Mount Kisco	LF	17.60	4	08/16/74-11/16/76
29	—	Croton River Tributary near Croton-on-Hudson	LF	—	1	03/18/63
30	0137448800	Brady Brook near Pawling	LF	7.80	1	07/27/77
31	0137449100	Stephens Brook near Patterson	LF	1.45	1	07/27/77
32	0137485900	Plum Brook Tributary at Lincolndale	LF	0.25	2	10/06/87-11/16/87
33	0137497010	Muscoot River Tributary near Whitehall Corners	LF	0.16	2	10/09/87-11/16/87
34	0137497100	Angle Fly Brook at Lincolndale	LF	0.41	2	10/09/87-11/17/87
35	0137497200	Angle Fly Brook Tributary 2 at Lincolndale	LF	0.46	2	10/09/87-11/16/87
36	0137497400	Angle Fly Brook near Whitehall Corners	LF	2.17	2	10/09/87-11/16/87
37	0137497500	Angle Fly Brook Tributary 3 at Whitehall Corners	LF	0.84	2	10/09/87-11/16/87
38	0137497690	Angle Fly Brook Trib. at Site 4 near Katonah	LF	0.41	1	10/21/86
39	0137497700	Angle Fly Brook Trib. at Site 5 near Katonah	LF	0.56	3	10/21/86-11/16/87
40	0137498200	Kisco River at Site 1 near Mount Kisco	LF	0.35	1	10/22/86
41	0137498260	Kisco River at Site 5 at Mount Kisco	LF	1.42	1	10/22/86
42	0137465200	Middle Branch Croton River at Lake Carmel	LF	13.10	—	—

Table 1. (continued) Types of data collected at surface-water data-collection sites.

No. on Fig. 4	Site identification number	Site name	Type of measurement	Drainage area	No. of meas. for period	Period of record
43	0137467000	Michael Brook at Carmel	LF	1.72	—	—
44	0137464000	Stump Pond Stream at Ludingtonville	LF	5.33	2	03/25/54-09/29/54
45	—	Croton River Tributary, East Branch, at West Patterson	LF	3.85	2	03/25/54-09/29/54
46	0137448900	East Branch Croton River at Akins Corners	LF	17.30	1	07/27/78
47	0137464500	Stump Pond Stream at Kent Corners	LF	10.30	17	02/21/75-08/19/80
48	0137492700	Secor Brook at West Mahopac	LF	2.65	—	—
49	0137499200	Hunter Brook near Yorktown	LF	2.49	1	08/04/76
50	0137499300	Hunter Brook Below Mill Pond near Yorktown	LF	5.82	3	07/06/76-11/16/76
51	0137486000	Plum Brook at Lincolndale	LF	5.81	1	08/05/76
52	0137484000	Muscoot Reservoir Tributary at Somers	LF	2.14	1	08/05/76
53	0137497650	Angle Fly Brook Trib. at Site 1 near Katonah	LF	0.20	3	10/21/86-11/16/87
54	0137497670	Angle Fly Brook Trib. at Site 2 near Katonah	LF	0.35	1	10/21/86
55	0137497680	Angle Fly Brook Trib. at Site 3 near Katonah	LF	0.38	1	10/21/86
56	0137478000	Titicus River at Salem Center	LF	12.40	4	08/15/74-11/16/76
57	0137487500	Waccabuc River near South Salem	LF	—	—	—
58	0137489000	Cross River near Cross River	LF	17.10	4	08/15/74-11/16/76
59	—	Croton River Tributary No. 2 near Croton-on-Hudson	LF	—	1	03/18/63
60	0137498800	Gedney Brook near Mount Kisco	LF	2.01	1	08/04/76
61	0137498250	Kisco River at Site 4 near Mount Kisco	LF	1.16	1	10/22/86
62	0137498210	Kisco River at Site 2 near Mount Kisco	LF	0.38	1	10/22/86
63	0137449400	Haviland Hollow Brook near Putnam Lake	LF,PF	12.20	12	07/10/62-04/10/80
64	0137470500	West Branch Croton River at Croton Falls	LF,PF	54.30	1	08/05/76
65	0137449000	East Branch Croton River at Patterson	LF,PF	17.60	2	03/25/54-09/29/54
66	0137454500	East Branch Croton River at Croton Falls	LF,CS	119.00	1	08/05/76
67	0137454550	East Branch Croton River at Croton Falls	LF,CS	—	1	03/24/54
68	0137449490	East Branch Croton River Trib. near Deforest Corners	PF,CS	0.61	3	01/09/78-04/10/80
69	0137449500	East Branch Croton Reservoir at Sodom	LK	—	—	—
70	0137450000	Bog Brook Reservoir at Sodom	LK	—	—	—
71	0137458000	Boyd Corners Reservoir near Clear Pool Camp	LK	—	—	—
72	0137482000	Titicus Reservoir at Purdy Station	LK	—	—	—
73	0137494000	Muscoot River (Amawalk Res) at Dam at Amawalk	LK	—	—	—
74	0137498000	Croton River at Muscoot Reservoir Dam at Katonah	LK	—	—	—
75	0137490500	New Croton Reservoir near Croton-on-Hudson	LK	—	—	—
76	0137449600	East Branch Croton River near Brewster	PF	79.50	—	—
77	—	Titicus R. Below Lake Naraneka	MS	—	—	—
78	—	Titicus River nr North Salem	MS	—	—	—
79	—	Titicus River nr Ridgefield	MS	—	—	—

*Low flow, LF, is a site where instantaneous discharge measurements have been made during a low flow period.

†Peak flow, PF, is a site where instantaneous or continuous discharges have been measured or determined during a peak flow period.

‡Crest stage, CS, is a site where peak stage is measured during a peak flow period and may or may not have a calculated discharge associated with the peak stage.

Ground-Water Data

Four data sets were developed for the ground-water data category—surficial geology (fig. 5A), bedrock geology (fig. 5B), selected potentially high-yielding wells, and ground-water withdrawal sites for public water supply.

Surficial and bedrock geology (figs. 5A, 5B).—These data sets represent the boundaries of the surficial deposits and the bedrock formations; the boundary data were digitized from bedrock and surficial geology maps obtained from the New York State Geological Survey (Cadwell and others, 1986; Fisher and others, 1970). The surficial material in the study area consists primarily of till. Recent deposits and(or) stratified drift are present in many streams valleys, but only the most extensive deposits are shown in figure 5A. Recent deposits include swamp deposits or alluvium and outwash sand and gravel. Most wells finished in stratified drift are generally more productive than wells finished in other surficial withdrawals. The five most common types of bedrock in the study area are the Biotite-quartz-plagioclase-gneiss (bqpc), the Inwood marble (OEi), the Manhattan schist (Om), the Fordham gneiss (f), and the Amphibolite (am) units.

Potential sites for high-yielding wells (figs. 5A, 5B).—The ground-water data coverage (figures 5A and 5B) represents ground-water withdrawal sites within the study area. Figure 5A represents 30 wells screened in surficial aquifers, and figure 5B represents 102 wells finished in bedrock aquifers. The largest yield from a surficial aquifer (#93, Westchester 1063, near Cross River Reservoir) was 600 gal/min, and the largest yield for a bedrock well (#24, Westchester 2048 near Croton Falls Reservoir) was 235 gal/min. The data base includes the rate of water withdrawn at each site, site-identification numbers, and source aquifers (table 2). These data were obtained from the USGS NWIS data base and represents all wells in the study area that had a reported yield of at least 50 gal/min.

Ground-water-withdrawal sites for public water supply (figs. 5A, 5B).—This data base includes the amount of ground water withdrawn at each site, the population served, and well-identification numbers (table 2). A retrieval of public-water-supply ground-water withdrawal sites was made from the USGS NWIS data base; the data for this data set originally came from the New York State Department of Health and represent the year 1981. The largest amount of water withdrawn from a ground-water source by a public water supplier in the study area was 459 gal/min by Bedford Consolidated (#61); the smallest amount withdrawn was 0.69 gal/min by Spring Knoll Estates (#5).

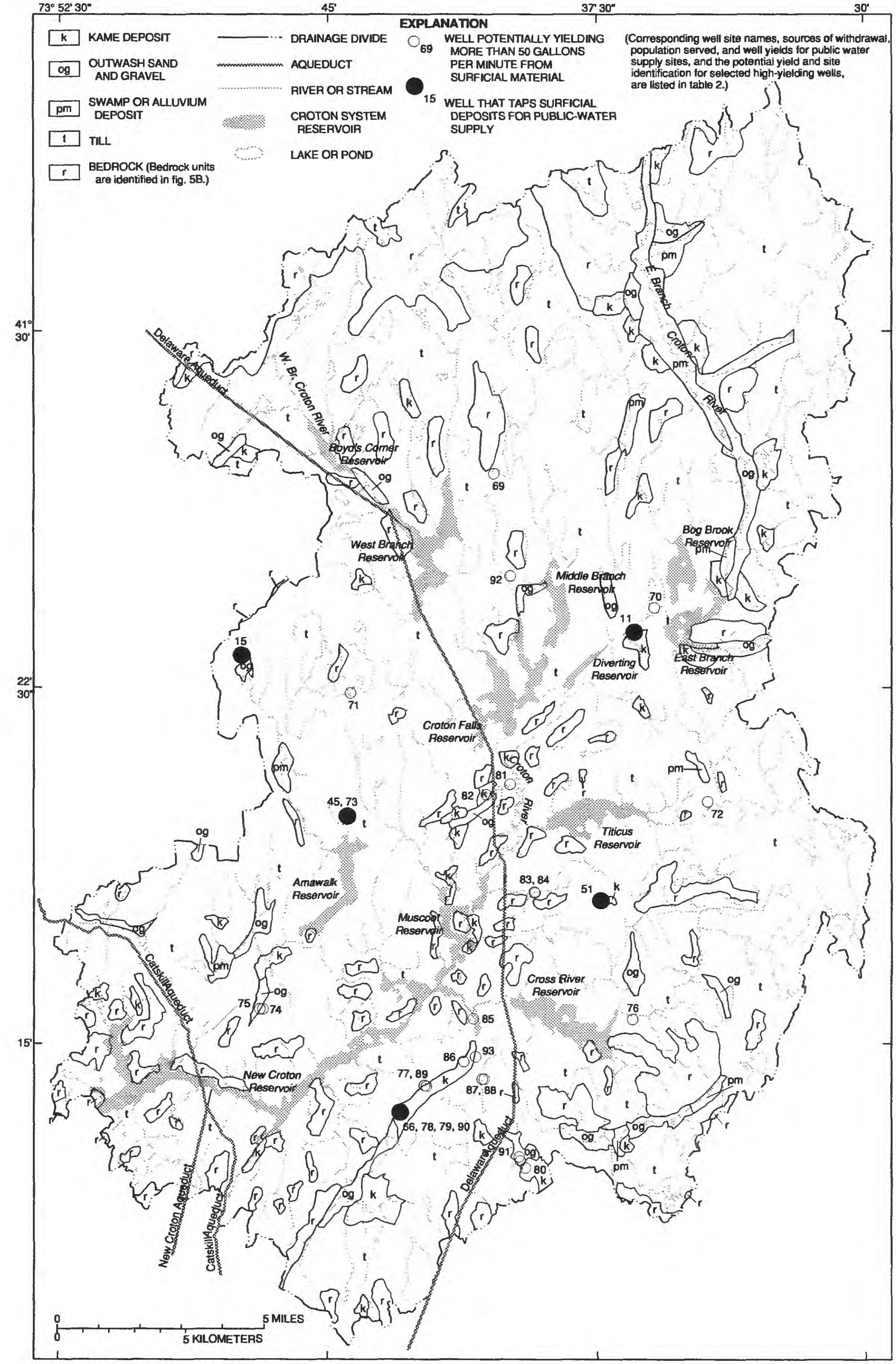
Water-Quality Data

The water-quality data category contains two data sets—water-quality data-collection sites and land use; also included is a data compilation listing sites that may be point sources of pollution.

Water-quality data collection sites.—This coverage contains information on the locations of past and present USGS and NYCDEP water-quality sites within the study area (fig. 6) and includes the identification number, site name, type of site, period of record, and which chemical analyses were completed on samples from each site. These data are listed in table 3. The USGS had made water-quality measurements at 42 surface-water sites, 53 ground-water sites, and 19 lake or reservoir sites in this study area before this study began (1990). The NYCDEP currently collects water-quality data at 45 sites on reservoirs, 23 sites on streams or rivers, and at 1 aqueduct.

Data on water-quality data collection sites were obtained from USGS NWIS databases and from the NYCDEP. A retrieval was made from the USGS NWIS Water-Quality Database to identify all USGS data-collection sites (ground water or surface water) in the study area at which water samples had been previously collected for analysis; information on these sites included the site name, the type of site (ground water, surface water, or lake/reservoir), the latitude and longitude, number of samples collected and analyzed, the range of dates of sample collection (samples were collected as early as 1964), and the physical, chemical, and biological constituents for which each sample was analyzed. Also included in the water-quality data-collection site coverage are the locations of surface-water sites run by the NYCDEP at which water samples have been collected for chemical analysis. The NYCDEP provided maps showing locations of the sampling sites and tables containing the following information on each site: type of site (reservoir, stream, aqueduct), number of samples collected, frequency of sample collection, period(s) during which samples were collected, and the physical, chemical, and biological constituents for which the samples were analyzed.

Land use.—The land-use coverage represents the major land-use practices in the study area. Land-



Base from U.S. Geological Survey digital data, 1:100,000, 1983

Figure 5A. Surficial geology and location of public-supply wells and wells yielding at least 50 gallons per minute from surficial deposits within the Croton Reservoir system.

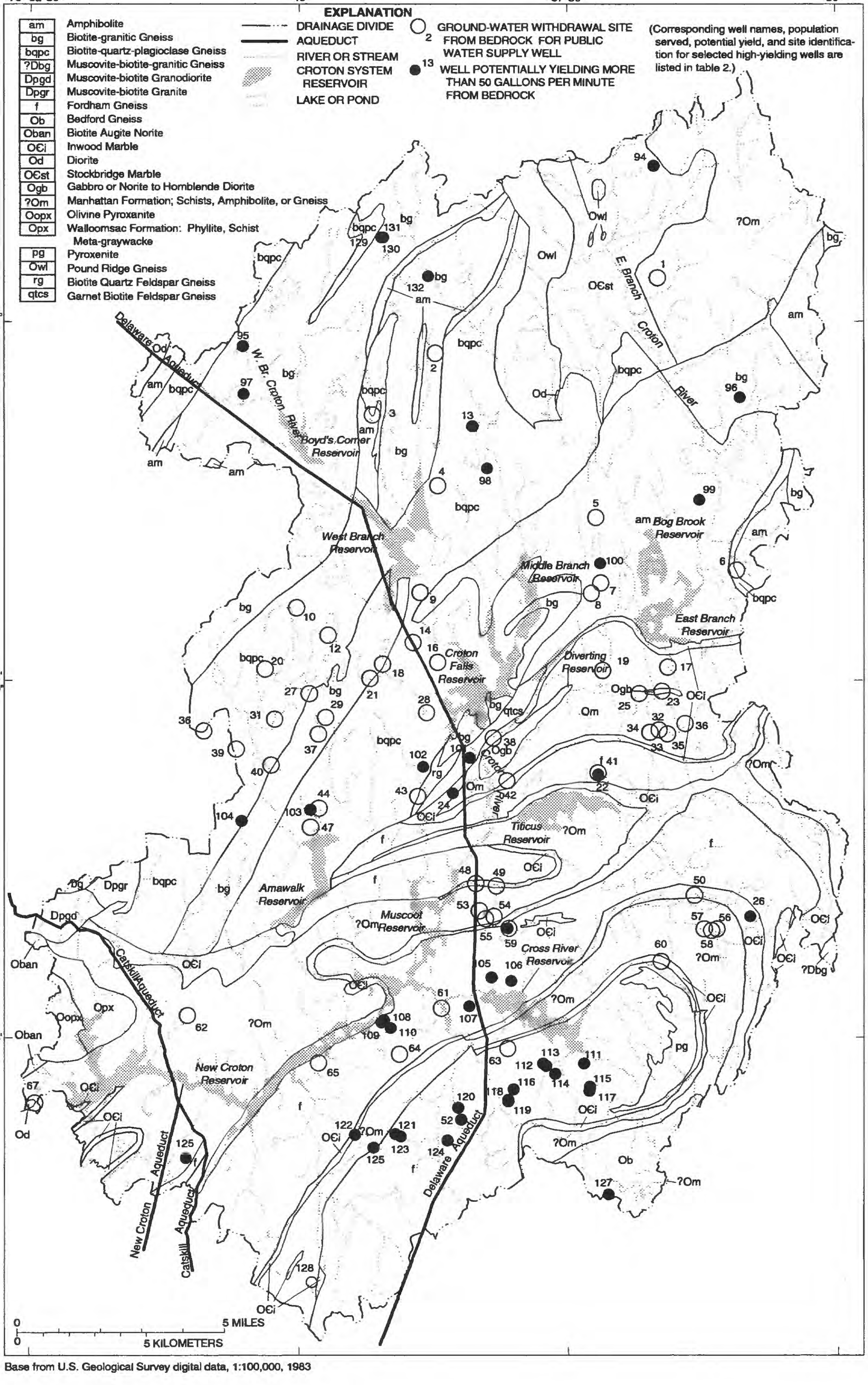


Figure 5B. Bedrock geology and location of public-supply wells finished in bedrock and wells yielding at least 50 gallons per minute from bedrock within the Croton Reservoir system.

Table 2. Data on ground-water withdrawal sites for public water supply and selected high-yielding wells
[Well locations are shown in figs. 5A and 5B. Dash indicates not applicable.]

Well no. in figs. 5A or 5B	Site-identification number	Site name	Aquifer (B, bed-rock; S, surficial deposit)	Popula-tion served	Reported rate of ground-water withdrawal (gal/min)	Potential rate of ground-water withdrawal (gal/min)
1	413055073345901	Alpine Village	B	340	17	—
2	412920073411301	Leeside Estates	B	256	18	—
3	412803073425901	Gypsy Trail Club	B	300	14	—
4	412634073410901	Kent Wd. No. 1	B	360	26	—
5	412554073364301	Spring Knoll Estates	B	20	0.69	—
6	412447073324901	Wildwood Homes	B	148	2.8	—
7	412431073363501	Blackberry Hill	B	400	28	—
8	412418073365101	First Brewster Corp.	B	255	31	—
9	412419073413901	West Branch Acres	B	240	20	—
10	412400073450501	London Bridge Water Works	B	288	14	—
11	412340073362701	Brewster Village	S	3,200	210	—
12	412326073441301	Mahopac Lake Shore Estates	B	80	6.1	—
13	412749073401101	Putnam 1083	B	—	—	150
14	412317073415101	Carmel Wd. No. 7-Tomahawk C	B	68	5.6	—
15	412311073472401	Crescent Road Water Supply	S	20	1.7	—
16	412252073410901	Country Hill Estates	B	200	14	—
17	412246073344301	Fox Hill Estates	B	128	2.6	—
18	412250073424201	Carmel Wd. No 6-Shell Valy	B	324	18	—
19	412242073363201	George Walsh	B	48	3.3	—
20	412244073455801	Red Mills Water Supply	B	400	28	—
21	412232073430301	Capri Estates	B	140	9.7	—
22	412038073364101	Westchester 461	B	—	100	—
23	412216073345301	Vails Grove	B	510	16	—
24	412007073404401	Westchester 2048	B	—	235	—
25	412213073353101	Star Ridge Manor	B	368	3.5	—
26	411733073322701	R 4	B	—	220	—
27	412213073444401	Indian Hill	B	56	2.6	—
28	412149073412801	Union Valley Estates	B	290	20	—
29	412143073441701	Mahopac Water Co.	B	500	42	—
30	412135073341501	Pietschs Gardens	B	250	8.3	—
31	412141073454201	Carmel Wd. No. 5-maple Terr	B	180	12	—
32	412127073345801	Bloomerside Realty Inc.	B	100	3.5	—
33	412129073350301	Bloomerside Realty Inc.	B	100	3.5	—
34	412124073351301	Bloomerside Realty Inc.	B	100	3.5	—
35	412122073344401	Pabst Water Co. Inc.	B	260	6.7	—
36	412126073474001	Wood Hill Estates	B	100	4.2	—
37	412122073442901	Chateau Ridge	B	300	21	—
38	412117073393701	Juengstville Farm Assoc.	B	50	3.5	—
39	412103073464601	Boniville Water Co.	B	360	27	—
40	412043073454801	Carmel Wd. No. 4-Baldwin WC	B	1,600	17	—
41	412033073364001	Salem Acres Association	B	154	10	—
42	412023073391401	Sunset Ridge Wd.	B	600	28	—

Table 2. (Continued) Data on ground-water withdrawal sites for public water supply and selected high-yielding wells

Well no. in figs. 5A or 5B	Site-identification number	Site name	Aquifer (B, bed-rock; S, surficial deposit)	Popula-tion served	Reported rate of ground-water withdrawal (gal/min)	Potential rate of ground-water withdrawal (gal/min)
43	412003073414301	Greenbriar Subdivision	B	240	17	—
44	411948073442801	Amawalk-Shenorock Wd.	B	480	28	—
45	411948073442701	Amawalk-Shenorock Wd.	S	480	28	—
46	411718073391301	Westchester 2023	B	—	—	100
47	411924073444201	Horton Estates Water Trust	B	200	8.3	—
48	411814073400601	Candlewood Park	B	175	9.7	—
49	411811073393201	Wild Oaks Water Co.	B	410	21	—
50	411759073340001	Twin Lakes WW Corp.	B	350	17	—
51	411801073372401	Indian Hill Subdivision	S	96	6.7	—
52	411325073403201	Westchester 449	B	—	—	100
53	411740073400001	Golden Bridge Community	B	43	3.0	—
54	411733073393601	Golden Bridge Community	B	43	3.0	—
55	411730073395001	Golden Bridge Community	B	44	3.0	—
56	411717073332301	Truesdale Lake Prop. Owner	B	133	6.0	—
57	411717073334401	Truesdale Lake Prop. Owner	B	133	6.0	—
58	411715073333201	Truesdale Lake Prop. Owner	B	134	6.0	—
59	411718073391101	Lake Katonah Club Inc.	B	390	20	—
60	411636073345501	Pamela Lane Water Supply	B	40	2.4	—
61	411537073410301	Bedford Consolidated	B	6,150	460	—
62	411528073480701	Westview Well Assoc	B	18	1.2	—
63	411446073391301	Bedford Farms Water Co.	B	280	5.6	—
64	411439073421401	Roosevelt Drive Water Users	B	84	6.5	—
65	411428073442901	Cedar Downs Wd.	B	251	8.9	—
66	411334073425901	Mount Kisco Village	S	9,000	200	—
67	411338073522201	Windsor Oaks Prop. Owners	B	55	3.8	—
68	412054073393701	Croton Falls Wd.	B	250	8.5	—
69	412659073402601	Putnam 154	S	—	—	50
70	412410073360101	Putnam 825	S	—	—	70
71	412222073442101	Putnam 566	S	—	—	50
72	412018073343201	Westchester 464	S	—	—	80
73	411947073442801	Westchester 1460	S	—	—	50
74	411546073465101	Westchester 549	S	—	—	50
75	411547073465701	Westchester 548	S	—	—	50
76	411535073363301	Westchester 322	S	—	—	70
77	411408073421901	Westchester 2001	S	—	—	60
78	411342073430501	Westchester 505	S	—	—	70
79	411341073430201	Westchester 504	S	—	—	70
80	411228073372301	Westchester 695	S	—	—	50
81	412028073395601	Westchester 2049	S	—	—	350
82	412015073403601	Westchester 2047	S	—	—	146
83	411812073391501	Westchester 2028	S	—	—	120
84	411811073391401	Westchester 2029	S	—	—	120
85	411532073405801	Westchester 501	S	—	—	400
86	411440073411401	Westchester 502	S	—	—	180
87	411415073403701	Westchester 991	S	—	—	300

Table 2. (Continued) Data on ground-water withdrawal sites for public water supply and selected high-yielding wells

Well no. in figs. 5A or 5B	Site-identification number	Site name	Aquifer (B, bed-rock; S, surficial deposit)	Popula-tion served	Reported rate of ground-water withdrawal (gal/min)	Potential rate of ground-water withdrawal (gal/min)
88	411416073404301	Westchester 2022	S	—	—	270
89	411407073421601	Westchester 2002	S	—	—	120
90	411335073430401	Westchester 503	S	—	—	150
91	411232073393901	Westchester 4824	S	—	—	120
92	412451073395501	Putnam 787	S	—	—	500
93	411448073405201	Westchester 1063	S	—	—	600
94	413316073350501	Dutchess 1804	B	—	—	60
95	412928073463201	Putnam 586	B	—	—	50
96	412825073324301	Putnam 1104	B	—	—	50
97	412830073463401	Putnam 1082	B	—	—	50
98	412656073394701	Putnam 1043	B	—	—	50
99	412616073335101	Putnam 1139	B	—	—	80
100	412456073363601	Putnam 1151	B	—	—	50
101	412052073401601	Westchester 1231	B	—	—	60
102	412041073413401	Westchester 2031	B	—	—	66
103	411946073444201	Westchester 1434	B	—	—	50
104	411932073463801	Westchester 539	B	—	—	75
105	411616073394001	Westchester 1319	B	—	—	50
106	411612073391001	Westchester 4271	B	—	—	50
107	411540073401701	Westchester 4268	B	—	—	60
108	411522073424001	Westchester 4437	B	—	—	75
109	411519073424401	Westchester 4912	B	—	—	75
110	411512073422901	Westchester 4326	B	—	—	50
111	411428073371101	Westchester 4198	B	—	—	50
112	411428073381601	Westchester 4307	B	—	—	55
113	411432073381201	Westchester 1250	B	—	—	60
114	411414073375601	Westchester 4390	B	—	—	50
115	411357073365701	Westchester 4443	B	—	—	60
116	411402073390401	Westchester 456	B	—	—	65
117	411353073365501	Westchester 4866	B	—	—	60
118	411342073391201	Westchester 4870	B	—	—	60
119	411340073391201	Westchester 4447	B	—	—	60
120	411337073404201	Westchester 451	B	—	—	60
121	411259073422101	Westchester 4310	B	—	—	75
122	411303073432901	Westchester 1058	B	—	—	50
123	411301073421501	Westchester 455	B	—	—	50
124	411251073405301	Westchester 4894	B	—	—	50
125	411242073425701	Westchester 4169	B	—	—	50
126	411229073480001	Westchester 931	B	—	—	50
127	411145073362501	Westchester 4325	B	—	—	50
128	410954073443101	Westchester 976	B	—	—	75
129	413146073424101	Dutchess 1659	B	—	—	109
130	413146073424102	Dutchess 1089	B	—	—	109
131	413146073424401	Dutchess 1658	B	—	—	103
132	413057073412501	Dutchess 1774	B	—	—	100

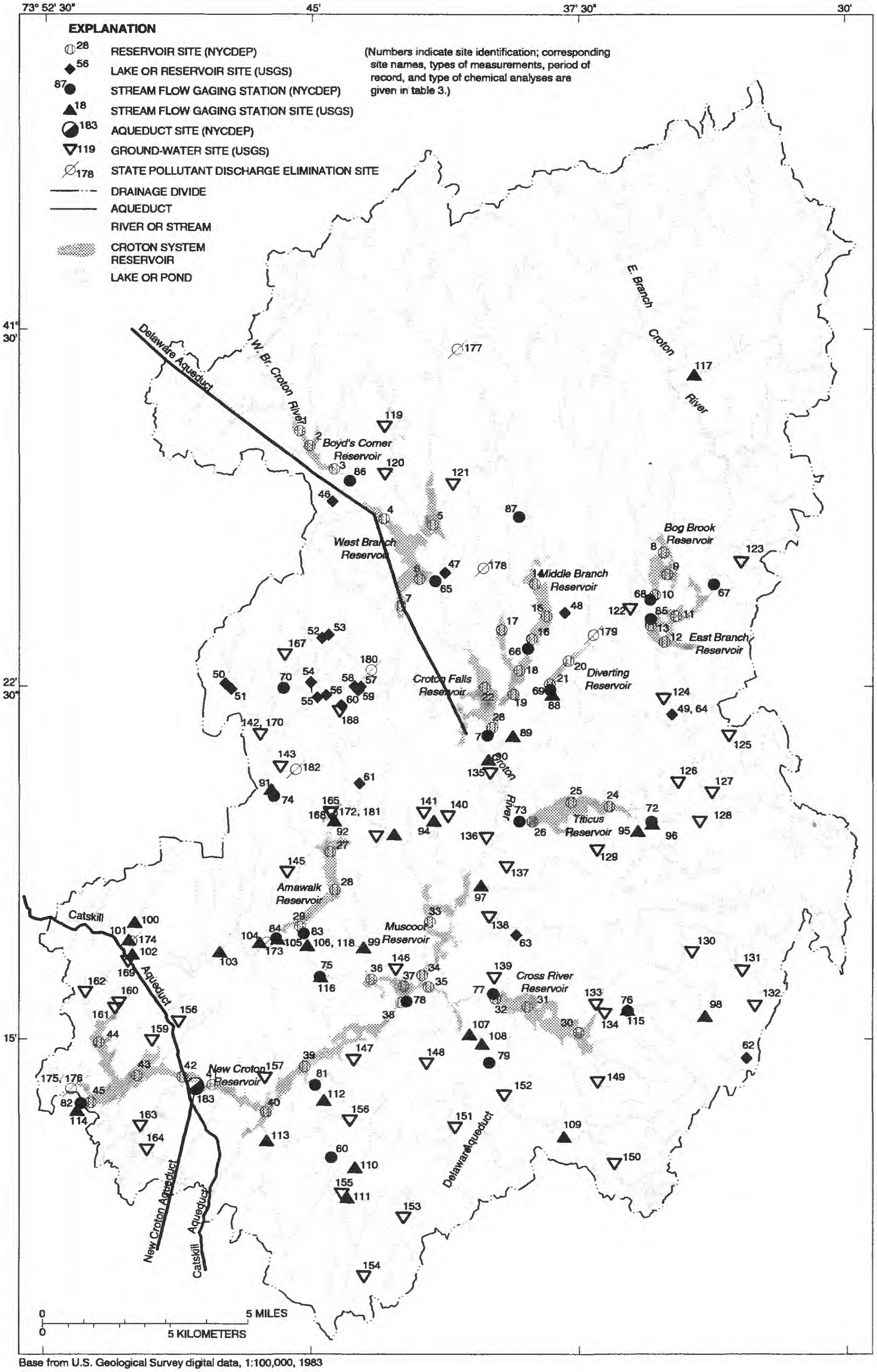


Figure 6. Past and current U.S. Geological Survey and New York City Department of Environmental Protection water-quality-data collection sites in the Croton Reservoir system.

Table 3. Summary of data collected at water-quality sites

[—, no USGS site-identification number assigned; n/a, no data available; LK-RES, lake or reservoir site; SW, surface-water site; GW, ground-water site; KEY POINT, aqueduct site; B, background water-quality constituents; N, nitrogen; P, phosphorus; Q, discharge; O, other constituents.]

No. on fig. 6	Site-identification number	Site name	Type of site	Period of Record	Constituents analyzed
1	—	Boyd Corners 3	LK-RES	1991-present	BONP
2	—	Boyd Corners 2	LK-RES	1991-present	BONP
3	—	Boyd Corners 1	LK-RES	1991-present	BONP
4	—	West Branch 3	LK-RES	1984-present	BONP
5	—	West Branch 4	LK-RES	1984-present	BONP
6	—	West Branch 2	LK-RES	1984-present	BONP
7	—	West Branch 1	LK-RES	1984-present	BONP
8	—	Bog Brook 3	LK-RES	1986-present	BONP
9	—	Bog Brook 2	LK-RES	1986-present	BONP
10	—	Bog Brook 1	LK-RES	1986-present	BONP
11	—	East Branch 3	LK-RES	1986-present	BONP
12	—	East Branch 2	LK-RES	1986-present	BONP
13	—	East Branch 1	LK-RES	1986-present	BONP
14	—	Middle Branch 3	LK-RES	1986-present	BONP
15	—	Middle Branch 2	LK-RES	1986-present	BONP
16	—	Middle Branch 1	LK-RES	1986-present	BONP
17	—	Croton Falls 5	LK-RES	1986-present	BONP
18	—	Croton Falls 4	LK-RES	1986-present	BONP
19	—	Croton Falls 3	LK-RES	1986-present	BONP
20	—	Diverting 2	LK-RES	1986-present	BONP
21	—	Diverting 1	LK-RES	1986-present	BONP
22	—	Croton Falls 2	LK-RES	1986-present	BONP
23	—	Croton Falls 1	LK-RES	1986-present	BONP
24	—	Titicus 3	LK-RES	1986-present	BONP
25	—	Titicus 2	LK-RES	1986-present	BONP
26	—	Titicus 1	LK-RES	1986-present	BONP
27	—	Amawalk 3	LK-RES	1986-present	BONP
28	—	Amawalk 2	LK-RES	1986-present	BONP
29	—	Amawalk 1	LK-RES	1986-present	BONP
30	—	Cross River 3	LK-RES	1986-present	BONP
31	—	Cross River 2	LK-RES	1986-present	BONP
32	—	Cross River 1	LK-RES	1986-present	BONP
33	—	Muscoot 6	LK-RES	1984-present	BONP
34	—	Muscoot 5	LK-RES	1984-present	BONP
35	—	Muscoot 4	LK-RES	1984-present	BONP
36	—	Muscoot 2	LK-RES	1984-present	BONP
37	—	Muscoot 3	LK-RES	1984-present	BONP
38	—	Muscoot 1	LK-RES	1984-present	BONP
39	—	Croton 7	LK-RES	1984-present	BONP
40	—	Croton 6	LK-RES	1984-present	BONP
41	—	Croton 5	LK-RES	1984-present	BONP

Table 3. (Continued) Summary of data collected at water-quality sites

No. on fig. 6	Site-identification number	Site name	Type of site	Period of Record	Constituents analyzed
42	—	Croton 4	LK-RES	1984-present	BONP
43	—	Croton 3	LK-RES	1984-present	BONP
44	—	Croton 2	LK-RES	1984-present	BONP
45	—	Croton 1	LK-RES	1984-present	BONP
46	412622073442600	Edgewood Club Dist Syst-China Lake 1920d	LK-RES	09-19-72	BOP
47	412451073411700	Carmel Wd #2 Dist Syst-Lake Glinda 0189d	LK-RES	09-19-72	BOP
48	412401073375500	Brewster Heights Ds-middle Branch Res 1295d	LK-RES	12-10-73	BOP
49	412152073345400	Peach Lake at Peach Lake NY	LK-RES	07-07-76 to 11-17-76	BONP
50	412232073472601	Carmel Water District No 3 WTP-Lake Secor 0190t	LK-RES	01-16-75	BOP
51	412225073471601	Carmel Wd#3 WTP-Lake Secor 0190t	LK-RES	10-19-71	BOP
52	412329073444300	Lk Mahopac Gardens Dist Syst-Lake Mahopac 0192d	LK-RES	09-19-72	BOP
53	412333073443200	Lk Mahopac Woods Dist Syst-Lake Mahopac 0194d	LK-RES	09-19-72	BOP
54	412233073450200	Mahopac Hills Dist Syst-Lake Mahopac 0198d	LK-RES	09-19-72	BOP
55	412214073445100	Lake Gardens Dist Syst-Lake Mahopac 0713d	LK-RES	09-19-72	BOP
56	412217073443600	Lake View Park Dist Syst-Lake Mahopac 0195d	LK-RES	09-19-72	BOP
57	412228073433800	Lake Mahopac Ridge WTP-Lake Mahopac 0193t	LK-RES	04-24-75	BOP
58	01374910	Lake Mahopac Ridge WTP-Lake Mahopac 0193r	LK-RES	04-24-75	BOP
59	412223073434200	Lk Mahopac Ridge Dist Syst-Lake Mahopac 0193d	LK-RES	09-19-72	BOP
60	412204073441000	Mahopac Point Dist Syst-Lake Mahopac 0201d	LK-RES	09-19-72	BOP
61	412024073434000	Lake Lincolndale at Lincolndale NY	LK-RES	06-29-76 to 10-21-76	BONP
62	411436073325000	Lake Kitchawan at Lake Kitchawan	LK-RES	07-06-76 to 11-17-76	BONP
63	411713073391700	Lake Katonah at Lake Katonah NY	LK-RES	07-01-76 to 10-21-76	BONP
64	412152073345401	Peach Lake at Peach Lake NY	LK-RES	07-07-76	BONP
65	—	West Branch Release	SW	1987-present	BONP
66	—	Middle Branch Release	SW	1987-present	BONP
67	—	East Branch River	SW	1987-present	BONP
68	—	Bog Brook Release	SW	1987-present	BONP
69	—	Diverting Release	SW	1987-present	BONP
70	—	Kirk Lake Release	SW	1987-present	BONP
71	—	Croton Falls Release	SW	1987-present	BONP
72	—	Titicus River	SW	1987-present	BONP
73	—	Titicus Release	SW	1987-present	BONP
74	—	Muscoot River	SW	1987-present	BONP
75	—	Hallocks Mill Brook #2	SW	1987-present	BONP
76	—	Cross River	SW	1987-present	BONP
77	—	Cross River Release	SW	1987-present	BONP
78	—	Muscoot Release	SW	1987-present	BONP

Table 3. (Continued) Summary of data collected at water-quality sites

No. on fig. 6	Site-identification number	Site name	Type of site	Period of Record	Constituents analyzed
79	—	Beaver Dam Brook	SW	1987-present	BONP
80	—	Kisco River #2	SW	1987-present	BONP
81	—	Kisco River #1	SW	1987-present	BONP
82	—	Croton Release	SW	1987-present	BONP
83	—	Amawalk Release	SW	1987-present	BONP
84	—	Hallocks Mill Brook #1	SW	1987-present	BONP
85	—	East Branch Release	SW	1987-present	BONP
86	—	Boyd's Release	SW	1987-present	BONP
87	—	Middle Branch River	SW	1987-present	BONP
88	01374540	Holly Stream Near Brewster NY	SW	07-14-70	QBO
89	01374545	East Branch Croton River at Croton Falls NY	SW	08-05-76	QBONP
90	01374705	West Branch Croton River at Croton Falls NY	SW	08-05-76	QBONP
91	01374930	Muscoot River at Baldwin Place NY	SW	06-28-76 to 08-06-76	QBONP
92	01374937	Lake Shenorock Outlet at Shenorock NY	SW	08-04-76	QBONP
93	01374860	Plum Brook at Lincolndale NY	SW	11-09-64 to 08-05-76	QBONP
94	01374840	Muscoot Reservoir Tributary at Somers NY	SW	08-05-76	QBONP
95	01374788	Crook Brook at Salem Center NY	SW	08-05-76	QBONP
96	01374780	Titicus River at Salem Center NY	SW	06-28-76 to 08-05-76	QBONP
97	01374830	Croton River Tributary at Goldens Bridge NY	SW	08-04-76	QBONP
98	01374880	Waccabuc River at Boutonville NY	SW	07-07-76 to 08-04-76	QBONP
99	01374976	Angle Fly Brook at Whitehall Corners NY	SW	08-04-76	QBONP
100	01374992	Hunter Brook Near Yorktown NY	SW	08-04-76 to 09-01-76	QBONP
101	411707073500900	Mill Pond Trib Off Hunter Brook Rd. at Yorktown	SW	08-05-76	n/a
102	01374993	Hunter Brook Below Mill Pond Near Yorktown NY	SW	07-06-76 to 09-01-76	QBONP
103	01374948	Crom Pond Outlet at Yorktown Heights NY	SW	08-04-76	QBONP
104	01374960	Hallocks Mill Brook at Yorktown Heights NY	SW	07-06-76 to 07-21-76	QBNP
105	01374963	Hallocks Mill Brook at Amawalk NY	SW	07-19-76 to 08-04-76	QBNP
106	01374942	Muscoot River at Amawalk NY	SW	07-06-76 to 07-21-76	QBNP
107	01374919	Stone Hill River at Katonah NY	SW	06-28-76 to 08-05-76	QBONP
108	01374917	Broad Brook at Katonah NY	SW	08-05-76	QBONP
109	01374908	Stone Hill River at Bedford NY	SW	07-07-76 to 08-04-76	QBONP
110	411218073434700	Kisco River Trib at Green St. at Mount Kisco NY	SW	08-04-76 to 11-16-76	n/a
111	01374983	Kisco River at Lexington Ave. at Mount Kisco NY	SW	07-07-76 to 08-04-76	QBONP

Table 3. (Continued) Summary of data collected at water-quality sites

No. on fig. 6	Site-identification number	Site name	Type of site	Period of Record	Constituents analyzed
112	01374987	Kisco River Below Mount Kisco NY	SW	07-07-76 to 08-04-76	QBONP
113	01374988	Gedney Brook Near Mount Kisco NY	SW	08-04-76	QBONP
114	01375000	Croton R @ New Croton Dam near Croton-on-hudson NY	SW	10-06-70 to 06-21-72	QBON
115	01374890	Cross River Near Cross River NY	SW	06-28-76 to 08-05-76	QBONP
116	01374970	Muscoot River Near Amawalk NY	SW	07-06-76 to 07-21-76	QBNP
117	01374494	Haviland Hollow Brook Near Putnam Lake NY	SW	07-14-70	QBO
118	01374965	Hallocks Mill Brook Below Amawalk NY	SW	07-06-76 to 07-20-76	Q
119	412757073425800	Putnam 30	GW	01-15-75	BOP
120	412757073425801	Putnam 900	GW	01-14-75	BOP
121	412644073410400	Putnam 28	GW	01-21-75	BOP
122	412405073360400	Putnam 26	GW	10-19-72	BOP
123	412504073325800	Putnam 27	GW	09-19-72	BOP
124	412212073350800	Putnam 23	GW	01-16-75	BOP
125	412125073331801	Westchester 3864	GW	10-17-86 to 05-06-87	BON
126	412025073344401	Westchester 3865	GW	10-17-86 to 05-06-87	BON
127	412012073334701	Westchester 3862	GW	10-17-86 to 05-06-87	BON
128	411935073340801	Westchester 3861	GW	10-17-86 to 05-06-87	BON
129	411900073370101	Westchester 3863	GW	10-17-86 to 05-06-87	BON
130	411651073342101	Westchester 3856	GW	10-17-86 to 05-05-87	BON
131	411627073325701	Westchester 3857	GW	10-17-86 to 05-05-87	BON
132	411542073323601	Westchester 3858	GW	10-17-86	BON
133	411544073370301	Westchester 3855	GW	10-17-86	BON
134	411532073364801	Westchester 3854	GW	10-17-86 to 05-05-87	BON
135	412037073400001	Westchester 3869	GW	10-15-86 to 05-04-87	BON
136	411915073400701	Westchester 3870	GW	10-15-86 to 05-05-87	BOP
137	411839073393301	Westchester 3860	GW	10-15-86 to 05-04-87	BON
138	411736073400301	Westchester 3853	GW	10-15-86 to 05-04-87	BON
139	411618073395401	Westchester 5010	GW	10-15-86 to 05-04-87	BON

Table 3. (Continued) Summary of data collected at water-quality sites

No. on fig. 6	Site-identification number	Site name	Type of site	Period of Record	Constituents analyzed
140	411942073411201	Westchester 3871	GW	10-15-86 to 05-05-87	BON
141	411947073415301	Westchester 3868	GW	10-15-86 to 05-06-87	BON
142	412127073462700	Putnam 8	GW	12-10-73	BOP
143	412045073455300	Putnam 6	GW	01-16-75	BOP
144	411917073431200	Westchester 40	GW	03-05-74	BOP
145	411832073454201	Westchester 3872	GW	n/a	n/a
146	411629073423901	Westchester 3873	GW	10-15-86 to 05-06-87	BON
147	411433073434901	Westchester 5012	GW	10-16-86 to 05-05-87	BON
148	411429073414800	Westchester 39	GW	12-08-71 to 03-05-74	BOP
149	411405073370001	Westchester 5017	GW	10-16-86 to 05-05-87	BON
150	411222073363201	Westchester 5018	GW	10-16-86 to 05-06-87	BON
151	411308073410001	Westchester 5015	GW	10-16-86 to 05-05-87	BON
152	411349073393701	Westchester 5016	GW	10-16-86 to 05-05-87	BON
153	411116073422301	Westchester 4424	GW	10-16-86 to 05-06-87	BON
154	410958073433201	Westchester 3866	GW	10-16-86 to 05-05-87	BON
155	411144073440900	Westchester 36	GW	12-08-71	BOP
156	411317073435601	Westchester 5011	GW	10-16-86 to 05-05-87	BON
157	411411073461901	Westchester 2095	GW	08-22-88	BO
158	411522073484401	Westchester 2113	GW	08-24-88	BO
159	411458073492901	Westchester 2094	GW	08-22-88	BO
160	411546073502501	Westchester 2107	GW	08-24-88	BO
161	411539073503201	Westchester 2106	GW	08-24-88	BO
162	411600073512201	Westchester 2108	GW	08-24-88	BO
163	411310073494901	Westchester 2097	GW	08-22-88	BO
164	411240073493801	Westchester 2096	GW	n/a	n/a
165	411947073442801	Westchester 1460	GW	12-08-71	BOP
166	412156073441300	Putnam 16	GW	02-05-75	BOP
167	412308073454600	Putnam 24	GW	01-16-75	BOP
168	411947073442800	Westchester 41	GW	12-08-71	BOP
169	411643073500101	Westchester 1132	GW	08-25-88	BO
170	411946073443001	Westchester 3867	GW	10-15-86 to 05-05-87	BON
171	412127073462701	Putnam 9	GW	12-10-73	BOP
172	NY0208027	Amawalk-Shenorock Water Dist.	SW	n/a	n/a

Table 3. (Continued) Summary of data collected at water-quality sites

No. on fig. 6	Site-identification number	Site name	Type of site	Period of Record	Constituents analyzed
173	NY0026743	Yorktown (T)	SW	n/a	n/a
174	NY0026727	Yorktown (T)	SW	n/a	n/a
175	NY0149195	Croton-Harmon School District	SW	n/a	n/a
176	NY0149195	Croton-Harmon School District	SW	n/a	n/a
177	NY0207969	Kent Elementary School	SW	n/a	n/a
178	NY0031356	Carmel (T)	SW	n/a	n/a
179	NY0026581	NYC Dept. Env Protection	SW	n/a	n/a
180	NY0026590	NYC Dept. Env. Protection-Mahopac	SW	n/a	n/a
181	NY0208027	Amawalk-Shenorock Water Dist.	SW	n/a	n/a
182	NY0233625	Spain Oil	SW	n/a	n/a
183	—	Croton-raw	KEY POINT	1987-present	BONP

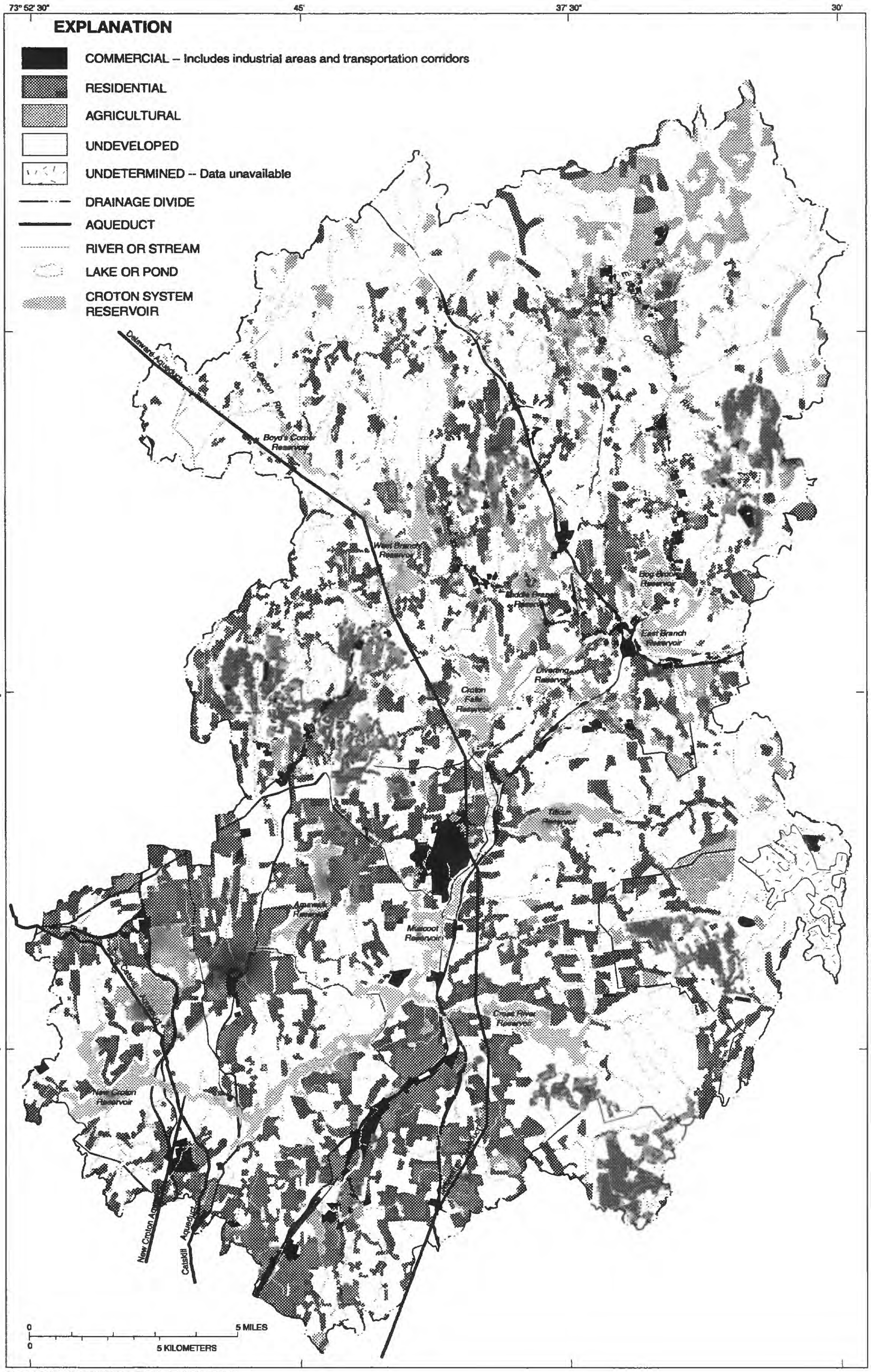
use data for the study were obtained from a variety of sources. Putnam County data were obtained from the NYCDEP as a polygon data set at the scale of 1:24,000, interpreted from 1987 aerial photographs and updated in 1991 with field checking; this data set represented about 50 land-use categories. Westchester County data were obtained from the Westchester County Department of Planning as a polygon data set at a scale of 1:24,000 containing land-use information from the early 1980's; this data set contained 13 land-use categories. Data for Dutchess County and the parts of the study area that are in Fairfield County, Conn., were obtained from the USGS Geographic Information Retrieval and Analysis System (GIRAS) data base, which represents data from the mid-1970's and includes more than 30 land-use categories. Land-use categories that are found in the above data sets include low-, medium-, and high-density residential development; transportation corridors; commercial; industrial; cropland; orchards; deciduous forest land; quarries; light manufacturing; inactive urban; and shopping centers. For the purpose of this study, all land-use categories were combined into four general groups—undeveloped land, residential land, agricultural land, and commercial land (including industrial areas and transportation corridors, fig. 7).

The dominant land-use category in the study area is undeveloped land which represents 56.7 percent of the study area. The next largest land-use category is residential land (25.3 percent of the study area); although it is present throughout the study area, it is concentrated primarily around transportation corridors, reservoirs, and lakes. The next largest category is agricultural land (7.4 percent of the study area); this category is primarily in the northern and eastern parts of the study area. Commercial land use (4.1 percent of the study area) is concentrated mainly west of the Croton River, between the Muscoot Reservoir and the Croton Falls Reservoir, but also is found along transportation corridors. Lakes and reservoirs (5.7 percent of the study area) and undetermined land use (0.8 percent of the study area) occupy the rest of the study area.

Potential point-source-contamination sites include active and inactive hazardous-waste sites within the study area; data on these sites are listed in table 4. The data were obtained from the NYSDEC, Region 3 (NYSDEC, 1992). The study area contains 24 potential point-source-contamination sites; two are on the USEPA National Priorities List—one in Putnam County and one in Westchester County.

POTENTIAL MONITORING SITES

Sites for a water-resources monitoring network in the Croton Reservoir system were selected subjectively with the aid of the GIS coverages described



Base from U.S. Geological Survey digital data, 1:100,000, 1983

Figure 7. Land use within the Croton Reservoir system.

Table 4. Sites that are potential point-sources of contamination in southern Dutchess, Putnam, and northern Westchester Counties, N.Y.

[—, unknown; GW, ground water; SW, surface water; DW, drinking water. Data from New York State Department of Environmental Conservation.]

Owner	County	Town	Type of site	Resource affected
Pawling Rubber Co.	Dutchess	Pawling	Landfill	GW/DW
Texaco Research Center	Dutchess	East Fishkill	Lagoon/Landfill	GW
Royal Carting Service	Dutchess	East Fishkill	Open dump	—
Old Beekman Site	Dutchess	Beekman	Open dump	—
Pawling Village landfill	Dutchess	Pawling	Landfill	—
Hopewell Precision Inc.	Dutchess	East Fishkill	Open dump	—
IBM-East Fishkill	Dutchess	East Fishkill	Open dump	GW
East Fishkill Landfill	Dutchess	East Fishkill	Landfill	GW
Metro North (Conrail-Harlem Div.)	Putnam	Southeast	Open dump	—
Champion Building Products	Putnam	Patterson	Open dump	GW/DW
Cross Co. Sanitary-Kessman L.F.	Putnam	Patterson	Landfill	GW/Air
Brewster Village Well Field 1	Putnam	Southeast	Open dump	GW
Mahopac Business District Wells	Putnam	Carmel	Open dump	GW/DW
Croton Point Sanitary Landfill	Westchester	Croton-on-Hudson	Landfill	GW/SW
Magna Metals	Westchester	Cortlandt	—	SW
Armonk Private Wells	Westchester	North Castle	Open dump	GW/SW/DW
Bedford Village Wells-Shopping Arcade	Westchester	Bedford	Open dump	—
Katonah Well (Bed Water Stor. & Dist.)[1]	Westchester	Bedford	Open dump	GW/DW
Bedford Village Wells-Hunting Ridge Mall	Westchester	Bedford	Open dump	GW/DW
Harmon Railroad Yard-Waste Water Area	Westchester	Croton	Lagoon	—
Westchester Colprovia Corporation	Westchester	Bedford	Structure	GW
Harmon Railroad Yard-Metro North RR	Westchester	Croton	—	GW
Baldwin Place Shopping Center	Westchester	Somers	Structure	GW/DW
Marx Residence	Westchester	New Castle	Structure	GW/DW

[1]on the USEPA National Priorities List

earlier. Three types of data-collection sites were identified that, together, would provide adequate water-resources monitoring for the basin: reservoir-outflow-monitoring sites (to document rate and chemical quality of reservoir outflow), reservoir-inflow-monitoring sites (to document rate and chemical quality of reservoir inflow), and ground-water-monitoring areas (to document ground-water levels and chemical quality of ground water).

Reservoir-inflow and -outflow rates can be used to calculate the change in reservoir storage for a given period, and ground-water levels at wells provide information on seasonal long-term trends in the major aquifers throughout the study area. The water-level data also can be used to (1) calculate the amount of water available from aquifers that provide base flow to streams, and (2) monitor long-term trends in water use and aquifer recharge.

The following paragraphs describe the subjective selection of monitoring sites for reservoir-outflow, reservoir-inflow, and ground-water-monitoring areas. The GIS coverages that were used in the selection of each of these three data categories are given in table 5.

Reservoir-Outflow Sites

Reservoir-outflow sites would be established either at a dam that forms the reservoir or at the closest site downstream that is suitable for a streamflow gage. Outflow data, when combined with inflow data, can be used to calculate chemical and nutrient loading and calculate the change in storage of the reservoir. Establishment of outflow-measurement sites at several dams throughout the Croton Reservoir system would enable calculation of change in storage and of chemical and nutrient loading within the watershed. GIS coverages that were used in the selection of locations for reservoir-outflow-monitoring sites are given in table 5. The coverages "surface-water gages" and "water-quality sites" were used to identify which reservoirs had long-term data that could (1) provide information on historical trends, and (2) be incorporated with new data-collection efforts. The "diversion," "dams," "public-water-supply withdrawals," and "water-quality point sources" coverages were used to identify areas that have been affected by man. Data-collection sites would be installed downstream from reservoirs to provide data on the quantity and quality of outflow. The "hydrography" and "basins" coverages provided the information needed to delineate the boundaries of the drainage areas represented by each reservoir-outflow site. Eight reservoir-outflow sites (fig. 8) were selected to provide data on the flow and quality of water discharging from the reservoirs; all are at reservoirs and dams maintained by NYCDEP—West Branch, Bog Brook and East Branch (combined), Diverting, Croton Falls, Titicus, Cross River, Amawalk, and Muscoot. Data on their drainage areas are given in table 6.

Reservoir-Inflow Sites

The second group of data-collection sites that was subjectively selected included sites on unregulated streams or rivers that discharge to reservoirs in the drainage basins of the Croton Reservoir system. This group provides information on the inflow to reservoirs and, when combined with reservoir-outflow data, can be used to calculate change in storage. Each drainage basin in which a reservoir-inflow site was under consideration was assigned two dominant land-use categories to allow the streamflow and water-quality data from these sites to be projected to similar ungaged sites in areas that represent other basins.

Selection of basins for reservoir-inflow-monitoring sites was based primarily on subbasin boundaries obtained from the GIS "basins" coverage and on the land use within the headwater basin, as indicated by the "land use" coverage. Originally, the basins considered for reservoir-inflow-monitoring were chosen to represent only areas that were either rural or urban, but basins with other secondary land uses were later allowed because most of the basins had other dominant land uses. Additional considerations in the subjective selection of basins for reservoir-inflow monitoring were: population distribution, potential hazardous-waste sites, long-term hydrologic data collected by NYCDEP, transferability of observed trends in flow and water-quality characteristics to other parts of the study area, and the spatial distribution of the selected basins.

Twelve GIS coverages were used in the selection of reservoir-inflow basins (table 5). Initially, the "basins" coverage was overlain by the "land use" coverage to indicate subbasins with only one or two major land uses; the remaining coverages were then used to further differentiate the subbasins.

Nine reservoir-inflow sites representing a combination of four major land uses were finally selected (fig. 9); the primary and secondary land uses and the drainage area of each basin are given in table 7. All of the four primary land-use categories in the Croton Reservoir system are represented in these nine basins. Information gathered in a gaged basin within this group is applicable to ungaged basins within the Croton Reservoir system that have similar land-use characteristics. Some of the basins were selected

Table 5. Monitoring categories to which each GIS coverage was applied in site-selection process in the Croton Reservoir system

GIS data set	Type of monitoring site		
	Reservoir outflow	Reservoir inflow	Ground water
Basins	yes	yes	yes
Population	no	yes	yes
Land use	no	yes	yes
Roads	no	yes	yes
Hydrography	yes	yes	yes
Surface-water gages	yes	yes	no
Inflows and diversions	yes	yes	no
Bedrock geology	no	no	yes
Surficial geology	no	no	yes
Public-water-supply withdrawals	yes	yes	yes
Ground-water wells	no	no	yes
Water-quality sites	yes	yes	yes
Water-quality point source	yes	yes	yes
Dams	yes	yes	no
Land surface	no	yes	yes

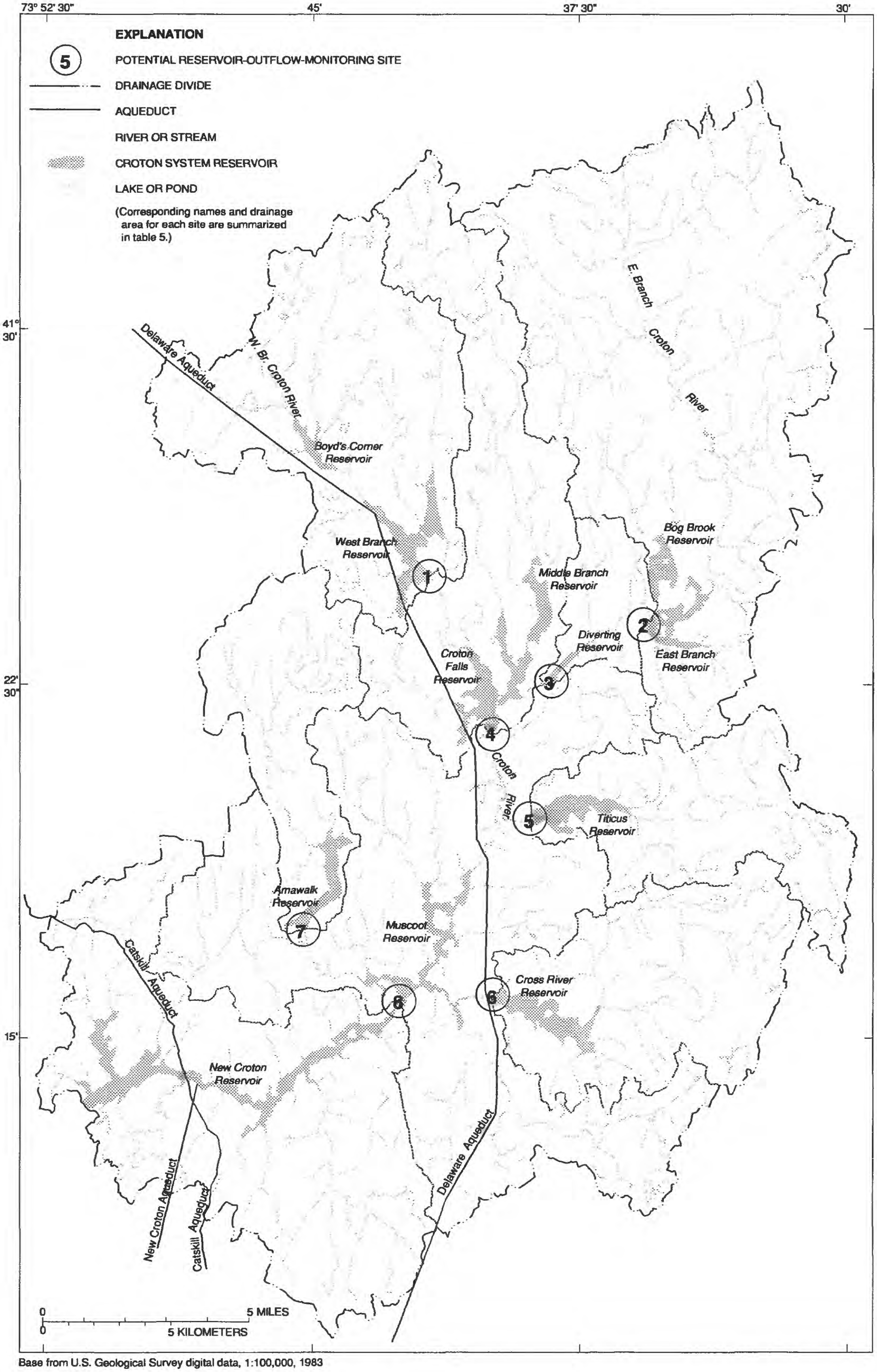


Figure 8. Potential monitoring sites at reservoir outflows in the Croton Reservoir system.

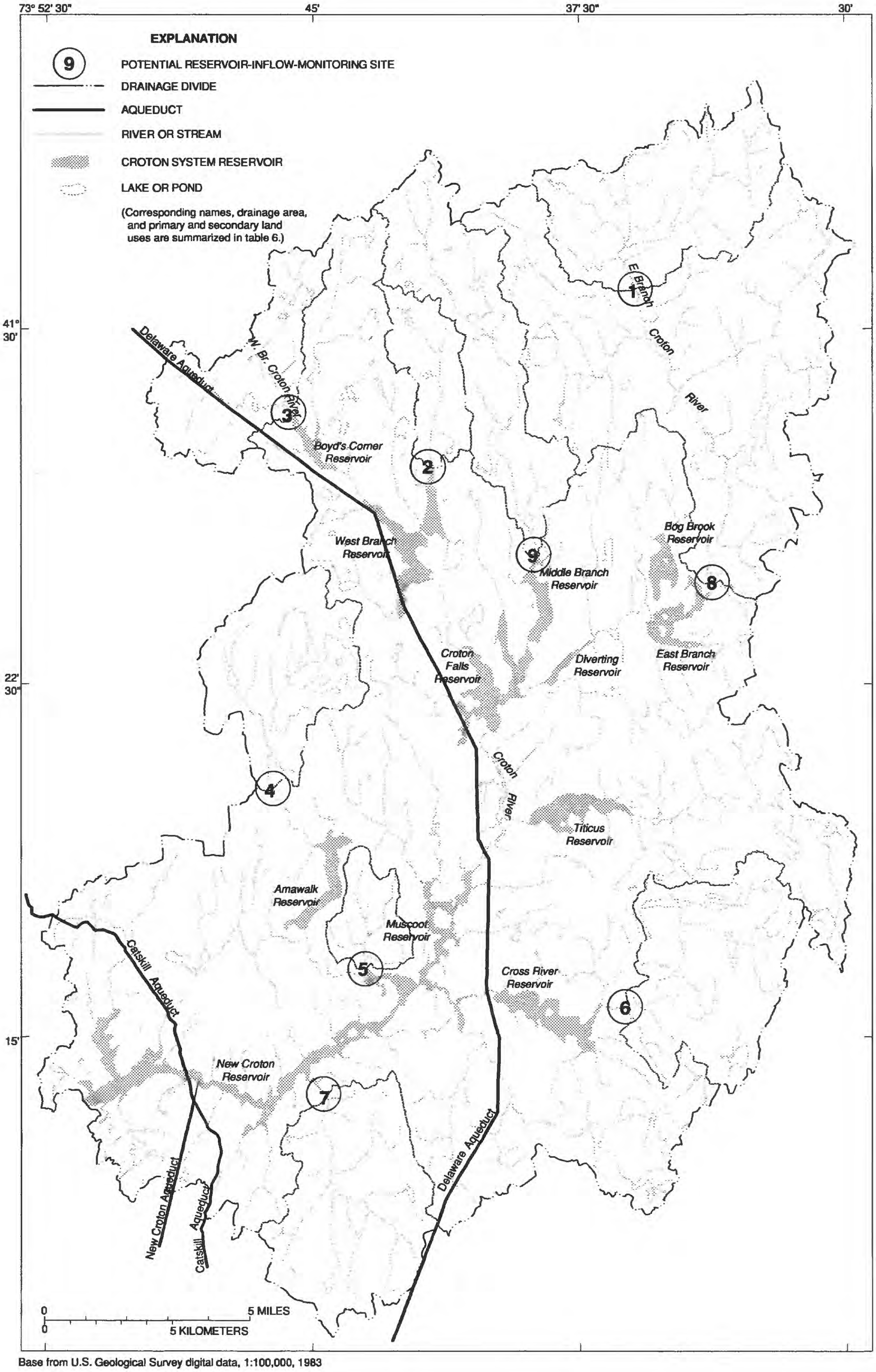


Figure 9. Potential monitoring sites in the headwaters of the Croton Reservoir system.

because certain secondary criteria (such as size or population) would allow comparison of trends in water-resources characteristics; for example, Site 8 was selected because its large drainage area allows study of a wide range in flow trends, and site 9 was selected because it has a large population and, thus, could provide information on the effects of urban development.

Table 6.—Potential reservoir-outflow monitoring sites in the Croton Reservoir system

[Locations are shown in fig. 8. All drainage areas are in square miles.]

Site number	Reservoir name	Drainage area at site	Drainage area not included with another upstream site
1	West Branch	42.7	42.7
2	Bog Brook / East Branch	79.4	79.4
3	Diverting	86.4	7.00
4	Croton Falls	169	39.9
5	Titicus	23.4	21.9
6	Cross River	29.9	31.4
7	Amawalk	19.7	19.7
8	Muscoot	319	72.8

Ground-Water-Monitoring Areas

The third group of data-collection sites that was identified, those in ground-water-monitoring areas, included sites where an observation well could be installed for sample collection and water-level measurement. As with the reservoir-inflow sites, all possible ground-water-monitoring areas were first identified, and the smallest number that would adequately describe the ground-water quality and ground-water levels within the study area was subjectively chosen.

Twelve GIS coverages were used to identify the ground-water-monitoring areas (table 5); the boundaries of the previously identified reservoir-inflow basins also were used. The "bedrock geology" and "surficial geology" coverages were used to identify the formations and aquifers of greatest importance in the study area, and the monitoring areas were selected to represent each of the primary geologic formations and aquifers. A monitoring area also would be selected in each of the eight selected reservoir-inflow-monitoring basins so that each reservoir's basin would have both surface-water and ground-water data. Final selection resulted in 16 ground-water-monitoring areas in the Croton Reservoir system (fig. 10). Each area represents a different geologic unit and(or) represents an entire reservoir-inflow basin. The locations represented and primary reasons for selection for each ground-water basins are listed in table 8. Eight of the areas contain reservoir-inflow basins; five others represent major bedrock formations; and the remaining three represent surficial aquifers.

Each of the 16 ground-water monitoring areas will have one well—an index well from which ground-water-level data and water samples will be collected on a routine basis. The process for selection of an index well in each ground-water-monitoring area will be to first collect water samples from five wells in each area, then identify which of these wells best reflects the chemistry characteristics of ground water in that area and use that well as the index well for that area.

Water-Quality-Monitoring Sites

The objective of the water-resources-monitoring network is to collect water-quality data that can be used to indicate the effects of land use on the quality of surface water and ground water in the basin and to identify temporal or spatial trends. Routine collection of water samples from all data-collection sites would provide the data. Water quality was given high priority during the site-selection process.

All data-collection sites described previously also serve as sampling sites for water-quality analysis. Samples from the surface-water sites (reservoir-outflow and -inflow sites, figs. 8 and 9, respectively) would be analyzed for major cations and anions, trace metals, pesticides, and nutrients, and samples from wells would be analyzed for major cations and anions, trace metals, volatile organic compounds, pesticides, nutrients, and radon.

SUMMARY

Urbanization in the Croton River watershed in southeastern New York has led to the deterioration of water quality within the basin. A GIS data base was used in the site-selection process for a water-resources-monitoring network in the Croton Reservoir system. The monitoring network could enable water managers to detect future changes in the quality of surface water and ground water.

Table 7. Sites selected for reservoir-inflow monitoring in the Croton Reservoir system

[Locations are shown in fig. 9. Drainage areas are in square miles.]

Site number	Headwater basin name	Drainage area	Land use	
			Primary	Secondary
1	Upper East Branch Croton River	17.3	Agriculture	Undeveloped
2	Horse Pound Brook	5.75	Undeveloped	Residential
3	Upper West Branch Croton River	11.0	Undeveloped	none
4	Upper Muscoot River	13.5	Residential	Undeveloped
5	Angle Fly Brook	4.05	Undeveloped	Residential
6	Upper Cross River	17.1	Undeveloped	Residential
7	Kisco River	17.5	Residential	Commercial
8	East Branch Croton River [1]	63.2	Undeveloped	Agriculture
9	Middle Branch Croton River	18.7	Undeveloped	Residential

[1] This basin includes site 1.

Table 8. Potential ground-water-monitoring areas in the Croton Reservoir system

[Area-identification numbers are shown in fig. 10.]

Area-identification number	Location name	Size of area represented [1] (square miles)	Reason for selection
1	Upper East Branch Croton River	17.3	reservoir-inflow basin
2	Horse Pound Brook	5.75	reservoir-inflow basin
3	Upper West Branch Croton River	11.0	reservoir-inflow basin
4	Upper Muscoot River	13.5	reservoir-inflow basin
5	Angle Fly Brook	4.05	reservoir-inflow basin
6	Upper Cross River	17.1	reservoir-inflow basin
7	Kisco River	17.5	reservoir-inflow basin
8	Middle Branch Croton River	18.7	reservoir-inflow basin
9	Great Swamp, East Branch Croton River	4.42	major surficial aquifer
10	Upper Stoney Brook	1.48	major surficial aquifer
11	Central Somers	1.02	major surficial aquifer
12	Southern Croton River basin	11.7	(Inwood marble, OEi) bedrock aquifer
13	Southern Croton River basin	73.7	(Manhattan schist, Om) bedrock aquifer
14	Southern Croton River basin	27.3	(Fordham gneiss, f) bedrock aquifer
15	Eastern central Croton River basin	28.0	(Amphibolite, am) bedrock aquifer
16	Northwestern Croton River basin	59.9	(Biotite-quartz-plagioclase gneiss, bqpc) bedrock aquifer

[1] Bedrock areas overlap part of some reservoir-inflow basins.

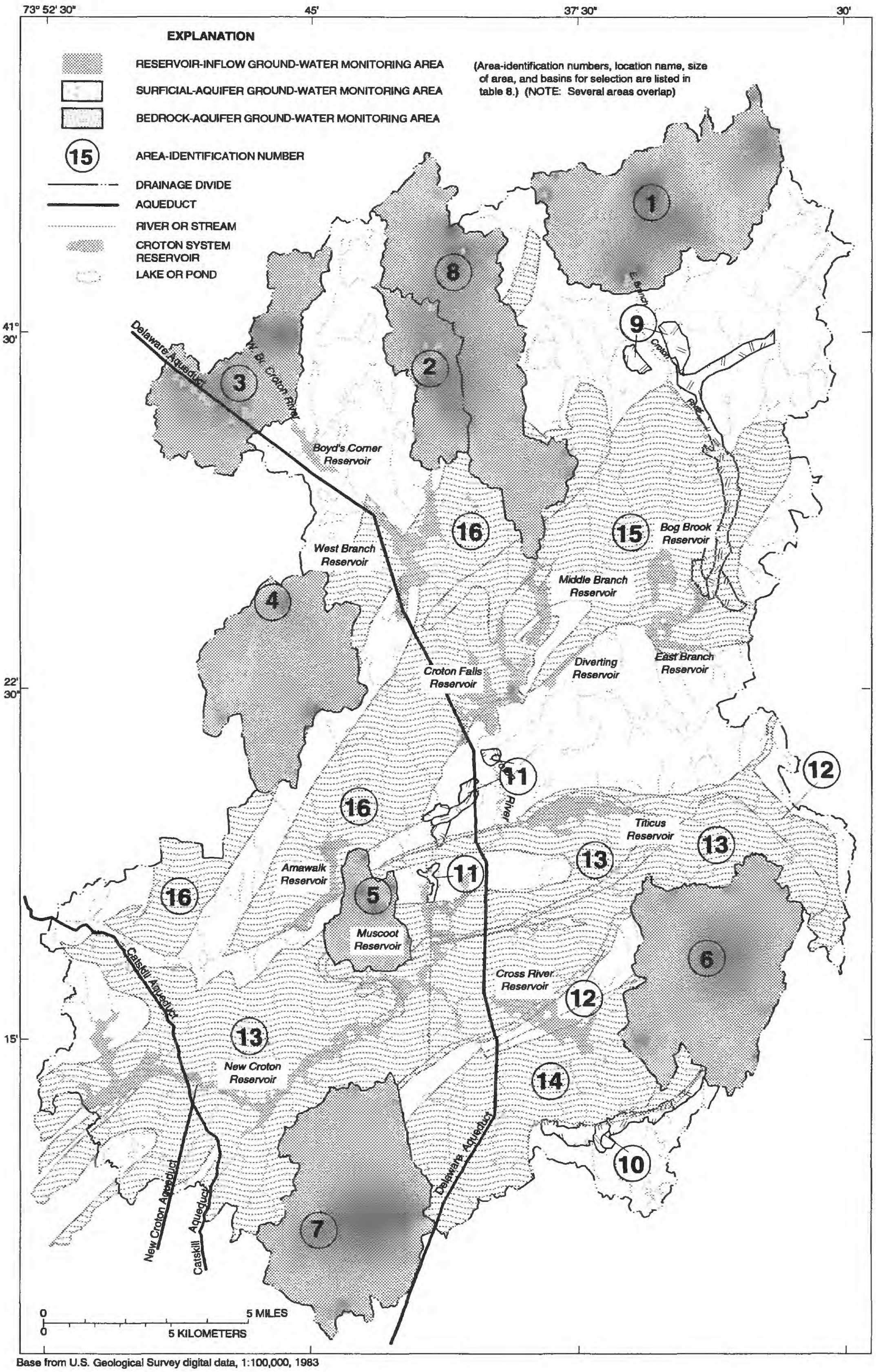


Figure 10. Potential ground-water monitoring areas in the Croton Reservoir system.

The site-selection process consisted of two steps. The first was to develop a GIS data base of long-term and current water-resources data; the second was to apply the GIS data base to subjectively identify potential locations for measurement of surface-water discharge and ground-water levels and for sampling of surface water and ground water. The GIS data base consisted of 15 coverages "basins," "population," "land use," "roads," "hydrography," "surface-water gages," "inflows and diversions," "bedrock geology," "surficial geology," "public-water supply withdrawals," "ground water," "water-quality sites," "water-quality point sources," "dams," and "land surface." The GIS provided an efficient method of storing data for use in the identification of suitable locations for monitoring sites.

Three types of potential monitoring sites were subjectively identified: reservoir-outflow sites, to provide data on the rate of water flowing out of each reservoir; reservoir-inflow sites, to provide unregulated-streamflow data that could be transferred to ungaged sites; and ground-water monitoring areas, in which an index well would be established to monitor ground-water levels. Water samples would be collected at all surface-water and ground-water sites for chemical analyses, and the results would be used in conjunction with streamflow data and ground-water levels to evaluate and monitor all water resources of the Croton Reservoir system. Eight reservoir-outflow sites, nine reservoir-inflow sites, and 16 ground-water monitoring areas were subjectively selected.

REFERENCES CITED

Cadwell, D.H., Connally, G.G., Dineen, R.J., Fleisher, P.J., Fuller, M.L., Sirkin, Les, and Wiles, G.C., 1986, Surficial geologic map of New York: New York State Museum, Geological Survey, Map and Chart Series no. 40, Lower Hudson Sheet, scale 1:250:000.

Fisher, D.W., Isachsen, Y.W., and Richard, L.W., 1970, Geologic map of New York: New York State Museum and Science Service, Geological Survey, Map and Chart Series no. 15, Lower Hudson Sheet, scale 1:250,000.

Goldin, H.J., 1989, Waste not, want not — managing New York City's water supply: City of New York, Office of the Comptroller, 48 p.

Greeson, P.E., and Robison, F.L., 1970, Characteristics of New York lakes, part 1—Gazetteer of lakes, ponds, and reservoirs: U.S. Geological Survey Bulletin 68, 124 p.

Greeson, P.E., and Williams, G.E., 1970a, Characteristics of New York lakes, part 1A—Gazetteer of lakes, ponds, and reservoirs by counties: U.S. Geological Survey Bulletin 68A, 121 p.

_____ 1970b, Characteristics of New York lakes, part 1B—Gazetteer of lakes, ponds, and reservoirs by drainage basins: U.S. Geological Survey Bulletin 68B, 122 p.

New York State Department of Environmental Conservation, 1992, Inactive hazardous waste disposal sites in New York State, annual report, appendix volume 3—list of sites by county: New York State Department of Environmental Conservation, Division of Hazardous Waste Remediation.

Robideau, J.A., Burke, P.M., and Richard Lumia, 1984, Maximum known stages and discharges of New York State streams through September 1983: U.S. Geological Survey Open-File Report 83-927, 83 p.

U.S. Department of Commerce, Bureau of Census, 1990, 1990 census of population and housing: Public Law 94-171.

U.S. Geological Survey, 1971, Index of surface-water records to September 30, 1970, part 1.—North Atlantic Slope Basins: U.S. Geological Survey Circular 651, 89 p.

_____ 1984-92, Water resources data—New York, water years 1984-1992, volume 1, Eastern New York excluding Long Island: U.S. Geological Survey Water-Data Report (issued annually).

Wagner, L.A., 1982, Drainage areas of New York streams, by river basins—A stream gazetteer, part 1, data compiled as of October 1980: U.S. Geological Survey Open-File Report 81-1055, 359 p.

APPENDIX

Geographic Information System (GIS) Data-Base coverages with description, scale, data type, source, and procedures used in development of each coverage used in selection of monitoring sites in the Croton Reservoir system.

Coverage: BASINS—USGS-delineated basin boundary of Croton Reservoir system
Scale: 1:24,000
Data type: Lines (Arcs)
Source agency: USGS
Coverage Development: The USGS New York drainage-area compilation (Wagner, 1982) is continually updated, and ARC/INFO coverages for all of New York State are being developed as part of this process. These coverages contain basin and subbasin boundaries, which are delineated by the USGS and checked by the Natural Resources Conservation Service.

Coverage: POPULATION—Population density
Scale: 1:250,000
Data type: Points
Source agency: U.S. Department of Commerce, 1990, Census of Population and Housing
Coverage Development: A point coverage of the 1990 Census of Population and Housing (U.S. Department of Commerce, 1990) for the conterminous United States was obtained, and the data for the study area were made into a separate coverage that includes the locations of population points retrieved at the "block group" summary level and the total number of persons and housing units represented by that point. Each point represents data from a polygon whose boundaries are not indicated in the coverage.

Coverage: LAND USE—Land use, divided into four major land-use categories: urban-commercial/industrial, urban-residential, rural-agriculture, and rural-undeveloped.
Scale: 1:24,000 and 1:250,000
Data type: Polygons
Source agency: Dutchess County and Connecticut: USGS; Putnam County: New York City Department of Environmental Protection (NYCDEP); Westchester County: Westchester County Planning Department
Coverage Development: Land-use data for Dutchess, Putnam, and Westchester Counties and Fairfield County, Conn., were obtained from different sources. Westchester County data were provided by the Westchester County Planning Department as an ARC/INFO coverage at a scale of 1:24,000, containing land-use data from the early 1980's. This coverage indicated 13 different types of land use that, in this study, were combined into the four major land-use categories listed above. Putnam County data were provided by the NYCDEP as an ARC/INFO coverage of land use at a scale of 1:24,000. This coverage was interpreted from 1987 aerial photographs and updated in 1991 with field checking and represents about 50 land-use categories, which were combined into the four major land-use categories mentioned above. Dutchess County data and the parts of Fairfield, Conn., that lie in the study area were obtained from USGS 1:250,000 scale Geographic Information Retrieval and Analysis System (GIRAS), which represents data from the mid-1970's and includes more than 30 types of land use. These were combined into the four major land-use categories referred to above. After the land-use data for each county had been combined into the four categories, the separate coverages for each county were joined to create a single land-use coverage representing the entire study area. The boundaries of the land-use polygons were then checked to ensure matching across county and state boundaries.

Coverage: ROADS—Transportation routes
Scale: 1:24,000
Data type: Lines (arcs)
Source agency: USGS
Coverage Development: Digital Line Graphs (DLGs) at 1:100,000 scale were obtained from the USGS and converted to an ARC/INFO coverage. The linework of this coverage was enhanced by digitizing some of the smaller roads from 1:24,000-scale planimetric maps provided by the New York State Department of Transportation.

Coverage: HYDROGRAPHY—Streams, aqueducts, and outlines of lakes and reservoirs
Scale: 1:100,000
Data type: Lines (Arcs)
Source agency: USGS
Coverage Development: Digital Line Graphs (DLGs) at a scale of 1:100,000 were obtained from the USGS and converted to an ARC/INFO coverage. The linework of this coverage was enhanced by digitizing smaller streams from 1:24,000-scale USGS topographic maps. In this coverage, wetlands were represented as lines through the center of the wetlands rather than by the boundaries of the wetlands.

Coverage: SURFACE-WATER GAGES—USGS streamflow and reservoir-stage-measuring sites
Scale: 1:24,000
Data type: Points
Source agency: USGS
Coverage Development: Data on active and inactive continuous streamflow-measurement sites were obtained through a retrieval from the USGS- National Water Information System (NWIS) data base. Data on miscellaneous streamflow-measurement sites were obtained from the following publications: Robideau and others (1984), U.S. Geological Survey (1971), Greeson and Robison (1970), Greeson and Williams (1970a,b), and annual USGS Water-Data Reports (v. 1) for 1984-92 (NY-84, NY-85, NY-86, NY-87, NY-88, NY-89, NY-90, NY-91, and NY-92).

Data Set: INFLOWS AND DIVERSIONS—Diversions into and out of the Croton Reservoir system
Scale: 1:24,000
Data type: Table
Source agency: New York City Department of Environmental Protection (NYCDEP)
Coverage Development: A tabulation of information on the diversions into and out of the Croton Reservoir system, provided by the NYCDEP, included the losing body or receiving body of water, the amount of water and the party responsible for the diversion.

Coverage: BEDROCK GEOLOGY
Scale: 1:250,000
Data type: Polygons
Source agency: New York State Geological Survey (NYSGS)
Coverage Development: The bedrock geology of the study area was unavailable in digital format. Data from a map of the bedrock geology of New York State (Fisher and others, 1970, scale 1:250,000) was digitized into an ARC/INFO coverage.

Coverage: SURFICIAL GEOLOGY
Scale: 1:250,000
Data type: Polygons
Source agency: New York State Geological Survey (NYSGS)
Coverage Development: The surficial geology of the study area was unavailable in digital format. Data from the New York State surficial geology map (Cadwell and others, 1986, scale 1:250,000) was digitized into an ARC/INFO coverage.

Coverage: PUBLIC-WATER-SUPPLY WITHDRAWALS—Public-supply well locations and associated well yields

Scale: 1:24,000
Data type: Points
Source agency: USGS
Coverage Development: A retrieval was made from the USGS National Water Information System (NWIS) Site-Specific Water-Use database (SSWUDS) to identify all the public-water supply withdrawal points within the study area. Information on each site included the name of the public-water supplier, the latitude and longitude of the withdrawal point, whether the withdrawal was from a surface-water supply or a ground-water supply, and the amount of water withdrawn. The data in the SSWUDS database were obtained from the New York State Department of Health and represent the year 1981.

Coverage: GROUND-WATER-WELLS—Locations and yields of wells finished in bedrock and stratified-drift well locations and yields (wells with yields greater than 25 gallons per minute)
Scale: 1:24,000
Data type: Points
Source agency: USGS
Coverage Development: A retrieval was made from the USGS National Water Information System (NWIS) Ground-Water Site Inventory database (GWSI) to identify all the wells in the study area that had a reported yield of at least 25 gallons per minute. Information on each site included the identifying name, the latitude and longitude, the primary water use, depth of well, and yield of well. The type of aquifer (bedrock or surficial) tapped was interpreted from the well location, water use, and well depth.

Data Set: WATER-QUALITY POINT SOURCE—Site and type of possible point-source contamination, including State and Federal Superfund sites
Scale: 1:24,000
Data type: Tabulation
Source agency: New York State Department of Environmental Conservation (NYSDEC)
Coverage Development: A table was developed listing the location and type of possible point-source contamination within the study area. Site locations were obtained from the NYSDEC (1992).

Coverage: WATER QUALITY SITES—Site location, date, and type of water-quality analyses
Scale: 1:24,000
Data type: Points
Source agency: USGS and New York City Department of Environmental Protection (NYCDEP) computer data bases.
Coverage Development: A retrieval was made from the USGS National Water Information System (NWIS) Water-Quality database (QWDATA) to identify any USGS data-collection sites (ground water or surface water) in the study area at which water samples had been collected for chemical analysis. Information on these sites included the site name, whether it was a ground-water site or a surface-water site, the latitude and longitude, the number of samples collected and analyzed, the range of dates of sample collection, and the physical, chemical, and biological constituents for which each sample was analyzed. Also included in this coverage are the locations of surface-water sites run by the NYCDEP at which water samples have been collected and analyzed. Information from the NYCDEP on these sites includes the type of site (reservoir, stream, aqueduct), the location of the site, the number of samples collected, the frequency of sample collection, the period(s) during which the samples were collected, and the physical, chemical, and biological constituents for which for each sample was analyzed.

Coverage: DAMS—Locations of dams, including information on owner and body of water on which dam is located.
Scale: 1:24,000
Data type: Points
Source agency: New York State Department of Environmental Conservation (NYSDEC)
Coverage Development: A list of dams in New York State was obtained from the NYSDEC as a computer retrieval from the NYSDEC Dam Safety Project data base in July 1983. Included in the list are the dam name; the body of

water impounded by the dam; the owner of the dam; and the stream, river, or reservoir on which the dam is located. Data on the dams in the study area were developed into an ARC/INFO point coverage.

Coverage: LAND SURFACE—Land-surface contours at 50-foot intervals
Scale: 1:100,000
Data type: Lines (Arcs)
Source agency: USGS
Coverage Development: Digital Elevation Models (DEMs) at 1:100,000 scale for the study area were obtained from the USGS and converted into an ARC/INFO coverage which, in turn, was modified to include only 50-foot land-surface contours and even multiples thereof.