

Water Resources

A watershed ultimately connects the communities within it through their common dependence on water resources. Our flowing creeks and streams are perhaps the best barometer of how well we accept stewardship of the land on which we live. Watersheds are important in every community because they embody our sense of place in the landscape, and their waters are important in our daily life. Watersheds are the geographic addresses for our communities.

In addition to being an important source of recreation and wildlife habitat, the Brodhead watershed provides the drinking water supply for area residents and visitors. The boroughs of Stroudsburg and East Stroudsburg and surrounding areas are served by public water systems which draw on the Brodhead and Sambo Creeks and nearby wells. The water resources of the Brodhead watershed include the Brodhead Creek and its tributaries, and the connected but unseen water in aquifers below the surface of the land.

Subwatersheds

The Brodhead watershed drains an area of about 285 square miles, almost half of Monroe County, emptying into the Delaware River just north of where the Delaware River flows through the dramatic cut in Kittatinny Mountain known as the Delaware Water Gap. The Brodhead watershed can be divided into six major subwatersheds:

- Upper Brodhead Subwatershed;
- Lower Brodhead Subwatershed;
- Marshalls Creek Subwatershed;
- Paradise Creek Subwatershed;
- Pocono Creek Subwatershed; and
- McMichael Creek Subwatershed.

Upper Brodhead Subwatershed

The Upper Brodhead subwatershed includes the headwater tributaries, as well as eight miles of the main stem of the Brodhead Creek above its confluence with Paradise Creek. The Upper Brodhead subwatershed drains an area of 65.9 square miles, including parts of Coolbaugh, Barrett, Price, and Middle Smithfield townships. A small portion of the upper headwaters extends into Greene Township, Pike County. The Upper Brodhead Creek is paralleled by Route 447. Most of the headwater streams of the Brodhead Creek are found in Barrett and Price townships. These include Buck Hill Creek, Middle Branch, Leavitt Branch, Goose Pond Run, Spruce Cabin Run, Stony Run and Poplar Run.

The headwater tributaries of the Brodhead Creek sustain a 900-foot vertical drop, resulting in waterfalls found on Stony Run, Goose Pond Run, Spruce Cabin Run, two on Buck Hill Creek, Spruce Mountain Run, Rattlesnake Creek, and Leavitt Branch (Indian Ladder Falls). Alpine Mountain ski area is located along the Brodhead Creek, upstream of the confluence with Paradise Creek. Skytop Lodge is located on the highest elevation of the Brodhead watershed, on the Pocono escarpment.

The headwater streams of the Upper Brodhead were named for their location, appearance or function. Some, like Red Run, emerge from acidic bogs on the edge of the Pocono Plateau and are named for their colored acidic water. Others, like Clear Run, are spring fed and named for their crystal clear appearance. Flowing through the rock outcrops of Cresco Heights, Rattlesnake Creek was named for the reptiles found in these parts.

In the century past, the streams provided power for the tanneries, which brought prosperity to the region. Mill Creek, which flows through Mountainhome, was one of the more heavily used creeks. Later, visitors experienced the joys of fishing the small runs and brooks. Canadensis, the village where the streams converge to form the Brodhead, has often felt the power of all that water. Spring floods regularly affect the surrounding homes; most devastating was the flood of 1955 when bridges and dams up and down the creeks washed out and isolated many areas.

The large tracts of undeveloped land in state gamelands or owned by private individuals, hunting clubs and the older resorts of Skytop and Buck Hill serve as buffer areas protecting these streams.

Two sewage treatment plants discharge to the streams, one serving the community of Buck Hill Falls and one the Skytop Lodge and community. Of concern are areas with a high water table, where conventional septic systems are likely to malfunction. Fortunately, population growth in the headwaters areas has been relatively slow, so streams have not been significantly impacted.

Exceptional Value streams in the Upper Brodhead subwatershed include Buck Hill Creek, Rattlesnake Creek, Mill Creek, Spruce Cabin Run, Stony Run, Mud Run, Deep Hollow, and Poplar Run.

Named Streams:

Brodhead Creek

- Pine Mountain Run
- Poplar Run
- Stony Run
 - Mud Run
- Lucky Run
- Mill Creek
 - Rattlesnake Creek
 - Beaver Brook
 - Schafer Swamp Run
- Spruce Cabin Run
- Goose Pond Run

- Andy Sommer Run
- Horse Meadow Run
- Bon Hill Run
- Buck Hill Creek
 - Griscom Creek
 - Clear Run
 - Red Run
 - Gilpin Run
- Leavitt Branch
- Middle Branch
 - Dry Run
 - Laurel Run
 - Spruce Mountain Run

Municipalities:

- Barrett Township
- Price Township
- Coolbaugh Township
- Middle Smithfield Township
- Greene Township, Pike County

Named Lakes, Ponds, and Impoundments¹⁰:

- Mountain Lake (on Leavitt Branch)
- Lake Jamie (on Leavitt Branch)
- Lake in the Clouds (on Leavitt Branch)
- Skytop Upper Lake (on Leavitt Branch)
- Skytop Lower Lake (on Leavitt Branch)
- Leavitt Branch Dry Dam¹¹ (on Leavitt Branch)
- Goose Pond, *natural* (on Goose Pond Run)
- Ransberry Pond (on Goose Pond Run)
- Annunziata (on Goose Pond Run)
- Goose Pond Run Dry Dam¹² (on Goose Pond Run)
- Vanderwheel Dam (on Goose Pond Run)
- Canadensis Hotel Dam (on Goose Pond Run)
- Longacre Pond (on Middle Branch)
- Gravel Pond (on Laurel Run)
- Kresge Dam (on Rattlesnake/Mill Creek)
- Mill Creek Dam (on Rattlesnake/Mill Creek)
- Onawa Lake (on Rattlesnake/Mill Creek)
- Geissinger Dam (on Rattlesnake/Mill Creek)
- Pace Pond (on Griscom Creek)
- Spruce Cabin Pond, *natural* (on Spruce Cabin Run)
- Reinhart Lake (on Spruce Cabin Run)
- Sommers Dam (on Spruce Cabin Run)
- Browns Lake (on Stony Run)
- Dormoy Lake (on Stony Run)
- Snow Hill Dam (on Stony Run)
- Hiawatha Lake (on Pine Mountain Run)
- Manzanedo Lake (on Pine Mountain Run)

¹⁰ All lakes and ponds are manmade impoundments, with dam, unless otherwise noted.

¹¹ Two dry dams were built for flood control following the 1955 flood.

¹² Ibid.

Lower Brodhead Subwatershed

The Lower Brodhead subwatershed includes the Brodhead Creek and its tributaries below the Brodhead's confluence with Paradise Creek, at Routes 191 and 447. The Lower Brodhead flows for 6.5 miles through Price and Stroud Townships, then forms the boundary between Stroudsburg and East Stroudsburg Boroughs for another 5.5 miles before joining the Delaware River, draining a total of 28.2 square miles. After the flood of 1955, the Brodhead was channelized from below Analomink thru the boroughs of Stroudsburg and East Stroudsburg and levees were built through the boroughs. Intense commercial and residential development occurs along and near the stream in the mid and southerly sections of the subwatershed. Major tributaries include Sambo Creek, Cranberry Run, and Michael Creek.

The Lower Brodhead and the Sambo Creek are important sources of drinking water for the boroughs of Stroudsburg and East Stroudsburg. The reservoir for East Stroudsburg's drinking water supply is found on the Sambo Creek. The Stroudsburg Municipal Authority draws fifty percent of its water from the Brodhead Creek and has permits to withdraw 5.38 million gallons per day (mg/d) from the Brodhead Creek and nearby wells. In 1999, the average daily use was approximately 1.9 mg/d or about 35 percent of its total permitted capacity. Of the permitted 5.38 mg/d, approximately 2.5 mg/d is withdrawn directly from the Brodhead Creek and approximately 2.88 mg/d is drawn from the nearby wells. On an annual basis, approximately 8-12 million gallons are exported from the watershed to be used for bottled water.

The East Stroudsburg borough, Rock Tenn, Inc, and Manwalamink (Shawnee) sewage treatment plants discharge to the Brodhead. Blue Mountain Lake Development and Smithfield township sewage treatment plants discharge in the Sambo subwatershed. Penn Estates Development discharges to Cranberry Run, which enters the Brodhead near Pinebrook Camp, and Bible Fellowship Camp sewage treatment plant discharges to the Brodhead in this section.

Named Streams:

Brodhead Creek

- Sambo Creek
 - Little Sambo Creek
- Cranberry Run
- Michael Creek
- Marshalls Creek

Municipalities:

- East Stroudsburg Borough
- Stroudsburg Borough
- Stroud Township
- Smithfield Township
- Middle Smithfield Township

Named Lakes, Ponds, and Impoundments:

- Hallwood Lake (on Long Run)

- Woodland Lake (on Michael Creek)
- Analomink Lake (on trib to Brodhead Creek)
- Pocohontas Dam (on trib to Brodhead Creek)
- Blue Mountain Lake (on trib to Brodhead Creek)
- Pinebrook Lake (on trib to Brodhead Creek)
- Spring Lake (on trib to Brodhead Creek)
- Gregory Pond (on Zacharias Run)
- East Stroudsburg Upper Reservoir (on Sambo Creek)
- East Stroudsburg Middle Reservoir (on Sambo Creek)
- East Stroudsburg Lower Reservoir (on Sambo Creek)
- Eagle Lake (on unnamed trib to Sambo Creek)
- Mountain Vista Campgrounds Lake (on unnamed trib to Sambo Creek)
- Lake Valhalla (on Little Sambo Creek)
- Zacharius Pond (in East Stroudsburg)

Marshalls Creek Subwatershed

Marshalls Creek flows for 10.5 miles through Middle Smithfield and Smithfield Townships before joining the Lower Brodhead Creek, just above where the Brodhead meets the Delaware. Only two major tributaries flow into the Marshalls Creek: Bear Swamp Run and Pond Creek, both second-order streams. The headwaters of Marshalls Creek flows in an easterly direction from the edge of the Pocono escarpment, like other headwaters tributaries of the Brodhead watershed. Pond Creek flows from two spring fed lakes, Echo Lake and Coolbaugh Lake, which give the stream its name. Pond Creek parallels Route 209 from the stream's beginning to the village of Marshalls Creek, where it joins the stream of that name. Marshalls Creek then parallel's Route 209, a major commercial artery and thoroughfare. The Marshalls Creek subwatershed drains an area of 26.8 square miles.

Marshalls Creek and its tributaries are distinguished by harboring rare fishes. Two species of shiner that have been found in Marshalls Creek have a proposed endangered status.¹³ The bridle shiner (*Notropis bifrenatus*) has a current status as a candidate species. The ironcolor shiner (*Notropis chaleybaeus*) was thought to be extirpated.

Collectively, endangered, threatened, and candidate species (ETC species) are vulnerable species and account for approximately 30 percent of Pennsylvania's native fish diversity. These fishes represent an important component of Pennsylvania's fish diversity and as such, deserve protection afforded under Section 2305 of the Fish and Boat Commission's code. Geographic representations of ETC species' distributions may provide a foundation for developing preventative (proactive) management strategies and aid conservation biologists to curb biodiversity loss. Existing populations need to be monitored. The ironcolor shiner population is one of only two known in Pennsylvania. The bridle shiner is sympatric with the ironcolor shiner in Marshalls Creek and appears in good numbers.

¹³ *Application of Geographical Information System Technology to Fish Conservation in Pennsylvania, Phase I*, June 1998, revised October 1998

Named Streams:

Marshalls Creek

- Pond Run
- Bear Swamp Run

Municipalities:

- Smithfield Township
- Middle Smithfield Township

Named Lakes, Ponds, and Impoundments:

- Lake Monroe (on Bear Swamp Run)
- Belon Lodge Dam (on Marshalls Creek)
- Meadow Lake (on Clark Run)
- Longshore Dam (on Clark Run)
- Pocono Highlands Lake (on Clark Run)
- White Heron Lake (on Newton Creek)
- Echo Lake, *natural* (on Pond Creek)
- Coolbaugh Lake, *natural* (on Pond Creek)
- Davidson Dam (on Pond Creek)
- Williams Pond (on Pond Creek)
- Rakes Dam (on Pond Creek)
- Pardee Place Dam (on Pond Creek)
- Marshall Lake (on Pond Creek)
- Deer Lake (on Pond Creek)

Paradise Creek Subwatershed

Paradise Creek drains the Pocono Plateau in its headwaters in Mount Pocono Borough, and Barrett, Coolbaugh and Tobyhanna Townships, flowing for nine miles in a southeasterly direction through Paradise Township before joining the Brodhead Creek. The Paradise Creek subwatershed drains a surface area of approximately 44.5 square miles. The Paradise Creek is paralleled for much of its length by PA Route 191. This highway is largely undeveloped, primarily due to the land being owned by fishing clubs. Major tributaries include Devils Hole Creek, Cranberry Creek, Butz Run, Swiftwater Creek and Forest Hills Run.

Seven sewage treatment plants discharge into the Paradise watershed: Paradise Stream Resort and Monsignor McHugh High School discharge to the Paradise, Mt. Pocono Municipal Authority and Mt. Airy Resort discharge to Forest Hills Run and Pocono Manor Inn, Pocono Mountain School District, Swiftwater Campus, and Aventis-Pasteur, Inc. discharge into the Swiftwater.

Paradise Creek boasts a healthy population of native and stocked trout. The good water quality can be attributed primarily to the high gradient of the streams in the watershed. The streams in the Paradise Creek subwatershed drop 800 feet in 8 miles. As the water bubbles over rocks and down slopes, it absorbs oxygen from the air and moves nutrients through rapidly so they are not absorbed. In addition, the high water table contributes

groundwater flows into streams. Devils Hole Creek, a headwaters tributary of the Paradise, is designated Exceptional Value.

The Paradise, along with the Brodhead, is credited as the birthplace of American trout fishing tradition. Paradise Valley is home to the first licensed trout hatchery in Pennsylvania. (Paradise Brook Trout Hatchery.) Teddy Roosevelt, Annie Oakley, and Calvin Coolidge fished the Paradise.

Named Streams:

Paradise Creek

- Butz Run
- Cranberry Creek
- Forest Hills Run
 - Swiftwater Creek
 - Indian Run
- Devil's Hole Creek
 - Tank Creek
 - Yankee Run

Municipalities:

- Paradise Township
- Mt. Pocono Borough
- Pocono Township
- Coolbaugh Township
- Barrett Township
- Tobyhanna Township

Named Lakes, Ponds, and Impoundments:

- Crawford Lake (on Paradise Creek)
- Pocono Gardens Pond (on Paradise Creek)
- Greevy Dam (on Paradise Creek)
- Paul Dam (2) (on Paradise Creek)
- Sabatino Dam (on Devils Hole Creek)
- Harriton Dam, Paradise Stream Pond (on Devils Hole Creek)
- Mt. Airy Lake (on Forest Hills Run)
- Fairview Lake (on Forest Hills Run)
- Swiftwater Lake (on Swiftwater Creek)
- Lake Minausin (on Swiftwater Creek)
- Pocono Manor Dam (on Swiftwater Creek)
- Whitestone Dam (on Swiftwater Creek)
- Wetbrook Dam/Weiler Pond (on Cranberry Creek)
- Daigle Dam (on Cranberry Creek)
- Alpine Lake (on Butz Run)
- Freeland Pond (on Butz Run)
- Lake Tanelo (on Butz Run)
- Meisertown Dam (on Butz Run)
- Tanners Henry Lake (on Butz Run)

Pocono Creek Subwatershed

The Pocono Creek drains the Pocono Plateau in its headwaters in Tobyhanna and Tunkhannock Townships and flows for 16 miles in a southeastern direction through Pocono, Jackson, Hamilton and Stroud Townships where it converges with the McMichael Creek in Stroudsburg. The Pocono watershed drains a surface area of approximately 48 square miles and contains 14 sub-basins within its boundaries. The Pocono Creek is paralleled by Interstate-80 and the county's primary commercial artery, Route 611, which was built in the floodplain. Intense commercial development occurs along and near the stream in the mid and southerly sections of the watershed.

The Pocono Plateau escarpment forms the watershed's most prominent topographic feature, Big Pocono Mountain, which forms the western watershed boundary. The watershed includes the Tannersville Cranberry (peat) Bog, which is believed to have formed during a glacial retreat. The Cranberry Bog is the southernmost alpine boreal bog in the United States and is found in the east-central portion of the watershed. A large portion of the bog is protected through ownership and management by the Nature Conservancy. The Bog forms the eastern edge of the watershed.

The major tributaries running south into the Pocono Creek are Dry Sawmill Run, Sand Spring Run, Wolf Swamp Run in the north and Scot Run, Transue Run, Bisbing Run, Bulger's Run, and Cranberry Creek in the mid-section. Those running north into the Pocono Creek's mid-section are Colmoor Creek and Reeder's Run. Wigwam Run, Flagler Run, Big Meadow and Little Pocono are within the lower third of the watershed. Sand Spring Run and Wolf Swamp Run are designated Exceptional Value.

A number of sewage treatment plants discharge into the Pocono and its tributaries, including: Caesars Brookdale, discharges to Brookdale Lake; Crossings Outlet Mall, Camelback Ski Resort, Big Pocono Utilities, and Pocono Auto-Truck Stop discharge to the Pocono; PennDot rest-stop on Rte 80, Fountain Court and Fountain Court West discharge to tributaries; Barton Court Trailer Park and Monroe County Vo-Tech School discharge to Laurel Lake Run; Birchwood Resort discharges to the Cranberry Bog.

Evidence indicates that the Pocono Creek watershed is a high-quality resource on the edge of decline, and that same evidence may reveal the thresholds at which impairment occurs. Many negative impacts have been observed in localized areas. The natural resilience of the watershed is currently taxed by development, transportation, and maintenance practices. Storm water runoff from parking lots and roads causes habitat damage and numerous localized stream modifications such as roads, bridges, culverts, channelized areas, floodplain development, and riparian vegetation removal degrade the watershed's streams as well.¹⁴

¹⁴ *Pocono Creek Pilot Study, Phase I*, Monroe County Conservation District, 2001

Big Pocono Mountain (Camelback) forms the watershed divide between the McMichael and the Pocono watersheds. Camelback ski area, on the north face of the mountain, drains to the Pocono Creek.

Named Streams:

Pocono Creek

- Little Pocono Creek
- Big Meadow Run
- Flagler Run
- Wigwam Run
- Rocky Run
- Reeders Run
- Coolmoor Creek
- Cranberry Creek
- Bulgers Run
- Scot Run
 - Transue Run
- Wolf Swamp Run
 - Sand Spring Run
 - Dry Sawmill Run

Municipalities:

- Pocono Township
- Jackson Township
- Stroud Township
- Stroudsburg Borough
- Tobyhanna Township
- Tunkhannock Township

Named Lakes, Ponds, and Impoundments:

- Wolf Swamp Run Dam (on Wolf Swamp Run)
- Pine Tree Lake (on Dry Sawmill Run)
- Emerald Lakes/Youngs Pond (on Dry Sawmill Run)
- Crescent Lake (on Dry Sawmill Run)
- Mountaintop Lake (on Dry Sawmill Run)
- Wilson Dam (on Dry Sawmill Run)
- Deer Pond (on Dry Sawmill Run)
- Little Deer Pond (on Dry Sawmill Run)
- Deep Lake (on Sand Spring Run)
- Lindemere Dam (on Pocono Creek)
- Barneys Pond (on Pocono Creek)
- Camelback Reservoir (on Pocono Creek)
- Shaeff & Peters Dam (on Pocono Creek)
- Brookdale Lake (on Scot Run)
- Leisure Lake (on Scot Run)
- Massad Camp Dam (on Scot Run)
- Noah's Ark Dam (on Scot Run)
- Hemlock Lake (on Cranberry Creek)
- Hunter Lake (on Rocky Run)
- Lenape Lake (on Rocky Run)
- Wigwam Lake (on Wigwam Run)

- Flagler Dam (on Flagler Run)
- Lower Dam (on Flagler Run)
- Laurel Lake (on Laurel Run)
- Twin Hills Dam (on Little Pocono Creek)

McMichael Creek Subwatershed

The McMichael Creek forms at the confluence of three headwater tributaries: Hypsy, Bowers, and Fall Creeks, which arise from wetlands and springs on the Pocono Plateau in Tunkhannock and Jackson Townships. The headwaters area of these creeks is relatively steep terrain forested primarily with second-growth hardwoods and a streamside canopy of rhododendron.

The McMichael Creek flows in a southerly, then northeasterly direction before converging with the Brodhead Creek in Stroudsburg. The McMichael Creek flows approximately 19 miles with a vertical drop of 1700 feet and drains an area of 69.5 square miles. Headwaters streams begin at elevations ranging from 2100 feet at the top of Big Pocono Mountain to 1800 feet at Hypsy gap; the McMichael Creek enters the Brodhead at an elevation of about 400 feet. The main channel separates at two locations: one mile below the town of McMichaels and again one mile above Brodheadsville, forming two distinct “splits” which rejoin downstream.

A significant portion of the McMichael Creek subwatershed is designated Exceptional Value, including Fall Creek, Bowers Creek, Hypsy Creek, and the upper part of the McMichael Creek.

The Stroudsburg Borough sewage treatment plant discharges to the McMichael Creek, near its confluence with the Brodhead. Plants at Snydersville Diner, King Arthur Restaurant and Monroe County Jail/Pleasant Valley Manor discharge to the McMichael or tributaries in the Snydersville area.

Lake Creek flows from Saylor's Lake, joining the McMichael near Sciota. Formerly known as Lake Poponoming, Saylor's Lake is the most southern moraine lake in the State. “It lies absolutely on the top of the moraine, and its surroundings are especially interesting from the fact that large boulders have been found on its shores which originally came from a point not nearer than the Adirondack region, 250 miles away, and which must have been transported by the slow moving ice masses of the ice age.” (Report of the State Commissioner of Fisheries, 1896, p. 234) The lake is fed by strong bubbling springs in the bottom of the lake.

The Northern Bullrush, a globally rare plant, is found at Lake Mineola in the McMichael watershed.

The Kettles, located on an unnamed tributary to Kettle Creek, are deep, circular depressions in bedrock created by the melting of large blocks of stagnant ice left behind by the glaciers.

Big Pocono Mountain (Camelback) forms the northeastern boundary of the McMichael watershed.

Named Streams:

McMichael Creek

- Appenzell Creek
 - Kettle Creek
 - Sand Spring Run
- Lake Creek
 - Spring Run
- Fall Creek
- Hypsy Creek
- Bowers Creek
- Pocono Creek

Municipalities:

- Jackson Township
- Hamilton Township
- Chestnuthill Township
- Stroud Township
- Stroudsburg Borough
- Ross Township
- Tunkhannock Township

Named Lakes, Ponds, and Impoundments:

- Lake Akiba (on Sand Spring Creek)
- Mountain Springs Lake (on Appenzell Creek)
- Trout Lake (on Appenzell Creek)
- Grubers Lake (on Appenzell Creek)
- Sheridan Dam (on Kettle Creek)
- Saylor's Lake, *natural* (on Lake Creek)
- Lake Watawah (on Lake Creek)
- Lenape Lake (on Spring Run)
- Lake Mineola, *natural* (on trib to McMichael)

Watershed Management Units

At the heart of watershed planning and management is the concept of watershed management units. This watershed conservation plan is meant to set up additional planning efforts at a more manageable scale, to keep the focus of the plan clear. Overall the plan represents a long-term process and continuous management commitment. There are many different watershed management units, including river basins, watersheds, subwatersheds, and catchments. A watershed can be defined as the land area that contributes runoff to a particular point along a waterway. In our case, the Brodhead watershed is all the land that drains to the point where the Brodhead meets the Delaware River. A typical watershed can cover tens to hundreds of square miles, and extend over several political boundaries or jurisdictions. The largest management unit is the basin. The Brodhead Creek flows to the Delaware River basin.

Watersheds are broken down into smaller geographic units called subwatersheds. Subwatersheds typically have a drainage area of 2 to 15 square miles, or larger, and include the land area draining to the confluence of two second-order streams or to the limits of a third order stream. This plan has identified six major subwatersheds from between 40 to 70 square miles each that form the Brodhead watershed based on the Brodhead Creek's major tributaries: Pocono Creek, Paradise Creek, McMichael Creek, Marshalls Creek, Upper Brodhead Creek, and Lower Brodhead Creek.

Management at the subwatershed level refers to assessment-level studies and specific projects within the smaller subwatershed units, while management at the watershed level refers to broader management issues across an entire watershed. The management units of watershed and subwatershed are most practical for local plans such as this one. Every watershed is composed of many individual subwatersheds, each having its own unique water resource objectives.

The recommendations of this plan focus on the broader issues across the entire watershed. However, the plan recognizes the importance of focusing on the subwatershed unit for several reasons:

- The influence of impervious cover on water quality, hydrology, and biodiversity is most evident at the subwatershed level, where the influences of individual development projects are easily recognizable.
- Because subwatershed management areas are limited to a smaller area, fewer pollutant sources are present to confuse management decisions.
- Subwatersheds are small enough to be within just a few political jurisdictions where it is easier to establish a clear regulatory authority and incorporate the smaller number of stakeholders into the management process.
- A subwatershed plan can generally be completed within two to three years and still allow ample time for goal development, agency coordination, and stakeholder involvement.

Stream Order

Stream order is a measure of where in a watershed a stream is and how many tributaries it has. First-order streams have no tributaries. Second-order streams have only first-order streams as tributaries. Third-order streams have only first- and second-order streams as tributaries, and so on.

The Brodhead Creek is a sixth-order stream below its confluence with the McMichael Creek, and a fifth-order stream below its confluence with Paradise Creek. The McMichael Creek is also a fifth-order stream, below its confluence with Appenzell Creek. Third-order streams in the watershed include the Upper Brodhead Creek, the lower portions of Paradise and Pocono Creeks, and the middle section of the McMichael Creek. Marshalls Creek is a third-order stream for most of its length.

Headwater streams are defined as first- and second-order streams. Headwater streams, although the smallest streams, are crucial in watershed management because they dominate the landscape through their sheer number and cumulative length. Although typically short in length, headwater streams actually comprise about 75% of the total stream mileage in the United States.

What happens in the local landscape is directly translated to headwater streams. As urbanization increases, streams handle increasing amounts of runoff, which degrades headwater streams and eventually, major tributaries.

Focusing on the headwater stream level in watershed management is important for several reasons:

- Headwater streams are exceptionally vulnerable to watershed changes;
- Headwater streams are often on the same scale as development projects;
- The public intuitively understands streams and strongly supports their protection;
- Headwater streams are good indicators of watershed quality.

Headwater streams have fewer upstream uses to cause problems and can be a reservoir of biodiversity, if protected. In addition, lower-order streams are narrower and therefore are more likely to have overarching trees, lower temperatures, and better food sources for aquatic invertebrates.

Headwaters areas in the Brodhead watershed are delineated by the presence of first- and second-order streams on the map *Stream Order*.

Stream Designations

Water quality throughout the Brodhead watershed is generally high. Much of the watershed is classified as a high quality cold water fishery (HQ-CWF) under Pennsylvania's water quality criteria (PA Code Title 25, Chapter 93.) Several sub-basins are classified as Exceptional Value streams. The lower part of the watershed also contains some sub-basins designated as Trout Stocking Fisheries, Cold Water Fisheries, and Migratory Fisheries.

In recognition of the pristine water quality in the headwaters streams of the Brodhead and its major tributaries, several of the streams in Barrett, Price, Coolbaugh, Tunkhannock, Jackson, and Chestnuthill Townships are classified as Exceptional Value. This regulatory definition determines the level of protection provided for the stream when discharge permits are issued by the PA Department of Environmental Protection.

Exceptional Value streams in the Brodhead watershed include:

- Buck Hill Creek
- Rattlesnake Creek
- Mill Creek (headwaters)
- Spruce Cabin Run
- Stony Run
- Poplar Run
- Devils Hole Creek
- Upper McMichael Creek to its headwaters
- Sand Spring Run
- Hypsy Creek
- Bowers Creek
- Fall Creek
- Wolf Swamp Run

Most of the rest of the watershed, including the Brodhead main stem downstream to Stokes Mill Avenue, is designated High Quality Cold Water Fishery, which means the streams are provided less protection in permit reviews but must be maintained at a water quality level sufficient to protect cold water fishes. Sambo Creek is designated a Cold Water Fishery / Migratory Fishery. The Lower Brodhead (from the bridge at Stokes Mill Road to the mouth at the Delaware) and a short section of the lower McMichael Creek are designated Trout Stocking Fisheries.

HQ and EV status signifies that these streams are suitable for Pennsylvania's anti-degradation water quality protection strategies for waters that exceed state standards, and that possess exceptionally high water resource values. The Pennsylvania Fish and Boat Commission (PFBC) classifies the several streams as Class A wild trout streams, finding significant populations of wild brook trout and wild brown trout.

State regulations in Chapter 93 define stream classifications and designated uses and describe how designated uses are used to determine what impact can be allowed from various permitted activities.

- Permitted discharges to Exceptional Value streams cannot change existing water quality.
- Permitted discharges to High Quality streams must maintain existing water quality except when social or economic justification for lowering water quality can be demonstrated.
- Permitted discharges to all other streams must protect existing uses (designations).

Stream Classifications and Designated Uses¹⁵

EV = Exceptional Value Waters. Special Protection. A surface water which is of exceptional ecological significance, such as thermal springs or wetlands which are exceptional value wetlands under Chapter 105,17(1); or a surface water that has excellent water quality, meeting the tests for High Quality Waters, and also meets other requirements such as: is located in a National wildlife refuge or a State game propagation and protection area; or is located in a designated State park natural area or State forest natural area, National natural landmark, Federal or State wild river, Federal wilderness area or National recreational area; or is an outstanding National, State, regional or local resource water; or is a surface water of exceptional recreational significance; or meets a biological test set forth in DEP regulations at Chapter 93.4b(a)(2) or is designated by the Fish Commission as a "Wilderness Trout Stream."

HQ = High Quality Waters. Special Protection. A surface water having quality which exceeds levels necessary to support designated uses as shown by meeting chemical or biological standards set forth in DEP regulations at Chapter 93.4b (a).

CWF = Cold Water Fishery. Maintenance and/or propagation of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.

TSF = Trout Stocking Fishery. Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.

MF = Migratory Fishery. Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which ascend to flowing waters to complete their life cycle.

Class A Wild Trout Water. A surface water classified by the Fish and Boat Commission based on species specific biomass standards, which supports a population of naturally produced trout of sufficient size and abundance to support a long term and rewarding sport fishery.

¹⁵ Chapter 93, Title 25, Pennsylvania Code of Regulations.

Wetlands

Wetlands are the transitional areas between clearly defined aquatic environments and clearly defined terrestrial environments. These areas are inundated by water at or near the surface of the land or are covered by shallow water. Wetlands can be scientifically delineated by the presence of hydric soils, hydrophytic plants, and water.

Wetlands serve many valuable functions. They provide quality wildlife habitat, filter runoff before it enters streams, and provide natural catchment basins for stormwater runoff. The natural filtration processes of wetlands have inspired communities and conservation districts to design and construct wetlands for the purposes of stormwater and sewage treatment.

Wetlands have important value in reducing water turbidity and improving water quality. They provide recreational opportunities for fishermen, hikers, hunters, and wildlife watchers. Wetlands also provide extremely important wildlife habitat. They provide water, food, and shelter for a multitude of creatures, ranging from the smallest amoeba to fish, reptiles, amphibians, furbearers, and waterfowl.

The biggest threat to wetlands today is development. Statewide statistics show that between 1956 and 1979 there was a 6 percent loss of wetlands. Forty-six percent of the loss was due to pond and lake construction, 37 percent to development, and 17 percent to agriculture. More recently, the Monroe County Conservation District has issued 142 permits for minor road crossings in wetlands in the last 10 years.

According to the U.S. Fish and Wildlife study, *Wetlands Trends for Selected Areas of the Northeast Glaciated Region of Pennsylvania (1981-82 to 1987-88)*, “the overall trend for the study area’s¹⁶ wetlands was losses of vegetated wetlands and gains in non-vegetated wetlands (mostly ponds)... As development increases, the quality of wetlands can be expected to deteriorate due to increased sedimentation, groundwater withdrawals, increased water pollution, agricultural runoff, and other factors, unless adequate safeguards are taken to protect not only the existence of wetlands, but their quality.”

Woody wetlands cover about 2.55 percent of the watershed, or 1,889 hectares. Emergent herbaceous wetlands cover about 0.06 percent of the watershed, or 42 hectares.

The *Tannersville Cranberry Bog* is an outstanding feature of the watershed and is designated a National Natural Landmark. Located east of PA Route 611 near Tannersville, the Cranberry Bog is the best-developed, southernmost low altitude boreal bog along the eastern seaboard. The Cranberry Bog is owned by The Nature Conservancy.

Various programs, such as the Conservation Reserve Program run by the U.S. Department of Agriculture or Ducks Unlimited’s PA Habitat Stewardship Program, offer

¹⁶ Study area of Towanda, Montrose, and Tunkhannock.

incentives to farmers and others to protect existing wetlands. Additionally, funds are available to farmers to fence off wet areas, allowing the area to revert to its natural state. Along with incentives, present regulations require anyone filling a wetland to mitigate the action by restoring or constructing replacement wetlands.

Floodplains

Early settlers in the Brodhead watershed established communities along the rivers, as these were the most opportune locations for transportation, trade, and natural resources. Unfortunately, many of these towns were established in floodplains, leaving some residences and businesses prone to frequent flooding. Flooding in the watershed typically occurs in the early spring as melting snow and rainstorms combine to raise river levels. Levees have been constructed by the Army Corps of Engineers along the Brodhead Creek where it forms the border between Stroudsburg and East Stroudsburg Boroughs and along the McMichael Creek through the borough of Stroudsburg.

The Monroe County Conservation District, through a contract with the Pennsylvania Department of Community and Economic Development, has completed a detailed evaluation of the Floodplain Management practices for the 20 municipalities that comprise Monroe County. All 17 municipalities in the Brodhead watershed are enrolled in the National Flood Insurance program. As such, they are required to regulate activities within the flood hazard areas of the municipality as delineated by the Flood Insurance rate map and the Flood Insurance Study.

Although there are minimum floodplain management standards established by the Federal Emergency Management Agency and the PA Dept. of Community and Economic development, the municipalities are not restricted to providing the minimum protection. In fact, they are encouraged by FEMA and DCED to adopt more restrictive measures.

A matrix has been developed showing the level of floodplain resource management by municipality. Seven municipalities have adopted floodplain regulations that meet the minimum standards. Six have some degree of added resource protection and of them; two have indicated a willingness to study the possibility of adopting even more protective measures. The remaining four municipalities have enacted regulations that either prohibit any new development in the floodplain or that permit only those activities that will not adversely alter the hydrologic functions of the floodplain.

There are varying degrees of protection allotted to floodplains throughout the watershed. This has led to the disjunct management of floodplain corridors from a watershed protection perspective. Given the present atmosphere of inter-municipal cooperation, the time is right to consider the conservation of floodplain resources on a watershed basis.

Floodplain Ordinance Provision Matrix					
Municipality	Enrolled in NFIP	Minimum Regulatory Provisions	Some Restrictive Regulatory Provisions	More Restrictive Regulatory Provisions	Considering More Restrictive Regulatory Provisions
Barrett Twp.	X		X		
Chestnuthill Twp.	X			X	
Coolbaugh Twp.	X	X			
East Stroudsburg Bor.	X	X			
Hamilton Twp.	X	X			
Jackson Twp.	X	X			
Mid. Smithfield Twp.	X		X		
Mount Pocono Bor.	X			X	
Paradise Twp.	X	X			X
Pocono Twp.	X		X		
Price Twp.	X	X			
Ross Twp.	X			X	
Smithfield Twp.	X		X		
Stroud Twp.	X		X		X
Stroudsburg Bor.	X		X		
Tobyhanna Twp.	X			X	
Tunkhannock Twp.	X	X			
Greene Twp., Pike Co.	X				

Storm Water

The Act 167 Stormwater Management Plan Update, for the Brodhead and McMichael Creek watershed, is currently underway. Initially, Act 167 Plans were developed for the Brodhead Creek (1991) and the McMichael Creek (1988) separately. Since the plans and new issues to be addressed are similar, the update currently underway is for the combined area of the Brodhead and McMichael watersheds. Addressing stormwater runoff will help to reduce flooding, protect the quality of surface water, and address groundwater recharge.

A municipal questionnaire sent out as part of the Act 167 Update showed several occurrences of small stream flooding and stream bank erosion through the watershed during major storm events, resulting in both public and private property damages. These problems were found to be more pronounced in the more populated areas, most likely due to encroachments onto floodplain areas and undersized culverts or bridges. During winter months, frozen ground coupled with high snowfall and rapid melting can also lead to flooding. Shallow bedrock can also contribute to rapid runoff.

An additional concern of stormwater runoff relates to water quality. The conversion of farmland, forests, wetlands, and meadows to rooftops, roads, parking lots, and lawns creates a layer of impervious cover in the landscape. Water from storm events and melting snow runs rapidly off these surfaces, carrying pollutants to streams and aquifers, instead of slowly percolating into the soil. Research has shown that the amount of impervious cover in a subwatershed can be used to project the current and future quality of streams. In many regions of the country, as little as ten percent watershed impervious cover has been linked to stream degradation, with the degradation becoming more severe as impervious cover increases.

In residential areas, streams are contaminated by residential nutrient runoff from excessive applications of fertilizers, animal waste or malfunctioning septic systems; soil erosion, and streambank erosion. Bacteria, nutrients, sediments and erosion have been identified as water quality problems in the watershed, as a result of agricultural non-point source pollution and sediment from stream bank erosion. Habitat loss and eutrophication are other problems associated with stormwater runoff.

Water Quality

Although water quality is generally high throughout the watershed, human activities appear to be measurably contributing nutrients and increasing conductivity and hardness in surface waters in parts of the watershed. A slight but significant increase in nutrient concentrations in the main channel over the past two decades is not surprising given the rapid increase in population. Population has nearly doubled since 1980 in Monroe County, and is expected to grow by 60 percent by 2020.

Extensive water quality data has been collected in the watershed by a variety of groups including the Monroe County Planning Commission, the Brodhead Watershed Association, townships and fishing clubs, as well as by the Department of Environmental Protection. The results of County monitoring efforts are documented in the annual *Monroe County Water Quality Study*. Monroe County's annual water quality monitoring efforts began in 1985. For an abstract of one of these reports, as well as other reports incorporated into this plan by reference, see *Appendix F, Prior Studies*.

However, with the exception of the current assessment of the Pocono Creek watershed by the Delaware River Basin Commission and others, no thorough analysis of the available data has been completed. Assessments similar to the Pocono study of the other sub-watersheds in the Brodhead watershed would provide a valuable analysis of current conditions and trends.

Threats to the quality of water in the Brodhead watershed may be either "man-made" or naturally occurring. Threats to drinking water sources in the Brodhead watershed can be considered as Groundwater Threats or Surface Water Threats; since the two are inseparably linked in the hydrologic cycle, a problem with one will inevitably mean a problem with the other.

Groundwater Threats

Man Made Threats. Many human activities can negatively affect groundwater quality as well as quantity. For many years it was generally believed that the filtering capabilities of the soil protected groundwater from contamination by human activities on the surface.

But with the discovery in the 1970's of human-made organic chemicals in groundwater, people began to realize how extensively our activities can affect groundwater. In fact, in a nationwide study commissioned by the U.S. Environmental Protection Agency, 65% of the private wells tested failed to meet at least one drinking water standard.

Those activities that can have a negative impact on groundwater can be categorized in four groups: waste disposal, resource extraction, agricultural practices, and urbanization.

Waste Disposal. The best-known source of groundwater contamination is waste disposal sites (landfills), both municipal and industrial, that were in existence before new regulations went into effect in 1988.

Septic systems are another potential source of groundwater contamination. If septic systems are improperly installed or maintained, bacteria, viruses, nitrate, phosphorus, chlorides, and the organic solvents that are found in many household cleaners as well as products sold to "clean" septic systems can all make their way into groundwater. As a result of poor construction or maintenance of their septic systems, rural homeowners are frequently the cause of contamination of their own wells. Improper management of land application of wastewater may also be a threat.

Resource Extraction. As mines intersect aquifers and collect water, they interfere with groundwater storage and can lead to lowered water levels in wells. In the Brodhead Watershed, stone quarries can have a negative impact on both groundwater and surface water sources.

Agriculture. Common agricultural practices such as fertilizing and applying pesticides are coming under increased scrutiny because groundwater samples have revealed nitrates and, in some cases, pesticides. The most prevalent problem is high levels of nitrate from over application of manure and fertilizer. Nitrate is especially harmful to babies, interfering with the blood's ability to transport oxygen, which causes the baby to suffocate ("blue baby" disease).

Urbanization. Many human activities and land use practices, which proliferate with urbanization, can negatively affect groundwater. Even cemeteries, for example, can contaminate groundwater.

One effect of urbanization is recharge diversion. Soils that have been covered with impervious surfaces – roofs, parking lots, or streets – obviously cannot absorb precipitation. Nor can soils that have been compacted by heavy machinery. As a result, much of the water from rain and snowmelt goes directly into streams and is never available to recharge groundwater.

Large concentrations of people can also lead to over pumping of aquifers. This can result in significant aquifer drawdown, which in turn reduces the quantity of stream flow. Stream water quality then suffers due to higher concentrations of sewage treatment plant effluent. Intensive pumping in coastal areas can cause salt water to be drawn into aquifers and wells. Polluted stream water can also be drawn into drinking water wells.

With increased population comes industrialization and an increase in the amount and variety of industrial activities, many of which can potentially contaminate groundwater. Leaking storage tanks at both industrial sites and gas stations have contaminated groundwater in many instances.

Individual homeowners also impact groundwater through a number of activities. These include improper disposal of used oil and over application of fertilizer and pesticides on lawns and gardens. Homeowners use four to eight times the amount of fertilizer and pesticides per acre than farms. Golf courses are another potential source of groundwater contamination from overuse of fertilizer and pesticides.

Natural Contamination. The natural constituents of water that may affect its suitability for drinking and other purposes most commonly found in groundwater are dissolved solids, calcium carbonate, and iron. Concentrations of chlorides and nitrates can also restrict use of water. These constituents enter water by leaching from rocks as water moves through them. Hardness is a property of water, usually measured by the concentration of calcium carbonate, which increases the amount of soap needed to produce lather.

Radon, a naturally occurring radioactive gas formed from decaying uranium or radium deposits, is a natural contaminant of increasing concern. Where radon is present in bedrock it can dissolve in groundwater and become a health hazard either when consumed or when the gas escapes into the air during showering, cooking, and laundering.

Hydrogen sulfide is an infrequent natural contaminant of groundwater caused by water storage in certain types of shale rock. It imparts a characteristic rotten egg odor to the water, but is not seen as a health threat at the levels at which it makes water unpalatable.

Corrosive groundwater is common. Corrosivity involves many factors including high acidity and low concentrations of calcium carbonate. In a recent Penn State survey of groundwater in private wells, 60 percent had corrosive water. Corrosive water dissolves lead and copper from pipes and plumbing fixtures thus causing a health risk.

Surface Water Threats

Because surface water (rivers, streams, ponds, lakes, reservoirs and springs) are by their nature more "visible," most people have more experience with this water source. Surface waters are often used for recreation, providing us with opportunities for swimming, boating, fishing, and camping. Most of us have pleasant memories and experiences related to these water habitats and view them as a wonder of nature, representing crisp, clear, clean water.

However, surface waters are even more at risk of contamination than groundwater, especially in the Brodhead watershed. This is due to the fact that the watershed is both a recreational area and a high growth area. This increases the human activity within the watershed and, thus, increases the chances of pollution. Surface waters can be contaminated by pollution from non-point sources or point sources – usually permitted discharges from sewage treatment or industrial waste treatment plants.

Point Sources. Point sources of pollution are those sites, such as industries or sewage treatment plants, that discharge wastewater directly into a body of water. The entry point of the discharge is at one or more discrete locations in the stream and therefore its effects can be readily measured and regulated. The primary regulatory mechanism of point sources is the National Pollutant Discharge and Elimination System (NPDES), a permitting system set up by the Clean Water Act and enforced by the EPA and DEP. Most often these are permits for industrial waste, sewerage wastewater or a stormwater discharge. The permitting process attempts to minimize the impact of human activity on the surface water sources. In the Brodhead watershed, a total of 39 facilities have NPDES permits.

In the Brodhead watershed there are numerous discharge permits and discharge points, ranging from systems discharging 1,000 gallons per day up to 2.25 million gallons per day in size. While point source sites do not contribute the volume of discharge to surface water sources that non-point source sites do, they must be maintained and operated

properly or they can have an immediate negative impact on the receiving water body. The following is a key to explain the permit type in the chart of NPDES permittees:

STP/P = Sewage treatment plant, public STP/NP = Sewage treatment plant, non-public IW = Industrial waste S-I = Stormwater industrial IND = Individual

MUNICIPALITY	PERMIT #	PERMITTEE / SITE NAME	TYPE	DISCHARGE POINT	WATERSHED	MGD
E. Stroudsburg	PA0020168	East Stroudsburg Boro	STP/P	Brodhead	Lower Brodhead	2.25
Smithfield Twp	PA0060143	Manwalamink Sewer	STP/NP	Brodhead	Lower Brodhead	0.245
Smithfield Twp	PA0012963	Rock Tenn Co	IW	Brodhead	Lower Brodhead	0.326
Stroud Twp.	PA0035033	Bible Fellowship Church	STP/NP	Brodhead	Lower Brodhead	0.021
Stroud Twp.	PA0060992	Stroudsburg Municipal Authority	IW	Brodhead	Lower Brodhead	0.0125
Stroud Twp.	PA0060283	Penn Estates Utilities	STP/NP	Cranberry Run	Lower Brodhead	0.1
Smithfield Twp	PA0061361	Smithfield Twp Sewer Authority	STP/P	Little Sambo	Lower Brodhead	
E. Stroudsburg	PA0034517	East Stroudsburg/ Water Filtration Plant	IW	Sambo	Lower Brodhead	0.03
Stroud Twp.	PA0062464	Blue Mt. Lake Development	STP/NP	Sambo	Lower Brodhead	
E. Stroudsburg	PA0012394	Patterson-Kelley	IW	UNT Brodhead	Lower Brodhead	0.016
E. Stroudsburg	PA0013269	McGraw Edison	IW	UNT Brodhead	Lower Brodhead	0.06
Hamilton Twp.	PA0029220	Snydersville Diner	STP/NP	Kettle	McMichael	0.0125
Hamilton Twp	PA0063649	Howard Newhard/King Arthur Restaurant	STP/NP	McMichael	McMichael	
Hamilton Twp.	PA0060704	Monroe Co/Jail &Pleasant Valley Manor	STP/NP	McMichael	McMichael	0.038
Stroudsburg	PA0029289	Stroudsburg Boro	STP/P	McMichael	McMichael	2.5
Paradise Twp.	PA0061808	Royle George	IND	(land)	Paradise	
Mt. Pocono Boro	PA0044997	Mt Pocono Municipal Authority	STP/P	Forest Hills Run	Paradise	0.6
Paradise Twp.	PA0060054	Mt Airy Lodge	STP/NP	Forest Hills Run	Paradise	0.22
Paradise Twp.	PA0061115	Caesars Paradise Stream	STP/NP	Paradise	Paradise	
Paradise Twp.	PA0040444	Pocono Mt. School Dist.	STP/NP	Swiftwater	Paradise	0.0286
Pocono Twp.	PA0029149	Ireland Hotels/ Pocono Manor	STP/NP	Swiftwater	Paradise	0.14
Pocono Twp.	PA0060071	Aventis-Pasteur	IW	Swiftwater	Paradise	0.053
Barrett Twp.	PAS222202	Bestway Lumber Treatment Center	S-I	Cranberry Creek	Paradise	
Barrett Twp.	PA0029190	Monsignor McHugh High School	STP/NP	UNT Paradise Creek	Paradise	0.022
Pocono Twp.	PA0061921	Caesars Brookdale	STP/NP	Brookdale Lake	Pocono	
Pocono Twp.	PA0063024	Jeff Snyder Fountain Court	STP/NP	Cranberry	Pocono	0.005
Pocono Twp.	PA0034631	GP Mgmt/Birchwood (Onetime Inc.)	STP/NP	Cranberry Bog	Pocono	0.03
Pocono Twp.	PA0035335	Papillion Contracting/Barton Court	STP/NP	Laurel Lake Run	Pocono	0.0117
Stroud Twp.	PA0061093	Monroe Co. Vo-Tech	STP/NP	Laurel Lake Run	Pocono	0.015
Hamilton Twp.	PA0013676	Pocono Auto-Truck Stop (Oil Separator)	IW	UNT Pocono	Pocono	
Pocono Twp.	PA0061026	Big Pocono Utilities	STP/NP	Pocono	Pocono	0.0369
Pocono Twp.	PA0060569	Camelback Ski Resort	STP/NP	Pocono	Pocono	0.4
Pocono Twp.	PA0062979	Gem Corp. & Insalaco /Crossings)	STP/NP	Pocono	Pocono	0.024
Pocono Twp.	PA0041076	PA DCNR	STP/NP	UNT Scot Run	Pocono	0.005
Pocono Twp.	PA0063673	Jeff Snyder Fountain West	STP/NP	UNT Pocono	Pocono	0.0095
Pocono Twp.	PA0061051	Summit Resort (Farda)	STP/NP		Pocono	0.2
Stroud Twp.	PA0060631	Stroud Twp / Pocono Auto-Truck Stop)	STP/NP	UNT Pocono	Pocono	0.014
Pocono Twp.	PA0032859	Penn DOT Reststop 41	STP/NP	UNT Pocono	Pocono	0.00921
Pocono Twp.	PA0063584	Progressive Labels - PENDING	STP/NP	Scot Run	Pocono	0.00075
Barrett Twp.	PA0029483	Buck Hill Falls Co.	STP/NP	Buck Hill Creek	Upper Brodhead	0.2
Barrett Twp.	PA0029874	Skytop Lodge	STP/NP	Leavitt Branch	Upper Brodhead	0.075

Non-Point Sources. Non-point source pollution threats are those threats to surface water sources that cannot be traced to one particular discharge location. Run-off from farms, golf courses, street and highway systems, parking lots, recreational fields, leaking storage tanks or septic systems, railroad or vehicle accidents (i.e., chemical and fuel spills), are all considered "non-point source pollution." Atmospheric deposition is also a significant non-point source of pollution. Airborne pollutants, from sources such as automobiles and coal fired power plants, fall to the ground through rain, snow, or fog, entering surface water.

Combined, these potential sources of pollution in the Brodhead watershed area pose the greatest threat to the water quality. These threats run the full course of human activity from industrial and manufacturing centers, to the tourist industry, agriculture, residential homes and recreational uses.

Nutrients and pesticides from golf courses, agricultural uses and residential homes threaten the receiving waters. Chemicals and waste products from industrial and commercial facilities, if not properly treated and disposed of, threaten surface waters; air pollution from automobiles and combustion can find its way into the hydrologic cycle; auto and truck accidents can introduce chemicals or fuels into a water source, and run-off from parking lots and streets and other roadways contains oil and grease, nutrients, sediment and road chemicals.

A contaminated aquifer can influence a surface water source when it discharges into a surface water source (e.g. when groundwater, contaminated by malfunctioning septic systems, parking lot runoff, or overuse of fertilizers or pesticides, enters a stream).

Water Supply

Private Drinking Water Systems

Everyone who lives, works, or visits the Brodhead watershed depends on the watershed for their drinking water supply. Water supplies can be either a private water system (an individual homeowner's well) or a public system.

A common source of drinking water in the Brodhead watershed is the private well. Fifty percent of homeowners and small businesses in the Brodhead watershed depend on private wells for their drinking water supplies. Most wells are used for residential purposes, although small commercial entities also utilize wells for their drinking water source.

Unlike Public Water Systems, private systems are neither monitored nor regulated by the Department of Environmental Protection (DEP). The private individual (residential or small commercial operation) is responsible for both the quality and quantity of their private water systems.

Private drinking water systems (wells) can vary in depth from less than 100' to over 700' deep. These wells face the same threats to their water sources (groundwater) as Public Water Systems, yet without the monitoring requirements of the Public Water Systems. Private systems depend on pumps, storage tanks and electrical service and, most importantly, the care of the homeowner, in order to operate.

Whether affected by a drought, water contamination or a mechanical/electrical malfunction, private drinking water system owners, for the most part, are "on their own" and are responsible for the operation and maintenance of these systems.

Public Drinking Water Systems

Public Water Systems are licensed and regulated by the Pennsylvania Department of Environmental Protection (DEP). A Public Water System is defined as one which provides water to the public for human consumption. The term includes collection, treatment, and storage and distribution facilities used in connection with the system. The term also includes a system which provides water for bottling or bulk hauling for human consumption.

Within this definition, the Department of Environmental Protection regulates three different categories of Public Water Systems as follows:

- **Community water system** - a water system which serves at least 15 service connections, is used by year-round residents, or regularly serves at least 25 year-round residents.
- **Non-transient non-community water system** - a water system that regularly serves at least 25 of the same persons over 6 months per year; examples are a factory or a school.
- **Transient non-community water system** - a water system which serves a facility, such as a restaurant, where 25 or more different people may drink the water each day.

All of these types of systems are represented in the Brodhead watershed. From a school or large commercial building, to strip malls, doctor's office complex, a municipal authority, or municipal water department, all depend on the watershed for their water source.

Water systems may use "surface water" sources (streams, creeks, springs, lakes or reservoirs) and/or they may use "groundwater" sources (wells). Regardless of their size or the complexity of their treatment facilities, all are regulated by and report to DEP. Of course, these Public Water Systems are at risk from the various threats common to all water users in the Brodhead watershed, whether they utilize groundwater sources or surface water sources.

Community Water Systems in the Brodhead watershed include:

- Stroudsburg Municipal Authority
- East Stroudsburg Borough Water Department
- Pennsylvania American Water Company (Mt. Pocono, Pine Hill, Summit Pointe, Pocono Country Place, Pocono Farms East)
- National Utilities, Inc. (Mountainhome Division and Hamilton Division)
- Pocono/Jackson Joint Water Authority
- Buck Hill Water Company
- Skytop Lodge
- Pocono Manor
- Village at Camelback

Stroudsburg Municipal Authority

The Stroudsburg Municipal Authority (SMA) is the largest Public Water System in Monroe County, serving over 20,000 people in the Borough of Stroudsburg, Stroud Township and Smithfield Township. The Authority is located in Stroud Township, on the west side of the Brodhead Creek. Its annual operating budget is approximately \$2.2 million, with an annual capital improvement program of \$200,000 - \$300,000. In the 1990's, the Stroudsburg Municipal Authority spent over \$13.5 million to upgrade and extend its water distribution system, develop new sources of water (wells #1 and 2) and modernize its Water Treatment Plant into a "state-of-the-art" facility.

The Authority is permitted to withdraw 5.38 million gallons per day (mgd) from its wells and the Brodhead Creek. Wells #1 and 2 can produce up to 1,000 gallons per minute (gpm) each for a total capacity of 2.88 mgd. The wells are located approximately ¼ of a mile north of the Water Treatment Plant, on the west side of the Brodhead Creek. The Water Treatment Plant can generate 2.5 mgd with its source being the Brodhead Creek. In 1999, the average daily use was approximately 1.9 mgd or about 35% of its total permitted capacity.

The SMA has developed a Watershed and Wellhead Protection Program of its own within the larger Brodhead watershed area. The Authority continually monitors its sources and its finished water supplies for both quality and quantity. Its annual Water Quality Report (Consumer Confidence Report) is distributed to its customers on a yearly basis.

Borough of East Stroudsburg Water Department

East Stroudsburg Borough operates its water system, the only government operated system in the Brodhead watershed. The system is supplied primarily from a reservoir on the headwaters of Sambo Creek. Approximately 900,000 to 1,000,000 gallons per day are drawn from that reservoir. In addition, two supplemental wells are available from the campus of East Stroudsburg University, drawn when needed. A well located in Dansbury Park provides the balance of the 1.2 million gallons per day used by the 3,650 customers of the system; a fourth well, also located at Dansbury Park, is now coming on line. The two largest customers of the system are East Stroudsburg University and Pocono Medical Center. Capacity available in the East Stroudsburg system is 2.2 million gallons per day.

Pennsylvania American Water Company

Pennsylvania American Water Company (PAWC), an investor owned public water system, operates several water supply systems in the Mt. Pocono area: Pocono Country Place, Pocono Farms East, Summit Pointe, Pine Hill and Mt. Pocono Borough (formerly served by Fairview Water Company). Each of these is located partly or wholly in the Brodhead watershed. All systems are interconnected, so if a problem develops in one area, water can be provided from one of the other systems.

Pocono Country Place and Pocono Farms East are served by four wells which, combined, produce 614,000 gallons per day for residential and commercial use. The wells range from 175' to 700' deep. Water is provided to more than 3,000 customers in developments along Route 196, including Pocono Country Place, Pocono Farms East, Carriage Estates, and Whispering Glen.

Mt. Pocono Borough (portions of), including Summit Pointe development and the Pocono Mountain Industrial Park, are served by one well and a treatment station located in the Industrial Park which produces an average of 198,150 gallons per day for 558 residential, commercial and industrial customers. The well is 438' deep.

A third well in the PAWC system, located along Route 611 at the Coolbaugh Township Municipal Building property, delivers 500 gallons per minute (720,000 gallons per day) and serves the Tobyhanna village area and northern portion of the service area.

Several self-supplied developments in the Borough operate their own public water systems, independent of PAWC. These include: Limekiln Manor, Oakview Terrace Condo Association and Snow Shoe Condominium Association.

It is noted that Summit Pointe, Pine Hill, the Pocono Mountain Industrial Park, and Mt. Pocono Borough have sewer service provided by the Mt. Pocono Municipal Authority, which operates a sewage treatment plant located on and discharging to Forest Hills Run, a tributary of Paradise Creek. All water supplied to these areas (except for a few private wells) comes from the Tobyhanna watershed.

National Utilities Company

National Utilities Company, an investor owned public utility with offices in Scranton, Pennsylvania, operates two water systems in the Brodhead watershed, the Mountainhome Division and the Hamilton Division. The Mountainhome Division operates two wells located at the old reservoir site and supplies water to 547 customers. The Hamilton Division draws water from two wells, one located on Anchorage Road and one on Lily Road, and supplies 500 customers in the Saylorburg area.

Pocono-Jackson Water Authority

Pocono-Jackson Water Authority was formed to provide water to homeowners in Jackson Township when their private wells were contaminated by the Butz Landfill, a Superfund

site. The Authority provides water to 47 customers from 3 wells located at the base of Big Pocono Mountain in Jackson Township.

Resort Communities and Private Developments

Many residential communities and resort communities are served by public water systems operated by the resort, a homeowners association or a private investor. Some of these are:

- Buck Hill Water Company - Service is provided to 279 customers; water sources are Buck Hill Creek, Big Spring and Well #2.
- Skytop Lodge - Water supply is 4 wells; service is provided to 45 customers.
- Pocono Manor Inn - Water supply is two springs; service is provided to 45 customers.
- Village at Camelback - Operates as three separate service areas:
 - Reservoir #1 provides water for Townhomes #1 through # 104
 - Reservoir #2 provides water for Townhomes #105 through # 260
 - Reservoir #3 provides water for Townhomes #261 through # 310
 - Water is drawn from four wells which are all interconnected.
- Penn Estates Utilities, Inc (owned by Utilities, Inc. Northbrook, Illinois) provides water from 6 wells to 1275 customers in Penn Estates. The system has capacity available for an additional 500 homes. Current water usage is 120 million gallons per year. (32,875 gallons per day).

Wellhead Protection Areas

Because it is out of sight, groundwater is often out of mind. For many of us, we only take notice of well water if it looks, smells, or tastes funny. But groundwater can be contaminated well before any obvious signs appear. Yet it can be difficult to clearly track a groundwater pollutant to its source, especially considering the many layers of soil and rock that water seeps through to reach an aquifer. Cleaning up a contaminated well is very difficult and costly, and it may not return to potable for a relatively long time. Thus it is important to create a “safe zone” around a wellhead by protecting the surrounding land from any potentially harmful activities.

DEP’s Wellhead Protection Program is predicated on the principle that it is cheaper to protect drinking water sources than to clean up after contamination occurs.

The following pollution vulnerability map illustrates the relative vulnerability of water supplies to pollution from surface or near-surface releases of contaminants. Natural protection of bedrock aquifers is provided by soil and sediment cover. Highly permeable soils (hydrologic soil groups A & B) provide little protection while less permeable soils (hydrologic soil groups C & D) provide progressively greater levels of protection. Alluvial deposits of sand and gravel serve as shallow water table aquifers in Monroe County. These deposits are highly permeable and regardless of soil cover and are highly vulnerable to pollution.