

Hydrology

Hydrology is the study of the properties, distribution, and circulation of water in the atmosphere, on the earth's surface, and underground. This chapter describes the surface water and groundwater resources of Dutchess County. Atmospheric water is discussed in the Climate chapter.

Water is a renewable resource that is continuously recycled through a process referred to as the hydrologic cycle, depicted in Figure 4.1. Within this cycle, water enters the atmosphere by evaporating from large water bodies, streams, and ponds, and by transpiring from plants. This water vapor condenses into clouds and eventually falls back to earth as precipitation in the form of rain, snow, sleet, or hail. In this manner, water that evaporates from the Great Lakes can be transported to New York State to fall as a warm spring rain.

The Hydrologic Cycle

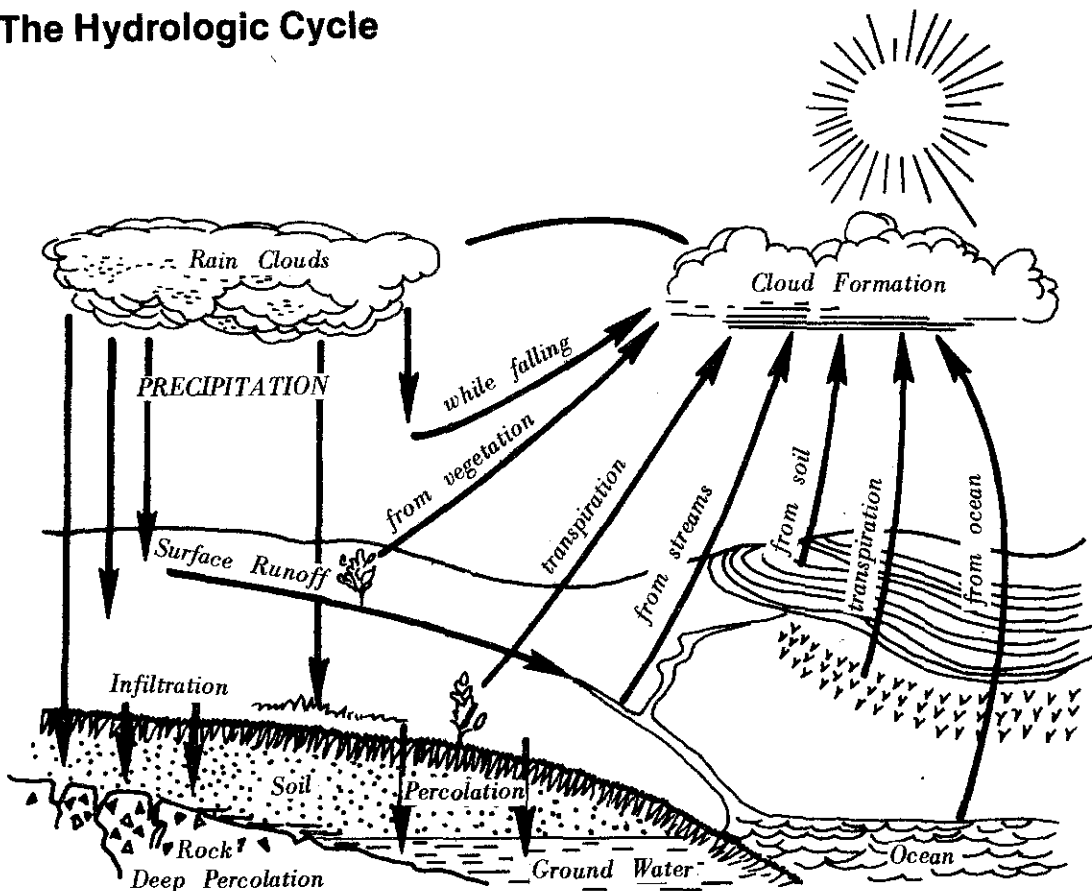


Figure 4.1

Some of this rain water may evaporate immediately. Plants will take part of it into their roots. The rest will run off into brooks, streams, and rivers or seep into underground water storage areas, called aquifers, where it can be tapped for human use. Some may find its way into deep aquifers through cracks in the underlying bedrock. It may be stored there for centuries before working its way to the surface to evaporate, thus closing the cycle. In effect, the hydrologic cycle is an enormous distillery, powered by the sun and gravity, which renews our water resources.

Human activity can have a profound impact on this natural cycle. Our water resources are increasingly threatened by pollution and misuses that can be related to the way we use our land. For example, urban development commonly results in paving over large areas of land. This increases water runoff, decreases infiltration to groundwater, and aggravates downstream flood problems. One result is an annual toll in human lives and property damage from flooding; diminishing groundwater supplies can be another. Water quality is increasingly threatened by pollution from pavement runoff, excessive use of fertilizers and pesticides, failing or inadequate septic systems and landfills, erosion from poor farming and land clearing practices, and improper disposal of hazardous wastes. Understanding the county's water resources is essential if they are to be protected from these threats.

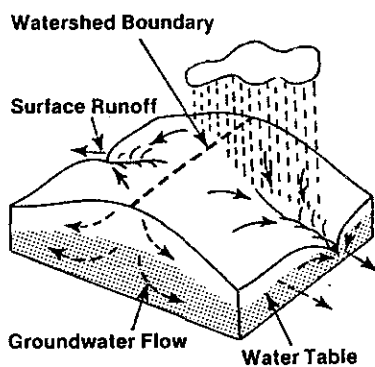
Drainage Basins and Watercourses

Water drains from the land surface through drainage features ranging from rivulets in shopping center parking lots to large rivers like the Hudson. The entire area drained by a particular rill, creek, stream, or river is called a drainage basin or watershed. The ridge that nearly encircles a drainage basin and separates one basin from another is called the basin or watershed boundary. Figure 4.2 illustrates how this boundary affects the direction of water flow in adjacent basins.

A hierarchy of drainage basins covers any land area. For example, each small tributary of the Little Wappinger Creek has its own drainage basin, and is included in the 33.4 square-mile watershed of the Little Wappinger Creek. This watershed is considered part of the 210 square-mile Wappinger Creek basin. The Wappinger watershed, in turn, is included in the lower Hudson subdivision of the Hudson River watershed, shown in Figure 4.3.

All of the water within a given watershed is part of the same hydrologic system. Watersheds, therefore, are the most appropriate geographic area for the study of

Water Flow at the Watershed Boundary



Redrawn from Marsh, *Environmental Analysis for Land Use and Site Planning* 1978, page 65.

Figure 4.2

water resources, the development of water resource management strategies, and the development of comprehensive waste treatment plans. Because all land uses both depend on and influence the quality and quantity of water supplies, watersheds are also the most logical physical units for natural resource management and land use planning.

Table 4.1 Major Drainage Basins in Dutchess County

Basin	Size (square miles)	Percent of County Area
Hudson River	140	17
Wappinger Creek	210	26
Fishkill Creek	194	24
Tenmile River	209	26
Croton River and Roeliff Jansen Kill	54	7
Total	807	100

Source: Ayer and Pauszek, Streams in Dutchess County, 1968.

Most of Dutchess County is within the Hudson River drainage basin. As shown in Figure 4.3, a portion of the Harlem Valley drains into the Housatonic River in Connecticut. Within these two major basins, as indicated on the Drainage Basin Map, there are four primary watersheds in the county: the Wappinger, the Fishkill, the Hudson, and the Tenmile. Wappinger Creek, the Fishkill Creek, and numerous smaller streams that feed directly into the Hudson drain approximately 67 percent of the county's 807 square miles. The Tenmile River basin, which is part of the Housatonic basin, covers nearly 210 square miles or 26 percent of the county, including all of Dover and Amenia and most of Northeast and Pawling. The remaining 7 percent of the county is divided between two other watersheds. A small area in the southeastern corner drains into the Hudson River via the Croton River, through Putnam and Westchester counties. Part of the northeastern section of the county drains into the Hudson River via the Roeliff Jansen Kill and its tributaries. The appendix contains a detailed list of the lengths, drainage areas, and elevations of most of the streams in Dutchess County.

Hudson and Housatonic Drainage Basins

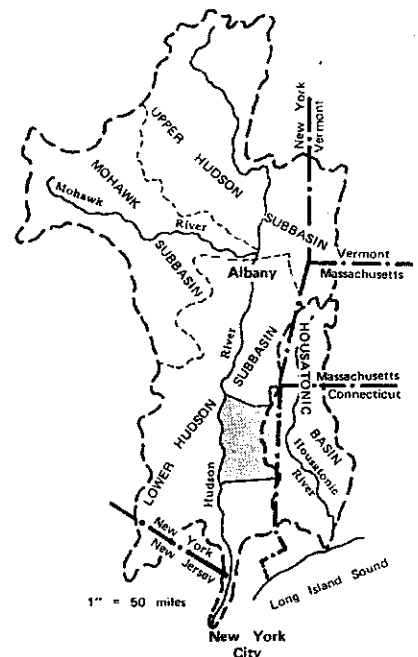


Figure 4.3

Hudson River Basin

The Hudson River basin covers a relatively small area and discharges a low volume of water compared to other major river basins in North America. The river is tidal from its mouth in New York City to the locks at Troy. Fresh water meets salt water in a transition zone generally found below Chelsea, in the town of Wappinger.

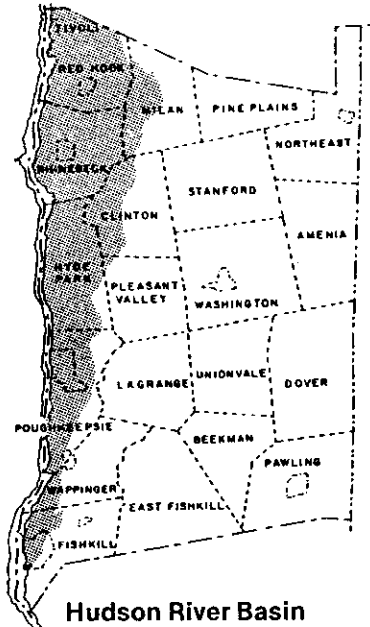
Surface water from the Hudson River shore towns of Poughkeepsie, Hyde Park, Rhinebeck, and Red Hook drains directly into the Hudson River via streams that serve small secondary watersheds. These secondary basins within the Hudson basin include Stony Kill, Saw Kill, Landsman Kill, Crum Elbow, Fallkill, and Casper Creeks.

The sizes of the secondary watersheds within the Hudson River drainage basin range from one-half square mile to 30 square miles, averaging 20 square miles. Many of these watersheds include areas in more than one town. In times of heavy precipitation the relatively small size of these basins results in fairly uniform distributions of stormwater runoff. Flooding in these small watersheds is localized, therefore, and less severe than that which can occur along major waterways, such as the Tenmile River. However, poorly planned development in the urban and suburban portions of the basins could cause drainage and flooding problems in the future.

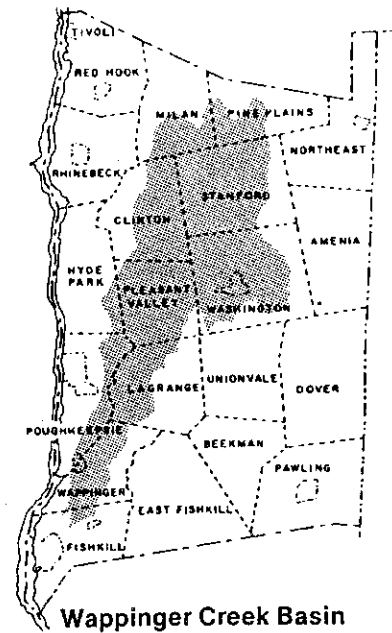
As previously described, the Wappinger and Fishkill Creeks are within the Hudson River basin. However, because of their size and significance in the county's hydrologic system, these two creeks are discussed separately below.

Wappinger Creek Basin

The Wappinger Creek and its tributaries drain approximately 210 square miles, roughly one-fourth of Dutchess County. The drainage area is 30 miles long, extending southwest from the town of Pine Plains toward New Hamburg at the southern tip of the town of Poughkeepsie. The width of the basin ranges from ten miles in the north to four miles in the south. Three primary branches--the Little Wappinger, the Main Branch, and the East Branch--drain the northern area before converging near Salt Point in the town of Pleasant Valley. The Wappinger drainage basin includes large parts of the towns of Pleasant Valley, Washington, Pine Plains, Milan, Stanford, and Clinton, as well as portions of the towns of Wappinger, Poughkeepsie, and LaGrange. In the lower basin the creek receives runoff from the county's most intensely developed areas.



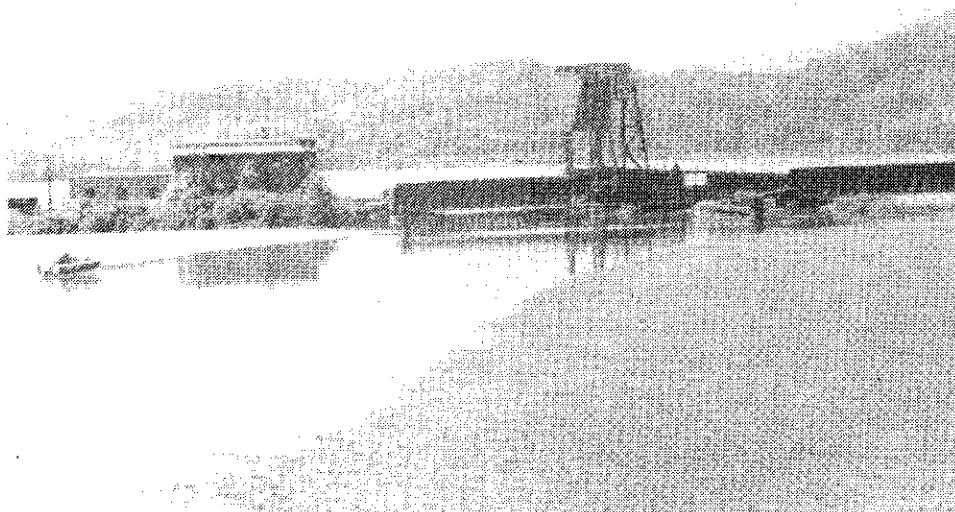
The topography of the Wappinger Creek drainage basin is varied, ranging from nearly flat meadows along the creek to the rocky slopes of Stissing Mountain, the highest point in the watershed at 1,403 feet above sea level. Most of the principal tributaries are permanent streams with elevations of 400 to 600 feet and average gradients of 10 to 15 feet per mile. The water rarely descends, however, at the average rate. Instead, it falls fastest along the steep upstream portion of the creek, especially where hard rock ridges in the stream bed have resisted erosion and created waterfalls.



Wappinger Creek Basin

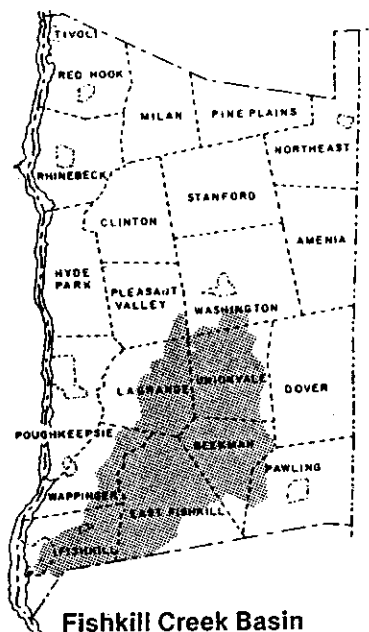
Much of the land along Wappinger Creek and its major tributaries is subject to flooding. The section downstream of the confluence of the Little Wappinger and the East Branch, at Salt Point, is especially floodprone. The entire flow from the expansive upper basin, which is three times as large as the lower portion of the watershed, funnels through this section of the creek.

The lower portion of the Wappinger basin is more urban than the upper basin, and contains large expanses of land sealed by pavement or buildings. This urbanization aggravates flood hazards by increasing the volume and speed of storm runoff; this increase, in turn, often overloads the storm drainage capacity of lowlands along the creek. Several settlements in these floodplain lowlands, including the hamlet of Pleasant Valley, the Overlook section of the town of LaGrange, and the Shady Brook Trailer Park in the town of Poughkeepsie have suffered severe flood damage in the past.



Fishkill Creek Basin

The Fishkill Creek basin covers approximately 194 square miles. Like the Wappinger basin to its north, it is long and narrow. Stream gradients are also similar. Fishkill Creek, the basin's primary stream, begins in the



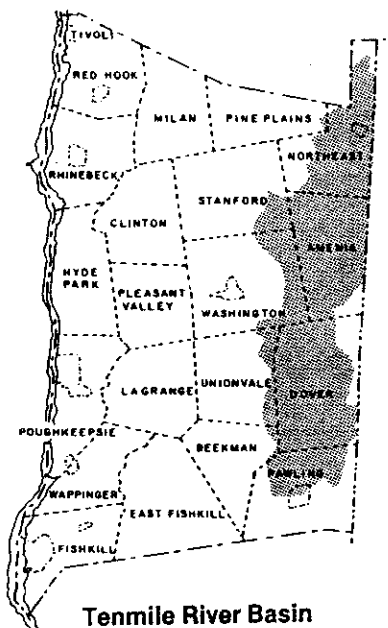
Fishkill Creek Basin

center of the county in Unionvale. From there it flows southwest, entering the Hudson River at Beacon. It drains a large part of Unionvale, Beekman, East Fishkill, and Fishkill. Sprout Creek, Fishkill Creek's primary tributary, drains major sections of LaGrange and Unionvale and small portions of Wappinger and East Fishkill.

The creeks in the Fishkill basin drain comparatively flat farm land and wetlands. In the upper reaches of the basin the stream drops slightly more than 200 feet in 10 miles. In the lower portion, where Fishkill Creek falls over slate and limestone ledges, the gradient is 200 feet in 5 miles. Most of the Fishkill Creek is 1 to 2 feet deep and less than 50 feet wide during periods of moderate flow. Tributaries funnel runoff from the upstream portion of the Fishkill Creek basin into the main stem at Lomala, along the Fishkill-East Fishkill boundary. As in the Wappinger Creek basin, this funneling effect increases the burden on downstream lowland areas during periods of heavy runoff, and can lead to flooding. The problem of inappropriate land uses in floodprone areas is not as evident in the Fishkill basin as in the Wappinger.

Tenmile River Basin

The Tenmile River drains 210 square miles in the eastern section of Dutchess County, from the Columbia County line south to the town of Pawling. The basin ranges from 5 to 8 miles wide, is 33 miles long, and is served by four principal watercourses: the main stream, Swamp River, Webatuck Creek, and Wassaic Creek. The Tenmile River falls an average of 16 feet per mile as it travels its narrow path southward from the town of Northeast, through the Harlem Valley lowlands in Amenia and Dover, to enter Connecticut near Dogtail Corners. The Swamp River, which flows north from the heart of Pawling, joins the Tenmile River south of Dover Plains.



Tenmile River Basin

The Tenmile River and its tributaries wind through extensive floodplains and wetlands. During periods of increased runoff these areas retain flood waters, helping to minimize downstream flooding. Because the Tenmile River basin is not as developed as other drainage basins in the county, there are still many opportunities to preserve the functional and wildlife values of these wetlands and floodplains while accommodating agricultural activity and growth. Homesites have, however, been developed within the Tenmile River floodplain along Lime Kiln Road, south of Dover Plains. The results of such development have been property damage to residents of flood prone areas and increased public costs for flood relief and flood management efforts.

Surface Water Quantity

Dutchess County is fortunate to have abundant surface water resources. More than 600 miles of named streams traverse the county, as listed in the appendix. Unnamed streams and tributaries bring the total to more than 800 miles.

Table 4.2 Lakes and Ponds

Dutchess County, New York
(25 Acres or Larger)

Name	Location	Approximate Size in Acres
Abell's Lake	Unionvale	39
Black Pond	East Fishkill	176
Bontecou Lake	Washington	113
Lake Carvel	Pine Plains	38
Cobalt Lake	Poughkeepsie	29
Crane Pond	Dover	38
DeFlora Bros. Lake	Hyde Park	43
Dieterich Pond	Millbrook	32
Lake Dutchess	Pawling	51
Ellis Pond	Dover	61
Green Mountain Lake	Pawling	35
Halcyon Lake	Pine Plains	26
Hillside Lake	East Fishkill	26
Hunns Lake	Stanford	68
Indian Lake	Northeast	194
Little Whaley Lake	Pawling	52
Long Pond	Clinton	66
Nuclear Lake	Pawling	55
Quaker Lake	Pawling	64
Round Pond	Amenia	49
Round Pond	Milan	40
Rudd Pond	Northeast	76
Sepasco Lake	Rhinebeck	26
Sharpe Reservation Pond	Fishkill	26
Shaw Pond	Washington	26
Silver Lake	Clinton	113
Spring Lake	Milan	26
Stissing Lake	Pine Plains	78
Swift Pond	Amenia	61
Sylvan Lake	Beekman	116
Thompson Pond	Pine Plains	68
Twin Island Lake	Pine Plains	62
Tyrrel Lake	Pleasant Valley	45
Upton Lake	Stanford	43
Lake Walton	East Fishkill	42
Wappingers Lake	Wappingers Falls	122
Lake Weil	Dover	34
Whaley Lake	Pawling	287



Source: Dutchess County Department of Planning.

Unlike Putnam County to the south, Dutchess County is not well-endowed with large lakes and reservoirs. There are, however, 93 named lakes and ponds in Dutchess and dozens that are unnamed. Many were artificially created. Lakes larger than 25 acres are listed in Table 4.2. The largest lake in the county is Whaley Lake in the town of Pawling.

The Hudson River is by far the county's largest supplier of drinking water, providing more than 11.7 million gallons per day (mgd) to the city and town of Poughkeepsie and the village of Rhinebeck. With an average outflow of nearly 19,700 cubic feet per second (cfs), the Hudson remains the largest and last undeveloped surface freshwater source in southeastern New York. It has the capacity to supply drinking water to all of the county's urban and suburban areas.

The 1980 census indicates that 60 percent of the county's total population of 245,055 is served by community surface or groundwater systems; the remaining 40 percent relies on private domestic wells. Approximately 70,000 people in the county use Hudson River water; another 24,000 draw at least part of their water from surface supplies. In addition to the 11.7 mgd from the Hudson, community surface and groundwater systems provide 10.4 mgd to county residents.

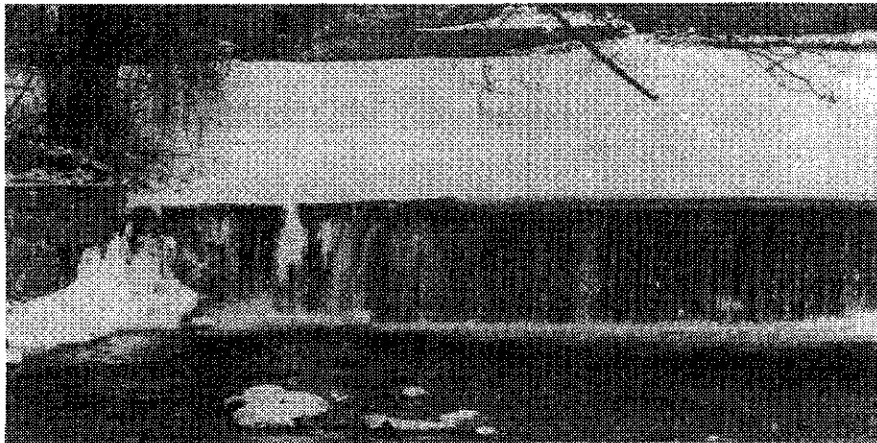
New York City has established a Hudson River tap and pumping station at Chelsea in the town of Wappinger as a precaution against water shortages in its upstate system. Although the Chelsea tap has not been used for many years, it could draw significant quantities of freshwater from the river if the need arose.

The salt front of the Hudson River shifts regularly and predictably along the southwestern border of the county. It moves with the balance between the upstream inflow of freshwater and the downstream forces of the ocean tides. Increased use of the upper Hudson River for water supplies and power plant cooling water could increase the likelihood of the salt front advancing north of Chelsea. Under such conditions the suitability of Hudson River water as a source of drinking water for Dutchess County and as an emergency source for New York City could deteriorate.

If precipitation remains constant and water quality improves, the three major streams in the county could accommodate substantial increases in demands for drinking water. However, precipitation is not constant; variations produce stream flow fluctuations which, in turn, affect both the quantity and quality of water available. Wide stream flow fluctuations have occurred in the past.

From 1928 to 1965, the flow of the Wappinger Creek near the village of Wappingers Falls ranged from 0.9 to 18,600 cfs, with an average of 236. The flow of the Tenmile River near Gaylordsville, Connecticut ranged from 7 to 17,400 cfs during the same period, with an average of 287 cfs. From 1944 to 1965, the flow of the Fishkill Creek at Beacon ranged from 0.4 to 8,800 cfs, with an average of 279 cfs. Even under severe drought conditions the three major streams sustained some flow.

The combined average flow of the Tenmile River, Fishkill Creek, and Wappinger Creek today is 840 cfs, or 543 million gallons per day. The flow may be below average 70 percent of the time. Excessive stream flow and flooding occur after severe storms, such as the hurricanes that struck the county in 1938 and 1955, and during spring runoff periods.



Little information has been collected about recent flow rates of the county's streams and rivers. At one time, the U.S. Geological Survey monitored water flow rates at 13 stream locations in the county, and once participated in a study of flow rates at 24 stream sites. Today, the USGS operates only two gaging stations: one on the Tenmile River near the Connecticut line, and another on the Wappinger Creek near Wappingers Falls. The scarcity of up-to-date information about surface water flow rates makes it difficult to assess the hydrological impacts of recent land use changes on the county's watersheds.

Many public wellfields tap aquifers adjacent to the county's major interior waterways. At present no public water supplies are drawn directly from these larger streams and rivers. Several smaller streams or reservoirs, however, do provide water for community systems in Beacon, Hyde Park, and the village of Pawling as well as for large institutions in Dover, Beekman, and Red Hook.

Table 4.3 Runoff Coefficients for Uniform Level Surfaces

Surface Type	Approx. Fraction of Rainfall that Runs Off Surface ¹
Asphalt or concrete paving, roofing, other waterproof surfaces	.90
Bituminous macadam	.85
Compacted earth and gravel without vegetation	.70
Impervious soil with vegetation	.50
Gravel	.30
Gardens and lawns	.20
Farmland and meadows	.15
Woodlands	.10

Source: Kelly, H., Planning Guidelines for Dutchess County Drainage, 1968, and

Lynch, K., Site Planning, 1971.

¹Coefficients should be adjusted to reflect land use of entire tributary area, site slopes, soil characteristics, and other variable factors.

Land use has a dramatic effect on the amount of water that finds its way into the county's streams and rivers. The conversion of forest and agricultural land to urban and suburban uses increases the number of water users while decreasing the amount of open land available to absorb, store, and filter surface and groundwater supplies. The fraction of total rainfall that runs off a site increases rapidly as the permeability of the site surface decreases. This relationship is indicated by the runoff coefficients listed in tables 4.3 and 4.4. Woodlands, for example, usually absorb 90 percent of the rainfall they receive; the percentage may be lower on steep wooded hillsides, and considerably higher in nearly level, dense woods with highly porous soils. When woodlands are cleared and developed for commercial uses, the portion of rainfall absorbed can drop to 1 to 10 percent, leaving 90 to 99 percent to run off the site.

A normal amount of runoff is necessary to sustain the county's lakes, ponds, wetlands, and streams, and the

Table 4.4 Runoff Coefficients for Composite Land Uses

Land Use Type	Approx. Fraction of Rainfall that Runs Off Surface ¹
Residential lots	
2 acres and larger	.15
1/2 - 2 acres	.25
15,000 ft. ² , (.34 acre) to 1/2 acre	.30
7,000 ft. ² , (.16 acre)	.40
40 dwelling units per acre (1,089 ft. ² , each)	.50-.70
Industrial uses	.60
Commercial uses	.75
Dense urban commercial use	.70-.90

Source: Kelly H., Planning Guidelines for Dutchess County Drainage, 1968, and

Lynch, K., Site Planning, 1971.

¹Coefficients should be adjusted to reflect land use of entire tributary area, site slopes, soil characteristics, and other variable factors.

uses and natural communities they support. The large volumes of runoff shed by developed sites, however, can adversely affect drainage systems, surface water volume and quality, flood patterns, soil erosion rates, and groundwater supplies. Careful land use practices play an essential role in minimizing these impacts and ensuring that adequate supplies of clean water will be available in the future.

Surface Water Quality

Both natural processes and human activities affect water quality. The types of rocks and soils that water passes through, the length of time it remains in contact with them, and the amount of soil that water carries in suspension are all natural factors that influence water quality. Erosion is one form of natural "pollution" that can be greatly increased by poor land use management practices. Other human activities may adversely affect water quality by discharging physical, chemical, or thermal pollutants into water bodies.



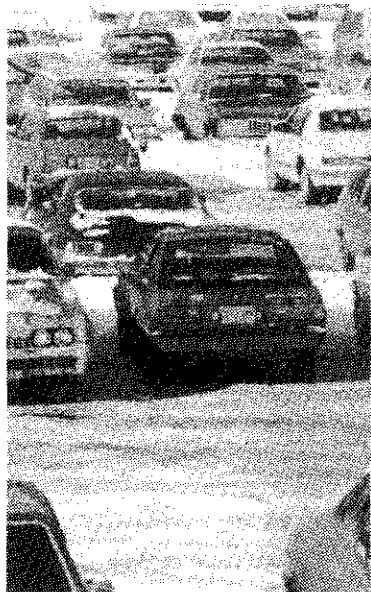
Natural Factors

The type and quantity of minerals in solution determine water hardness. For example, large concentrations of magnesium and calcium make water hard. Hardness is often recognized by its soap-consuming character and by the tendency of the minerals to form solid deposits, called precipitates, in the water. Many streams in Dutchess County have hard water. Some of the minerals in such water have beneficial effects. Fluoride concentrations of one milligram per liter (mg/l), for example, are known to reduce the incidence of dental cavities. Water in Dutchess County was found to have significant natural fluoride content during a sampling period from 1970 to 1975.

Groundwater usually has a higher dissolved mineral content than surface water because of its increased contact with rocks and soil. Because most streams are fed by ground sources, they often show some of the hard-water characteristics of groundwater. This phenomenon is most pronounced during dry periods; after a heavy rainfall, or during snowmelts, the concentration of dissolved minerals in these streams is diluted.

Human Influences

Water pollution caused by human activities may appear in the form of dissolved and particulate solids, biodegradable and non-biodegradable organic materials, infectious agents, nutrients, toxic substances, or unnatural changes in heat, taste, odor, and color in ground and surface waters. Selected sources of these pollutants, their effects on water, and ways to prevent and abate such pollution are listed in the appendix.



Information about Dutchess County's surface water quality is spotty and inconsistent. A 1981 report by the New York State Department of Environmental Conservation (DEC) examined 19 county streams, lakes, and ponds considered to be under stress from various pollutants. The major suspected pollution sources named in the report were landfills, petrochemical-laden runoff from parking lots and streets, and failing septic tanks. Industrial waste discharges, sediment, agricultural chemicals, and sewage treatment plant discharges have also been identified as sources of water pollution. The DEC report was based on past tests or observations by government officials. No large-scale program for systematically monitoring the quality of the county's surface waters is currently in place.

The flow rate is a major factor in determining a stream's ability to absorb wastes. With increased flow

this assimilation capacity increases if other factors affecting purification, such as waste type and quantity and water temperature, are held constant. Low flow periods, therefore, are critical times for maintaining water quality.

Upstream erosion and pollution are gradually choking many of the county's lakes and ponds. Materials carried downstream fill the lakes with silt and accelerate the natural eutrophication process through which lakes evolve into dry land. Eutrophic lakes are of limited use for recreation or water supply. Controlling erosion and pollution discharges is an essential step in prolonging the useful life of these water resources.



Acid rain is gaining recognition as a serious pollution problem. As a result of the combustion of tremendous quantities of fossil fuels, such as coal and oil, the United States annually discharges approximately 50 million metric tons of sulfur and nitrogen oxides into the atmosphere. Through a series of complex chemical reactions some of these pollutants are converted into acids, which return to earth in rain or snow. As discussed in more detail in the Climate chapter, investigators have concluded that acid rain and the chemical changes it seems to induce in soil and runoff water are responsible for the destruction of plant and animal life in hundreds of Adirondack lakes. Studies report that acid rain has damaged buildings, significantly increased the acidity of surface waters, and affected forests throughout the midwestern and northeastern United States and Canada, but the true magnitude of the problem is still under debate. Studies of the impact of acid rain on the Hudson Valley are underway.

Hudson River water is known to contain at least 26 toxic chemicals, including federal priority pollutants such as PCBs, DDT, arsenic, cadmium, mercury, and cyanide. Recent studies indicate that 225 facilities in four states, including 208 permitted facilities in New York, discharge toxic chemicals into the river. The most commonly discharged pollutants are oil and grease, which contain carcinogenic benzene and lead.

The Hudson is considerably cleaner than it was in the 1960s and early 1970s, before major water pollution control laws were passed. The presence of toxic chemicals in discharges and in river-bottom sediments, however, fuels a continuing debate about the river's suitability as a drinking water source, and raises questions about the need for more extensive water and waste treatment systems.

Water Quality Standards

The federal and New York State governments have developed water quality and purity standards. The Federal Water Pollution Control Act of 1972, as amended, imposes strict standards on water quality and pollutant levels. Part 701 of the 1974 New York Environmental Conservation Laws outlines the water quality and priority classifications and standards for New York State.

Under New York State law, fresh surface waters are classified according to their present quality and the "best" or most pollution-sensitive uses for water of that quality. The New York State Department of Environmental Conservation (DEC) applies standards that correspond to these classifications when reviewing stream disturbance or pollutant discharge permit applications. This is to prevent the existing water quality from deteriorating. The major classifications are listed in Table 4.5.

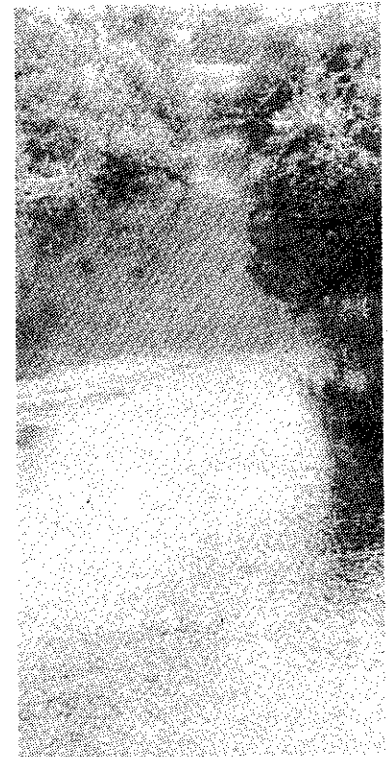
Table 4.5 Stream Classifications

Class	Best Use
AA	Drinking (after chlorination)
A	Drinking (after chlorination and filtration)
B	Bathing
C (+)	Fishing (trout)
C	Fishing
D	Secondary contact recreation

Source: NYS Department of Environmental Conservation.

Most of the streams, rivers, lakes, and ponds within Dutchess County are Class B, C, or D. Some of the more significant AA and A streams and lakes are listed below:

- Clove Creek - at Fishkill water supply
- Crum Elbow Creek and tributaries - upstream of Hyde Park Fire and Water District intake
- Ellis Pond
- Fishkill Creek - at Beacon water supply
- Gardiner Hollow Brook - at Green Haven State Prison water supply
- Green Mountain Lake
- Hiller Brook and tributaries - at Pawling Village water supply.
- Indian Kill - at Staatsburg water supply
- Long Pond
- Pawling Reservoir
- Silver Lake
- Swamp River - at Harlem Valley Hospital water supply
- Tenmile River, wells, stream, and tributaries - at Dover Plains auxiliary water supply
- Tributaries of Cargill Reservoir

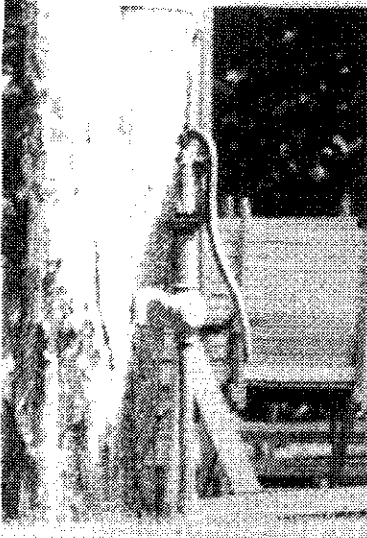


These classifications affect, but do not unduly restrict, land uses along waterways. If wastes are treated to satisfy the appropriate standards, they can be discharged under permit. The standards protect the rights and property values of landowners along water courses by protecting them from water pollution. Stream classifications are periodically revised by the New York State Department of Environmental Conservation. Public hearings are an integral part of the reclassification process.

Groundwater Resources

Groundwater is the supply of water beneath the earth's surface. After precipitation is absorbed by soil, it travels beneath the surface and is stored in a

water-saturated underground layer of earth, unconsolidated deposits, or porous stone. Aquifers are natural groundwater reservoirs that recharge surface streams, support plant life, and provide water for drinking, home, and industrial use.



The importance of the county's groundwater is often underestimated because aquifers are out of sight and difficult to measure. Yet, at least 60 percent of the county's population relies on community or individual wells. Wells serve as back-up or auxiliary supplies for another 15 to 25 percent of county residents. Many of these wells draw on groundwater supplies that lie outside sand and gravel or limestone aquifers, and they often give yields that are low compared to the volumes of water that the major aquifers can provide.

The largest and most productive aquifers occur along the county's major stream and river valleys, where thick glacial deposits of sand and gravel overlie limestone. As shown on the following Groundwater Occurrences Map, these aquifers are found in the Harlem Valley along the Tenmile and Swamp Rivers, along the Wappinger Creek, and along the Fishkill Creek. Extensive sand and gravel deposits also exist along the Sprout Creek in East Fishkill and LaGrange, the east branch of the Wappinger Creek in Washington, and the Sawkill Creek in Red Hook. Relatively little is known about the boundaries and interrelationships of these aquifers, their capacity, their quality, or their sensitivity to development pressures.

As explained in the Geology chapter, the water-bearing characteristics of unconsolidated deposits vary widely because of differences in porosity and permeability. Permeability is a measure of the ability of a material to transmit water. In unconsolidated deposits, permeability depends on the size of the pores between the particles of sand, gravel, silt, or clay. In bedrock, permeability depends on the degree of fracturing and how well the rock fractures, crevices, and cavities interconnect. The higher the permeability of a material, the greater its potential yield as a water supply.

Porosity is a measure of how much pore space a given volume of material contains; this amount determines how much water the material can hold. The more pores there are and the larger they are, the more water can be held in storage.

Sand and gravel are especially valuable aquifer materials because they are highly porous and permeable. The pores in sand and gravel deposits are large enough to hold considerable volumes of water, while allowing water to flow easily toward wells, springs, and other discharge

points. Known yields from sand and gravel aquifers in Dutchess County range from 2 to 1,400 gallons per minute (gpm). Clay, on the other hand, is an extremely dense, impermeable material whose microscopic pores and particles inhibit groundwater flow. Glacial till falls between clay and sand in porosity, permeability, and water yield. Till contains an assortment of particle types and sizes. Reported yields from wells tapping glacial till range from 1 to 180 gpm. The water storage characteristics of the county's unconsolidated deposits are discussed in more detail in Chapter Two. Reported well yields are summarized Table 4.6.

The consolidated deposits of limestone and dolostone, called the Wappinger Group, are the most productive bedrock formations in the county, with an average yield of 22 gpm from drilled wells. This productivity is due to the fact that limestone dissolves easily, allowing water to flow into the numerous channels, caverns, and fissures that characteristically develop in the rock. Water from these sources is hard, with a median mineral content of 229 parts per million (ppm), and relatively high in dissolved solids, at 316 ppm.

Table 4.6 Reported Well Yields

Dutchess County
(gallons per minute)

Formation	Range	Median	Mean
<u>Unconsolidated Deposits</u>			
Glacial Till	1 to 180	10	22
Clay and Silt	not available	not available	not available
Sand and gravel	2 to 1400	20	136
<u>Bedrock</u>			
Pelitic Rock	0 to 135	9 to 15	16
Poughquag Quartzite	2 to 30	8	10
Wappinger Group	1 to 220	13	22
Austin Glen			
Graywacke	0 to 135	10 to 15	16
Hudson Highlands and Housatonic Gneiss	1 to 45	8	11

Source: Unconsolidated deposit yield figures and bedrock median yields:

Gerber, Water Resources Study for Dutchess County, 1982.

Bedrock range and mean yields:

Simmons, et al., Groundwater Resources of Dutchess County, 1961.

As described in Chapter Two, much of Dutchess County's bedrock is composed of pelites, primarily shales and slates. All of the pelitic units in the county have low porosity and low permeability. The bedding planes and fissures in these rocks serve as channels for the storage and movement of groundwater. Studies by the United States Geological Survey show that yields from drilled wells in pelitic rock units and in Austin Glen Graywacke average 16 gpm, with hilltop wells yielding 14 gpm and valley wells yielding 17 gpm. The water from pelitic rock wells is relatively soft, with a median of 138 ppm, while the median content of dissolved solids is comparatively high at 234 ppm. Hydrogen sulfide affects some of the water drawn from this bedrock, resulting in a "rotten egg" odor. Water in the Austin Glen formation is moderately hard.

The more mountainous parts of Dutchess County are underlain by crystalline types of bedrock such as Hudson Highlands Gneiss and Poughquag Quartzite. Because these are denser than pelitic bedrock, there are fewer openings for water infiltration. Well yields are relatively low, averaging 11 gpm for the gneiss and 10 gpm for the quartzite. Like the pelitic rock, water from these formations is relatively soft at 138 ppm, and the median content of dissolved solids is 234 ppm.

Although Dutchess County has made considerable progress in mapping and gathering information about its aquifers, little is known about the detailed characteristics of these groundwater supplies. What is known is that improper land use practices can deplete and pollute aquifers, leaving them unfit or inaccessible for human use. The processes through which such damage can occur are described below.

Depletion

Groundwater supplies are replenished by precipitation that gradually percolates through the soil, into deposits of sand, gravel, clay, till, or bedrock formations. This process of replenishment is called groundwater recharge. Groundwater travels through subsurface deposits and into wells, streams, lakes, springs, and other discharge points.

Aquifers exist in a state of equilibrium when the rate of recharge matches the rate of water withdrawal. As water is drawn off into surface water supplies, it is replaced through groundwater recharge so that the volume of water in the aquifers remains stable. This equilibrium can persist as long as water use does not over-tax the ability of the groundwater reservoir to replenish itself.

Wherever development densities become great enough to disrupt the groundwater recharge process, groundwater supplies diminish. Water tables subside and, eventually, wells go dry. If such groundwater "mining" is allowed to continue, water supplies can permanently disappear over large areas.

Three interrelated land use practices contribute to aquifer depletion. The first is overcrowding. If the homes, businesses, industries, and institutions using wells in any area demand more water than the area's groundwater receives from rainfall and other sources, the amount of groundwater available will decrease. Often it takes many years before such steady depletion is noticed. The effect of residential overcrowding on groundwater supplies is depicted in Figure 4.4.

Effects of Overcrowding on Groundwater Supplies

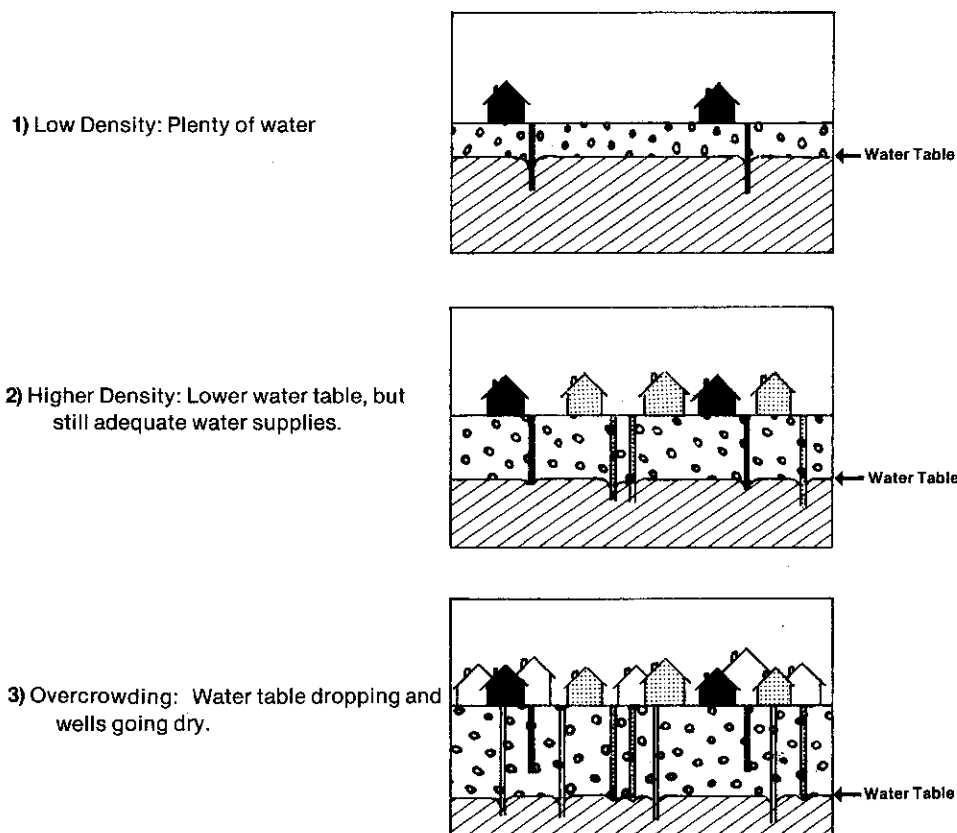


Figure 4.4

A second cause of groundwater depletion is the common practice of converting groundwater into surface water. This happens in communities and industries that

depend on wells for their water supplies, and discharge their waste water into surface streams or rivers. These waterways carry the treated waste water downstream, away from the source aquifers, and prevent it from recharging the underground supplies. Individual septic systems are designed to return well water to the ground, but community sewers and industries usually discharge wastes into surface waters.

The third contributor to aquifer depletion is reduction of the aquifer recharge area. The recharge area absorbs rainfall, floodwaters, and snowmelt and allows them to filter down into the aquifer to replenish groundwater supplies. Covering the recharge area with buildings, parking lots, roads, and other impervious materials reduces the soil acreage available for recharge; rain that previously would have soaked into the soil runs off into streams and rivers instead.

The ability of groundwater supplies to sustain different land uses depends on the recharge rate of the subsurface materials as well as the land uses themselves. Thick sand and gravel deposits have an estimated natural recharge rate of 0.93 gallons per minute per acre, compared to a rate of 0.12 gpm per acre for clay and silt. These rates reflect differences in porosity and permeability that enable sand and gravel to absorb and transmit water more quickly than clay can. Recharge rates also depend on the slope of the land, the surface vegetation, and the intensity and amount of precipitation.

Table 4.7 Recharge Rates and Recommended Maximum Densities
(For Homes on Septic Systems)

Surficial Deposit	Natural Recharge Rate (gpm/acre)	Maximum Dwellings per Acre ¹	Minimum Acres per Dwelling ¹
Thin sand and gravel	0.74	1.45	0.70
Thick sand and gravel	0.93	1.80	0.55
Thin soil over bedrock	0.35	0.70	1.40
Thick silty till	0.17	0.30	3.30
Clay-silt	0.12	0.24	4.20

Source: Hauser, E., for Dutchess County Department of Planning. Adapted from Gerber, R.G., Water Resources Study For Dutchess County, 1982.