Pennsylvania's Watershed Regions

Lower Susquehanna

Introduction

Each of Pennsylvania's major drainage basins has an array of individual characteristics that distinguish it from other regions of the state. These include diverse geographic and geologic features as well as major differences in historical settlement, economic and land use patterns. To reflect these variations, six regional water resources committees were created by the Water Resources Planning Act to ensure that individual regional priorities were developed and highlighted in the plan. The priorities and actions of the Lower Susquehanna Regional Water Resource Committee are significant and influence not only local streams and rivers, but also the Chesapeake Bay.

The committee members represent a broad range of interests in their region – business and industry, agriculture, local government and the environment. Each committee has identified and given consideration to a broad set of water resources issues and concerns specific to their region. The water resource management goals and objectives of the Lower Susquehanna Regional Water Resource Committee include:

- Evaluate water supply and demand
- Protect "at risk" water resources and reduce or prevent point and nonpoint source pollution with a focus on impaired streams
- Promote more uniformity, communication and interrelationships among water resources stakeholders for consistency and joint advancement of mutually beneficial initiatives. This includes planning by regions and watersheds, sharing water resources data, promoting integrated water resources planning initiatives and planning across disciplines
- Recognize land use interrelationships that affect our water resources and develop strategies to reduce watershed and ecological impacts
- Promote the protection and conservation of our water resources to ensure a reliable supply of quality water for meeting human and ecological needs by supporting healthy watershed activities and initiatives to enhance source water protection and by promoting water conservation practices, including water recycling and reuse

The regional committee members will continue to work with DEP and other partners to make recommendations for attaining these goals.

Pride of the Susquehanna Riverboat. Photo courtesy of SRBC.

The Lower Susquehanna Region at a Glance

The Susquehanna River, in its entirety, is the 16th largest river in the United States and is considered "Pennsylvania's River" for its importance as a source of drinking water, recreation and hydropower to millions of people in its watershed. The river starts at Otsego Lake near Cooperstown, N.Y., flows through Pennsylvania and Maryland, before emptying into the Chesapeake Bay at Havre de Grace, Md. This river is responsible for providing half of the freshwater received by the Chesapeake Bay. The Susquehanna River Basin encompasses almost half of the state's land area—more than any other river basin in the commonwealth—while Pennsylvania makes up more than three-quarters of the basin's total area.

From its northwestern boundary along the Nittany Mountain range and its eastern extent at the Schuylkill River south to the Chesapeake Bay, the Lower Susquehanna Region drains nearly 9,215 square miles of land (including 275 square miles in Maryland) and includes all land contained in the Lower Central Susquehanna, Lower Susquehanna, Upper Juniata and Lower Juniata subbasins. This region is home to more than 2.5 million people—more than half of the population for the entire Susquehanna River Watershed. Sunbury in Northumberland County demarcates the boundary that separates the upper and lower regions. It is here that the West Branch of the Susquehanna River meets the river's mainstem, creating the Lower Susquehanna River which flows 103 miles before emptying into the Chesapeake Bay. One of the more prominent features of this region is the Appalachian Mountains. Nearly all headwaters originating in these mountains flow into the Juniata River, eventually reaching the Susquehanna River near Duncannon in Perry County.

Introduction, continued

Susquehanna River Facts

Possible meanings of "Susquehanna": muddy current; mile wide, foot deep; the long reach river; long crooked river; the place of the straight river

Basin Area:
- Total – 27,510 square miles
- Lower Susquehanna River Region - 9,215 square miles

Headwaters: Otsego Lake, Cooperstown, N.Y.
Mouth: Chesapeake Bay, Havre de Grace, Md.
Susquehanna River Total Length: 444 miles
Lower Susquehanna River in Pennsylvania – 103 miles

Major Tributaries (in Pennsylvania)

Codorus Creek	Conodoguinet Creek	Juniata River
Conestoga River	Penns Creek	Swatara Creek
Conewago Creek	Pequea Creek	Yellow Breeches Creek

Watersheds in the Lower Susquehanna Region

"Watershed" is a generic term used to identify an area of land that drains to a particular waterbody. Watersheds can vary in size, from the acreage that drains to a brook to a major river. For purposes of this atlas, watersheds are classified by a nested hierarchy based on landscape scale. A subwatershed is the land area that drains into a stream or river (or in some cases, two streams) and is the smallest in size in the classification hierarchy. Pennsylvania's original State Water Plan divided the commonwealth into 104 subwatersheds, ranging in size from approximately 100 to 1,000 square miles, named for the major streams of the subwatershed. A subbasin includes all of the subwatersheds that drain into a particular reach of a larger watercourse. A basin encompasses all of the subbasins that drain into a major waterway. In Pennsylvania, there are six basins—Lake Erie, Genesee, Ohio, Susquehanna, Potomac and Delaware—each with a different outlet. The Lake Erie Basin empties into Lake Erie, the Genesee Basin contributes to Lake Ontario, the Ohio Basin drains into the Mississippi River, the Susquehanna Basin and Potomac Basin empty into the Chesapeake Bay, and the Delaware Basin drains into the Delaware Bay.

A particular tract of land can belong in multiple watersheds, depending on the scale of the landscape. For example, in Juniata County, Tuscarora Creek is a tributary to the Juniata River, which is a tributary to the Susquehanna River. The land that encompasses the Tuscarora – Buffalo Creeks Subwatershed is part of the Lower Juniata Subbasin, which, in turn, is part of the Susquehanna Basin. The Water Planning Area on the next page depicts the 21 subwatersheds found in the four subbasins of the Lower Susquehanna Region.

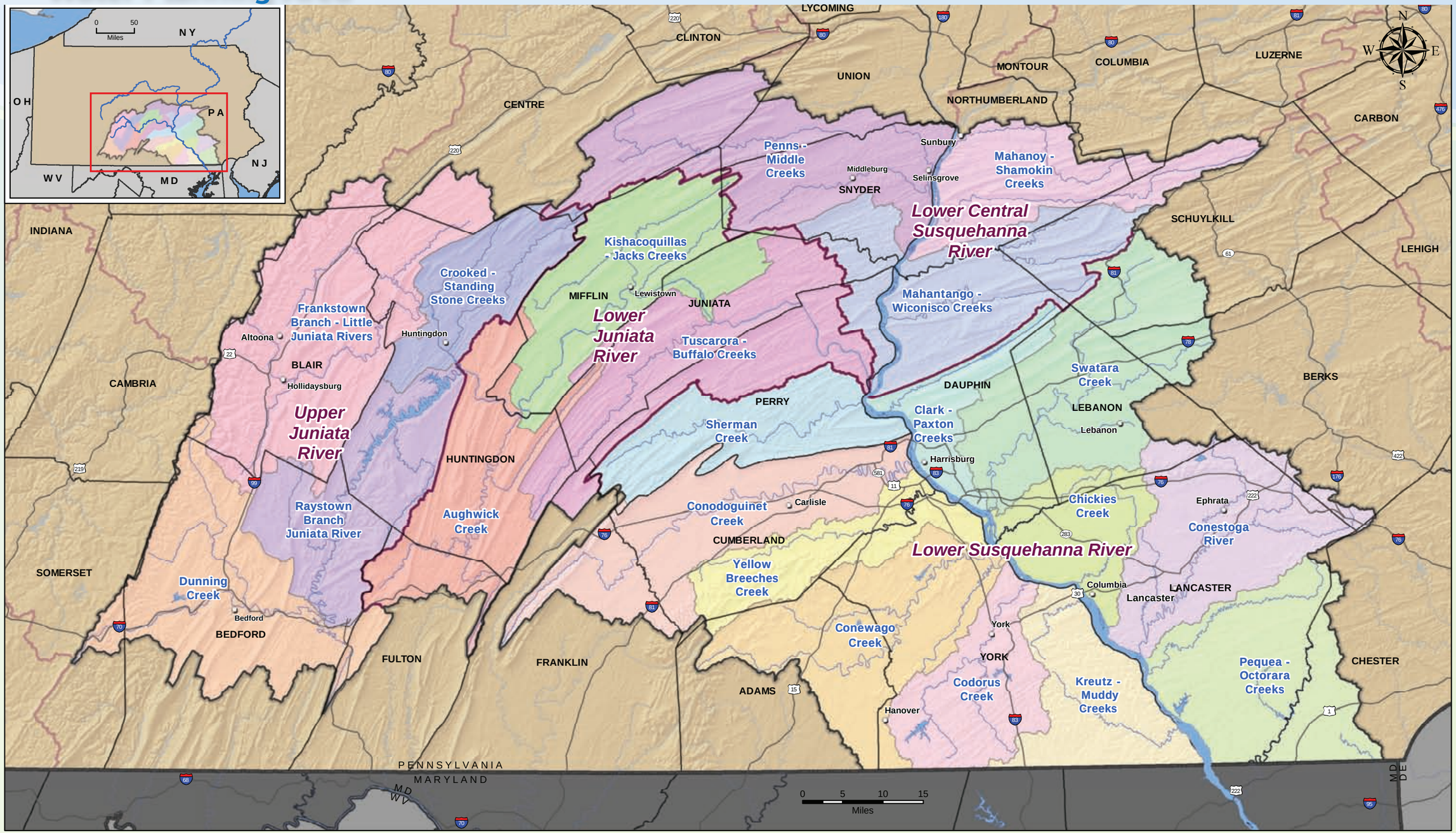
Regional Climate

The Lower Susquehanna Region has a moderate climate, lacking long periods of extreme hot or cold weather. A majority of the region has a minimum temperature of 16 to 19 degrees Fahrenheit and a maximum temperature of 82 to 85 degrees Fahrenheit. Average annual precipitation for most of the region ranges from 38 to 41 inches per year. Normal rainfall amounts are generally enough to support the vast agricultural lands of the region without irrigation. Almost half of the region's annual precipitation falls during storms between May and September, the primary plant-growing season. The remainder precipitation, including snowmelt, during the winter months infiltrates the ground and recharges groundwater reserves.

The maps on the following pages show Precipitation, Average Minimum Temperature and Average Maximum Temperature, averaged from 1961 to 1990, for the Lower Susquehanna Region.

Aerial view of Susquehanna River Water Gaps looking south from Penn Township, Perry County.

Water Planning Area



Water Planning Area Boundary
Subbasin Boundary
River/Stream
Waterbody
County Boundary
State Boundary
City/Town
Major Roads

Introduction, continued

Scenic Rivers

Total: . . . . . 64.3 miles
Stony Creek . . . . . 16.0 miles
Yellow Breeches Creek . . . . . 55.9 miles
LeTort Spring Run . . . . . .7.6 miles
Tucquan Creek . . . . . .8.1 miles
Octoraro Creek . . . . . 36.5 miles

Points of Interest in the Region

- State Capitol - Harrisburg, Dauphin County
- The covered bridges of Bedford and Lancaster counties
- Gravity Hill - New Paris, Bedford County
- Bedford Springs Hotel – Bedford Springs, Bedford County
- Leap-the-Dips, the world's oldest roller coaster, at Lakemont Park - Altoona, Blair County
- Hollidaysburg, Home of the Slinky Toy - Blair County
- Raystown Lake - Huntingdon, Huntingdon County
- Burnt Cabins Grist Mill, National Register of Historic Places – Burnt Cabins, Fulton County
- Penns Cave, America's only all-water cavern – Centre Hall, Centre County
- Penns Creek, Pennsylvania's longest limestone stream – Centre, Union and Snyder counties
- Millersburg Ferry, last remaining ferry system on the Susquehanna River – Liverpool, Perry County and Millersburg, Dauphin County
- Hersheypark and Hershey's Chocolate World - Hershey, Dauphin County
- Three Mile Island - Dauphin County
- Appalachian National Scenic Trail - Schuylkill, Lebanon, Dauphin, Perry, Cumberland, Adams and Franklin counties
- Half-way point of Appalachian Trail at Pine Grove Furnace State Park - Cumberland County
- Blue Mountain-Kittatinny Ridge Conservation Project – Franklin, Perry, Cumberland, Dauphin, Lebanon, Schuylkill and Berks counties
- The Narrows Geologic Formation – Adams County
- York County, The Factory Tour Capital of the World (including tours of Harley-Davidson, Martin's Potato Chips, Snyder's of Hanover, and Wolfgang Candy)
- Amish communities - Mifflin, Juniata, Lebanon and Lancaster counties
- Whitewater rafting on the Octoraro Creek – Lancaster and Chester counties
- Anthracite coal mining, Pioneer Tunnel Coal Mine, and Anthracite Museum – Northumberland and Schuylkill counties
- Susquehanna River Water Gaps, a National Natural Landmark - encompassing five ridge-and-river gaps from Liverpool, Perry County south to Route 81
- South Mountain Conservation Project - Franklin, Adams and Cumberland counties
- Union Canal, oldest existing transportation tunnel in the U.S. – Lebanon County
- Arch Spring – Blair County

Populations throughout the Region (2000 Census Estimate)

Lancaster	56,348	Sunbury	10,610
Altoona	49,523	Columbia	10,311
Harrisburg	48,950	Lewistown	8,998
York	40,862	Huntingdon	6,918
Lebanon	24,461	Selinsgrove	5,383
Carlisle	17,970	Hollidaysburg	5,368
Hanover	14,535	Bedford	3,141
Ephrata	13,213	Middleburg	1,382

Population and Future Projections

The maps on the subsequent pages show populations in the year 2000 and population projections for 2000 through 2030 for the Lower Susquehanna Region. As illustrated in the Population 2000 Map, the southern half of the region is generally more populated than the northern half. Higher populations are centered around towns and cities such as Altoona, Harrisburg, York and Lancaster. The communities surrounding these population centers exhibit the expansion of development that many areas across the state have been experiencing in recent decades.

In recent decades, populations of urban centers decreased while areas surrounding these urban areas increased. The Population Projection Map shows continued population declines in urban areas and declines in the northwestern and northeastern areas of the region, while the southern half of the region will grow in population.

Extreme Weather Conditions: Blizzard of 1996

While the blizzard of 1996 was not the greatest snowfall to hit the midstate, it remains the most memorable for its aftermath.

Snowfall began early Sunday morning, January 7, 1996, despite predictions that the storm would miss the east coast. Falling at alarming rates, the snow continued into the next day and the governor declared a snow emergency. When the snowfall ceased, 22.2 inches had fallen, according to the official measurement at the Harrisburg International Airport. By Thursday, main roads were far from ideal conditions, as they were reopened to only one lane. The commonwealth was hit yet again that Friday with 10.8 inches of snow. Packed three to four feet above the ground, the snow was quite a spectacle.

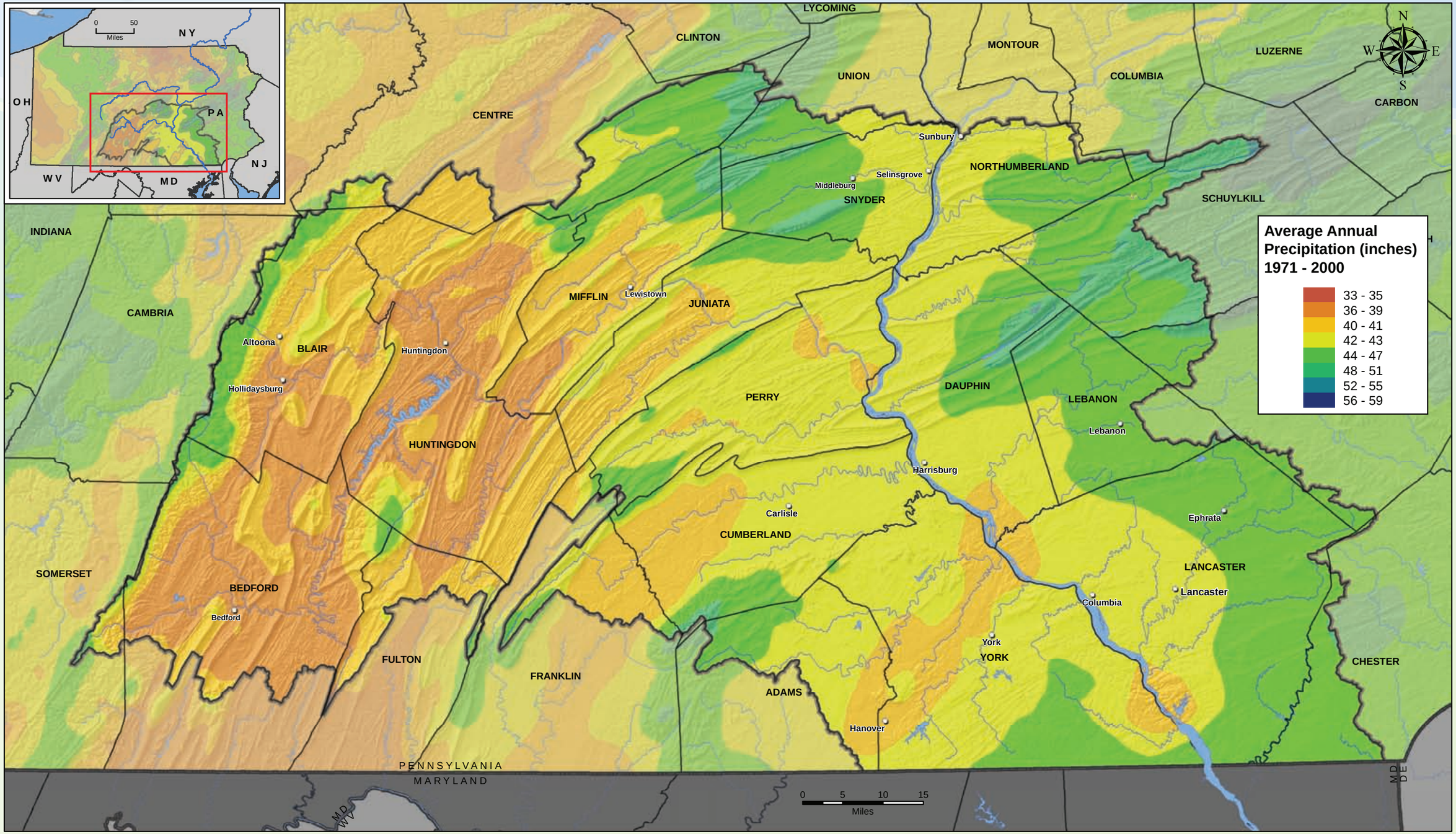
Within weeks, temperatures rose leading to severe flash flooding. On January 19, 1996, temperatures topped the record high at 56 degrees. Combined with heavy rains, the snow melted leaving many under water. The ice pack on the Susquehanna and Juniata rivers broke up and rapidly moved downstream, where it wreaked havoc along the shores of the state capital. That Saturday afternoon, the flowing ice swept away two spans of the Walnut Street Bridge, which had connected City Island to Wormleysburg. An additional span of the bridge fell later.

January 1996 proved to be a record month in Pennsylvania history with 38.9 inches of snow and the loss of one of the capital city's landmark bridges. Today, the bridge remains incomplete.

Did you know?

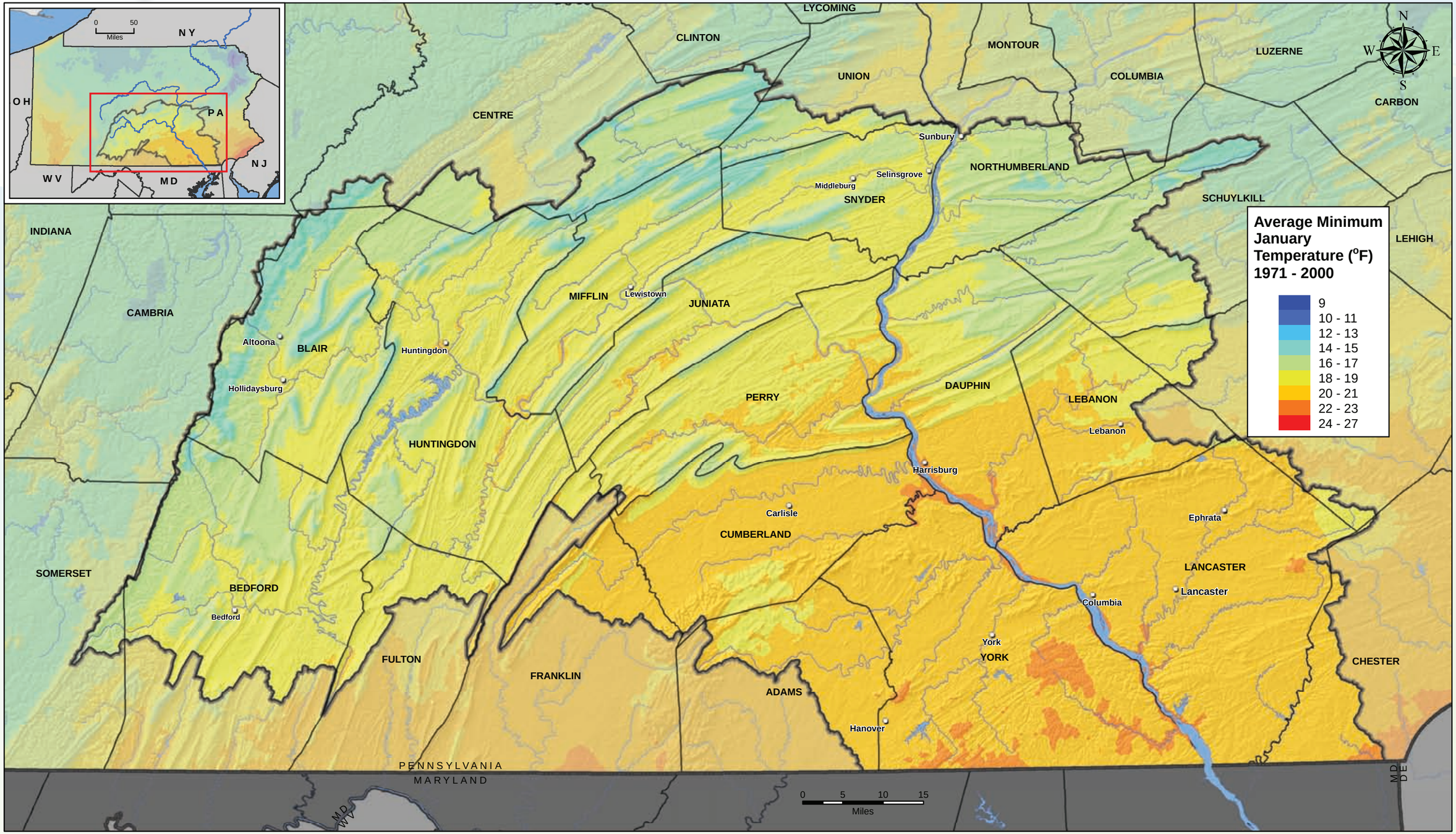
Stretching 3,820 feet, the Rockville Bridge over the Susquehanna River (north of Harrisburg, Dauphin County) is the longest multi-track stone arch railroad bridge in the world.

Precipitation

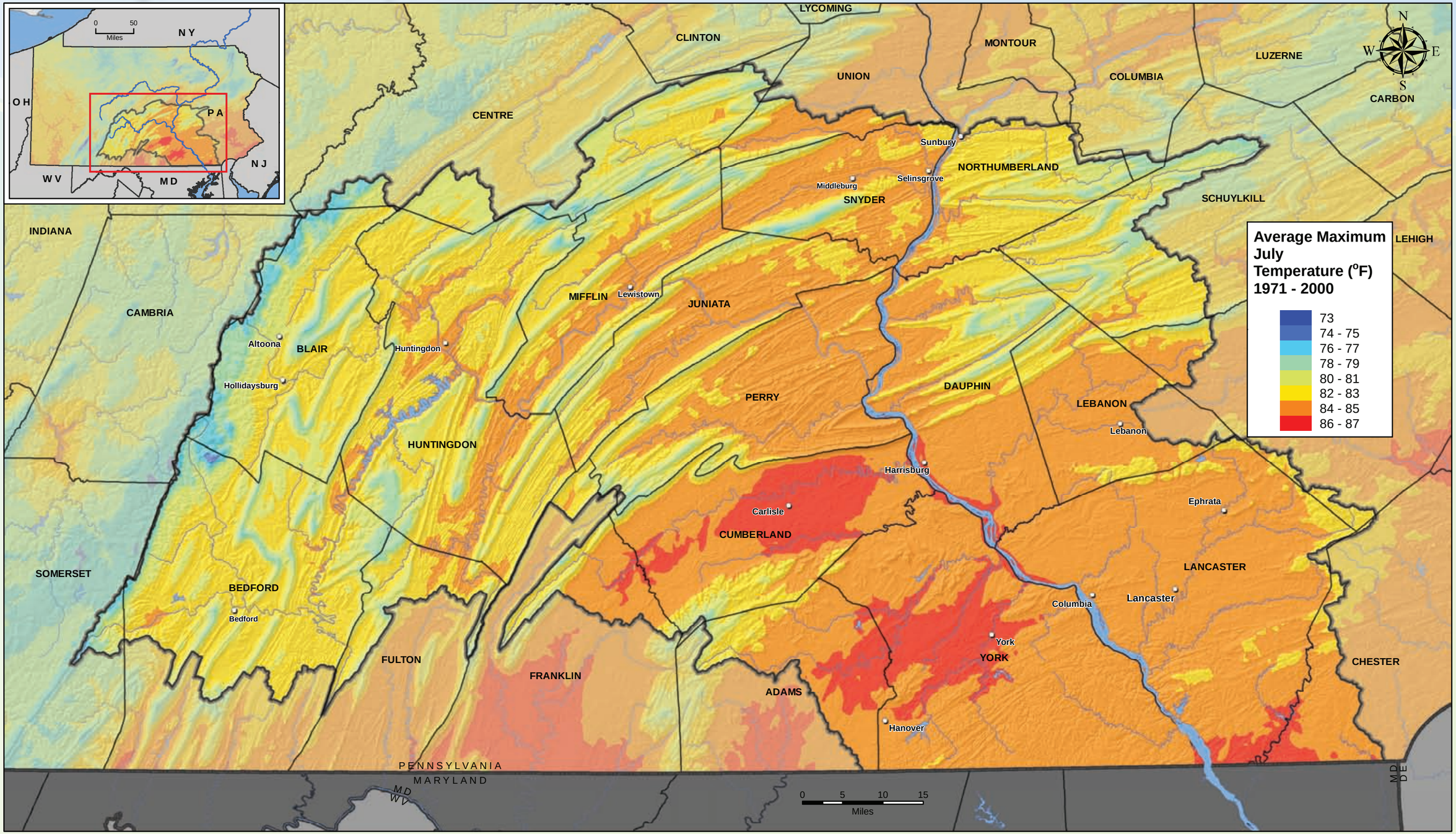


City/Town River/Stream Waterbody County Boundary State Boundary

Average Minimum Temperature



Average Maximum Temperature



City/Town River/Stream Waterbody County Boundary State Boundary

Introduction, continued

Yellow Breeches Creek, Cumberland County. Photo courtesy of Ryan Hale.

Land Cover (Percent of Watershed)

Forest	51.1%
Agriculture (crop/pasture)	36.0%
Developed	10.4%
Open Water	1.5%
Wetlands	<1%
Barren (rock/sand/clay)	<1%

Regional Water Use

The demand for water throughout the region can be measured in part by compiling and mapping data contained in the registry of water users maintained by the DEP. All public water supply agencies and hydropower facilities as well as anyone withdrawing more than 10,000 gallons of water per day are to register and report their usage to DEP. There are no fees associated with registering and reporting.

Although this registry information does not account for all water demands of the region, it provides useful information to predict areas of higher and lower demand, as shown by the Registered Water Withdrawals Map on the next page. Consumptive water use, as defined by U.S. Geological Survey (USGS), is "that part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment." The amount of water consumed in a region becomes an important consideration for resource management during times of drought or water shortages. On the Registered Water Withdrawals Map, the pie chart within each subbasin depicts the percentage of each major sector of water use.

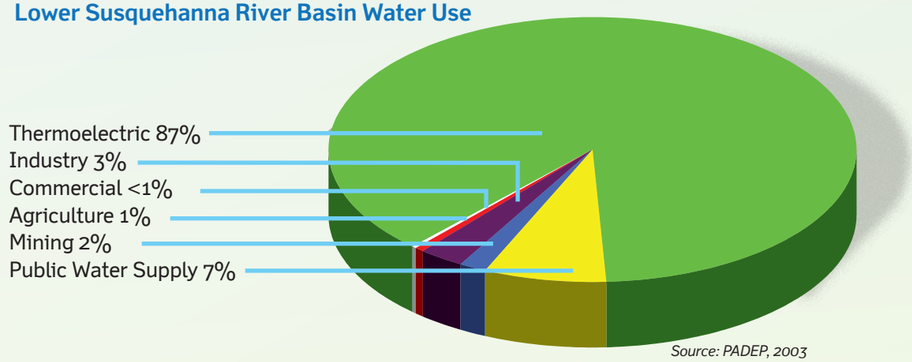
The pie chart to the right provides a breakdown of both consumptive and non-consumptive water use by sector in the Lower Susquehanna Region. Approximately 87 percent of the water used in this region is by utility and thermoelectric (power-generating) facilities, seven percent is used by public water suppliers, and the remaining six percent is used each by agriculture, mining, industry and commercial facilities. This data is based on information available primarily from the registrations submitted to DEP in 2003.

In the entire Susquehanna River Region (the upper, middle and lower regions combined), an estimated 500 million gallons of water are consumptively used every day. Public water supplies account for 200 million gallons a day, with losses from lawn maintenance, washing the car, evaporation from pools as well as leaks in water lines. Thermoelectric plants consume approximately 130 million gallons a day. A coal-fired or nuclear power plant evaporates a half gallon of water through its cooling tower to create the electricity needed to burn a 100 watt light bulb for 10 hours. At a consumption rate of 120 million gallons a day, agricultural operations are the fastest growing water use sector. In addition to the growing number of large animal feedlots, more and more water is used for irrigation as farmers try to improve the quality and productivity of their crops. Industry consumes about 30 million gallons a day. Hospitals, prisons, institutions and golf courses account for a combined 60 million gallons of water used every day.

Did you know?

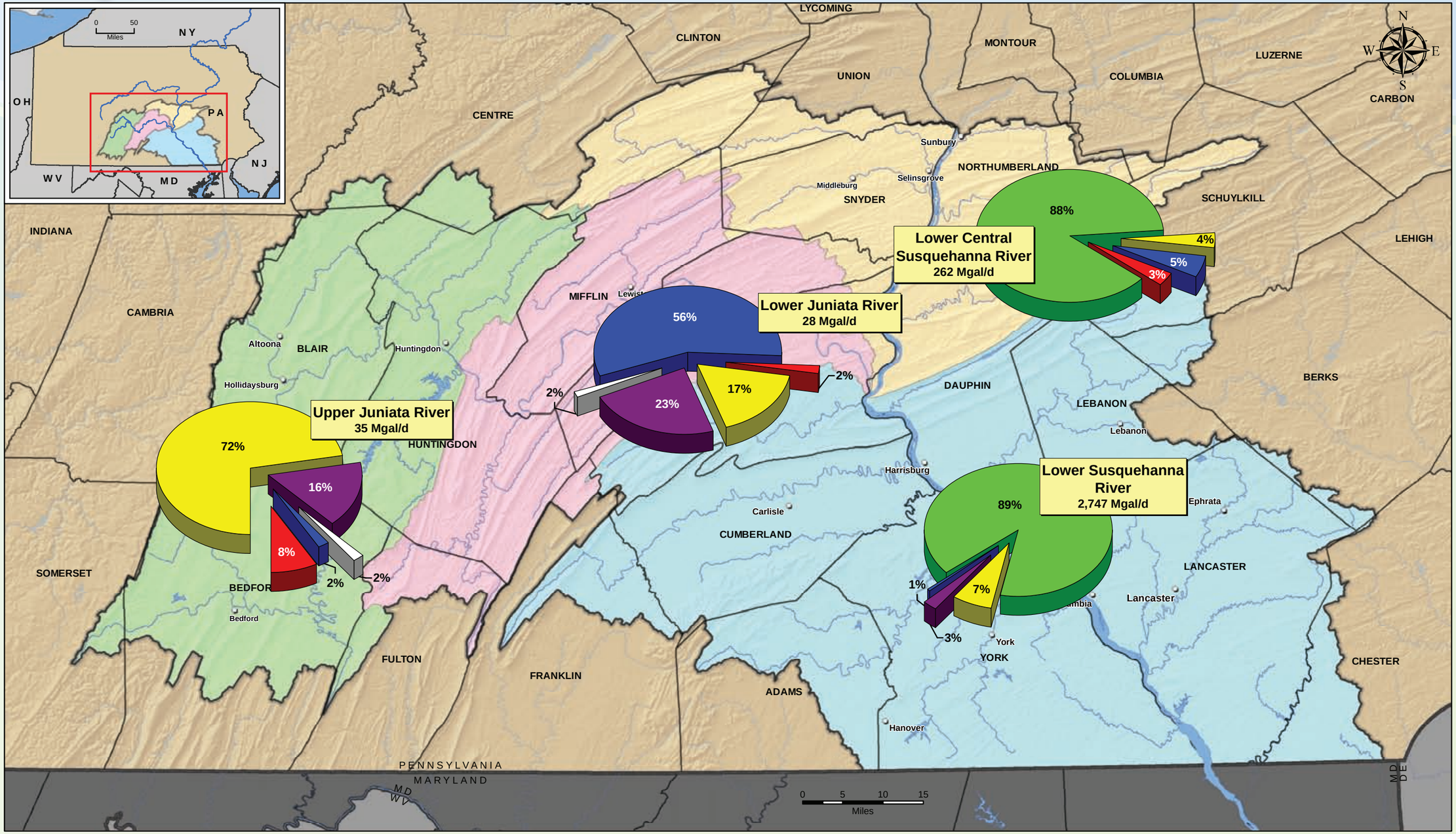
American Rivers proclaimed the Susquehanna River the #1 Most Endangered River of 2005. Immediately following the designation, the U.S. Environmental Protection Agency dropped its proposal to adopt a policy on "blending," or dumping partially treated sewage into rivers.

Lower Susquehanna River Basin Water Use



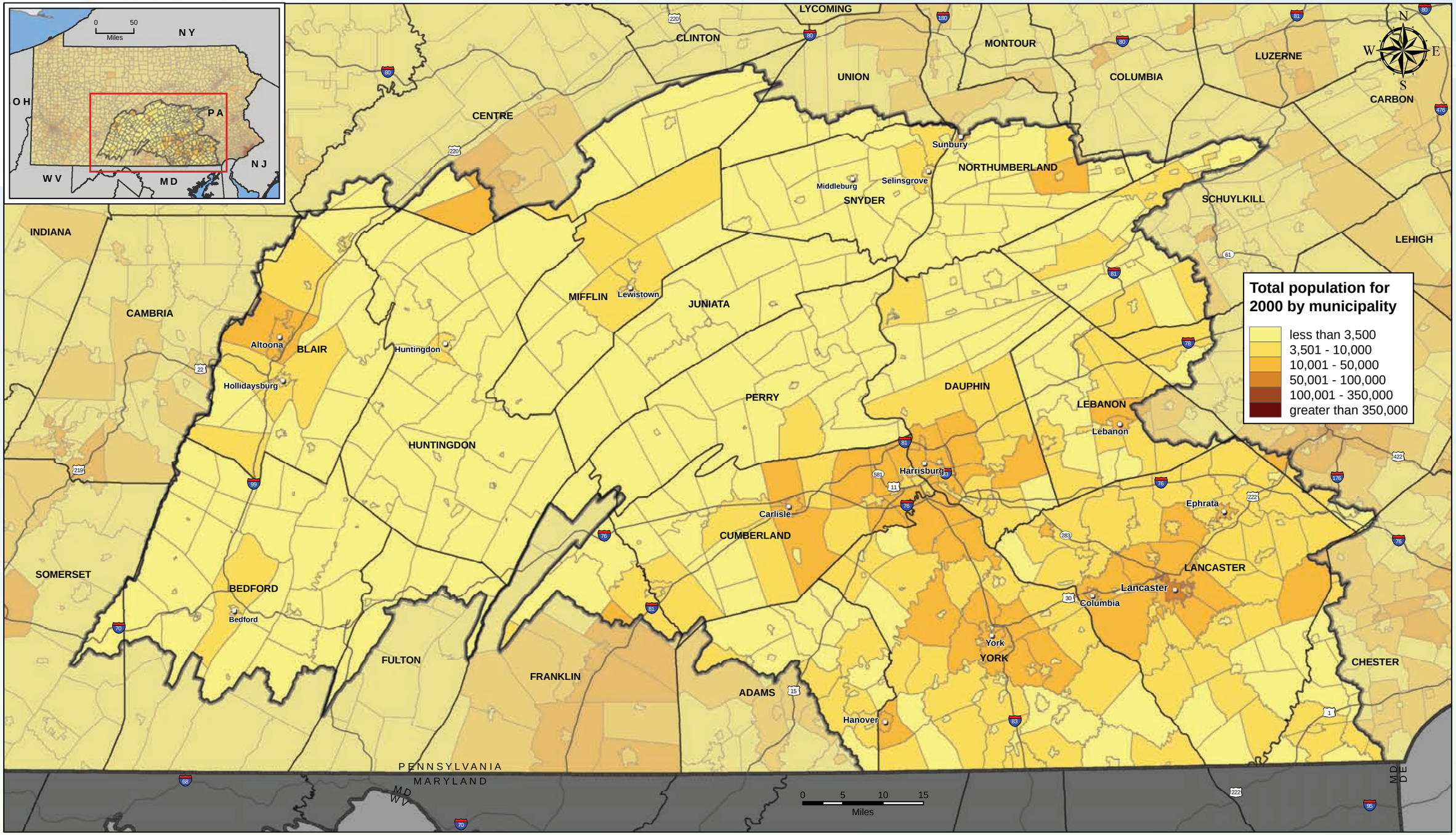
Source: PADEP, 2003

Registered Water Withdrawals

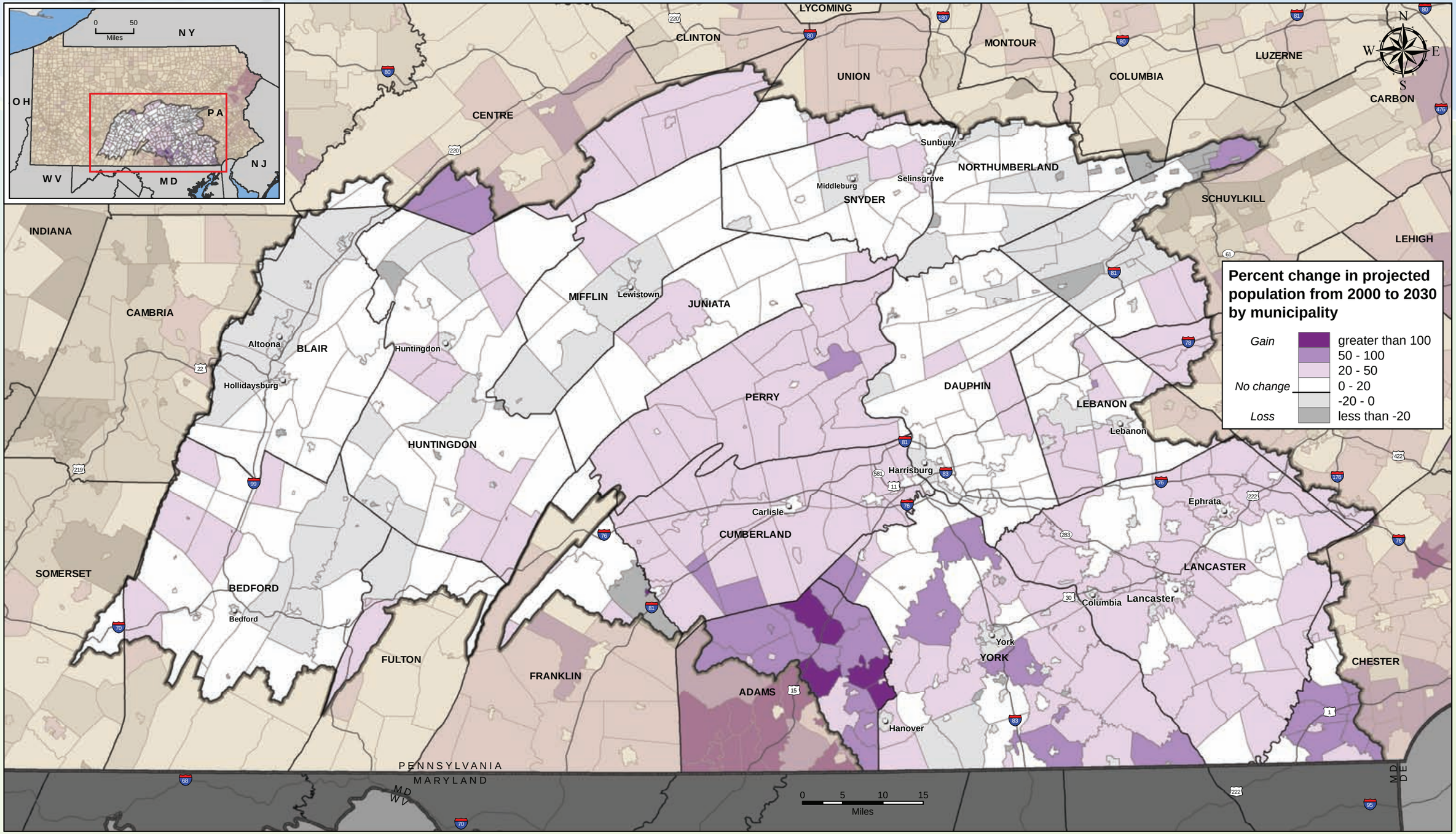


Amounts shown in millions of gallons per day, Mgal/d.

Population 2000



Population Projection



Water Resources

The focal point of the Lower Susquehanna Region is the Susquehanna River, which is one of the largest rivers on the east coast of the United States. In fact, the Susquehanna River is the largest river lying entirely within the United States that drains into the Atlantic Ocean. The Susquehanna River flows from north to south beginning with its headwaters in New York, through Pennsylvania, and discharging into the Chesapeake Bay in Maryland.

A map showing the larger streams, lakes and wetlands within the Lower Susquehanna Region is provided on the next page. Streams and rivers can be classified according to their size based on a hierarchy of its tributaries. The hierarchy designates headwater streams as a first order stream. When two first order streams meet, the waterway becomes a second-order stream. When two second-order streams meet, the waterway becomes a third-order stream and so on. If a lower-order stream flows into a higher-order stream, the order designation does not change. For instance, if a first-order stream meets a second-order stream, the waterway designation remains second-order. For purposes of making the map readable, only higher order streams of the Lower Susquehanna Region are shown in the Surface Waters Map.

Streams

The Susquehanna River, Juniata River and Conestoga River are the major waterbodies in the Lower Susquehanna Region. The major tributaries to the Susquehanna River in the Lower Susquehanna Region, listed from north to south are: Penns Creek, Juniata River, Conodoguinet Creek, Yellow Breeches Creek, Swatara Creek, Conewago Creek, Codorus Creek, Conestoga River and Pequea Creek. The tributaries to the Juniata River include Little Juniata River, Frankstown Branch of the Juniata River, Raystown Branch of the Juniata River and Kishacoquillas Creek.

These surface waters are part of the 21 subwatersheds in the Lower Central, Lower Susquehanna, Upper Juniata and Lower Juniata subbasins, which together make up the Lower Susquehanna Region. The subwatersheds in this region are shown on the Subwatershed Map in the Lower Susquehanna Region Introduction section of this atlas.

Approximately 42 U.S. Geological Survey (USGS) gaging stations that monitor peak stream flow conditions, water levels, discharge and water temperature are located in the Lower Susquehanna Region. Some gaging stations, including Sherman Creek at Shermans Dale, Yellow Breeches Creek near Camp Hill, and Juniata River at Newport also monitor water quality.

Lakes and Dams

Lakes are a prominent feature in the Lower Susquehanna Region. Many lakes along the Susquehanna River and throughout the region are created by dams; many of which have formed reservoirs for public water supply such as Mill Run Reservoir and Allegheny Reservoir in Blair County, DeHart Dam in Dauphin County, and Singers Gap Reservoir in Mifflin County. Some dams have been created for recreational purposes such as Pinchot Lake at Gifford Pinchot State Park, Walker Lake in Snyder County, and Speedwell Forge Lake in Lancaster County.

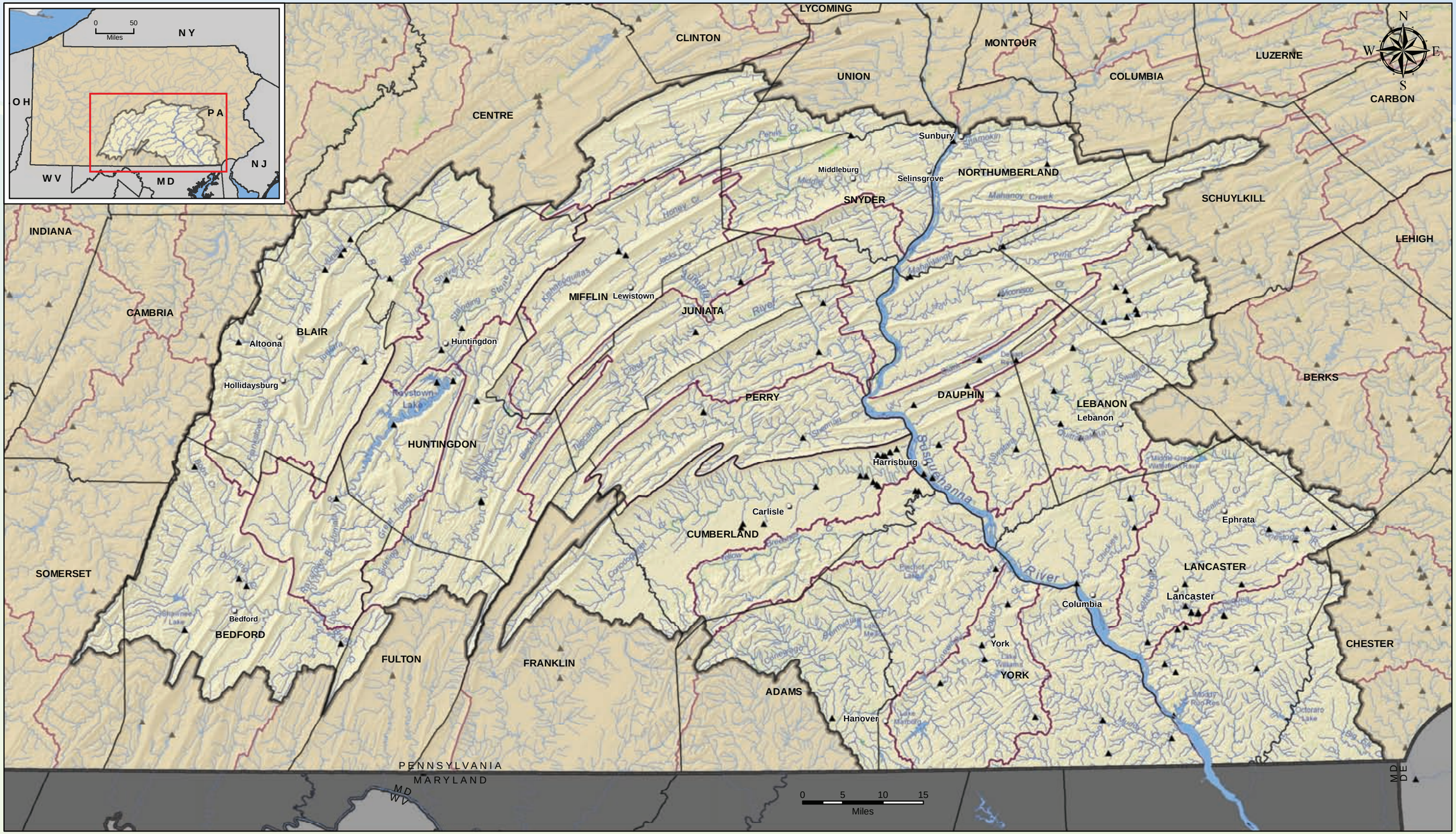
Dams are also an important source of hydroelectric power in this region. Four hydroelectric dams have been built across the Lower Susquehanna River, including the Conowingo Dam which is located in Maryland but is still used by Pennsylvania. Holtwood Dam, the oldest of three major dams in Lancaster County, produces up to 109 megawatts of power. Safe Harbor Dam, which is located north of the confluence of the Conestoga River and Susquehanna River, provides power for the area interconnected between Pennsylvania, New Jersey and Maryland. In one day, at maximum output, approximately 10 million kilowatt-hours of electricity are generated. An average house uses about one-hundredth of that amount in a year.

The surface water impoundments created by these hydroelectric dams often provide other uses than just electricity. For instance, the Conowingo Reservoir, created by the impoundment of the Susquehanna River by the Conowingo Dam not only provides the means for producing 1.6 billion kilowatt-hours of electricity annually, but is also used as a drinking water source for Baltimore and the Chester County Authority, as cooling water for the Peach Bottom Nuclear Generation Station, and for recreational boating and fishing. The Water-Based Economy section for the Lower Susquehanna Region has additional information regarding hydroelectric facilities in this region.

Lake Marburg, York County.

A glance at the Surface Waters Map on the next page immediately draws the eye to Raystown Lake in Huntingdon County. The 8,000-acre lake—the largest located entirely in Pennsylvania—was created by the Army Corps of Engineers when a dam across the Raystown Branch of the Juniata River was built for flood control, electricity generation and recreational activities. More information on the recreational benefits of the Raystown Lake can be found in the Water-Based Economy section of the Lower Susquehanna Region.

Surface Waters



Streams (Perennial)
Water Planning Area Boundary
Lake, Pond or Reservoir
Wetlands
Stream Gauges
City/Town
County Boundary
State Boundary

Water Resources, continued

Bear Meadows

Bogs and swamps receive all of their moisture from precipitation and do not have a connection to groundwater. Bear Meadows Natural Area, located on the border of the Lower Susquehanna Region and Upper Susquehanna Region, is home to the largest freshwater bog in the eastern United States. Bear Meadows is a National Natural Landmark that encompasses 890 acres of land, of which 360 acres is a bog.

Stream Releaf Program

DEP initiated the Stream Releaf Program in 1996 to restore streams and riparian areas in order to reduce and prevent stream bank erosion and sedimentation. The Stream Releaf Program has helped to create riparian buffers (vegetated areas along stream banks) along Shavers Creek in Huntingdon County, Penns Creek in Snyder County, and Buck Run in Mifflin County. These are just a few of the more than 1,300 projects found in the Stream Releaf database for this region. More than 500 of the stream bank stabilization projects have restored Lancaster County streams.

For more information on this program, see "Stream Releaf" under "DEP Programs" at www.depweb.state.pa.us.

For more information on wild trout streams in Pennsylvania, visit the Pennsylvania Fish and Boat Commission's Web site at http://www.fish.state.pa.us/.

Wetlands

Wetlands are areas where water covers the soil or remains at or near the surface for an extended period of the year. These habitats provide a hydrologic link between land and water resources (either surface water, groundwater or both). Wetland types differ according to characteristics such as topography, climate, hydrology, water chemistry and vegetation.

The U.S. Fish and Wildlife Service provides information on the nation's wetlands and deepwater habitats—including location, type and status—through the National Wetlands Inventory (NWI). There are two general categories of wetlands: coastal (including estuaries) and inland (including rivers, lakes and riparian areas). The NWI classifies inland waters according to the amount and type of vegetation present:

- Open water (rivers and lakes)
- Emergent/herbaceous (marshes, wet meadows and fens)
- Scrub-shrub (swamps and bogs); and
- Forested (swamps and bogs)

Wetlands provide unique habitat to many species of plants and animals and also serve as natural filters to surface and groundwater supplies. Many wetlands in the region have the ability to eliminate contaminants such as nitrates and phosphorus as water flows through the wetland. The vegetation present in the wetland utilizes the excess waste, eliminating it from the water and reducing negative impacts to the environment. Wetlands also have the excellent ability to remove sediment from surface runoff. The vegetation plays a large role in reducing sediment as the sediment particles are captured and slowly removed as the water progresses through the wetland. These traits of wetlands have led some scientists to describe wetlands as "nature's kidneys."

As illustrated in the Lower Susquehanna Region Surface Waters Map, the southern and eastern portions of the region have a high concentration of wetlands. These wetlands, as described, provide a natural defense against harmful contaminants in water supplies. Precaution should be taken to eliminate the destruction of these wetland areas. Allowing them to remain will protect our water sources and provide habitat for many plants and animals.

Susquehanna River Basin Commission

The Susquehanna River Basin Commission (SRBC) is a federal interstate commission that coordinates the water resources of the Susquehanna River. Created in 1970, the commission is administered by representatives from New York, Pennsylvania and Maryland appointed by or represented by the state governors. Also, the President of the United States appoints a commissioner to represent the federal government. The four commissioners meet periodically to act on issues pertaining to the Susquehanna River Basin. Together, they vote to impose regulations, promote communication between members, work to resolve water resource issues within the basin and provide coordinated management for the waters of the Susquehanna River.

A larger staff comprised of technical, administrative and clerical personnel work day to day to perform the operations of the commission. The commission staff develops and implements the programs as directed by the commissioners in a Comprehensive Plan. Six major areas of the Comprehensive Plan outlining goals of the SRBC are floodplain management and protection, sustainable use of surface water and groundwater, protection and restoration wetlands and aquatic habitats, improving water quality, and ensuring future available flow of the Chesapeake Bay.

For more discussion about SRBC and its goals, see the "Pennsylvania Regulations, Laws, and Public Policy" in the Statewide Overview section of this atlas or visit, SRBC's Web site at www.srbc.net.

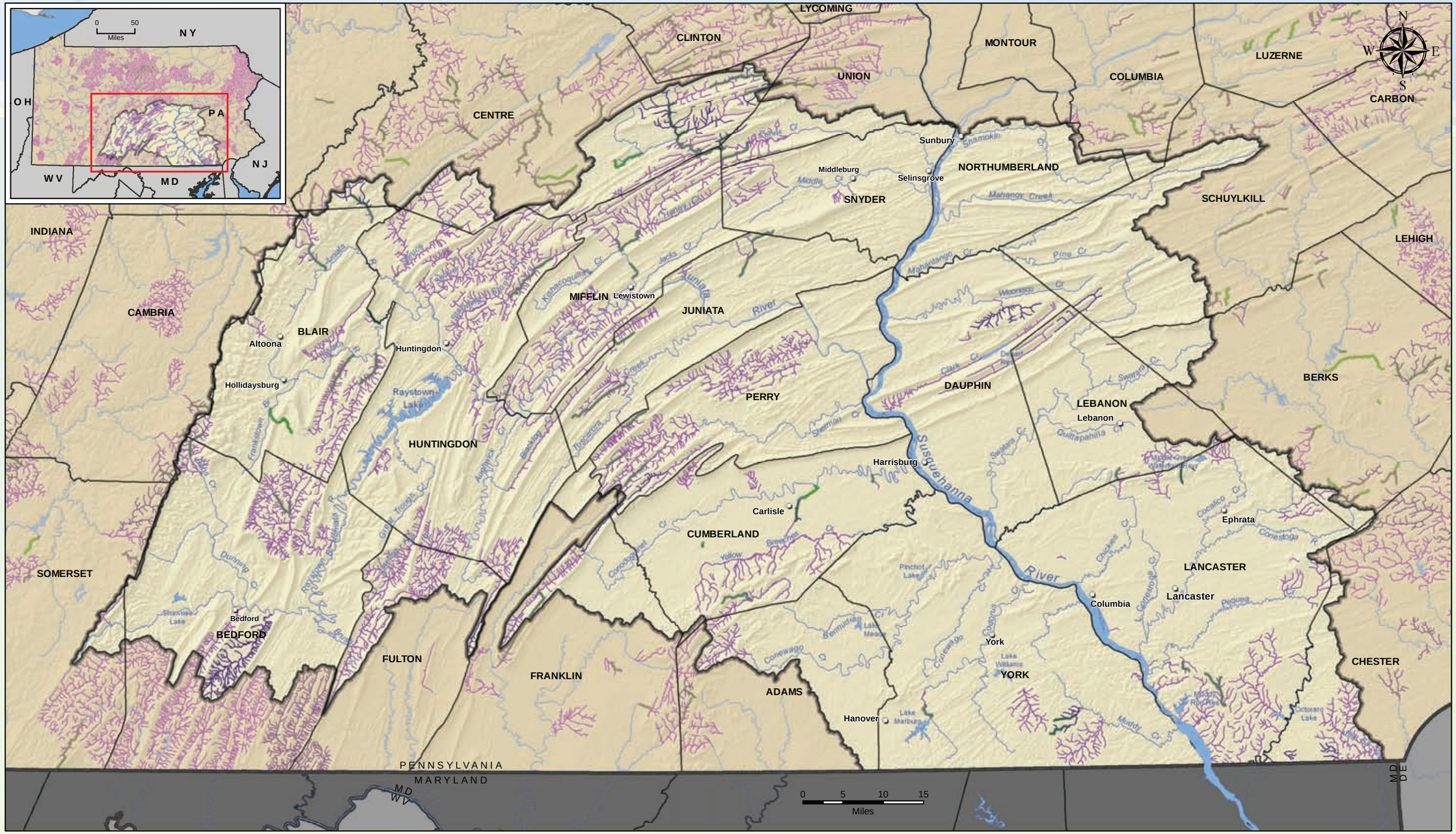
Special Protection Waters

Certain water bodies are designated special protection to prevent activities that could degrade water quality and therefore prevent these waters from meeting their uses. These special designations include federal or state Scenic/Recreational Rivers, High Quality and Exceptional Value Waters, and Class A Wild Trout Waters.

Scenic Rivers

Scenic rivers in Pennsylvania are designated for their exceptional aesthetic, pastoral or recreational value and must be maintained for these values. There are five scenic rivers, totaling more than 60 miles, in the Lower Susquehanna Region. More detailed information about this program is included in the Statewide section of this atlas.

Special Protection Waters



Exceptional Value Stream (EV)
High Quality Stream (HQ)
Class A Wild Trout Stream
River/Stream
Waterbody
City/Town
County Boundary
State Boundary

Water Resources, continued

HQ and EV Waters

There are two types of special protection waters classifications according to guidelines listed in Pennsylvania Code Title 25, Chapter 93 Water Quality Standards: High Quality (HQ) and Exceptional Value (EV). The Special Protection Waters Map on the next page shows the HQ and EV waters in the region.

- HQ waters are designated as such based on the water chemistry and the presence of a high quality aquatic community. Approximately 131 streams or stream sections are designated as HQ in this region. A majority of these HQ waters are found in the northwestern part of the region.

- EV waters are designated based on water quality and are waters of substantial recreational or ecological significance. There are approximately 24 streams or stream sections designated as EV in the Lower Susquehanna Region. Many waters are designated as EV based on the fact that they are classified as Class A Wild Trout Waters.

Did you know?

"The Susquehanna is many rivers in one. A ten-day voyage will take the canoeist through coal country, a wild canyon, small towns, fertile farmland, the state capital, hydroelectric dams and finally the coastal plain and Chesapeake Bay."

—Tim Palmer, author of *Rivers of Pennsylvania*

The classification of EV or HQ to a stream requires that new or expanded earth-disturbance does not degrade existing water quality. It is important to know that this does not mean that development will stop, but proposed projects will undergo a more detailed permit review by DEP and may result in meeting more stringent requirements to protect water quality.

Wild Trout Waters

Approximately 50 waters in the Lower Susquehanna Region are designated by the PA Fish and Boat Commission as Class A Wild Trout Waters. These waters support a population of naturally-produced trout of sufficient size and abundance to support a long-term and rewarding sport fishery. These streams are not stocked but are supported in full by the spawning of the wild trout populations, further illustrating their outstanding quality and protection they receive. Class A Wild Trout Waters include wild brook trout fisheries, wild brown trout fisheries, mixed wild brook/brown trout fisheries and wild rainbow trout fisheries. More than half of the Class A Wild Trout Waters are classified as brown trout fisheries. The only wild rainbow trout fishery in the entire state is Trindle Spring Run, located near Mechanicsburg, Cumberland County.

The Special Protection Waters Map on the next page shows the location of Class A Wild Trout Waters in the Lower Susquehanna Region.

Impaired Waters

Stream health assessments are complex and time consuming efforts put forth by many individuals. Assessments can include individual studies on the living organisms and habitat within and around the stream, studies on water chemistry and measurement of physical characteristics. There are also simple visual indicators one can look for to determine a stream's general health. Impaired streams may have eroded or undercut banks, low water clarity, foul odors, large amounts of algae or have deep deposition of sediments that cover larger rocks on the bottom of the stream. All these results help determine overall stream health. Restoring impaired streams requires plenty of time and effort combined with the most recent water quality evaluations available.

Trout fishing on the Little Juniata River. Photo courtesy of Shawn Rummel.

Codorus Creek Restoration

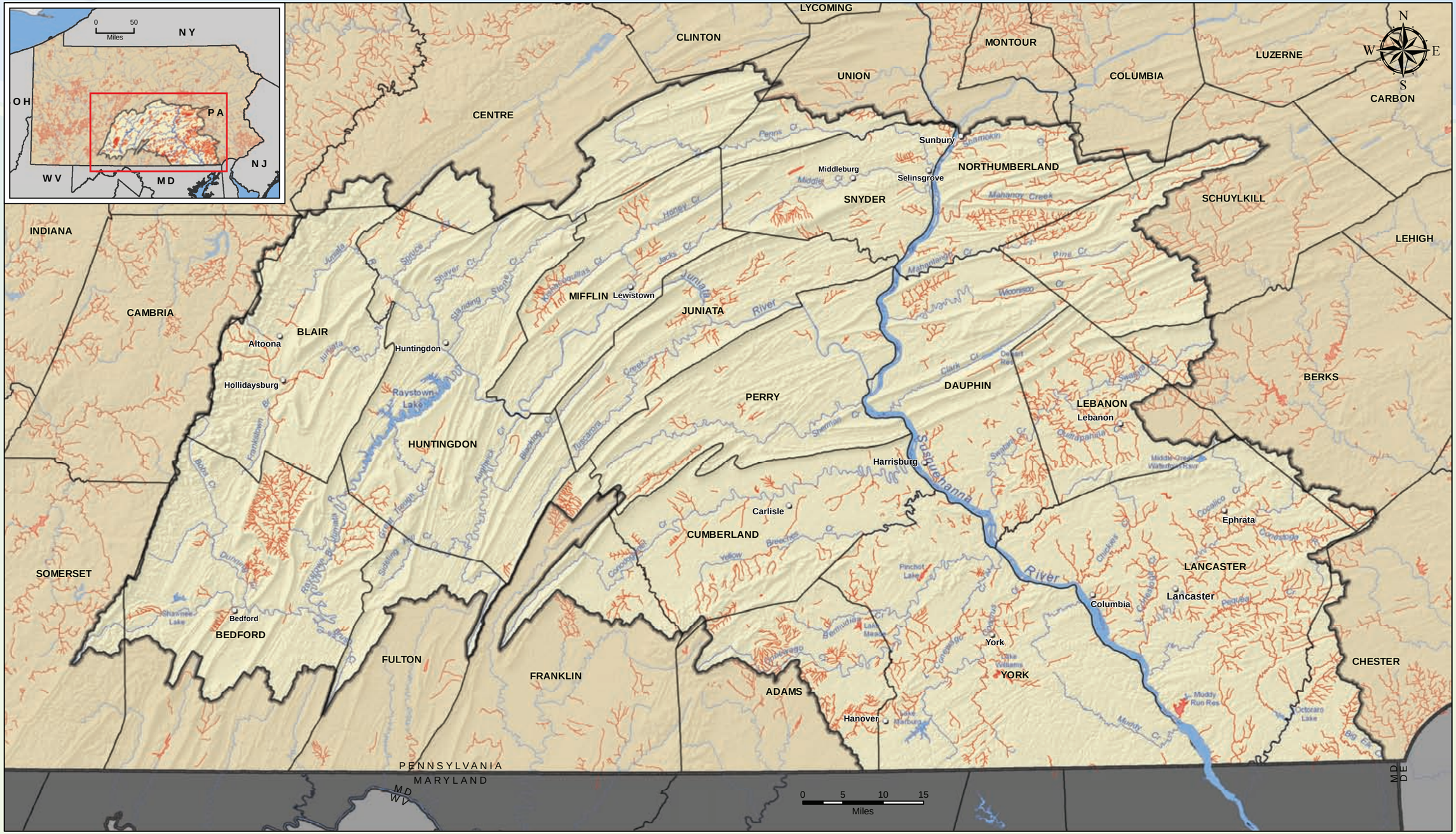
Located in the Piedmont region in York County, the Codorus Creek Watershed faces many pollution issues and impairments. While the Codorus Creek is a significant source of water for York County residents, it is also known to contribute suspended sediment and nutrient loading to the Chesapeake Bay. Impairments of the creek include loss of riparian vegetation, stream bank erosion along with unsatisfactory water quality issues, leading to concerns for not only local residents who rely on the creek for a water source, but also for the entire ecosystem.

While the watershed has been historically used for agriculture activities, some traditional farming practices are a contributing factor to stream impairment. Though better farming practices have been put into practice, stream channels are still impacted by eroding banks. Increasing development adds to the prevalence of stormwater drainage into the creek. Excess stormwater runoff results in sediment and nutrient contamination, due to increased bank erosion.

The impairments came to the attention of the state government, and restoration efforts were initiated. Pennsylvania's Department of Environmental Protection (DEP) developed TMDLs for phosphorus and sediment and the York County Conservation District prepared a Watershed Implementation Plan. DEP then invested 2.5 million dollars of Growing Greener and U.S. Environmental Protection Agency (EPA) 319 Program funds toward the restoration of Codorus Creek. The York Chapter 67 of the Izaak Walton League of America sponsored restoration projects on the East Branch and South Branch of the Codorus Creek. Chapter members performed various tasks to improve the creek including installing bank grading, backfilling channel cut-offs, installing in-stream structures, moving pasture fencing to create additional stream buffer and riparian planting.

Currently, the Army Corps of Engineers are reviewing reports of restoration activities along Codorus Creek to evaluate the allocation of funds and determine a project implementation plan. The plan is thought to have significant long-term, direct and beneficial impacts to the water environment of the Codorus Creek Watershed.

Impaired Waters



Impaired Stream
River/Stream
City/Town
County Boundary
Impaired Waterbody
Waterbody
State Boundary

Water Resources, continued

The Pennsylvania Department of Environmental Protection (DEP), under Section 303(d) of the federal Clean Water Act, implements a program that assesses the water quality of state waters and identifies waterbodies that do not meet the standards for their designated uses. These designated uses—including aquatic life, recreation and drinking water—are characterized by the in-stream levels of parameters (e.g., dissolved oxygen, pH, metals, siltation, etc). If a waterbody does not meet the standards for its designated use, it is identified as "impaired" on the Pennsylvania Integrated Water Quality Monitoring and Assessment Report. This report also identifies the cause of the impairment, which may be one or more point sources (like industrial or sewage discharges) or non-point sources (like abandoned mine discharge or agricultural runoff).

Once impaired waters and their reasons for impairment are established, the state determines what conditions are necessary to return the water to the quality that meets its designated use. DEP and the United States Environmental Protection Agency (EPA) work in conjunction with other organizations, such as Pennsylvania State University and the Susquehanna River Basin Commission (SRBC), to develop a Total Maximum Daily Load (TMDL) for each impaired waterbody. A TMDL defines the allowable pollutant loads a waterbody can receive from point and nonpoint sources and still be able to maintain its designated water quality standards.

The "Impaired Waters Map" shows the location of impaired streams and waterbodies in the Lower Susquehanna Region. A majority of these streams are concentrated in the agricultural areas of the region.

Efforts to Address Impairment

Many impaired waters exist within the Lower Susquehanna Region. DEP supports local watershed groups, conservation districts and municipalities in developing Watershed Implementation Plans, which identify pollution sources in these areas and recommend best management practices (BMPs) for cleaning them up. These plans are submitted to the EPA to provide a "road map" for future stream restoration efforts and funding. Currently within the Lower Susquehanna Region, nine Watershed Implementation Plans have been completed for Bear Creek Watershed, Broad Top Township, Codorus Creek Watershed, Conewago Creek Watershed, Conowingo Creek Watershed, Mill Creek Watershed, Shoup Run Watershed, Upper Kishacoquillas Creek Watershed and Upper Swatara Creek Watershed while two others are under way. Specific examples of watershed cleanup projects in the Lower Susquehanna Region include:

Conodoguinet Creek Watershed

The Conodoguinet Creek Watershed is a large tributary system that drains two-thirds of Cumberland County and the upper third of Franklin County. A study conducted in 1998 listed 123 miles of impaired tributary streams within the watershed.

Impairments to the watershed were identified as contributions by both point and nonpoint sources. Nonpoint sources of impairment include agriculture, waste leachate, habitat modification, construction and urban runoff. Point sources of impairment include facilities such as sewage plants or industrial sites that discharge into the watershed.

TMDLs for phosphorus and sediment were developed for 18 tributary watersheds of the Conodoguinet Creek Watershed. Through planning and funding, best management practices (BMPs) are being installed effect according to the needs of each watershed area. Officials believe that these BMPs, especially those directed towards agricultural practices, will lower pollutant loads and improve the watershed over time.

Conewago Creek, Conowingo Creek and Mill Creek

Agriculture is the dominant land use and, with stream bank erosion, the primary contributor to impairment in these three Lancaster County watersheds. First listed as impaired in 1996, each of these watersheds has seen the development of one or more TMDLs and the completion of a Watershed Implementation Plan.

TMDLs were created for phosphorus and sediment loading using a reference watershed approach. A reference watershed is typically unimpaired and has physical characteristics similar to the watershed being studied. They are used to help guide decision-making in setting limits for individual pollutants in the TMDLs.

Active watershed groups were formed in these areas even before the completion of Watershed Implementation Plans, with education and organizational support from the Lancaster County Conservation District. BMPs such as stream bank fencing, riparian buffers, cattle crossings and stream bank stabilization are being put into place using funds acquired from federal, state and non-profit organizations, and follow-up monitoring is being conducted.

Mifflin County stream restoration, before and after. Photos courtesy of Mifflin County Conservation District.

Southern side of Rockville Bridge crossing the Susquehanna River.

The Chesapeake Bay

The Chesapeake Bay Basin is made up of thousands of miles of rivers and streams that supply freshwater to the Chesapeake.

- The Chesapeake Bay Basin stretches from upstate New York to the Tidewater Region of Virginia. The drainage area covers 64,000 square miles or 41 million acres.
- Pennsylvania makes up more than one-third of the entire Chesapeake Bay Basin, more than any other state.
- About half of Pennsylvania (52 percent) lies within the Chesapeake Bay Basin.
- Within Pennsylvania's portion of the Chesapeake Bay Basin, the Susquehanna River drains 92 percent of the watershed and the Potomac River drains another seven percent. The remaining one percent of the watershed drains from the Elk Creek and Northeast River in Chester County, and Deer Creek and Gunpowder River in York County.
- Three million people, or about one-quarter of the entire Chesapeake Bay Basin population, live in Pennsylvania.

The Susquehanna River flows more than 440 miles from New York through Pennsylvania and Maryland and into the Chesapeake Bay. Most of the river lies in Pennsylvania.

- The Susquehanna River has an average flow of 19 million gallons of water per minute, the highest average flow of any river in the eastern United States.
- The Susquehanna River supplies 50 percent of the freshwater entering the Bay. Pennsylvania's portion of the Potomac River contributes an additional two percent to the Bay's freshwater supply.
- In the upper portion of the Chesapeake, as much as 90 percent of the freshwater comes from the Susquehanna River.
- Although the average depth of the Chesapeake is only 30 feet, a channel more than 180 feet deep runs through its center. The channel is the original Susquehanna River bed, dating back to the Ice Age.

Since 1985, Pennsylvania has been actively engaged in helping to save the Chesapeake Bay. More than half of our commonwealth is within the Chesapeake Bay Watershed, and the Susquehanna River-the Bay's largest tributary-provides roughly half of the Bay's freshwater flow.

Local Flooding Occurrence: Tropical Storm Agnes

With many tributaries to the Susquehanna River, the region is prone to flash floods during heavy periods of rainfall. Some of the most costly flooding occurred in the Lower Susquehanna Region when Tropical Storm Agnes (downgraded from a hurricane) devastated the region in 1972, dumping 15 inches of rain in parts of the watershed.

Tropical Storm Agnes started as a category one storm in the Gulf of Mexico and had been downgraded to a tropical depression when it hit the northeast. The destruction caused by Agnes in Pennsylvania alone resulted in $2.3 billion in damage. In the state capital, Harrisburg, where peak flows on the Susquehanna River were more than 7.5 million gallons per second, the entire first floor of the Governor's mansion was flooded as well as most of the capital region. To date, Tropical Storm Agnes is Pennsylvania's most costly natural disaster.

In the aftermath of Agnes' devastation, flood control and stormwater strategies were instituted throughout Pennsylvania to reduce and control flooding. Flood hazards are also being addressed in Hazard Mitigation Plans that are being prepared by each county in the state. Also, the Pennsylvania Emergency Management Agency (PEMA) uses the Federal Emergency Management Agency's (FEMA) hazard identification tool, HAZUS, to assist counties and local communities in assessing flood risks and preparing mitigation plans.

Susquehanna River Water Gap between Marysville, Perry County and Dauphin, Dauphin County.

Stormwater and Flooding

Stormwater as a Resource

Stormwater runoff and flooding are natural events that have helped shape our watersheds and rivers. Human activities on the landscape routinely alter natural drainage patterns. Because of this, stormwater runoff is now being examined as to its effects on water quality, stream morphology, baseflows and recharge. If not managed, these changes may increase localized flooding, stream bank erosion and loss of groundwater recharge. In addition to its physical impact on the environment, stormwater may carry a variety of pollutants.

By managing stormwater runoff as a resource rather than as a waste, a host of opportunities are available to protect the environment and complement water resource management. Since clean and abundant water is a vital resource, effective stormwater management provides for the protection and maintenance of the commonwealth's essential water resources. Stormwater management affects and involves all of the possible avenues precipitation might follow after falling to the ground: runoff from the surface of the land; groundwater by infiltrating (or soaking) into the ground; evapotranspiration by evaporating directly into the atmosphere or by transpiring through plant processes and then evaporating; or stored water for various uses.

Human activities that result in land development or changes in land cover, or land use, often dramatically affect the quantity and quality of stormwater runoff from the land surface. These changes can produce potentially harmful impacts on water resources, such as increases in damages from flooding; diminished stream flows and groundwater recharge; degradation of streams and stream channels from scour, erosion or deposition; and deterioration of water quality from pollution. These effects can be minimized, or avoided, through the careful preparation and implementation of comprehensive stormwater management plans and other planning or regulatory efforts.

Front Street in Harrisburg along the Susquehanna River during Hurricane Ivan Flooding, 2004. Photo courtesy of Tim Devine.

Problems Associated with Stormwater

Stormwater can have a detrimental effect on the agricultural lands,

More information can be gathered by visiting the PEMA Web site at http://www.pema.state.pa.us. In more recent years, Pennsylvania has examined impacts of stormwater on watersheds and found that flooding is not the only problem with stormwater.

Upper Yellow Breeches Watershed Plan

Stormwater management plans vary across the commonwealth because each county is responsible for the creation of their own plan within the guidelines set by Act 167. Stormwater management plans like that of Cumberland County's Upper Yellow Breeches and Cedar Run watersheds focus on a variety of problems. The Upper Yellow Breeches Watershed is not highly developed but possesses potential for growth. It is because of this potential that Cumberland County has developed a stormwater management plan for the six municipalities that are located in the Upper Yellow Breeches Watershed.

In the Upper Yellow Breeches Watershed more than half of the 40,000-plus acres of land are forested while the remaining land is mostly used for agriculture with some residential development. Cumberland County has set an objective to capture and treat 90 percent of the average annual stormwater runoff in this portion of the Yellow Breeches Subwatershed. In order to accomplish this objective, the county has determined that post-development peak stormwater runoff will not exceed pre-development levels.

Cumberland County also developed a plan for the Cedar Run Watershed located within the Yellow Breeches Subwatershed. In both cases the county recommends that any new development follow the Pennsylvania Stormwater BMP Manual.

developed areas and the water quality of streams and rivers that flow through the 9,000-plus square miles of land that make up the Lower Susquehanna Region.

Flooding

Flooding is a localized temporary condition of partial or complete inundation of normally dry land from the overflow of streams or rivers. This potentially hazardous condition is generally the result of excessive precipitation. Generally, floods can be classified into two categories: flash floods, the product of heavy localized precipitation in a short time period over a given location; and general floods, caused by precipitation over a longer time period over the river basin.

Flash floods can occur within a few minutes or several hours of heavy amounts of rainfall, rapid snow melt or from a sudden release of water held back by an ice jam. Flash floods can damage buildings and bridges, uproot trees and scour new drainage channels. Although flash flooding often occurs along small rural streams, it is also common in urban areas where much of the ground is covered by impervious surfaces. The impervious surfaces created by roads and buildings generate greater amounts of runoff than would typically occur over vegetated areas. As land is converted from fields and woodlands to impervious surfaces, it loses its ability to absorb rainfall. Urbanization greatly increases the quantity and velocity of runoff over what would occur naturally on vegetated and forested terrain. Fixed drainage channels in urban areas may be unable to contain the runoff that is generated by relatively small, but intense, rainfall events.

The severity of a flooding event is determined by a combination of river basin terrain, local thunderstorm movement, past soil moisture conditions and the degree of vegetative clearing. Abnormal weather patterns may also contribute to flooding of a local area.

Agricultural Runoff

The second major cause of water quality degradation and impairment in the Lower Susquehanna Region is stormwater runoff from agricultural lands. As stormwater flows over agricultural lands, it

Examples of erosion caused by stormwater. Photos courtesy of Kelly Hildebracht.

Agricultural Runoff Best Management Practice: No Till Farming

A farming practice introduced in the 1980s is growing in popularity with environmentally savvy farmers. No-till farming cuts down on the amount of fertilizer and soil washed away in rainstorms and also reduces carbon dioxide released into the atmosphere by eliminating the entire plowing system, commonly used by farmers.

Traditionally farmers solely used plowing to ready the fields for planting crops. Plowing, or tilling, turns over the top layer of soil. This practice eliminates most weeds and allows for fertilizers and pesticides to penetrate the ground. Also, plowing helps to rid fields of decayed crops and other organic matter.

However, tilling exposes topsoil making it susceptible to the effects of stormwater erosion. Over time, plowed fields lose measurable amounts of topsoil. In addition to the soil itself, fertilizers and pesticides are carried by stormwater to nearby creeks and streams, polluting those streams and adding to the pollution of larger waterways downstream. Especially in the Lower Susquehanna Region, water pollution in area streams leading to the Chesapeake Bay has proven to be a huge problem.

Instituting no-till farming is a simple solution to potential environmental

challenges. No-till farming does not use plows, and seeds are instead planted in undisturbed soil. The carbon-containing organic matter that provides nutrients to plants stays in the topsoil where it slowly decays, fertilizing the crops and protecting the soil from erosion. No-till farm equipment creates slots where seeds are planted, disturbing less than 30 percent of the total soil surface.

Among many no-till practitioners, some Lancaster County Mennonite farmers have accepted the benefits of no-till farming and have instituted the practice in their own fields. Along with the environmental benefits, local farmers have reported the benefits of the retained, rather than eroding, soil. These farmers have noticed a significant increase in their harvest, yielding higher profits. Fuel and fertilizer costs associated with plowing practices are reduced with no-till farming, also making the crop more profitable.

Overall, no-till farming is one of the top cost effective best management practices that help to improve environmental conditions. With government support, more farms can institute the practice to not only help reduce water pollution, but increase personal gain from potentially larger harvests.

Stormwater and Flooding, continued

can wash away excess nutrients like nitrogen and phosphorous which come from farming practices. Soils from plowed fields and unstable stream banks, sometimes exposed in part by grazing animals, can also be washed away with stormwater runoff. Excess nutrients and sediments in this watershed not only impair Pennsylvania's waters but also the Chesapeake Bay.

Urban and Suburban Runoff

As the Lower Susquehanna Region witnesses an expansion of development in the southern half of the region, stormwater runoff in the region is being scrutinized along with its effects on water quality. Stormwater runoff from developed areas in Pennsylvania is the third leading cause of stream impairment. Pollution in the Lower Susquehanna Region can result from urban and suburban development and impervious surface (surfaces that water cannot drain through such as concrete pavement, asphalt and roofing materials) expansion resulting in potential runoff of petroleum products, nutrients, etc.

In the Lower Susquehanna Region, Adams, Cumberland, Dauphin, Lancaster, Lebanon, Perry and York counties combined are predicted to see population growth of 280,000 people in the next 15 years. These population changes can result in development and an increase in impervious surfaces. As impervious surfaces increase so can the amount of pollutant-carrying stormwater from new developed areas. Soils washed away from exposed building sites during construction also contribute to the excess sedimentation of streams.

Stormwater can cause sewer overflows in older towns that channel stormwater runoff to wastewater treatment facilities or worse yet, combined stormwater and wastewater can overflow into surface waters. Stormwater also destabilizes stream banks, disperses litter, distributes unnaturally warm water from developed surfaces into streams and reduces groundwater recharge.

Karst Areas

Karst environments typically occur in areas where carbonate (limestone and dolomite) bedrock dominates the subsurface features. Natural breaks and fractures occur in carbonate bedrock which allows precipitation to infiltrate quite easily.

Lake in Perry County. Photo courtesy of Lori Mohr.

Ephrata Performing Arts Center, Lancaster County

In the Lower Susquehanna Region, stormwater runoff has been shown as a leading cause in pollution of area waters. Studies across the region are being done to test Best Management Practices (BMPs) that are anticipated to resolve environmental issues. In this case study, a porous parking area was added to an existing parking lot at the Ephrata Performing Arts Center which includes the Ephrata Playhouse, American Legion and other miscellaneous buildings. The project was proposed to accompany the expansion and remodeling of the playhouse to support additional use.

The new porous parking lot consists of two rows on each end of the existing lot, totaling 9,200 square feet of new parking area and 40 new parking spots. Vegetated swales were included in the design to promote additional infiltration of stormwater runoff conveyed by the parking area.

The site is located within the Cocalico Creek Watershed and is underlain by dolomite and sandstone. Percolation tests revealed that infiltration rates were a half-inch per hour or greater in the underlying soils.

The porous parking lot is underlain by a stone infiltration bed with various benches ranging in depth from 18 to 48 inches and receives runoff from surrounding driveways and parking areas. The existing bed at the northern parking row is designed to take overflow to a flat grassed area, and the new bed at the southern row discharges to a vegetated swale.

Swatara Creek Restoration Case study

The northern Swatara Creek Watershed begins north of Ravine, Schuylkill County and is a tributary of the Susquehanna River. Reports from the early 1990s revealed alarmingly high levels of sulfates, iron, aluminum and acidity in the creek, which proved to be detrimental to not only the water quality, but also to the aquatic life. The contamination levels were high enough to be toxic to most wildlife, practically leaving the creek bare of fish and other organisms that had previously lived in the area. In 1996, the State Department of Environmental Protection (DEP) partnered with USGS to implement a restoration program for Swatara Creek. The program's goals included designing and implementing treatment systems to neutralize and clean up the water along with rebuilding wildlife in the creek.

Historically, Swatara Creek was heavily impacted by acid mine drainage (AMD) and siltation due to runoff from abandoned mines. There is still some impact from AMD, which is evident by the orange color of stream bottoms.

Water quality in Swatara Creek has been improved through a multifaceted approach. Foremost, hundreds of acres of abandoned mine lands were reclaimed. These lands, with characteristic piles of waste coal and rock, open pits and bare areas had allowed water to percolate downward into underground mines. Reclamation activities, such as regrading and revegetating, has restored positive drainage such that water now runs over the surface and reaches the streams without picking up the pollutants along the way. A variety of passive treatment systems were installed including diversion wells, wetlands and limestone drains. These systems counteract or treat the acid water seeping from the mine workings.

Restoration of aquatic life to the Swatara Creek is the best measurement for success of the abatement measures. Whereas in 1990 there were no fish in the stream near the town of Ravine, there are now more than 25 species. The macroinvertibrate population (upon which the fish feed) has likewise shown dramatic improvement.

Did you know?

Erosion is very high in the Susquehanna Region—stormwater causes the loss of more than seven tons of soil per acre of cropland per year. In some critical areas, this loss can be up to 18 tons of soil per acre of cropland per year.

Sunken Gardens at Riverfront Park, Harrisburg; Hurricane Ivan flooding, 2004
Photo courtesy of Tim Devine

Water is a major reason for sinkhole collapses in Pennsylvania. Karst areas form over long periods of time as groundwater moves through breaks in the bedrock, dissolving the rock and creating caverns and spaces below the surface. The spaces may be filled with soil material or may be open. A sinkhole forms as soil material is flushed through underground spaces in the bedrock causing the surface to collapse. If more water in collected and redirected into a karst area this increases the potential for a sinkhole to occur.

The effects of stormwater on karst geology are of concern for the Lower Susquehanna Region. Carbonate bedrock, which allows for sinkholes to form, is common throughout counties like Lebanon, Dauphin, Lancaster and York. Likewise, the effects of sinkholes are a concern for groundwater quality. Water is naturally purified of contaminants as it passes through soil. Surface water that enters a sinkhole passes directly into the groundwater without any filtration, thereby contaminating groundwater resources.

Stream Impairment and Stormwater

In the Lower Susquehanna Region, water quality degradation of streams, rivers and groundwater has occurred throughout the region. Stormwater has degraded water quality in counties like Lancaster, Dauphin, Cumberland and York.

Paxton Creek located in urban and suburban Harrisburg has been negatively impacted by stormwater. The Paxton Creek Watershed and Education Association have made efforts to reduce the impact of new development on the Paxton Creek Watershed. The organization is also working with the Susquehanna River Basin Commission to obtain grants from EPA to develop stormwater management plans for the Paxton Creek Watershed's communities.

Some watersheds in the Lower Susquehanna Region, such as Deer and Octoraro, and sections of the West Conewago creeks appear to be less affected by stormwater runoff. These creeks, though surrounded by large amounts of agricultural land with low development, have more forested land therefore reducing the effects of stormwater runoff on stream water quality. The natural vegetation along streams acts as a buffer (called a riparian buffer) for stormwater and can absorb excess nutrients and filter out sediments that are carried away by heavy amounts of precipitation.

Right: Tea Creek, Mifflin County.
Far right: Remains of Hurricane Ivan flooding, Mifflin County, 2004.
Photos courtesy of Mifflin County Conservation District.

Geology and Groundwater

Geology and Groundwater

The Lower Susquehanna Region has a remarkable variety of geologic landforms and characteristics. The region encompasses large parts of the Ridge and Valley Province and the Great Valley Section of the Ridge and Valley Province as well as sections of the Piedmont Province and the Appalachian Plateaus Province. These provinces and their origins are discussed in the Statewide Overview Section and can be located on the map provided within the section. Diversity in underlying bedrock creates varying circumstances for groundwater supplies such as flow rate, recharge rate and chemical properties. These circumstances directly control the amount of discharge into local streams and also control output to wells for public and private consumption.

Bedrock Geology

As illustrated in the Bedrock Geology Map, the Lower Susquehanna Region contains several different types of bedrock including limestone and dolomite (carbonate rocks). The region also contains sandstones, shales and several igneous and metamorphic (crystalline) bedrock formations.

The sandstone, shale and carbonate formations in the Lower Susquehanna Region are consolidated rocks that comprise the majority of aquifers in the region. Groundwater is contained within and moves through fractures, spaces and partings in the consolidated rock. Aquifers exist here under two different conditions. Where water only partly fills the aquifer and is free to rise and fall, it is referred to as an unconfined aquifer or water table aquifer. Where water completely fills a rock unit and the aquifer is under a low-permeable feature or confining layer, this aquifer is said to be confined. This confining layer helps protect this kind of aquifer from contaminated water migrating from above. Another key difference between the two is the varying pressure regimes. The unconfined aquifers are under atmospheric pressure while confined aquifers are at a greater pressure due to the confining layer overhead.

The carbonate bedrock formations in the Lower Susquehanna Region are comprised of limestone and dolomite. Limestone bedrock formations in the region are prone to chemical dissolution, or dissolving, and form a landscape called “karst.” These voids may be filled with water, soil materials or air. Interconnected pathways can exist through the rock to allow water to be quickly transported in high volumes. If a contaminant reaches the void spaces, it easily enters the groundwater and can be transported extensive distances to other water supply or discharge areas. The creation of these interconnected voids in limestone bedrock can produce sinkholes, closed depressions and disappearing streams; common features of a karst environment are explained in more detail on the following pages.

The connection between surface water and the aquifers that store and discharge groundwater is often misunderstood. The water table, which is the boundary below which all the spaces and cracks in the soil and bedrock are completely saturated, is often times a reflection of the surface topography. As the topography changes due to hills, mountains or valleys, the water table’s elevation and depth will often times change with it reflecting the changes occurring at the surface.

However, streams, wetlands, springs or rivers will often form in areas where the water table intersects the land surface. These features form where the groundwater discharges from groundwater storage and becomes surface water. This discharge of groundwater into surface water is also known as base flow. Base flow can be thought of as the sustained low flow of a stream because it is supplied by the groundwater that is discharging from underground storage. Dry streambeds or springs that no longer supply water are a result of the water table being lower than the land surface.

Ridge and Valley Province

The Ridge and Valley Province makes up the largest portion of the Lower Susquehanna Region. Long and narrow mountain ranges accompanied by broad valleys depict the aging beauty of one of the world’s oldest mountain ranges, the Appalachian Mountains.

Bedrock in the Ridge and Valley Province was also formed by sedimentation from ancient saltwater and freshwater seas that covered the province, much like the Appalachian Plateaus Province. However, the ridges and mountains were formed from past geologic events when the continents collided with each other, forcing the bedrock upward and creating the Appalachian Mountains. The formation of the mountain chain was completed approximately 250 million years ago.

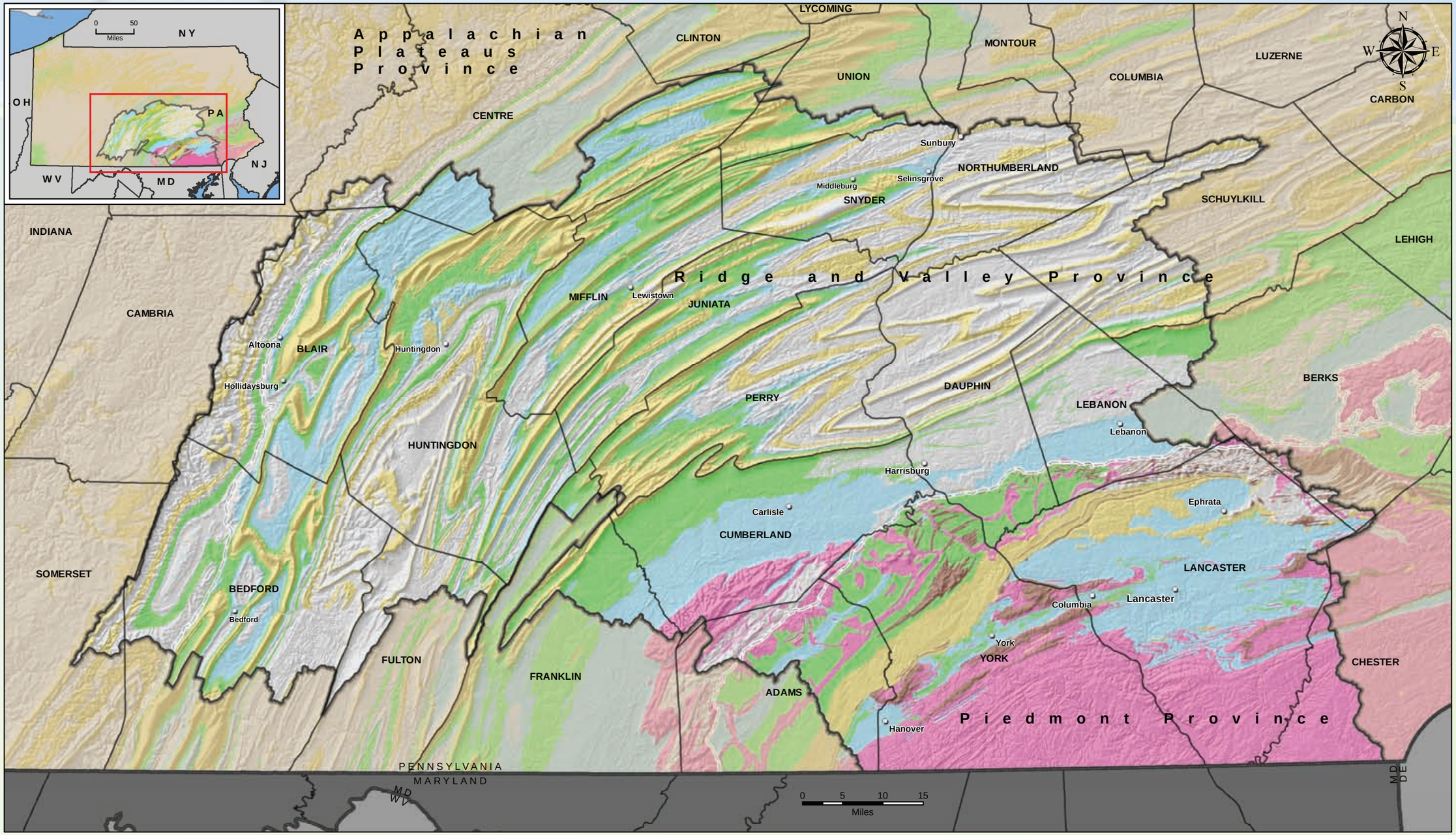
As the mountains eroded, resistant sandstones remained forming the ridges and mountains we see today. The valley areas consist of shale, carbonate, siltstone and other sedimentary bedrock formations. The extensive erosion that has occurred over millions of years has given the mountain range its characteristic surface topography.

Piedmont Province

The bedrock regimes of the Piedmont Province are combinations of metamorphic/igneous, carbonate, sandstone, shale and conglomerate rocks. These areas have varying groundwater geology between its uplands and lowlands. The lowlands and valleys typically are formed of carbonate, shale and sandstone rock. The upland areas of the Piedmont Province are composed of mainly metamorphic bedrock. These regions also contain the most widespread

Ridge and Valley Province, Bedford County. Photo courtesy of Ryan Hale.

Region Geology



City/Town

Physiographic Province Boundary

County Boundary

State Boundary

Bedrock

- Carbonate
- Conglomerate
- Interbedded Sedimentary
- Metamorphic/Igneous
- Sandstone
- Shale

Geology and Groundwater, continued

Susquehanna River near York Haven. Photo courtesy of SRBC.

aquifers of the province. Aquifer recharge is dependent on joints, which are cracks in the bedrock, and fractures found in these areas. Without these joints and cracks, the majority of the rock is nearly impermeable and would encourage runoff to the low-lying valley aquifers. These valley areas are also the discharge areas from the recharge that occurs in the upland areas. The downward flow of water through the ground caused by gravity and the pressure from the water above causes water to discharge into streams and creeks or as springs in the valley and low lying areas.

Recharge in these areas is greater where there is a large amount of regolith overlaying the consolidated bedrock. Regolith is simply the unconsolidated, weathered material typically found between the bedrock and Earth's surface. Thick areas of regolith act as a sponge, holding water and allowing it to slowly enter the groundwater aquifers.

Appalachian Plateaus Province

A small section of the Appalachian Plateaus Province is found on the western border of the region mostly in Bedford and Blair counties. Containing mostly sandstone, siltstone and shale, the small section of the region has groundwater aquifer recharge characteristics similar to the other physiographic provinces. Aquifers of this province rely on joints and fractures to transport water and allow groundwater supplies to be recharged.

This small section, also known as the Allegheny Front Section of the Appalachian Plateaus Province, forms the boundary between the Appalachian Plateaus and the Ridge and Valley Province. The escarpment rises in a step-wise fashion to the east and slopes away through undulating hills to the west. Karst Environments

An understanding of a karst environment is needed if water budgets are to be created in areas underlain with large amounts of carbonate-based rock. The Lower Susquehanna Region, encompassing large amounts of carbonate rock, in turn includes high concentrations of karst features associated with the carbonate bedrock. Many of these karst features are easily recognizable both above and below the Earth's surface.

Karst Environments: Nature's Natural Plumbing

These environments typically occur in areas where carbonate, or calcium-based, bedrock dominates the subsurface features. Limestone, dolomite and marble are the most common forms of carbonate bedrock, and the Lower Susquehanna Region is indeed dominated by limestone and dolomite.

Natural breaks or fractures occur in limestone and dolomite bedrock which allow water and precipitation to infiltrate quite easily. Carbonate rocks are easily dissolved by slightly acidic rainfall that is common in the northeastern United States. Over long periods of time, the cracks and voids in the bedrock become larger and transport water more easily, creating a natural plumbing system beneath the surface. This system of widened voids has the potential to transport great amounts of groundwater and also create interesting features that can be viewed by all Pennsylvanians.

Karst Environments: Sinkholes, Caves and Disappearing Streams

While surface and below-surface features of karst environments can provide unique opportunities to view geology in action, major problems can also develop for local residents living in an area affected by these environments. The Lower Susquehanna Region Karst Geology Map on the next page depicts the locations of karst geology features including sinkholes, surface depressions, surface mines and caves. These features are most dominant in the central and southern portions of the region—particularly around the Lancaster-Ephrata and Lebanon-Harrisburg-Carlisle areas.

Sinkholes

One of the most common features in the Lower Susquehanna Region is a sinkhole. A sinkhole forms as surface material is flushed through a void in the bedrock creating instability at the surface. This loss of surface material can result in ground depressions or open holes that extend to unknown depths. Typical sinkholes have varied in size anywhere from one foot to 20 feet in diameter and create safety issues when occurring in developed areas. Sinkholes can increase in frequency in developed areas when extensive areas are covered with asphalt or other impermeable surfaces. Runoff gets concentrated to specific areas that over time can accelerate subsurface erosion, resulting in sinkholes at the surface.

Caves

Also common in a karst environment, caves are possibly the most aesthetically pleasing of all karst features. Cave formation starts with the dissolution of bedrock but the voids become quite large over hundreds of thousands of years. Along with the dissolution of the limestone bedrock, moving groundwater transports sediment that acts as an abrasive and increases the formation of cave passages.

Disappearing Streams

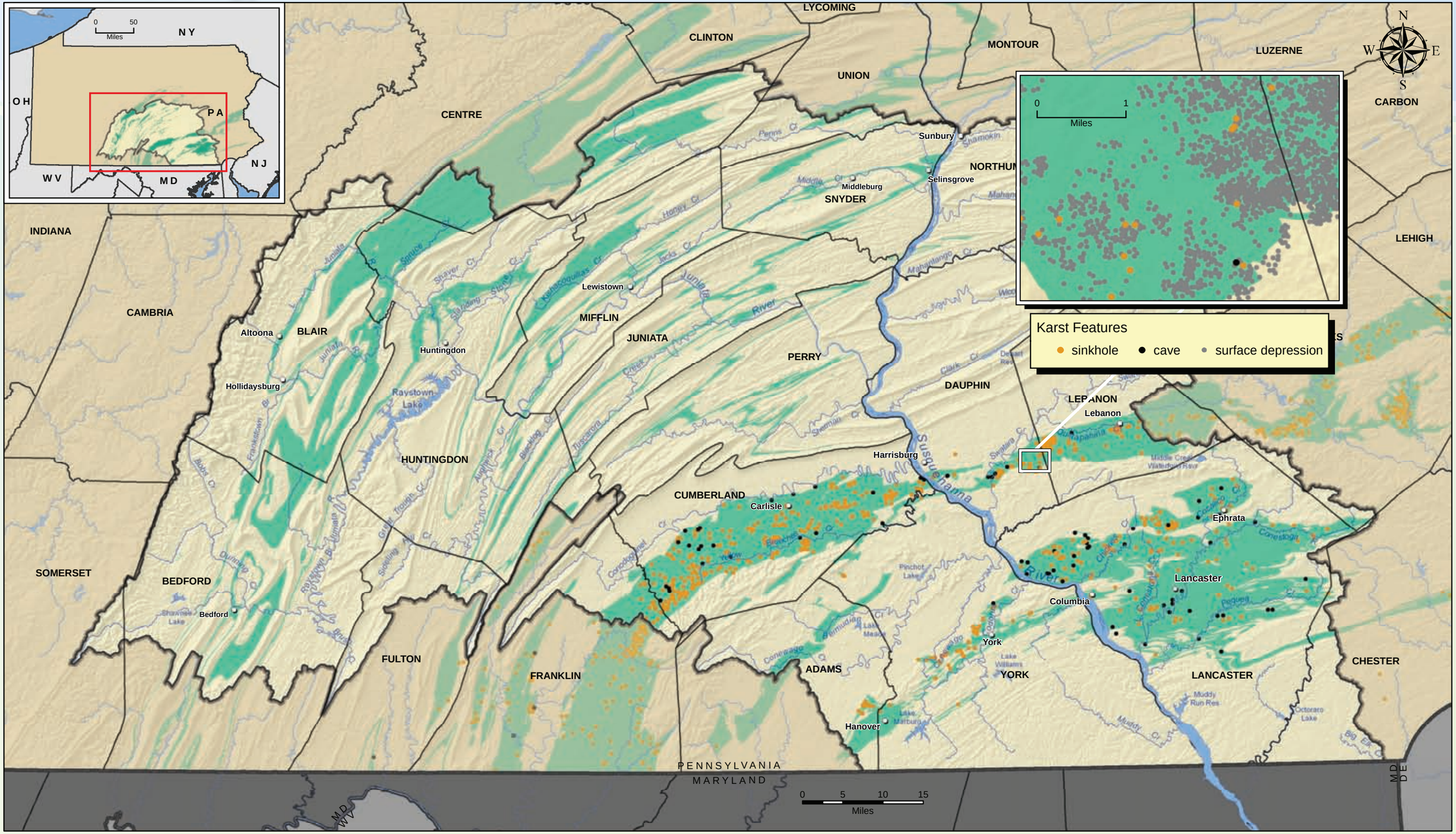
As their name implies, streams flowing over a subsurface karst environment can enter a bedrock drain, such as a sinkhole, and disappear underground. The water will travel within the karst system and emerge elsewhere, typically as a spring. However, this spring can be fed by numerous water sources underground so the actual discharge area of the disappearing stream can remain a mystery.

Water resource planning and budgeting becomes difficult because of these unknown sources and pathways of groundwater. Hydrologists and geologists can conduct tracer tests on these water supplies by placing harmless dyes in the headwaters of these disappearing streams and sinkholes then placing dye indicators at potential discharge areas. If the dye is detected then predictions can be made about flow rate and discharge

Did you know?

Additional information on sinkholes can be found on these Web sites:
DEP Sinkhole Web site
http://www.depweb.state.pa.us/sinkholes
DCNR, "Sinkholes in Pennsylvania"
http://www.dcnr.state.pa.us/topogeo/hazards/es11.pdf

Karst Geology



Karst Features*

- Cave
- Sinkhole

Carbonate Geology

River/Stream

Waterbody

City/Town

County Boundary

State Boundary

*partial mapping shown

Geology and Groundwater, continued

Penn's Cave

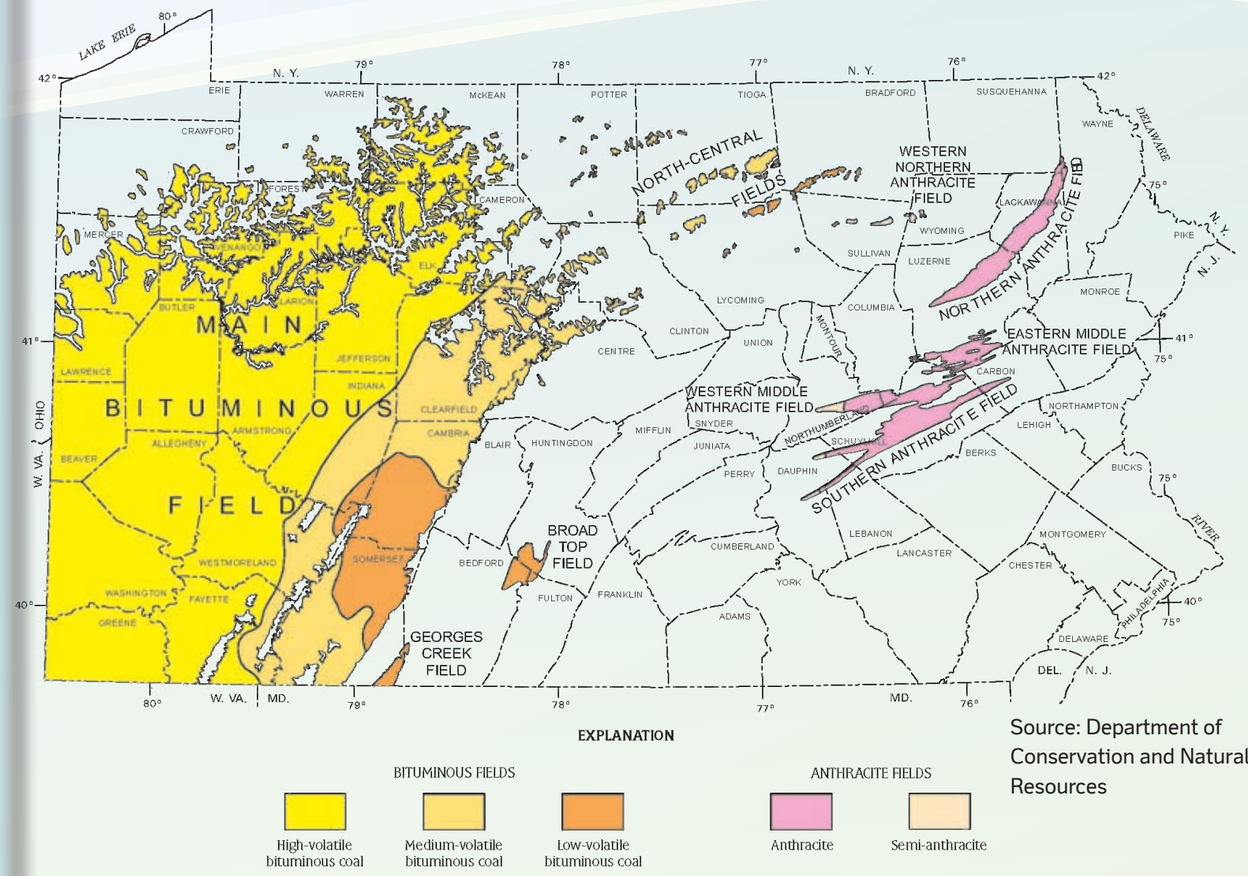
A fascinating karst feature of Pennsylvania, Penn's Cave is located in Centre County near State College. The cave is America's only all-water cave and offers a guided tour through the cavern passageways and Lake Nitanee. The cavern opened to the public in 1885, and today Penn's Cave is listed on the National Register of Historic Places.

The limestone cavern is a natural landmark and was formed from the bed of a shallow sea that existed millions of years ago. The Seneca Indians first discovered the cavern in Penn's Valley. A famous tale of a Native American girl, Nitanee, and her French Lover, Malachi Boyer, has been told for generations. Legend has it that the couple ran away due to Native American customs that kept them from marrying and once they were captured, Malachi was thrown in Penn's Cave to die. Also, the nearby Nittany Mountain and Nittany Lion, Penn State University's mascot, was named after the legend's young Native American girl.

A 60-minute tour on a 22-person flat bottom motorboat takes passengers through the cavern, exposing intriguing stalagmites and stalactites. Beneath the boat, rainbow, brook and brown trout swim the cavern water and occasionally jump up for food. The tour tends to be cold, as the temperatures deep within the cavern remain at about 52 degrees Fahrenheit.

Penn's Cave.
Photo courtesy of Tammy Farrell.

Distribution of Pennsylvania Coals



Source: Department of Conservation and Natural Resources

amounts. These predictions assist in creating water budgets and solve the mystery surrounding these disappearing streams.

Coal and Mineral Resources

Mineral resources, both used for fuel, industrial and commercial purposes, are prevalent in the Lower Susquehanna Region. Coal resources are more dominant in the northeastern reaches of the region, and non-fuel mineral resources such as limestone, sand and gravel are common elsewhere.

Quarry in Blair County.

Did you know?

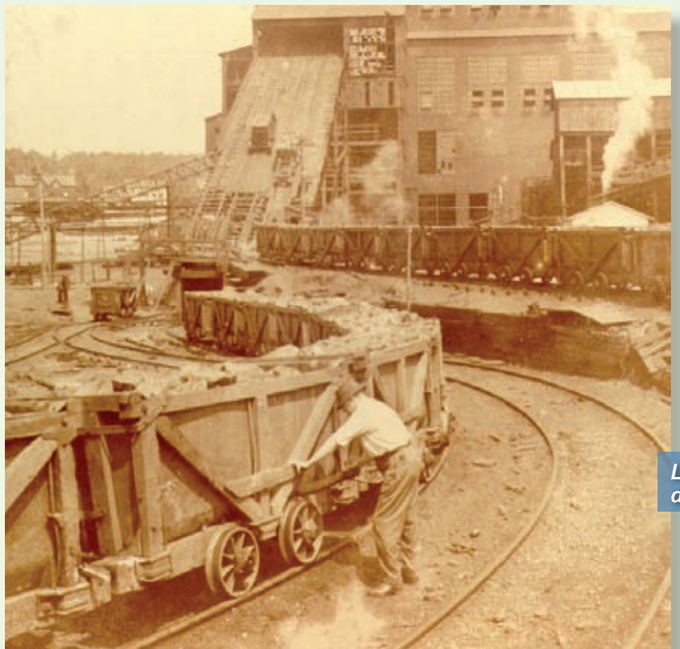
The Union Canal Tunnel in Lebanon County was completed in 1827 and is the oldest transportation tunnel in the U.S.

Coal Resources

Coal mining in the Lower Susquehanna Region dates back to the discovery of anthracite coal in the late 1700s and the settlement of the early Pennsylvania coal miners. Anthracite coal is the hardest and highest energy yielding of all varieties of coal and is greatly valued. The accompanying map shows the coal deposits in Pennsylvania, and particularly the anthracite fields in the northeastern part of the state. Coal mining is still an important industry, and the region provides the entire country with coal unique to this area.

Although the anthracite coal industry in this area has decreased since its heyday in the early 1900s, it is still mined and the rich coal mining heritage lives on in the mining towns of Schuylkill and Northumberland counties. The extraction of coal from beneath the Earth's surface can unfortunately result in degradation of the surrounding environment and local water sources. Sedimentation that occurs during heavy rain events from coal dust and exposed earth creates multiple problems to stream morphology and water chemistry. Other environmental challenges include groundwater depletion, mine collapse and landslides. Another prevalent problem that is easily recognized is acid mine drainage.

The formation of AMD is primarily a function of the geology, hydrology and mining technology employed for the mine site. AMD is formed by a series of complex geochemical and microbial reactions that occur when water comes in contact with pyrite (iron disulfide minerals) in coal, refuse or the overburden of a mine operation. The resulting water is usually high in acidity and dissolved metals. The metals stay dissolved in solution until the pH raises to a level where precipitation occurs. Solubility charts for the various metals show the pH at which precipitation begins and the pH at which maximum insolubility occurs. Neutralization with limestone addition and bioremediation are some solutions to alleviate these symptoms but the problem still persists.



Loaded coal cars ready at foot of plane and cars being hoisted into breakers.

Mineral Resources

Limestone is by far the dominant non-fuel mineral resource that is extracted in the Lower Susquehanna Region. Other resources mined include sandstone, shale, sand and gravel, clay and various types of metamorphic rocks. These resources benefit the construction, industrial and agricultural industries. Some limestone and dimension stone quarries also provide underwater scuba diving experiences where permitted.

Limestone

Limestone quarrying and mining in the Lower Susquehanna Region has remained an important resource for the construction industry as well as the agriculture industry. Crushed limestone is made into crushed aggregate that can be used in highway construction and similar activities and is a large commodity in Pennsylvania. Limestone is used to make cement and concrete which is produced in large quantities by many local suppliers.

The 2004 report on non-fuel minerals of Pennsylvania published by the U.S. Geological Survey (USGS) placed Pennsylvania's crushed aggregate production at $635 million. According to the USGS, Pennsylvania was ranked second in the nation in quantity of crushed aggregate produced.

Companies such as New Enterprise Stone and Lime located in New Enterprise, Penna. and Pennsy Supply based out of Harrisburg, Penna., a part of Oldcastle Inc, are large limestone enterprises within the Lower Susquehanna Region. Mineral industry surveys conducted in 2005 stated that New Enterprise Stone and Lime ranked first in the state in crushed aggregate production with 22 active quarries and 17th in the nation. Pennsy Supply currently operates 13 active quarries.

Limestone that is crushed to a near powdered form (lime) is used to improve the soil chemistry in agriculture settings. Calcium carbonate, the dominant constituent of limestone, acts as a neutralizer when it is combined with acidic precipitation or soil. Adding lime eliminates the acidity creating better growing conditions.

Mined limestone can also be used in industrial settings, such as coal-fired and cogeneration power plants that burn coal mine waste as fuel. These power plants use limestone in the combustion process to absorb the sulfur given off by combustion of any fossil fuel or combustible material. Industrial plants also use limestone-containing scrubbers located in smoke stacks that help reduce harmful emissions. The limestone removes harmful pollutants such as sulfur dioxide, a large contributor to acid rain, before it enters the atmosphere.

Concrete/Cement

The concrete and cement industry in Pennsylvania is one of the most valuable mineral industries in the state. The value of the cement industry, which includes masonry and Portland cement, is estimated to be more than $600 million according to a 2005 U.S. Geological Survey Minerals Yearbook report. The Lower Susquehanna Region is home to several cement producers due to the large and abundant supply of crushed aggregate, mainly limestone and dolomite, which is the backbone of the cement industry.

The environmental benefits of concrete production are also outstanding when compared to other nonfuel minerals. According to the American Concrete Pavement Association Pennsylvania Chapter, concrete is among the most recycled construction products in the nation and is completely recyclable. Concrete that is crushed can be reused in new batches of concrete or can be used as crushed aggregate for many construction projects. The concrete's alkali-rich carbonate components can also be used to treat acid mine drainage, providing the medium that will help neutralize the impaired water sources.

Clay

Mining and manufacturing of clay is a lesser known mineral industry in the Lower Susquehanna Region, as larger industrial areas for clay manufacturing exist elsewhere in the state. Non-manufactured clay is used for natural liners in landfills and also as final covers for landfills.

Land Use: Past and Present

History of the Lower Susquehanna Region

Studying the change in land use over time can offer insight into the development patterns that may influence the future landscape of an area.

Pennsylvania's Forests

Pennsylvania's water resources are closely tied to its forests. The vast forests of Penn's Woods provided clean, pure water not only for Native Americans, but also for the state's founder, by acting as a natural filter. However, William Penn might not recognize his property today.

When colonists first arrived in the mid-Atlantic, more than 90 percent of the landscape was forested. By the mid-1800s, most of the region's trees had been cut down to clear land for cities, towns and farms or to provide lumber. Once dominated by virgin pine hemlock and chestnut forests, the forests regenerated into current day second-growth mixed deciduous and evergreen forests.

The post-colonial changes to the forest were significant. At one time, the predominant tree species in the mid-Atlantic deciduous forest was the American chestnut. Unfortunately, with the accidental introduction of a fungus (*Endothia parasitica*) to the area in 1904, most American chestnut fell to this disease. The fungus survives in stumps and saplings affecting any trees approaching maturity. The great oak-chestnut forests of the mid-Atlantic have been replaced by an oak-hickory mix.

Lumber

The timber industry was an important one for the early inhabitants of the Lower Susquehanna Region. Originally, the timber was used for lumber and building boats and ships, but the forest also furnished fuel, potash, tanbark, wood for furniture and coopering, rifle stocks, shingles, household utensils and charcoal. After 1850, the lumber business expanded rapidly, partially due to the demand for lumber by an expanding country and the Civil War. The introduction of steam-driven machinery, combined with the use of the circular saw blade revolutionized sawmilling.

Lumbermen used the Susquehanna River to transport the lumber to the mills, and the mills in turn used the rivers to transport their products to market.

During the period between 1850 and 1870, the center of the lumber industry shifted into northern and central Pennsylvania with its most prominent city being Williamsport, which became known as the Lumber Capital of the World.

Today, Pennsylvania leads the nation in hardwood lumber production, and the commonwealth's forests contain several high-quality forest products. These products are necessary materials for an industry that produces $5 billion per year in forest products and employs nearly 100,000 people. Both Pennsylvania's consumers and general economy benefit from this regionally important supply of forest products.

Early Settlement and Agriculture

The primary inhabitants of the Lower Susquehanna Region at the time of European settlement were the Lenni Lenape, or Delaware tribe. A portion of the Shawnee tribe also inhabited the area under the protection of the Lenni Lenape. Another Native American tribe, the Susquehannocks, lived along the Susquehanna River in Pennsylvania and Maryland. The Iroquois, or the Five Nations, held power in the region, but did not have settlements in the area. The Native Americans survived through a combination of cultivating small cleared fields, hunting and gathering.

Early colonial farmers initially concerned themselves with feeding their own families, not with producing quantities for sale. Early colonial agricultural practices depleted the soil. Farmers cleared the land and burned the trees or left them to rot. Principles of crop rotation and fertilization were not well understood, and soil fertility quickly declined. Early farmers let the land lie fallow (uncultivated) for up to seven years while other fields were farmed. Other settlers farmed their fields until the soil was exhausted and then moved to a new location. It was not until the 1790s that a crop rotation system alternating corn, wheat and clover was widely adopted.

The first permanent settlers of the Lower Susquehanna Region consisted primarily of German farmers who were attracted to the area because of the rich, fertile limestone soils found there. Members of religious denominations also tried to settle close to each other so that they could give mutual support and could worship together. Pennsylvania German farmers did not apply the principles of crop rotation any better than other groups of the period, but they did apply manure as a fertilizer, allowing them to farm intensively without exhausting the soil. Commitment to and care of the land has always been especially important among the German Plain Sects (Amish and Mennonite), for whom farming continues to be the preferred occupation.

Forest-lined creek in Mifflin County.
Photo courtesy of Mifflin County Conservation District.

By the 1840s the Midwestern states could produce wheat at a cheaper price than Pennsylvania. The commonwealth ceased to be the grain belt of the nation, as it had been in the late-18th and early-19th centuries. A shift toward intensive agriculture, especially dairy farming, was made possible by mechanized farm equipment that was generally available by the 1850s. In the twentieth century, technological advances in fertilizers and pesticides helpedmaintain high agricultural production. However, runoff from agricultural fertilizers and chemicals became an ongoing source of nonpoint pollution, meaning that pollutants from several sources are picked up and deposited elsewhere.

Today, Pennsylvania ranks 19th overall in agricultural production in the United States, and the commonwealth ranks first in mushrooms, third in Christmas trees and layer chickens, and fourth in nursery and sod, milk, corn for animal feed, and horse production.

Did you know?

"The landscape along parts of the Juniata and its tributaries reflects what many people feel to be a classic Pennsylvania image—a well-blended scene of farms and forests, mountains and streams, all together in a way that makes you feel good again, like you've seen a part of the older Penn's Woods and not a land that gets remodeled every twenty years."

—Tim Palmer, author of *Rivers of Pennsylvania*

Amish plowing in Manheim, Lancaster County.

Land Use in the Lower Susquehanna Region Today

As the pie chart on this page indicates, more than half of the land area consists of forestlands found in the northern half of the region. Deciduous species make up the majority of the forest type throughout the region. Agricultural lands exist throughout the entire region, but is the dominant land use in the southern half. The largest expanses of developed areas are centered around Harrisburg, Lancaster, York and Hollidaysburg.

The Land Cover Map on the following page shows the various land uses and vegetative cover across the Lower Susquehanna Region. Definitions for the land use categories used in the Land Cover Map are as follows:

Development

Approximately 10.4 percent of the land in the Lower Susquehanna Region is developed for residential, commercial and industrial use. Developed areas are categorized by the by the amount of land area covered by impervious surfaces:

- Developed, Open Space – less than 20 percent of the area is covered by impervious surfaces, mostly vegetation in the form of lawn grasses (e.g., golf courses, parks, single-family housing units and vegetation planted in developed settings for recreation, erosion control or aesthetic purposes)
- Developed, Low Intensity - 20 to 49 percent of the area is covered by impervious surfaces (e.g., single-family housing units)
- Developed, Medium Intensity – 50 to 79 percent of the area is covered by impervious surfaces (e.g., single-family housing units)
- Developed, High Intensity – 80 to 100 percent of the area is covered by impervious surfaces, where people live and work in high numbers (e.g., apartment complexes, row houses and commercial/industrial areas)

Forest

More than half of the land in the Lower Susquehanna Region, 51.1 percent, is covered by forests. Forest lands are categorized by the type of trees that dominate the area:

- Deciduous Forest – greater than 20 percent of the area is dominated by trees that are taller than 5 meters and shed leaves in the autumn
- Evergreen Forest – greater than 20 percent of the area is dominated by trees taller than 5 meters and maintain their leaves all year round
- Mixed Forest – greater than 20 percent of the area is dominated by trees taller than 5 meters but are not dominated by deciduous or evergreen species

Agriculture

Approximately 36 percent of the land in the Lower Susquehanna Region is used for farming. Agricultural lands are categorized by the type of crop that is cultivated:

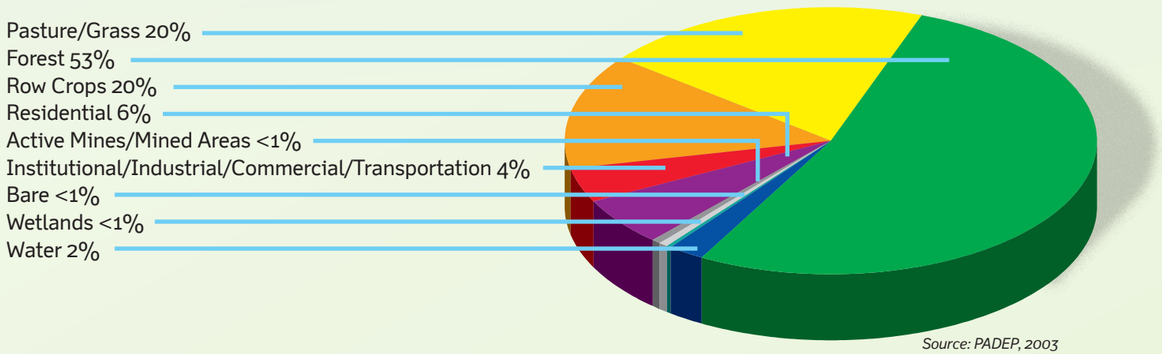
- Pasture/Hay – greater than 20 percent of the area is covered by grasses and legumes planted for livestock grazing or hay production
- Cultivated Crops – greater than 20 percent of the area is covered by annual crops (e.g., soybeans, vegetables, tobacco, cotton), orchards and vineyards and/or all land that is actively being tilled

Other

Less than three percent of the land in the Lower Susquehanna Region is covered by barren lands, open water, wetlands, shrub/scrub and grassland/herbaceous areas. These areas are categorized by the amount of land covered by vegetation (other than trees) and/or by water:

- Barren Land (Rock/Sand/Clay) – Areas of accumulated earthen material (e.g., bedrock, sand, glacial debris, strip mines, gravel pits) with less than 15 percent vegetation cover
- Open Water – all areas of open water with less than 25 percent of the area covered by vegetation or soil
- Wetlands – areas where the soil is periodically saturated or covered with water and greater than 20 percent of the area is covered with vegetation
- Shrub/Scrub – greater than 20 percent the area is dominated by shrubs and young trees smaller than 5 meters tall
- Grassland/Herbaceous – greater than 80 percent of the area is dominated by grasses and herbaceous vegetation

Lower Susquehanna Region Land Use



Source: PADEP, 2003

Did you know?

In 1725, German farmers in Lancaster County invented the "Conestoga" wagon. The wagon was revolutionary because of its steering mechanism, braking system and construction.

Land Use: Past and Present, continued

How Land Use Affects Water Resources

The various uses of land affect water in different ways, some better than others.

Importance of Forested Areas to Water Supplies

The Lower Susquehanna Region is comprised of the Central Appalachian Ridge and Valley Region. This mid-Atlantic region supports hardwood forests including pine-oak and oak-hickory forests, as well as coniferous (that is, trees that produce cones and have needles such as pine trees) forests, including Eastern hemlock. This area is mainly comprised of deciduous (that is, trees with leaves that fall when autumn arrives) forest type, with 46 percent deciduous, and an additional five percent mixed and coniferous forest types.

Forested areas are critical to the supply and quality of water resources. Tree canopies and the rich organic matter found in forest floors store, clean and slowly release the majority of water that replenishes groundwater and maintains streamflow. Areas of forested lands are reserves of clean groundwater, and forested areas are often good locations for municipalities to drill high-yield water wells.

Some forests are particularly effective at delivering water quality benefits. Wooded buffers along streams trap sediment and transform nutrients and other pollutants into less harmful forms. For example, properly managed woodlands can remove 90 percent of the nitrates in stormwater runoff given the right soil conditions.

With regard to drinking water, intact forests within wellhead protection areas play a vital role in protecting the amount and quality of water reaching public wells. In developed areas, urban forests are critical to reducing stormwater runoff from small storms.

Forests also protect local waterways by retaining nitrogen in air deposition. An oak/hickory forest retains an average of 90 percent of atmospheric deposition, while a spruce/fir forest retains 78 percent. In general, coniferous forests use less nitrogen than deciduous forests (a factor more of the soils than the tree itself). The exception is the Eastern hemlock forest, which is highly efficient at retaining nitrogen. Forests also sequester, or remove, carbon from the air helping to reduce the impact of carbon dioxide on global warming.

Some of the most important forests for water resource protection are the most threatened. Forests are vulnerable to development and other land uses that can fragment high quality forests and expose woodlands to invasive species. Parcelization is another threat – more people own forests than ever before but many own less than 10 acres. As larger tracts of forest land are subdivided, it is important that woodlot owners be educated about sustainable forest management practices.

In addition, efforts to protect woodlands can be misguided and serve to diminish forest health. Under the Municipalities Planning Code, forestry, which includes timber harvesting, is a permitted use by right in all zoning districts. Concerns over forest regeneration and wildlife habitat have led to the adoption of local timber harvesting ordinances that are, in some cases, overly restrictive in prescribing timber harvesting practices. Local governments can benefit from knowledge of state regulations protecting against poor timber harvesting practices and advice from a professional forester when planning and adopting local ordinances.

Timbering

Timbering in Pennsylvania has economic benefits as well as ecological

Top: Frederick Watts barn 1867 to 1988, Cumberland County. Photo courtesy of Cumberland County Historical Society.

Above: Former site of Frederick Watts barn now contains a warehouse, 2008. Photo courtesy of Ryan Hale.

Did you know?

In the 1830s, a minor gold rush occurred in the Susquehanna Basin when gold was discovered in several streams. Also, one of the largest sources of gold was a byproduct of iron ore production at the Old Cornwall Mines in Lebanon County.

NRCS

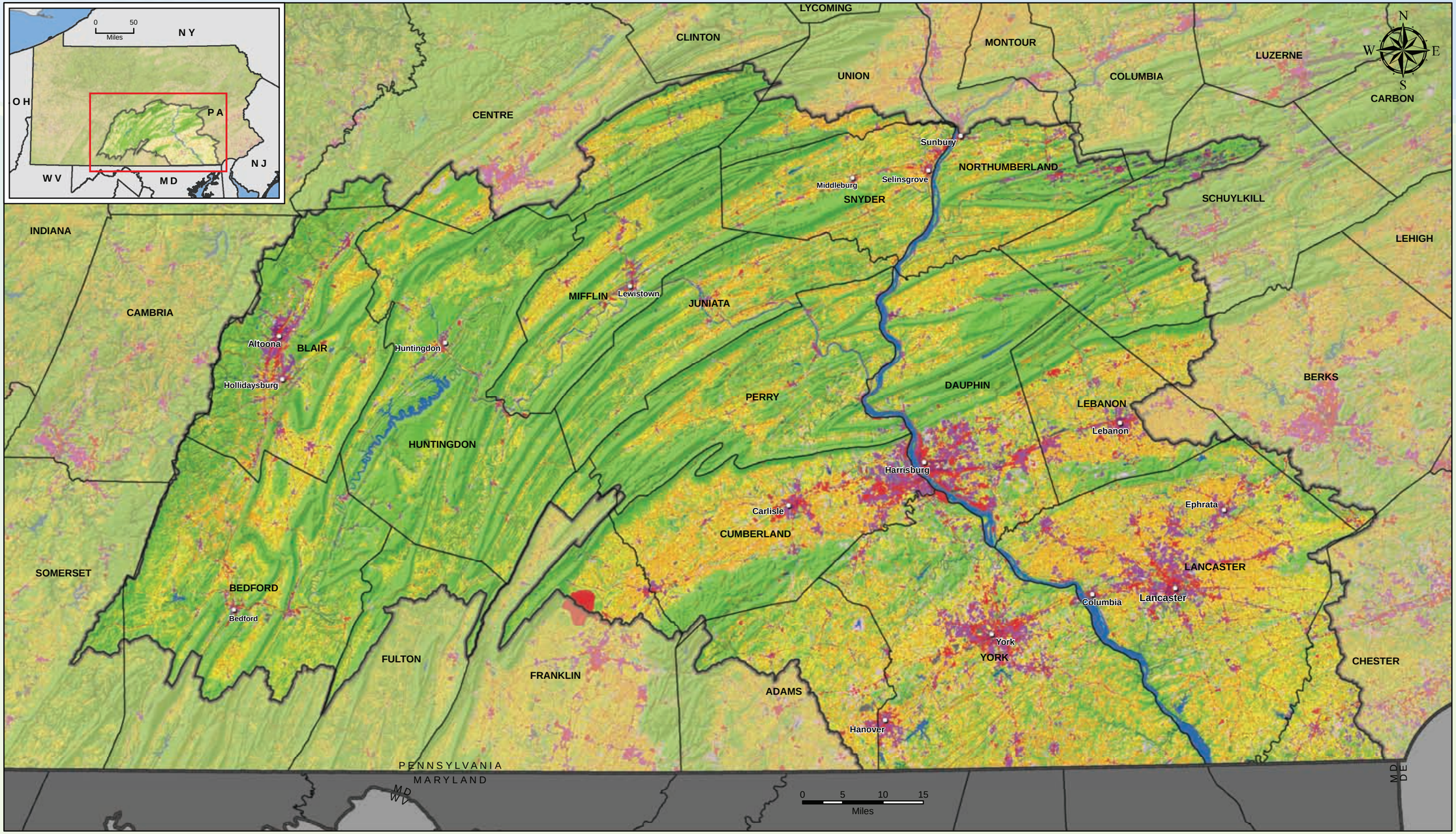
The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS), formerly known as the Soil Conservation Service, is a federal agency within USDA, charged with assisting America's land owners and managers to conserve their soil, water and natural resources. NRCS provides leadership and technical assistance catering to the specific needs of different locales. Environmental, societal, financial and technical experts lend their knowledge to NRCS to plan and implement effective conservation systems.

There are hundreds of branches of NRCS throughout the country that localize services to area projects. Districts of NRCS in the Lower Susquehanna Region specialize in a variety of concentrations pertinent to local environmental needs; rural development and farm service are targeted in this region.

Farming is an important industry in the Lower Susquehanna Region, and in some areas, such as Lebanon County, agriculture employs two out of every five people. The NRCS in these areas help in farmland preservation projects, which in turn helps the economy, makes farming more affordable for the future, and assures affordable and accessible produce in grocery stores. In addition to farm preservation, local NRCS offices aid in the local Chesapeake Bay Program to help with pollution control, take strides to increase watershed education, and help with local forestry and environmental education by having annual seedling sales at affordable prices.

NRCS offices work with local County Conservation Districts as the primary facilitator of conservation programs. They set goals, identify funding sources, prioritize needs, and implement plans to truly make a difference in the community.

Land Cover



City/Town

County Boundary

State Boundary

Land Cover

Developed
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Commerical/Industrial/ Institutional/Transportation

Forested
- Deciduous Forest
- Evergreen Forest
- Mixed Forest

Herbaceous Planted/ Cultivated
- Row Crops
- Pasture/Grass

Barren
- Bare
- Active Mines/ Mined Areas

Water and Wetlands
- Water
- Forested Wetlands
- Emergent Wetlands

Land Use: Past and Present, continued

benefits. Economically, Pennsylvania is the nation's largest producer of hardwood lumber, producing more than one billion board feet per year. The vast forested areas north of the Lower Susquehanna Region as well as forested areas within the region itself contribute a large amount to total production. Ecologically, timbering provides habitat diversity and mimics natural disturbances that sustain forests.

Timbering companies work hand in hand with agencies such as DEP, DCNR, EPA, U.S. Army Corps of Engineers and the U.S. Forest Service to protect water resources. Strict permitting is required for stream crossings, wetland crossings, and timbering near these resources. Timbering companies also are required to develop extensive erosion and sedimentation control plans for areas they plan to timber. Through these relationships between timbering companies and agencies, the timber business continues to thrive while protecting our invaluable water resources.

Agriculture

Farmers usually rely on groundwater wells or springs to provide drinking water for both their families and livestock. Because groundwater is buried beneath the earth's surface, it is sometimes thought that groundwater is protected from contamination. That is not the case. Activities on the land surface can harm groundwater quality. On a farm, preventing pollution by nitrate (a form of nitrogen), bacteria and pesticides deserves special consideration because sources of these contaminants are often easily identified. Health problems for human beings and livestock can arise when these contaminants pollute a water supply.

Animal manure, commercial fertilizers and pesticides can pollute local waterways and groundwater if they are misused or applied in excess of crop needs. Much of sediment pollution in streams comes from eroding and unprotected stream banks. More than half of the nitrogen and the phosphorus entering the Susquehanna River come from agricultural runoff. Improper storage, application or disposal of pesticides can also pollute the groundwater.

Fencing stream banks and limiting livestock access with crossings promotes the establishment of a healthy vegetative cover. Forested vegetation along streams, called riparian forest buffers, helps stabilize stream banks in reducing erosion and collapse. These buffers can also help trap soils and pollutants that may otherwise run off of adjacent fields into the waterways. Riparian buffers provide food, cover and nesting sites for birds and small animals. By providing shade from the sun and a food supply (leaves, etc.) to the stream, buffers can enhance the aquatic habitat.

Forestland and Farmland Conversion to Developed Land

Only about 9,600 of Pennsylvania's 58,000 farmers have sales of $100,000 or more. The cost to produce quality agriculture goods consumes nearly 85 percent of sales, leaving most farmers with a net farming income below $19,806, of which a 12.4 percent self-employment tax must be paid. For a family of four, this net income is below the poverty level (based on 2006 figures). As a result, many farms in the southcentral part of the commonwealth have been sold to housing developers in the past years. This movement is largely due to rising taxes and land prices, reflecting a high demand for land.

A map showing future population projections is presented earlier in the Lower Susquehanna Region Introduction pages of this atlas. This map depicts a general trend of historically developed areas losing population while the areas surrounding towns and cities are gaining population.

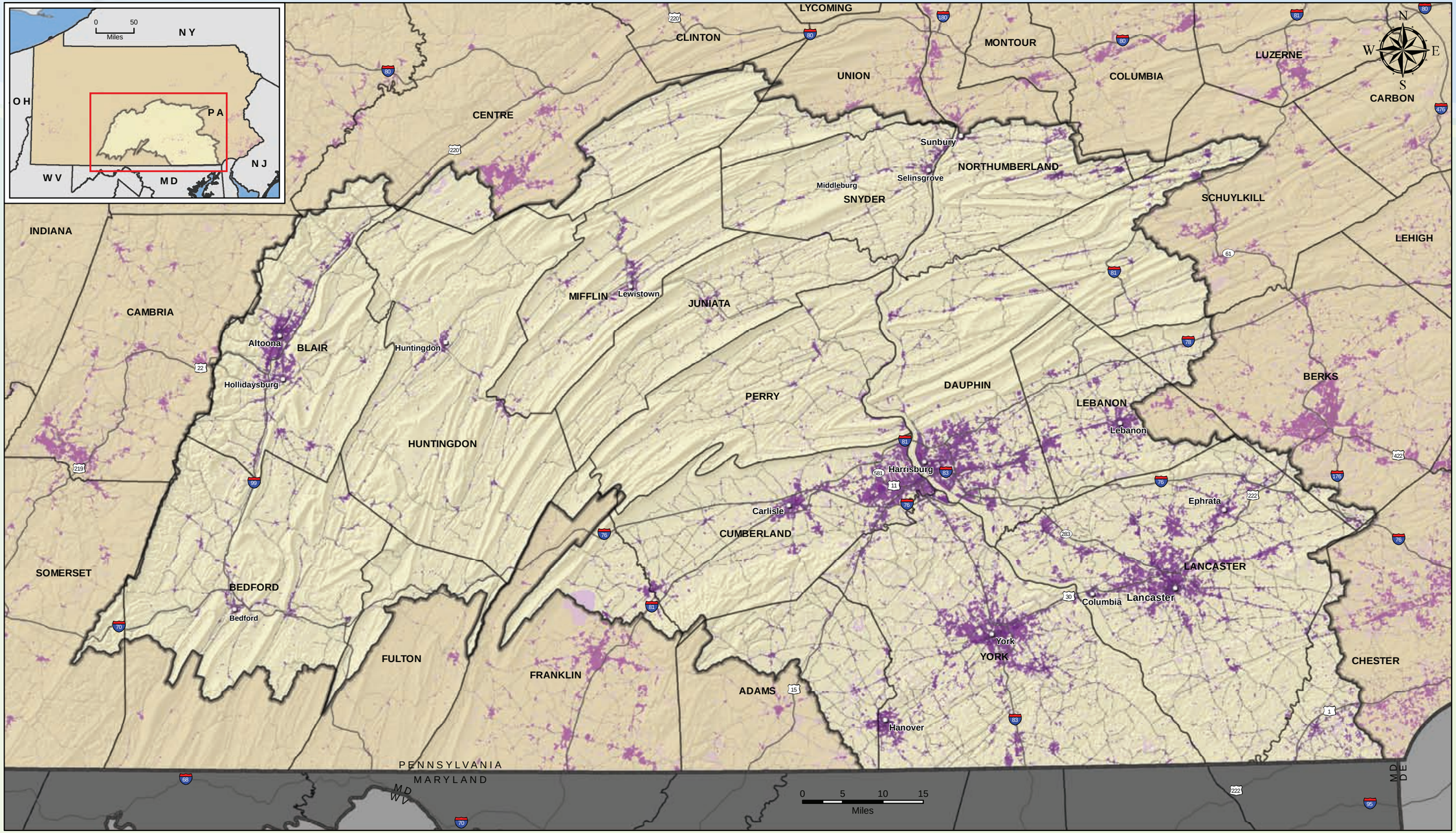
Many older towns and cities throughout Pennsylvania are currently losing population as people continue to settle in suburban and rural housing in areas that were once forest or farmland. During the 1990s, the total number of acres developed in Pennsylvania increased by 53.6 percent, while Pennsylvania's population grew by only 3.4 percent. The aerial photographs on this page illustrate the landscape changes that have occurred in the Lower Susquehanna Region over time. Both photographs were taken in the borough of Dover, York County at the intersection of PA-74 and PA-921. In the 1938 photograph, houses edge the two roads and are surrounded by expansive farm fields. In the 2003 photograph, a lot of the area still remains agricultural fields, but the development has expanded out from the intersection—particularly to the east—with housing developments and schools.

The relationship between development patterns and water resources is complex. Since Pennsylvania recommends a watershed approach to managing water resources, it's critical that the local decision-making framework consider water resources and land uses within the entire watershed area when planning for growth and development.

A watershed approach broadens the geographic planning area beyond political boundaries and extends it to the hydrological boundaries of the watershed. Protecting and managing water resources at the broader watershed scale are likely to require inter-municipal cooperation.

Borough of Dover, York County. Top, 1938; above, 2003.

Impervious Cover



City/Town
Major Roads
County Boundary
State Boundary

Impervious Surfaces

Roads
5 -30% cover
31 - 75% cover
>75% cover

Land Use: Past and Present, continued

Evaluating the percent of impervious cover in a watershed can be a useful indicator in planning future growth and development. Impervious surfaces, which prevent water from flowing through them and into the groundwater system, include roads, parking lots, rooftops, driveways and sidewalks. The Impervious Surface Map on the next page shows impervious surfaces based on land use/land cover in the Lower Susquehanna Region. With the exception of Hollidaysburg near the western limit of the region, developed lands are more prominent in the southern half of the Lower Susquehanna Region. Harrisburg, Lancaster and York are good examples of developed lands with higher density development originating in the center of the city and lower density development expanding outward.

Research has shown a strong inverse relationship between the percent impervious cover and water quality and stream health. However, the location of impervious cover within a watershed is another variable that needs careful consideration. For example, in an attempt to protect water quality by limiting impervious cover, many local governments have mistakenly applied impervious cover thresholds to individual sites within a watershed by adopting low density zoning districts, thereby encouraging scattered low density development.

Used alone, low density development consumes more land and generates more stormwater runoff than the same number of homes accommodated under a higher density scenario in a given watershed. (See illustration). In other words, when measured by the house, higher densities produce less stormwater runoff.

When runoff is measured by the acre, limiting density does minimize water quality impacts compared to higher-density scenarios. However, when measured by the house, higher densities produce less stormwater runoff. (Source: Protecting Water Resources with Higher-Density Development, EPA, 2006)

Higher density development — more people on less land — can effectively protect water resources if it occurs within the framework of a more encompassing watershed strategy that considers other factors, such as the location of old and new development, preservation of critical natural lands and the use of site-specific stormwater management practices.

In some situations, low density development can be a tool to preserve agricultural and forest lands if it too reflects a watershed strategy and includes such elements as the protection of water supply protection areas, streamside buffers and floodplains, or critical ecological habitats.

Average Annual Runoff - Lot Level Comparisons

Density of Houses/Acre	Impervious Cover (percent of total area)	Total Runoff (ft^3 per year)	Runoff per House (ft^3 per year)
8 houses on 8 acres	20%	149,600 (18,700 ft^3/yr x 8 acres)	18,700
8 houses on 2 acres	38%	49,600 (24,800 ft^3/yr x 2 acres)	6,200
8 houses on 1 acre	65%	39,600 (18,700 ft^3/yr x 8 acres)	4,950

William H. Kain Park, York County. Photo courtesy of Kelly Hildebracht.

When planning for future growth that will be protective of water resources, it's important that local governments use a wide range of land use strategies, based on a sound understanding of local watershed hydrology, assessment of undeveloped lands and local housing and infrastructure needs.

Land Use Planning for Water Resources

The Population Projection Map in the Lower Susquehanna Region Introduction predicts that most city and town populations will either stay constant or will decrease through the year 2030. The central and southern counties around Harrisburg, Lancaster and York are predicted to increase in population. The relocation of people from urban areas to suburban or rural areas will require foresight into resource management to meet the needs of the new development.

Juniata River, Mifflin County.
Photo courtesy of Mifflin County Conservation District.

Planning for adequate supplies of clean water is just as important as planning for roads, businesses and schools. In recognition of this fact, the Municipalities Planning Code (MPC), the enabling state legislation that empowers local governments to plan and regulate land use, was amended in 2000 to require the inclusion of a plan for the reliable supply of water in the preparation of local comprehensive plans.

Nearly 1,200 municipalities have adopted comprehensive plans to guide future land uses. More importantly, the number of municipalities engaged in cooperative, multi-municipal planning (permitted under the MPC since 2000) is growing – 760 municipalities and counties were involved in 207 multi-municipal comprehensive plans in 2005.

Collaborative planning is essential to sound water use planning since water almost always crosses political boundaries. By planning at a watershed scale, local government leaders can take advantage of the many land use tools that are particularly useful in protecting the long term supply and quality of water.

For example, a multi-municipal approach provides for joint zoning ordinances. Instead of each municipal government providing for every land use, joint zoning allows neighboring governments an opportunity to integrate land uses. A joint overlay zone may protect a wellhead protection area that crosses municipal lines. An agricultural district may make more sense in one municipality where prime farmland dominates, while higher density development can be better accommodated in another municipality where the soils are less productive.

Many more land use planning tools, adopted jointly or individually, are at the disposal of local government officials who recognize the need to protect water resource lands and allow for growth and development. Examples include:

- Effective agricultural zoning
- Transfer of development rights
- Conservation easements on agricultural or forested land (purchased or donated)
- Overlay zones to protect wellhead protection areas, streamside buffers
- Green infrastructure planning
- Conservation subdivision or open space design
- Traditional neighborhood development
- Infill and redevelopment incentives
- Site-level development regulations that reduce impervious cover and infiltrate and/or treat stormwater runoff

All of these land use planning tools are most effective when applied within the framework of local watersheds. It is up to municipal governments to integrate watershed strategies in their comprehensive plans and development regulations in order to truly protect our most precious natural resource – water.

Water Supply and Wastewater Treatment

History of Water Supply and Wastewater Treatment in the Lower Susquehanna Region

In the Lower Susquehanna Region, water resources have historically played a critical role in the development of the commonwealth and the nation. As early European colonists moved into the region, the Susquehanna River and its tributaries were thought to provide excellent transportation routes into western lands. William Penn envisioned building a city equal to Philadelphia along the shores of the Susquehanna River, and yet others saw the region's water resources as an opportunity to become wealthy.

Initial attempts to navigate the Susquehanna River were often unsuccessful because of shallow waters, rocks and waterfalls. This led businessmen, politicians and citizens to the conclusion that canal systems were needed along the river. In 1797, the construction of the Conewago Canal just below York Haven allowed boats to bypass the Conewago Falls. Several decades later in 1826, the Pennsylvania Canal was started in Dauphin County. The canals in conjunction with early railroad systems enabled the transport of goods and materials from northern Pennsylvania to cities like Baltimore and Philadelphia. Early land development in the region occurred primarily in Lancaster and York counties, but progressed to the north and west with the canals and railroads.

As land in the Lower Susquehanna Region developed, water resources became less of a concern for Pennsylvania's citizens. In 1852, the Pennsylvania Railroad began, and along with it the decline of canal systems in the commonwealth. As new forms of transportation were developed, the Susquehanna River and its tributaries became more widely used for disposal of industrial and municipal waste and less used for transportation.

Wastewater disposal into streams and rivers occurred well into the 20th century. The city of Harrisburg discharged untreated wastewater into the Susquehanna River until 1959. Later in 1970, Penn Central's (Pennsylvania Railroad) railroad yard in Enola, across the Susquehanna River from Harrisburg, was rated the number one site for water pollution in the state.

Water quality all over the region suffered and became less suitable for aquatic life and human consumption. Pennsylvania's citizens and government, ignited by Rachel Carson's writings on the environment, began changing the way water resources were looked at statewide. While Rachel Carson's work helped bring environmental issues into the mainstream public's view, many of Pennsylvania's outdoorsmen were already beginning to demand government help to protect water quality in the state.

By the beginning of the 1970s, the Lower Susquehanna Region began building or improving wastewater treatment plants along the Susquehanna River and its tributaries. The region also worked to reduce the amount of industrial wastewater being discharge into its streams. By the 1980s water quality in the region had considerably improved.

The Susquehanna Region Today

The Lower Susquehanna Region is composed of the Lower Susquehanna, Lower Central Susquehanna, Upper Juniata and Lower Juniata subbasins. The region has a wealth of water resources in the form of groundwater, streams and manmade reservoirs, including those that flow by the state capital, Harrisburg. The region spans more than 9,000 square miles, with nearly 2.5 million people. As the region's population continues to grow, so does the need for smart development planning. Since development tends to follow the availability of public utilities, thoughtful planning of utilities can help conserve resources by guiding where develpment occurs.

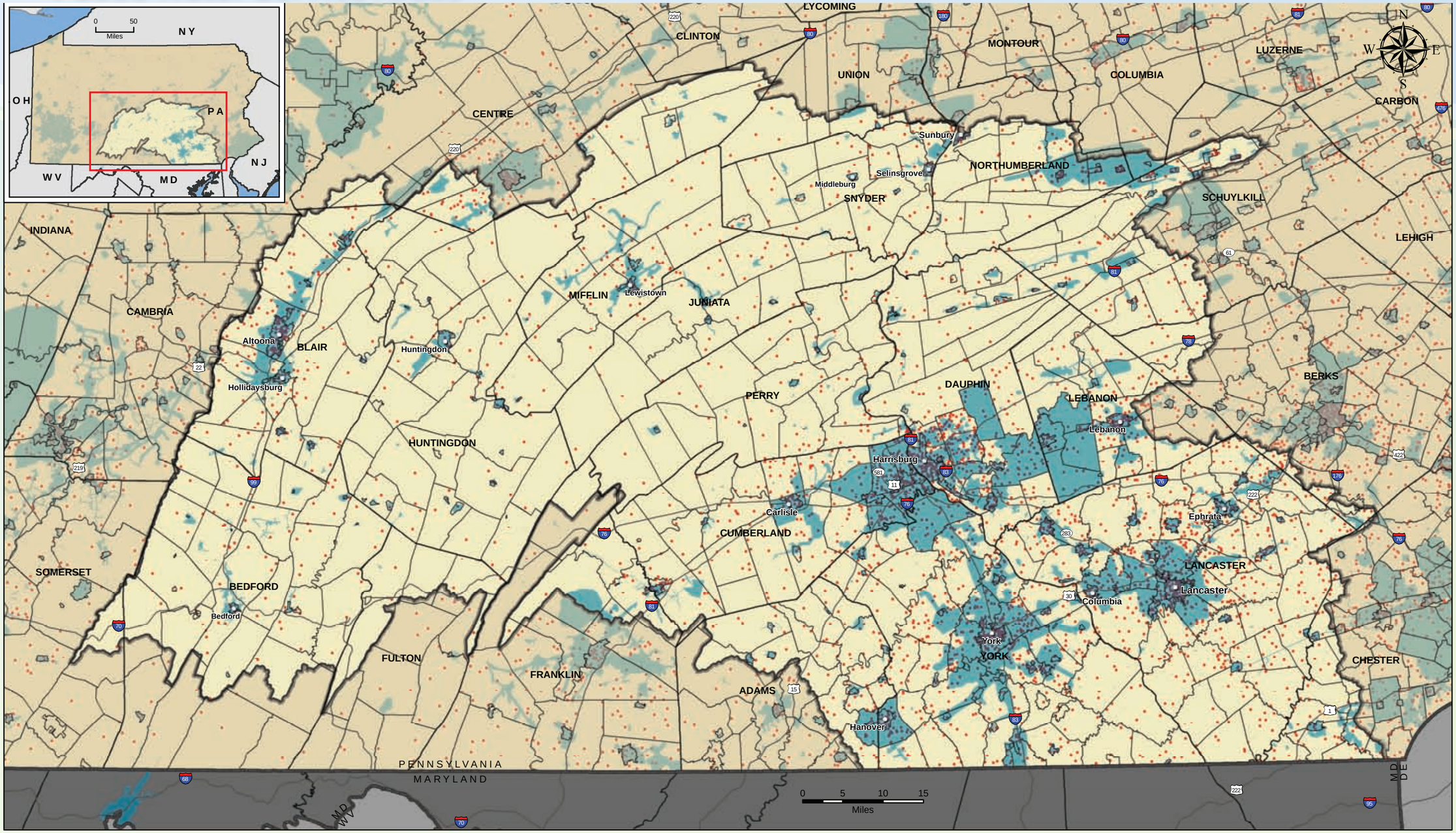
Did you know?

Seven Points Marina on Raystown Lake in Huntingdon County, is the largest marina in the commonwealth with 800 boats.

The Public Water Service Map on the following page depicts population density throughout the Lower Susquehanna Region in relation to areas served by public water suppliers. Each dot on the map represents 200 people living in the municipality (2000 Census). The dots are randomly placed within the municipality boundaries and do not represent the exact location of people living in a township, town or city. As the map shows, densely populated areas, represented by dots so close together that they form a solid color block, are generally served by public water supplies. In addition to Harrisburg and surrounding communities, Lancaster, York and Hollidaysburg are some of the boroughs that also have concentrated service areas. The sources of public water supplies are groundwater, lakes, reservoirs, rivers and streams. Sparsely populated areas, where the dots are farther apart, are not included in the public supply service areas and residents must find private sources of water, such as residential wells that tap into groundwater, to meet their water needs.

Gunter Valley Reservoir, Franklin County. Photo courtesy of DCNR.

Public Water Service Areas



City/Town

Major Roads

Public Water Service Area

Municipality Boundary

County Boundary

State Boundary

Population density for 2000 by municipality

1 Dot = 500 People

Water Supply and Wastewater Treatment, continued

Public Water Resources

Groundwater

Large groundwater withdrawals in the Lower Susquehanna Region occur primarily in the lower and western section of the watershed. In parts of Blair, Cumberland, Dauphin, Lancaster and York counties groundwater supplies can be stressed. Groundwater use for public water supplies can be found elsewhere throughout the Lower Susquehanna Region. For example, the borough of Lewistown in Mifflin County uses several groundwater wells for public water supply.

Lakes and Reservoirs

The Lower Susquehanna Region has lakes and reservoirs that provide drinking water, flood control and recreational use. Lakes throughout the watershed are maintained by state agencies like the Pennsylvania Department of Conservation and Natural Resources (DCNR) or the Pennsylvania Fish and Boat Commission (FBC), and federal agencies like the Army Corps. of Engineers. Lakes such as the 340-acre manmade Pinchot Lake located in York County or the 106-acre Speedwell Forge Lake in Lancaster County are maintained by DCNR and FBC, respectively. The U.S. Army Corps of Engineers maintains Raystown Lake in Huntingdon County. The Dehart Reservoir, created by the impoundment of Clark's Creek and other smaller tributaries, is the primary water supply source for the city of Harrisburg.

Rivers and Streams

The 9,215 square miles of the Lower Susquehanna Region contains many streams and rivers that are utilized for water supply and recreation. The city of Harrisburg in Dauphin County has a secondary water supply intake in the Susquehanna River. Other urban and suburban centers in the region like the borough of Carlisle utilize streams, such as the Conodoguinet Creek, for public water supply.

Drinking Water

Like all living organisms, humans need water to survive. Whether a person lives in a single family home in the country or a large metropolitan city, water supplies support daily life. Pulic drinking water may be supplied by a publicly-owned or privately-owned company while private drinking water is usually supplied by an on-site well. Water supplies require purification before human consumption. This purification is done to ensure that all harmful materials are extracted or minimized so not to adversely affect human beings.

Public Water Treatment

Water treatment for most urban and suburban centers involves a process of filtration, disinfection and distribution of purified water. The first process in filtration, coagulation, involves adding selected chemicals that stick to particles in the water and make them heavy. As the particles become heavy they drop to the bottom which is known as precipitation. Water is then filtered to remove the precipitate. During the filtering process, the water passes through layers of sand, gravel and charcoal that remove even smaller particles. Next, disinfection is accomplished by injecting chlorine or ozone into the filtered water.

Chlorine is the most common form of disinfection because it has a residual

Bedford Springs

In 1804, Dr. John Anderson began construction of the Bedford Springs Resort, just south of Bedford, Penna. With a rich history, the Bedford Springs was designated a National Historic Landmark in 1984, and was closed two years later for renovation.

The eight natural springs that flow through the resort had been coveted to have medicinal powers, and many wealthy aristocrats traveled to Bedford to cure illnesses and relax in luxury. Bedford Springs was renowned in the beginning of the 19th century as the fashionable place to recuperate.

Patients of Dr. Anderson and Dr. William Watson were prescribed to stay at the Springs and eat a strict diet, routinely exercise, along with drinking and wading in the spring waters. Of the eight springs, the Magnesia Spring was believed to help stomach ailments and the Iron Spring was believed to promote strong bones.

In the 1880s, the medical benefits of the spring water became in high demand. The Bedford Springs actually began bottling and barreling water from the springs to be shipped across the United States and Cuba.

The Springs were known to serve many American presidents, including Presidents Polk, Taylor, Harrison and Eisenhower. In fact, President James Buchanan loved the relaxing atmosphere of the Bedford Springs so much that it became the location of the Summer White House from 1857-1861.

The resort at the Springs also served as an internment camp for 180 Japanese diplomats and families who were detained in World War II. Also, Bedford Springs housed a United States Naval Radio School during the war, where more than 6,000 men were trained.

After intensive renovation, Bedford Springs reopened in the summer of 2007 with a 30,000 square foot Springs Eternal Spa with mineral springs treatments, along with an outdoor pool facility fed by the mineral springs. The state of the art resort continues to provide unrivaled luxury, just as it has for nearly 200 years.

The restoration efforts included a project to restore the Shober's Run stream and floodplain which runs through the historic golf course on the property. Shober's Run was impacted by streambank erosion. The restoration project included installation of native plants and the creation of wetland areas. In addition, the stream channel was restored to a more natural flow pattern and the floodplain was excavated to its historical elevation. The stream system was returned to full function and stability with improved wildlife habitat and aesthetics.

Bedford Springs Hotel. Photo courtesy of Lori Mohr.

effect, meaning it will remain in the water through the distribution system. Depending on where the source water to the aquifer comes from, groundwater resources may also require treatment for removal of organics and metals. The final aspect of water treatment is distribution, in which the treated water is sent through piping systems to homes, businesses and industries or to a storage facility for later use.

Did you know?

"And when I asked the name of the river from the brakeman, and heard that it was called the Susquehanna, the beauty of the name seemed to be part and parcel of the beauty of the land…That was the name, as no other could be, for that shining river and desirable valley."

–Robert Louis Stevenson

For example, the Harrisburg water treatment plant purifies and delivers an average of 12 million gallons per day to 60,000 residents in Harrisburg and its surrounding communities. The treatment plant is gravity fed by the Dehart Reservoir, where water is treated then pumped to Reservoir Park to a gravity distribution system.

Private Well Water Treatment

Homeowners with private wells have a variety of options for filtration and water softening systems that remove mineral particles from well water. The system selected usually depends on the amount of water a private residence uses per day as well as the most common types of contaminants necessary to filter from the water source. Fortunately for most private well users, little treatment is usually needed as a large portion of groundwater is unaffected by contaminants that typically affect surface water. Information on home water systems and contaminants can be obtained from the DEP, EPA, Center for Disease Control and the National Sanitation Foundation International.

For more information on private well water management and protection, visit Penn State's Master Well Owner Network located at http://mwon.cas.psu.edu/.

Susquehanna River vista, Lancaster County.

Source Water Protection

Pennsylvania, like all other states in the U.S., is required to ensure that healthy drinking water is available for its citizens through compliance with the Safe Drinking Water Act (For more information visit: http://www.epa.gov). Other federal and state laws, including the Water Resources Planning Act which prompted the creation of this atlas, lay the groundwork for water planning and protection. (Water laws and regulations are discussed in the Statewide Overview section of this atlas.)

Although federal and state level agencies are creating new policies, source water protection must literally begin at the source. Local governments–counties and municipalities–have the greatest opportunity to influence the future of Pennsylvania's water supply. By studying their water sources, identifying areas of concern or hazards that threaten those sources, developing water protection and conservation regulations, and implementing those regulations, local governments can protect water supplies for future generations. Many Pennsylvania counties in the Lower Susquehanna Region are rising to this challenge.

- Cumberland County has updated its comprehensive plan which aims to protect floodplains, wetlands and groundwater. Some major concerns identified in this county are that of contamination of groundwater in karst areas and stormwater impacts on county streams.

- Dauphin County is examining concerns of drought planning, groundwater quality and stormwater issues. The county has also worked to develop planned areas for growth to occur.

- Fulton County is located in a headwaters area and is working with almost all of its local municipalities to develop a comprehensive plan that emphasize water resources.

- Lancaster County has worked to update its strategies focusing on growth management in the county. Growth management is a critical issue that the county and municipalities are addressing to ensure that water supply and wastewater infrastructure remains consistent with growth areas. Since Lancaster County contains a high amount of agricultural and livestock farming, surface water quality is still a major concern along with groundwater contamination in karst areas.

- York County has emphasized watershed management through better land management practices. The county continues to work to address negative impacts from storm water, high nitrate levels in groundwater and aging infrastructure.

Importance of Forested Areas to Water Supplies

Forested areas are critical to the water supply. Wetlands, vegetated areas and forests along streams act as natural filters of soils and pollutants. Forests sequester carbon, helping to reduce the amount of carbon dioxide in the atmosphere. The forested areas that surround many streams and rivers also provide benefits to the waterways. Specifically, hemlocks are common residents

Water Supply and Wastewater Treatment, continued

of riparian areas that are beneficial by providing habitat and beneficial shade. Their dense canopies provide shade to streams which regulates stream temperatures providing an ideal ecosystem for many coldwater inhabitants, including brook trout. The loss of these hemlocks would be detrimental to many aquatic species as well as the species that live in and among the trees.

The Forested Areas Map on the following page shows the region's forested areas which are dominant in the northern half of the region. The Lower Susquehanna Region supports hardwood forests including pine-oak and oak-hickory forests, as well as coniferous (that is, trees that produce cones and have needles such as pine trees) forests, including Eastern hemlock. This area is mainly comprised of deciduous (that is, trees with leaves that fall when autumn arrives) forest type, with 46 percent deciduous, and five percent mixed and coniferous forest types. More information about the Lower Susquehanna Region's forests is provided in the Land Use pages of this Lower Susquehanna Region section of the atlas.

Wastewater Treatment

Long before mankind appeared on the earth, natural biological processes had already found a means to deal with waste in streams. Once human beings began to evolve, they created small communities, towns and cities. As these population centers grew larger so did the amount of wastewater being generated by mankind. Natural biological processes were easily overwhelmed by humankind's high outputs of wastewater.

It was not uncommon for older cities to fall victim to outbreaks of disease caused by pathogenic viral, bacterial or protozoan organisms from untreated wastewater contaminating drinking water supplies. This was exemplified in 19th century London, England's outbreaks of cholera that contaminated drinking water supplies and resulted in many deaths. It was because of harmful outbreaks like that in 19th century London that biologists, scientists and engineers developed methods for the treatment of wastewater.

Did you know?

One hundred forty-two major wastewater treatment facilities discharge treated human sewage into the Susquehanna River and its tributaries.

When water leaves a private residence or business through a drain or toilet it travels to a septic tank or wastewater treatment facility. Wastewater treatment facilities follow a series of processes that screen, aerate and disinfect water before discharging it back into a stream or river or back into the groundwater. The treatment process starts by screening any large debris from wastewater. The screened water is then aerated, which allows for natural biological processes to decay organic matter. Any solid material left in the tanks is then extracted and disposed of appropriately. The water is then disinfected, usually with chlorine, to kill any microorganisms that may be harmful to streams and rivers.

Public Wastewater Treatment

Pennsylvania has learned from history that discharging untreated sewage or industrial waste into the rivers and streams can have devastating results for its inhabitants and the natural environment. Just as high volume water purification facilities are needed to service urban centers and cities, so too are wastewater treatment facilities needed.

The state capital, Harrisburg, has a wastewater treatment facility that processes 37.7 million gallons of wastewater per day. The facility serves about 143,000 people in the city of Harrisburg and neighboring communities. The wastewater treatment plant utilizes methane gas from residual sludge to generate electricity which is then sold to a private utility company. Heat that is created from the electrical generating process is also used to heat the wastewater treatment plant's buildings. The Harrisburg Wastewater Treatment Facility has won the EPA's First Place Award for its wastewater pretreatment program, which is the top national award for water pollution control.

Private Wastewater Treatment

Private residences in some suburban and most rural areas of the Lower Susquehanna Region generally use private septic systems. Typical private septic systems allow for wastewater to flow to an underground tank. Once in the tank, heavy particles fall to the bottom while water can flow out of the top of a tank and into a drain field pipe. Once in the drain field pipe, the remaining wastewater is dispersed into a drain field where it slowly permeates down through the soil. Unfortunately, malfunctioning on-lot septic systems can be a significant source of groundwater pollution in these rural communities. DEP is continually searching innovative technology that aids in the most effective way to reduce pollution from private septic systems.

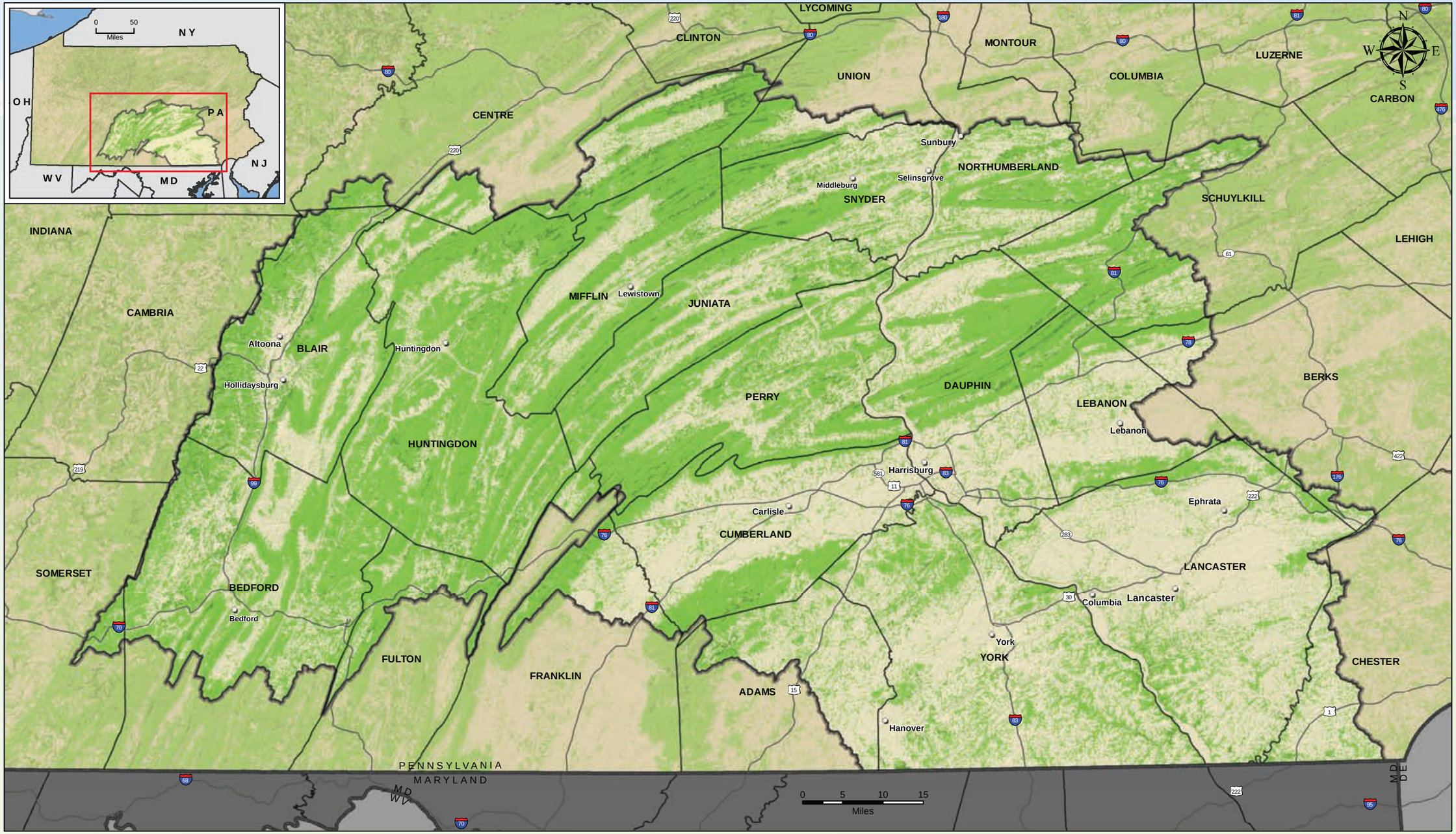
Lower Susquehanna Region Public Education Programs

Municipality and community based organizations have become more involved with increasing public awareness on Lower Susquehanna Watershed issues. More information can be found through the Pennsylvania Department of Environmental Protection or through the Water Resource Education Network.

- Various organizations in Lancaster County townships like Penn Township and Rapho Township in the Chiques Creek Watershed published a newsletter with the results of their stream monitoring programs.
- In Cumberland County, several partnering groups distributed educational brochures on drinking water source protection in the Yellow Breeches Creek and LeTort Spring Run areas.
- Swatara Township and West Hanover Township in Dauphin County educated municipal officials on stormwater management to help prevent nonpoint source pollution entering surface waters and streams.
- York County townships such as Carroll Township and Franklin Township created pamphlets on protecting groundwater quality for the community.
- Juniata County worked with several groups to create the Juniata Watershed Resource Center at Juniata College to serve several counties.
- The Shermans Creek Watershed in Perry County saw the development of a local newsletter with a fact sheet about the watershed to be distributed throughout the communities. Also, improvements were made to the water quality monitoring system which published the data in the local newsletter.

McCormick's Island on the Susquehanna River, Dauphin County.

Forested Areas



Water-Based Economy

Manufacturing, agriculture, electricity generation and recreation are major business sectors in the entire Susquehanna River Basin. All of these sectors rely on water — either directly or indirectly — to support their livelihood.

Manufacturing

The term "variety" describes the manufacturing industry in the Lower Susquehanna Region. The region is home to wood, food processing, apparel and specialty metal manufacturers. Producers of heavy equipment for agriculture as well as motorcycles and all-terrain vehicles are also found in the region. Thanks to abundant agricultural and livestock production in nearly every county, food manufacturing companies do not have to look far for a raw product. Canning and processing companies, meat packaging plants and bakeries are found throughout the Lower Susquehanna Region.

Agriculture

The Lower Susquehanna Region can arguably be considered the richest agricultural region in the state. Nearly every county in the region produces more than 100 million pounds of milk. Three counties, including Cumberland, Lebanon and Lancaster, produce between 250 and 2,050 million pounds of milk per year. This astonishing amount is produced by many small and large farms that are found in the region. The location of the region within the numerous fertile limestone valleys also contributes to the quality and quantity of agricultural production. Lancaster County alone is a top producing agricultural-based county in the commonwealth. According to the USDA Census of Agriculture, Lancaster County ranks at the top out of all counties in tobacco, vegetables, cattle and calves, milk and dairy products, hogs and pigs, broilers and meat chickens, egg-laying chickens, and corn for silage.

Hydroelectric Dams

The Susquehanna River has a collection of hydroelectric dams, which are a significant source of power to surrounding residents. Approximately 1.6 percent of Pennsylvania's electricity is produced from hydro facilities. The four dams, located on the Susquehanna River, are the Holtwood Dam, Safe Harbor Dam, York Haven Dam and Conowingo Dam. The York Haven Dam is the northernmost dam of the three, followed by the Safe Harbor Dam located in the middle, and the Holtwood Dam in the most southern region of the Lower Susquehanna. The Conowingo Dam is located in Maryland just outside the boundaries of Pennsylvania's Lower Susquehanna Region.

Hydroelectric dams are built to block part of a river, where currents put pressure against the dam. The moving water spins a turbine, which then spins the rotor of a generator. The generator then changes the kinetic, moving energy, to electricity. The dams supplement power for communities in Pennsylvania, Maryland, and New Jersey.

An issue studied by the USGS and various state and local agencies is the excess nutrients and sediments transported in the Susquehanna River to the Chesapeake Bay. Since the Susquehanna eventually flows into and contributes 50 percent of the freshwater of the Chesapeake Bay, many are concerned with the load of nutrients that are also brought in with the flow. To address these concerns, the Chesapeake Bay Agreement, which called for a 40 percent reduction in controllable nutrients, was formed. Steps were taken to reduce the amount of nitrogen and phosphorous flowing into the bay, which included the trapping of the nutrients in a reservoir system formed by the three dams on the Susquehanna River. While this strategy proved to be effective right away, it has been projected that the trapping of the sediments and nutrients behind the dams will only be effective for 15 more years at most. This has raised a need to institute additional control measures.

Holtwood Dam, Lancaster County.

Hydroelectricity Generation

The lower part of the Susquehanna River is a major producer of hydroelectricity. Three hydroelectric dams located in Pennsylvania—York Haven Hydro Station, Safe Harbor Hydroelectric Station and Holtwood Hydroelectric Plant—produces almost 550 megawatts of electricity for people within the watershed and beyond.

- The creation of the York Haven Hydro Station in 1904 created Frederic Lake along the Susquehanna River. The dam is 8,000 feet long and 26 feet high. It is maintained by York Haven Power Co. and owned by Metropolitan Edison Co. It generates an estimated 19 to 20 megawatts of electricity.
- The Safe Harbor Hydroelectric Station was opened in 1931. At 4,869 feet long and 75 feet high, the dam creates Lake Clarke along the Susquehanna River. The hydroelectric station is maintained by Safe Harbor Water Power Corp. and is co-owned by PPL Holtwood LLC and Constellation Power Source Generation Inc. The facility generates more than 417 megawatts of electricity.

Did you know?

"I started out thinking of America as highways and state lines. As I got to know it better, I began to think of it as rivers. Most of what I love about the country is a gift of the rivers… America is a great story, and there is a river on every page of it."

–Charles Kuralt, U.S. News Correspondent

Fishing in the Lower Susquehanna Region.

Aquaculture in the Lower Susquehanna Region

Aquaculture is one of Pennsylvania's oldest agricultural sectors. The practice of keeping fish was brought from Europe to Philadelphia during colonial times. Today, the industry is one of the fastest-growing agricultural niches in the United States. The increasing demand for low-calorie protein with Omega-3 fatty acids, which help reduce the risk of heart disease, has led to an increase in national per capita consumption of fish from 14.8 pounds in 2001 to 16.6 pounds today. Although the United States as a whole is at a disadvantage in the production of warm water species, the Lower Susquehanna Region is home to two fish farms that specialize in the production of temperate water and warm water fish.

Though tilapia is native to Israel, the New Tilapia Co. of Mahanoy Township in Schuylkill County has brought this tropical fish to the northeastern United States and Canada. Since 1998, the New Tilapia Co. has owned and operated a fish farm in Pennsylvania, bringing down former high supermarket prices of this light, exotic fish as well as making it widely available to consumers. New Tilapia sells to wholesalers and retail food stores that purchase live fish catering to communities in major metropolitan areas. A prolifically breeding fish, tilapia has been farmed for about 2,500 years. Indonesians once considered tilapia to be a national pest due to their extensive reproduction until locals began using them as a food source. To provide suitable conditions for the fish, New Tilapia regulates water temperatures between 76 and 84 degrees Fahrenheit to ensure survival in outdoor ponds and indoor systems. At only 105 calories per 3 ounce serving, tilapia appeals to health conscious consumers. It is a mild flavored fish and has moderate texture with a subtly sweet taste. When Susquehanna Aquaculture of York Haven, York County first started raising hybrid striped bass in 1989, the fish farm sold 56,000 pounds. Today, the fish farm is the only striped bass farm in the northeast, and is responsible for selling more than 385,000 pounds of the commodity to restaurant suppliers in New York City, Philadelphia and Toronto and for stocking lakes and ponds that attract recreational anglers. The hybrid striped bass is a cross between striped bass and white bass. Susquehanna Aquaculture is located near the Pennsylvania Power and Light's Brunner Island Power Plant and diverts the plant's discharge to the fish tanks to keep winter water at a constant 60 degrees Fahrenheit. In addition to hybrid striped bass, Susquehanna Aquaculture also raises trout, contributing to the commonwealth's $4 million trout industry, supported in large part by stocking programs for recreational fishing.

- The opening of the Holtwood Hydroelectric Plant in 1910 created Lake Aldred along the Susquehanna River. The dam is 2,392 feet long and 55 feet high and produces approximately 109 megawatts of electricity. The plant is owned and maintained by PPL Corp.

Recreational Areas

The Lower Susquehanna Region is dotted with outdoor recreational destinations that rely on water resources, such as golf courses, state forests and state parks. While each

Did you know?

The York Haven fish ladder was the fourth, and final, fish passage completed in the past decade at four Susquehanna River dams. When it went into operation in 2000, it was the first time in nearly a century that shad could freely return to most of the Susquehanna Basin, historically their largest spawning grounds on the east coast.

Water-Based Economy, continued

Fishing the Yellow Breeches Creek

Meandering from the South Mountains of Cumberland County to the Susquehanna River, the Yellow Breeches Creek has become one of the most popular fishing streams in the commonwealth, especially for fly fishing. The creek is fed by cold limestone springs and freestone tributaries which help moderate summer water temperatures. Fishing is open all year long as the Pennsylvania Fish and Boat Commission and the Yellow Breeches Anglers Club stock almost the entire length of the creek, and wild trout populations are sustained due to excellent spawning habitat within the stream banks. The entire reach of the creek is open to fishing, but a mile-long stretch between Boiling Springs Lake and Allenberry is restricted to catch and release.

With central Pennsylvania credited as the location where many fly-fishing techniques used worldwide were developed, it is no surprise that avid anglers travel to Yellow Breeches Creek to fish a waterway with a reputation for professional fly fishing. For first-timers or those looking to better their technique, opportunities are available to learn from experienced and professional fly fishermen. For instance, the Allenberry Resort Inn and Playhouse, located on Yellow Breeches Creek offers weekends of Fly Fishing School, taught by nationally recognized instructors. Students of the weekend school participate in activities that include: analyzing stream conditions; individual casting instruction; techniques and tactics with nymphs, wet flies, dry flies and streamers; and leader construction and knots.

of the numerous 18-hole golf courses in the region may be responsible for 200,000 gallons of water loss per day due to evapotransporation, recreational activities at state forests and parks do not require the consumptive use of water resources.

Fishing (including ice fishing), kayaking, canoeing, boating, skiing (water and snow), swimming and ice skating are just a few recreational activities that take advantage of the water resources found in the region's state parks. The following are examples of the numerous recreational destinations that attract anglers and boaters, as well as others seeking relaxation and fun:

For more information on these and other state parks, see DCNR's "Pennsylvania State Parks" Web site: http://www.dcnr.state.pa.us/stateparks/index.aspx

For more information on recreational areas managed by the Pennsylvania Fish and Boat Commission, see the Commission's "Boating Near You" Web site: http://www.fish.state.pa.us/boatinf.htm

For more information on Pennsylvania's Water Trails, see the Pennsylvania Fish and Boat Commission's "Water Trails" Web site: http://www.fish.state.pa.us/watertrails

- The 3,983 acres of Shawnee State Park (Bedford County) include the 451-acre Shawnee Lake. The lake is stocked with warm water fish such as small- and large-mouth bass, northern pike, walleye, muskellunge, pickerel, catfish, crappie, yellow perch, bluegill, sunfish, sucker, bullhead and carp. Anglers share the lake with motorboats, rowboats, canoes, paddleboats and swimmers. Winter activities include: snowmobiling, sledding, ice fishing and ice skating.
- Poe Valley State Park (Centre County) is 620 acres surrounded by the 198,000-acre Bald Eagle State Forest. The 25 acres of Poe Lake hosts swimmers, boaters and anglers fishing for brown and rainbow trout, catfish, pickerel, sunfish and perch. Winter activities include: snowmobiling, ice fishing, ice skating and cross-country skiing. Stream anglers can be found at nearby Penns Creek and Big Poe Creek.
- The 696 acres of Pine Grove Furnace State Park (Cumberland County) includes three fishing spots: the 25-acre Laurel Lake, 1.7-acre Fuller Lake, and Mountain Creek. Both Laurel Lake and Fuller Lake are stocked with pickerel, perch and trout while Mountain Creek is fished for brown, brook and rainbow trout. Both lakes support swimming and Laurel Lake is used for boating. Ice fishing and ice skating are permitted on Laurel Lake and cross-country skiing and snowmobiling are enjoyed on trails throughout the park.

Water Trails

Water trails are recreational corridors suitable for canoes, kayaks and small motorized watercraft. These trails are comprised of access points, boat launches, day use sites and in some cases overnight camping areas. Each water trail is designated by the Pennsylvania Fish and Boat Commission as a unique reflection of the state's diverse geology, ecology and communities.

The Lower Susquehanna Region includes eight water trails:

- The Middle Susquehanna River Water Trail – 51 miles between Sunbury to Harrisburg
- Lower Susquehanna River Water Trail – 52 miles from Harrisburg to Mason-Dixon Line
- Juniata River Water Trail – 80 miles from Canoe Creek State Park to Lewistown
- Conodoguinet Creek Water Trail – 40 miles from North Middletown Township to the mouth of the Susquehanna River
- Yellow Breeches Creek Water Trail – 3 sections totaling 13 miles from South Middletown Park to New Cumberland Borough Park
- Swatara Creek Water Trail – 60 miles from Jonestown to Middletown
- Conestoga River Water Trail – 60 miles from Caernarvon Township to the mouth of the Susquehanna River
- Raystown Branch Juniata River Water Trail – 60 miles from Bedford to Saxton

- One of the main attractions in the 3,329 acres of Codorus State Park (York County) is the 1,275-acre Marburg Lake. The lake is a warm water fishery, home to species such as yellow perch, bluegill, northern pike, crappie, largemouth bass, catfish and muskellunge. Motorboats, pontoon boats, canoes, rowboats, sailboats and paddleboats all use Marburg Lake. Winter sports enjoyed in the park run the gamut of ice fishing, ice skating, ice boating, sledding, cross-country skiing and snowmobiling.
- Speedwell Forge Lake (Lancaster County) is a 106-acre impoundment owned by the commonwealth of Pennsylvania and managed by the Pennsylvania Fish and Boat Commission. Speedwell Forge is popular with canoers and kayakers. The lake is fished for trout, bass and panfish.

Raystown Lake

Located in Huntingdon County, Raystown Lake is a premier site for recreational water activities in Pennsylvania. The lake is the largest within the state, with 118 miles of shoreline and 8,300 acres of water. The lake was created in 1973 when the Army Corps of Engineers built a dam on the Juniata River. Also managed by the Army Corps of Engineers, the beauty of the Raystown Lake is preserved by strict development restrictions.

The lake is available to the public for a variety of water sports and activities, including boating, canoeing and kayaking, scuba diving, jet skiing, swimming, water skiing and cliff jumping. Eight launch ramps are available for boaters who seek adventure. Raystown Lake has no size or horsepower restrictions, and shallow water is not an issue for boaters, as the average depth is 80 feet.

Camping and hiking areas around the lake add to its tourist appeal. Surrounding beaches are a favorite of those who like to get tan in the summer months. There are also waterparks, houseboat and cabin rentals and boat tours in the lake's surrounding area. A hidden Pennsylvania charm, Raystown Lake has something to interest anyone.

Raystown Lake, Huntington County