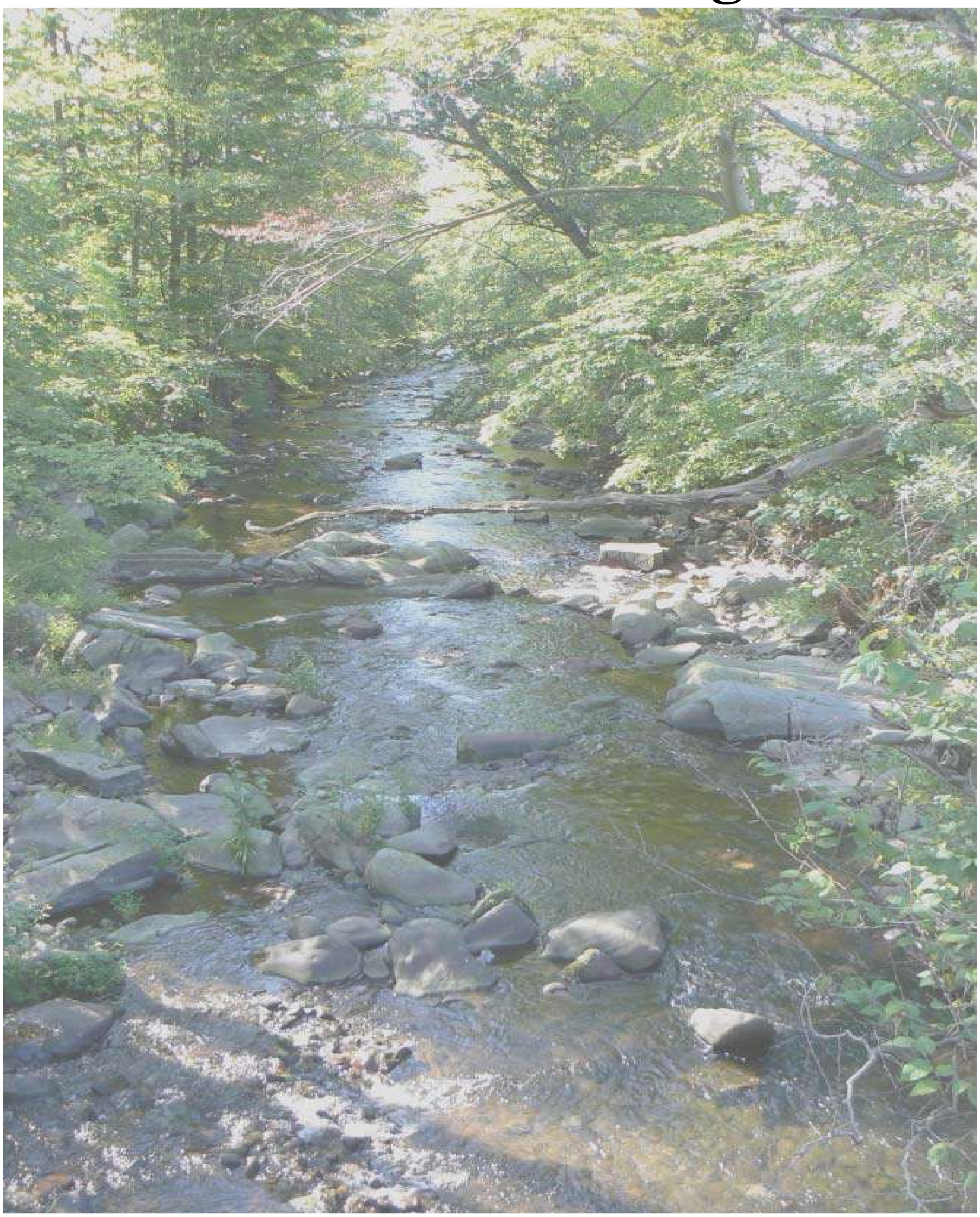
Framework for Sustainable Watershed Management



Pocono Creek

Final Report

May 2009

Framework for Sustainable Watershed Management
in
Pocono Creek Watershed
Monroe County, PA

Final Report
May 2009

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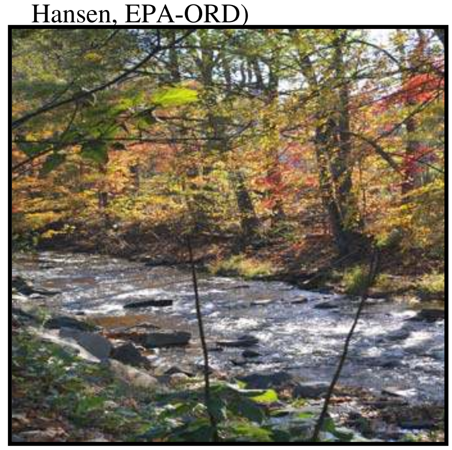
Executive Summary

The Pocono Mountains' abundant natural resources include pristine streams that support thriving trout populations. This northeastern corner of Pennsylvania is a popular destination for vacations and outdoor recreation for the 30 million people who live less than a 3 hours drive from the New York City, Philadelphia and Harrisburg metropolitan areas. During the last 2 decades, the area's beauty, quality of life and reasonable cost of living has made the Poconos an attractive choice for families to relocate, generating an unprecedented amount of growth.

Figure ES-1: Pocono Creek (Verle Hansen, EPA-ORD)



The Framework for Sustainable Watershed Management (Framework) was created to address a paradoxical issue many rural communities dependent on natural resources for economic stability face--how to develop sustainably. Using the Pocono Creek watershed as a "sustainability watershed laboratory," the aim of the Framework is to create a mechanism that would allow for development while protecting water resources in the region using science based decision making.

Much of the development in the Pocono Creek watershed is taking place along the 16-mile Pocono Creek mainstem that lies between Interstate Route 80 and Monroe County's primary commercial artery, State Route 611. In addition to the regional shopping attractions, the 48.5 square mile Pocono Creek watershed has a ski resort, water parks and vacation homes. A National Natural Landmark as well as an international corporation are located in the watershed and the county seat lies at the watershed's confluence with the McMichael's Creek in Stroudsburg. These attractions make the Pocono Creek watershed a special place for visitors, businesses and residents.

The Pocono Creek watershed is representative of watersheds in the region. The Pocono Creek and other streams in its watershed have superior water quality that support trout due to the cold, abundant and well oxygenated water. These existing conditions qualify some tributaries in the Pocono Creek watershed for the highest level of water quality protection under Pennsylvania regulations. In addition, the watershed is located in the Special Protection Waters (SPW) drainage area and subject to anti-degradation regulations of the Delaware River Basin Commission. However, even with these greater levels of protection, degradation of the high value waters and natural resources still occurs.

Altering the landscape can impact the hydrologic integrity of a watershed. Changes in water quality and quantity that can occur from stormwater runoff include but are not limited to:

- Decreased and/or lack of infiltration to groundwater recharge areas and potential aquifer depletion,
- Decreased seasonal stream baseflows,
- Increased stormwater volume and velocity contributing to streambank erosion, stream channelization, and more frequent and severe flood events,
- Increased surface water temperatures from heated stormwater runoff and lack of shaded riparian buffers, and
- Decreased filtration of pollutants from narrowing or damaging riparian buffers.

Maintaining baseflows in the Pocono Creek is a particular concern. Knowing that the demand for water increases as competition for existing water resources grows with a growing number of users, concerns about sustaining the exceptional water quality and supply for future generations were raised throughout the 2003 *Pocono Creek Pilot Project for Goal-based Watershed Planning* (Pilot), which was funded by a PA Growing Greener grant. This issue was emphasized by local resource managers and citizens during both the Pilot's goal setting (2000) and project evaluation stages (2003). The Environmental Protection Agency's Region 3 Office (EPA-3) organized and funded the current project, known as the *Framework for Sustainable Watershed Management* (Framework). The Framework's diverse partnership includes: Brodhead Watershed Association (BWA), Delaware River Basin Commission (DRBC), Environmental Protection Agency (EPA), Environmental Protection Agency's Office of Research and Development (EPA-ORD), Monroe County Conservation District (MCCD), Monroe County Planning Commission (MCPC), Pennsylvania Department of Environmental Protection (PADEP), Pennsylvania Fish and Boat Commission (PF&BC), Pocono Arts Council (PAC), United States Geological Survey Pennsylvania Water Science Center (USGS-WSC) and, United States Geological Survey's Science Center in Fort Collins (USGS-Fort).

The purpose of the Framework is to introduce a program that balances growth with natural resource protection, so that future generations can enjoy the highly valued natural resources of the region, while enjoying economic prosperity. This program is accomplished in three stages; technical, planning and watershed community outreach. The technical stage identifies the impacts of rapid growth on a watershed's water resources. The planning stage develops management strategies that balance regional growth needs with natural resource protection. The planning and watershed community outreach effort introduces an innovative approach to protecting the region's water resources through a community-wide public art event that receives extensive media coverage, has high visibility and generates enthusiastic community participation.

The technical stage consists of assessment of the effects of groundwater withdrawals and land use changes on the conditions supporting trout habitat. Trout are used as an indicator species to evaluate habitat, baseflows and water quality. Trout are highly sensitive to pollution, including excessive silt loads, increased water temperatures and reduced dissolved oxygen levels. Transferable technical work includes:

- Development of a Groundwater Model (USGS)
- Development of a Watershed Hydrology Model (EPA-ORD, Cincinnati OH)
- Population and land use projections, land use build-out scenarios (MCPC)
- Streamflow data collected and analyzed (EPA-ORD, Edison, NJ)
- Current water use (DRBC)
- Hydroecological Stream Classification (USGS-Fort)

The studies indicate that for the build-out scenario, on an average watershed-wide basis, groundwater recharge for the watershed is predicted to decline by 31% causing the average daily baseflow to be reduced by 31%. The low flow measure (7Q10) is expected to decline by 11%, and the monthly median daily flow is expected to be reduced by 10%. Monthly peak of daily flows and annual maximum daily flow are predicted to increase by 21% and 19%, respectively. (Hantush and Kalin, 2006). The predicted changes in streamflow indicate alterations of flow and impacts to water quality that potentially threaten the trout population.

Preventing degradation of trout habitat and water quality from diminished baseflows is a complex undertaking. As a result of this project, management strategies are presented to mitigate potential trout habitat degradation and protect ecological flows while working towards long term regional economic stability. The transferable management strategies and tools developed for the Framework include:

- Watershed Communities: Identification of local municipalities that share common geographical and socio-economic conditions. Watershed communities have the potential to collaborate with one another to implement management strategies and share resources.
- Watershed Management Areas (WMAs): Sub-watershed delineations (Headwaters, Transitional, and Urban) based on common geography and socio-economic character, that unify neighboring watershed communities approach to water management.
- WMA Specific Management Strategies: A suite of WMA specific strategies that watershed communities can implement locally, within a regional management plan.

The Pocono Creek watershed is unquestionably threatened by rapid growth. However, through this study "consistency among levels of government" is identified as the major challenge towards integrated watershed management. The challenges begin with coordination efforts between various regulatory agencies, governmental jurisdictions and the legal differences between land use and water laws. In addition, water laws and regulations are divided according to commonly separated practice areas such as water quality, water supply and critical/sensitive environmental areas. Compounding the matter, water laws seldom account for the critical connections between surface water and groundwater resources. Often times local or regional land use plans do not take water laws into consideration and the municipalities may receive support for infrastructure that can override the regional or local land use plans. The interactions between the public and private sectors, local, county, state and federal agencies, business interests and environmental advocacy groups that have vested interests in water quality, quantity and land use can be very unproductive at times. This project began the process of breaking down walls between the various agencies, communities and individuals within the Pocono Creek watershed.

Figure ES-2. "Bathing Beauty" Sculpture (P.V'Combe, DRBC)

The first step in the outreach for watershed community building was to "go public" locally. Getting the word out about "sustainable baseflows" requires an attention grabbing, community-wide effort. The outreach effort needed to introduce a general "Develop Right, Save the Trout" message to the public about the relationship between development, water resources and trout.

Throughout this project, there has been a significant shift in not only the public's perception about the value of water resources, but within state and local governments as well. Pennsylvania's *Sustainable Infrastructure Task Force* reported on similar challenges: legislative changes needed, watershed and regional coordination for water management, use of non-structural solutions, infrastructure and land use planning.

Chapter 8, Next Steps, includes a 5-point plan aimed at maintaining progress towards a sustainable watershed. These steps address: 1. Organizational capacity for a long term, multi-disciplined, inclusive oversight group; 2. Revitalization of existing planning efforts and programs as planning tools for a sustainable future, 3. Broadening the scale of future sustainability efforts in the region to include the entire Brodhead watershed; 4. Further review and analysis of the regulatory framework affecting sustainable watershed planning efforts, and 5. Continuation of an education and outreach effort through social marketing efforts.

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List of Terms

7Q10 – 7-day average low flow with a probability of occurrence of once in 10 years (10% probability in any given year)

BMPs- Best Management Practices

BWA- Brodhead Watershed Association

CEAs- Critical Environmental Areas

CNS- Collaborative Science and Technology Network for Sustainability

DHM - Distributed Hydrologic Model

DO- Dissolved Oxygen

DRBC- Delaware River Basin Commission

EPA- Environmental Protection Agency

EPA-ORD - Environmental Protection Agency's Office of Research and Development

EPA-R3- Environmental Protection Agency Region 3

EV- Exceptional Value

HIP- Hydroecological Integrity Assessment Process

HQ- CWF- High Quality Cold Water Fishery

HQ- High Quality

MC - Monte Carlo

MCCD- Monroe County Conservation District

MCPC- Monroe County Planning Commission

MODFLOW - USGS groundwater flow model

NEXRAD - Next Generation Weather Radar

NRCS- Natural Resource Conservation Service

PAC- Pocono Arts Council

PADEP- Pennsylvania Department of Environmental Protection

PF&BC- Pennsylvania Fish and Boat Commission

SPW- Special Protection Waters

SWAT - EPA's Soil and Water Assessment Tool

USGS-Fort- United States Geological Survey's Science Center in Fort Collins

USGS-WSC- United States Geological Survey Pennsylvania Water Science Center

WMAs- Watershed Management Areas

WUDS- Water Use Data System

Chapter 1 : Introduction

1.1 Purpose

The purpose of sustainable watershed planning is to protect the area's water resources and habitat supported by those resources for future generations, while meeting present needs. Science, planning and educational outreach are the three pillars of a sustainable watershed management effort. Sustainable watershed planning utilizes science, which in turns influences the development of watershed management strategies. Implementing watershed strategies requires education and outreach within and beyond a specific watershed.

In an undeveloped area, a sustainable watershed planning effort can balance future growth while protecting existing natural resources. The Pocono Creek, in rural Monroe County, Pennsylvania, has outstanding natural resources and excellent water quality in particular. Currently, Pocono Creek watershed is experiencing tremendous growth pressures including commercial development along the Pocono Creek mainstem. While there are anti-degradation regulations for water quality in effect, the water quality continues to be impacted, including diminishing streamflows that support trout. In order to sustain the watershed's trout population, high quality and abundant streamflows are essential.

Local natural resource managers, watershed groups, and planners in Monroe County are actively seeking to find innovative approaches to protect the region's water resources and are looking to apply the findings from this study throughout the area. This strong local interest was a major reason the Environmental Protection Agency Region 3 (EPA-R3) office selected the Pocono Creek watershed for funding by Collaborative Science and Technology Network for Sustainability, a grants program based on exploring innovative approaches to environmental protection that are systems-oriented, forward-looking, preventative, and collaborative.

The *Framework for Sustainable Watershed Management* (Framework) project arose out of the need for integrated long-term water resource management strategies for the Pocono Creek watershed. A systematic and transferable Framework for establishing sustainable watershed management programs in the Pocono Creek watershed was developed in response to the following concerns: diminishing streamflows, pollution from stormwater runoff, streambank erosion, degradation of aquatic ecosystems, and the apparent disconnect between economic development and environmental protection.

The Framework partners prepared numerous scientific studies that show the impact of land use changes and groundwater withdrawals on streamflows. The results of these studies are used to develop management strategies to mitigate the impacts. The partners also initiated a dual track outreach and education effort consisting of a public art project and a strategic marketing effort to form a multi-sector cooperative watershed oversight group. The Framework's diverse partnership includes: Brodhead Watershed Association (BWA), Delaware River Basin Commission (DRBC), Environmental Protection Agency (EPA), Environmental Protection Agency's Office of Research and Development (EPA-ORD), Environmental Protection Agency Region 3 (EPA-R3), Monroe County Conservation District (MCCD), Monroe County Planning Commission (MCPC), Pennsylvania Department of Environmental Protection (PADEP), Pennsylvania Fish and Boat Commission (PF&BC), Pocono Arts Council (PAC), United States Geological Survey Pennsylvania Water Science Center (USGS-WSC) and, United States Geological Survey's Science Center in Fort Collins (USGS-Fort).

The sustainable watershed management plan for this unique watershed goes beyond the traditional watershed planning approaches, and includes integration of water quality with water quantity. Technically, watershed planning must evolve from a superficial "top-of-land" drainage basin model, to a dynamic system with the linkages between the subsurface aquifers and the landscape. Management strategies include not only selection of appropriate best management practices implemented at a local level, but also the integration of water resource decision making with local land use practices, economic development and infrastructure decisions. Ideally, funding mechanisms supporting these activities would be aligned. This new approach includes strategic outreach to a multi-sector, multi-layered constituency and an on-going collaborative process that offers a better chance of sustaining water resources amidst a thriving local economy in the region.

Many approaches used in this study were developed for this sustainable framework project, but could be easily adapted for other watersheds in Pennsylvania. Additionally, aspects from each project stage are transferable universally if applied to similar landscapes and geology. Outreach products can be utilized for other sustainable watershed planning efforts.

1.2 Background

The northern section of the Delaware River Basin's scenic Pocono Mountains has pristine streams that support thriving trout populations, white water rafting, and picturesque waterfalls within forested river valleys. The 16-mile Pocono Creek and its 48.5 square mile watershed characterize Monroe County's waterways. Based on the existing water quality that includes abundant cold, spring-fed flowing water, the Pocono Creek's Wolf Swamp Run qualifies as a

Class A trout stream by the PF&BC. Pocono Creek and its tributaries (as well as most other Monroe County's streams) are designated as High Quality (HQ) or Exceptional Value (EV) by PADEP. Pocono Creek is also located within the DRBC Special Protection Waters (SPW) drainage area. Although these designations are intended to protect the existing water quality, degradation in the Pocono Creek and its surrounding streams still occurs. Of particular concern is that the existing streamflow currently supporting brown trout may be further reduced if proactive measures are not taken to sustain the watershed's "ecological" flows.

The superior water resources in the Pocono region drive significant economic and social structures. Tourism is the largest economic engine in the region's economy, and the area's natural resources are the primary driver for tourism (Henry, 2007). Tourism in the Poconos in 2006 generated over $420 million and employed over 10,000 people (Global, 2006). Each tourist dollar spent in the area is leveraged to $3 within the community (Pilcher, 2007). The region's world class trout streams and the "trout business" is a significant component of the regional tourist economy. Currently, the region's economic growth from tourism revenues may continue to grow as a result of current economic trends, which make "local" vacation destinations desirable to the neighboring metropolitan regions (Perez, 2005).

Figure 1.1: The Pocono Mountains entice visitors all year.

One tenth of the nation's population (about 30 million people) can drive to Pocono Creek in less than three hours. The region's beauty makes it a desirable place to live as well as visit, and migrations from the surrounding urban areas of Philadelphia (90 miles south), New York (75 miles east), and Harrisburg (60 miles west) are transforming the landscape from rural forested open space to suburban transit communities. Businesses and industry are aware that workers are willing to locate in the area because of the region's appeal. In 2006, Monroe County was the second fastest growing county in Pennsylvania due to the Pocono region's: 1) strategic location and quick access to major metropolitan centers; 2) natural resources; 3) second home markets; 4) history as a tourist destination area; and 5) expanding business and corporate sector. Since 1980 the population of Monroe County has nearly doubled and is projected to grow by an additional 60% by 2020 (Woodling, 2005).

The demand for water is predicted to increase as competition grows from escalating development, increasing tourism, and a growing year-round recreational destination. Concerns about sustaining the exceptional water quality and supply for future generations were raised throughout the *Pocono Creek Pilot Project for Goal-based Watershed Planning* (Pilot), a community-based watershed study, funded by a PA Growing Greener Grant and prepared by DRBC. This concern was emphasized by local resource managers and citizens during both the Pilot's goal setting in 2000 and project evaluation stages in 2003. Through an open-public process, the study established water resource and socio-economic goals. The seven watershed goals for the Pocono Creek established in the Pilot study are listed in Table 1.1.

Table 1.1: Pocono Creek Pilot Study Watershed Goals.

- Maintain water quality
- Preserve stream corridors and floodplains
- Maintain existing streamflow
- Coordinate watershed planning with all levels of government
- Establish an environmentally compatible economy
- Preserve open space
- Develop using village centers and conservation design

The Pilot study recommends integrating land use and water resource management in order to balance growth throughout the region to meet the community's current water use demands (human and ecological) without compromising the ability of future generations to meet their own water resource needs. The Pilot's participants anticipate that if not properly managed, the demands from projected growth, land use changes and accompanying increased groundwater withdrawals could exceed sustainable levels needed to support the thriving natural resource base, including the trout population. More recently, there are concerns regarding the secondary effects of the impending centralized sewage and wastewater developments on watershed streamflows. Yet, local municipal officials insist that before they would implement any protective water resource strategies, a sound scientific basis linking development practices to adverse consequences to existing natural resources was needed.

The *Framework for Sustainable Watershed Management* continues the work completed in the Pilot study. Currently, there is intense pressure to implement centralized infrastructure to meet sewer and water needs along the Pocono Creek valley. Water resource managers are concerned that a hard pipe system and intra-basin transfers will impact the Pocono's existing streamflow. *Monroe 2020*, the county's comprehensive plan, calls for the establishment of hamlet and town centers with decentralized water management systems. However, supporters for a new sewage plant maintain that the centralized plant is required in order to meet the needs of local industry.

Project partners seek to retain key elements of the area's basic economic and social structure by sustaining the natural resource base through sustainable planning and management practices. Sustainable watershed management would be directed at protecting not only the water resources and the impact of flows on its high quality, but the overall quality of life, which includes economic and social conditions for future generations. Discussing economic development in the Pocono region, Robert Phillips, from the Pocono Chamber of Commerce, stated that county officials are working to lure "clean" businesses that will complement tourism (Perez, 2005). Chuck Leonard, executive director of Pocono Mountains Industries, agreed that the same regional qualities and attractions that support the tourist economy, are "… a key factor in the location of …our other industries" (Hartmann, 2003). The same economic goals were established in the Pilot study, as well**.**

As the Pilot study was concluding, the EPA-ORD launched a new funded initiative, the Collaborative Science and Technology Network for Sustainability (CNS). This grant program is the cornerstone of EPA-ORD transition to sustainability. CNS is the national testing ground for scientifically-based tools and approaches that can make a sustainable future at a regional scale possible. The program addresses the long-term sustainability (in terms of quality and availability) of resources, including air, water, land, energy, materials, and ecosystems. Additionally, CNS projects will transfer tools, approaches, and lessons to other states, localities, and regions**.** The program enables grantees and EPA to collaborate and explore new approaches to environmental protection that are systems-oriented, forward-looking, preventative, and collaborative (see Table 1.2).

Table 1.2: Collaborative Science and Technology Network for Sustainability Program Goals.

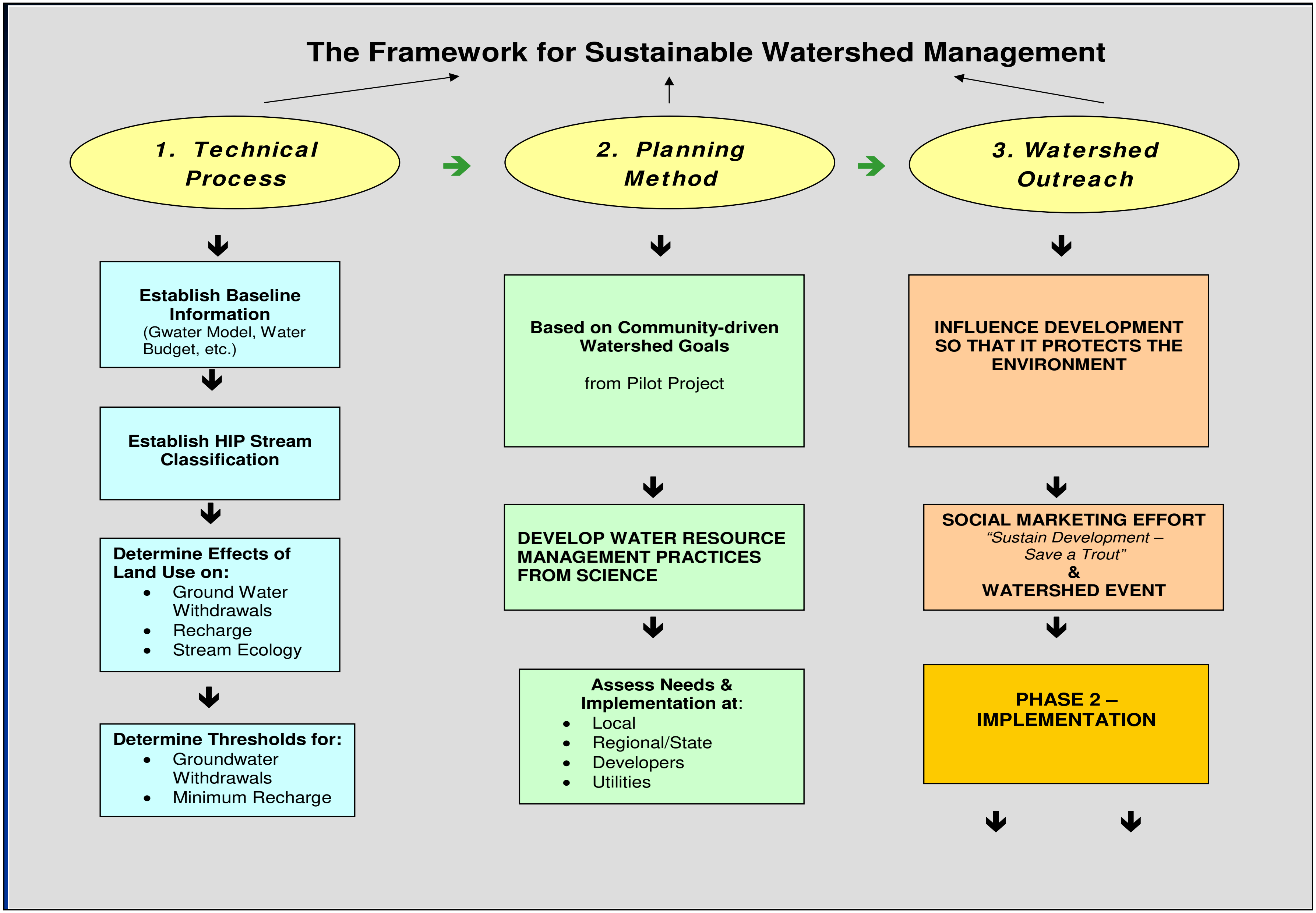
- Develop tools for sustainable management of resources
- Support the transfer of new technology and methods
- Promote systems oriented, preventative approaches
- Fund regional scaled demonstration projects
- Encourage collaboration among EPA-ORD innovators

EPA-R3, aware of the new CNS initiative, expressed interest in the Pocono Creek pilot project and the opportunity to collaborate on establishing a framework for sustainable watershed management for the Pocono Creek watershed. Building on the watershed community's goals established during the Pilot study, the EPA-CNS provided funding and technical support to establish a framework for watershed sustainability.

The Framework is supported by three pillars of sustainable watershed planning: technical, planning and community outreach (see Figure 1.2). The technical studies established the relationships among groundwater, surface water, land use and habitat. The findings of the technical studies provided the basis for planning and development of watershed management practices matched to the sub-watershed characteristics. However, implementation of management practices requires coordination and collaboration of a broad spectrum of shareholders. Management strategies include identifying the inconsistencies in the regulatory environment where water resource management takes place (see Chapter 6).

A regulatory review identifies the span of decision makers impacting water resources across numerous sectors (see Chapter 5). It is found that multiple levels of government, throughout numerous agencies, and within various departments in those agencies, have responsibility for water resource management. Conversely, in the private sector, it is found that industrial and business developers are regulated by a different universe of government agencies having similar complexities. These agencies (e.g., Public Utility Commission) have a parallel organizational structure that favors infrastructure development to manage growth. Meanwhile, sustainable watershed management requires land use decisions that are made at the local level where land use and resource protection are not frequently considered simultaneously. Thus, the third Framework pillar, outreach, is used to lay the groundwork for a more strategic social marketing effort that would provide long term multi-sector sustainability oversight. The BWA along with the Pocono Arts Council (PAC) orchestrated an innovative "watershed community'" program that laid the groundwork for a future social marketing efforts with a highly visible community art project that installed 15 five-foot artist decorated fiberglass trout throughout the watershed with "chapters" of a trout's water tale affixed to each statue. The "Trout Tale" story links streamflows to the economy, and suggests that economic and environmental systems can co-exist.

Figure 1.2: The Framework for Sustainable Watershed Management Includes Three Pillars; Technical, Planning and Outreach.



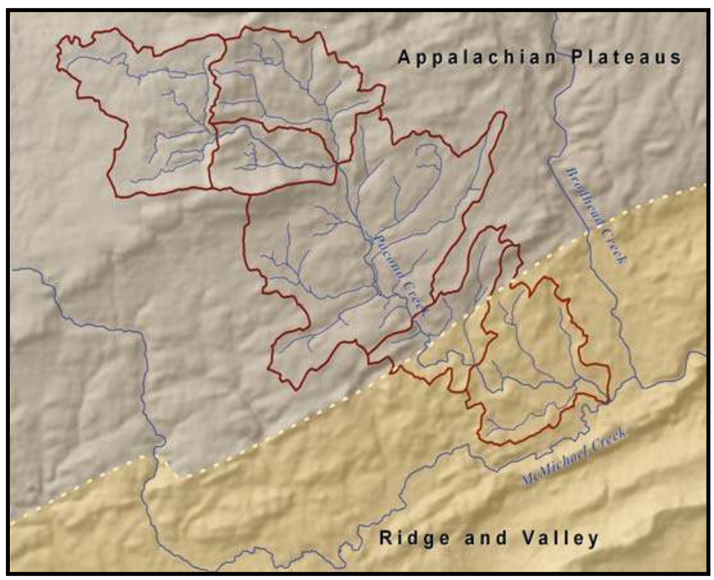
Chapter 2: Project Setting

The Pocono Creek watershed (see Figure 2.1) is a 48.5 square mile basin located in northeastern central Monroe County in Pennsylvania in the Delaware River Basin. The Pocono Creek headwaters drain from the Pocono Plateau and flow through a 16-mile valley to the McMichaels Creek, which in turn, drains into the Brodhead Creek, a tributary to the Delaware River (see Figure 2.2).

Pocono Creek's topography is characterized by rolling hills and its watershed is located within two physiographic provinces, the Appalachian Plateau to the north and the Valley and Ridge Province in the southern part of the watershed (see Figure 2.2). The Appalachian Plateau physiographic province is subdivided into the Pocono Plateau to the northwest and the Glaciated Low Plateau province by the Pocono Plateau escarpment. The Appalachian Plateau physiographic province is categorized by gently folded rocks and encompasses more than 75% of the area in the sub-basin. The Appalachian Mountain section occupies the southern portion of the watershed and is characterized by more intensely deformed sedimentary rocks (Sloto, 2008)

Figure 2.1: Location of Pocono Creek Watershed in Delaware River Basin.

Figure 2.2: Pocono Creek Topographic and Physiographic Regions.



The entire Pocono Creek watershed has been covered by continental glaciers at least 3 times, with the last ice age ending about 15,000 years ago (TNC website). The Pocono Plateau and a variety of features in the watershed are a result of the continental glaciation and exhibits features resulting from the deposition of glacial deposits including terminal moraines. The Pocono Plateau escarpment runs north/south and forms the study area's most prominent topographic feature, Camelback Mountain. Another important site in the watershed is the Tannersville Cranberry (peat) Bog that is located at the eastern edge of the watershed (see Figure 2.3). The Bog's designation as a National Natural Landmark establishes it as one of the nation's most valuable natural biotic and geologic forms. During the glacial retreat, a series of post-glacial lakes, or "Paternoster Lakes," were formed and drainage from these flowed eastward toward the Delaware River though the glacial valley. Glacial deposits overlie much of the bedrock in the watershed and are composed of varying amounts of gravel, sands, and clay. The Glaciated Low Plateau is composed of shale, siltstone and sandstone. The Appalachian Mountains within the Valley and Ridge Province contain more intensely deformed rocks than those of the Appalachian Plateau.

Figure 2.3: Tannersville Cranberry Bog. (Bob Limbeck, DRBC)

2.1 Hydrology

In the Pocono Creek watershed groundwater moves through a network of interconnecting fractures and joints in the bedrock where permeability depends on the number and size of fractures and the degree of fracture interconnections. Groundwater may be confined locally. In the unconsolidated surficial deposits, groundwater moves through the void spaces. All water supply wells in the Pocono Creek watershed are from bedrock (Sloto, 2008).

All wells have similar characteristics, with water levels responding to the groundwater recharge from precipitation and from the groundwater system to pumping wells, groundwater evapotranspiration, and streams. Water levels generally rise during November to May when evapotranspiration is at a minimum and recharge is at a maximum. Water levels generally decline during June to October when evapotranspiration is at a maximum and recharge is at a minimum. Most of the watershed's wastewater is disposed of through onsite septic systems. (Sloto, 2008)

The principal components of flow to and from bedrock aquifers include (1) direct recharge from precipitation where bedrock units are exposed; (2) flow to and from overlying surficial units; (3) recharge from streams; (4) groundwater discharge to surface water bodies, such as streams, lakes, and wetlands; and (5) evapotranspiration directly from the bedrock groundwater system. The principal components of flow to and from surficial aquifers include (1) direct recharge from precipitation where surficial units are exposed; (2) flow to and from underlying bedrock units; (3) recharge from streams, especially losing reaches in the lower part of the Pocono Creek valley; (4) groundwater discharge to surface water bodies, such as streams, lakes, and wetlands; and (5) evapotranspiration directly from the surficial groundwater system (Sloto, 2008)

2.2 Soils

The soils of the Pocono Creek watershed are a critical component of watershed hydrology. For planning purposes, establishing soil characteristics for water retention, permeability and runoff is necessary for appropriate selection and design of management strategies that may be employed to protect watershed hydrologic integrity.

2.2.1 Natural Soil Drainage Classes

Natural soil drainage classes represent the moisture condition of the soil in its natural condition throughout the year. Natural drainage classes indicate the degree, frequency, and duration of wetness and saturation and refer to the soil's capacity to eliminate excess water from its profile. Soils in the Pocono Creek watershed are predominately well drained and somewhat excessively well drained. For this study, DRBC has consolidated the seven soil categories used by the Natural Resource Conservation Service (NRCS) into three groups: excessively drained, well drained, and poorly (see Table 2.1). As shown on Figure 2.4, soils in the Pocono Creek watershed are predominately well drained and somewhat excessively well drained.

- **Excessively Drained:** This category includes excessively drained and somewhat excessively drained soils where water is removed from the soil rapidly. These soils are very porous with permeability. The occurrence of internal free water is very rare or very deep.

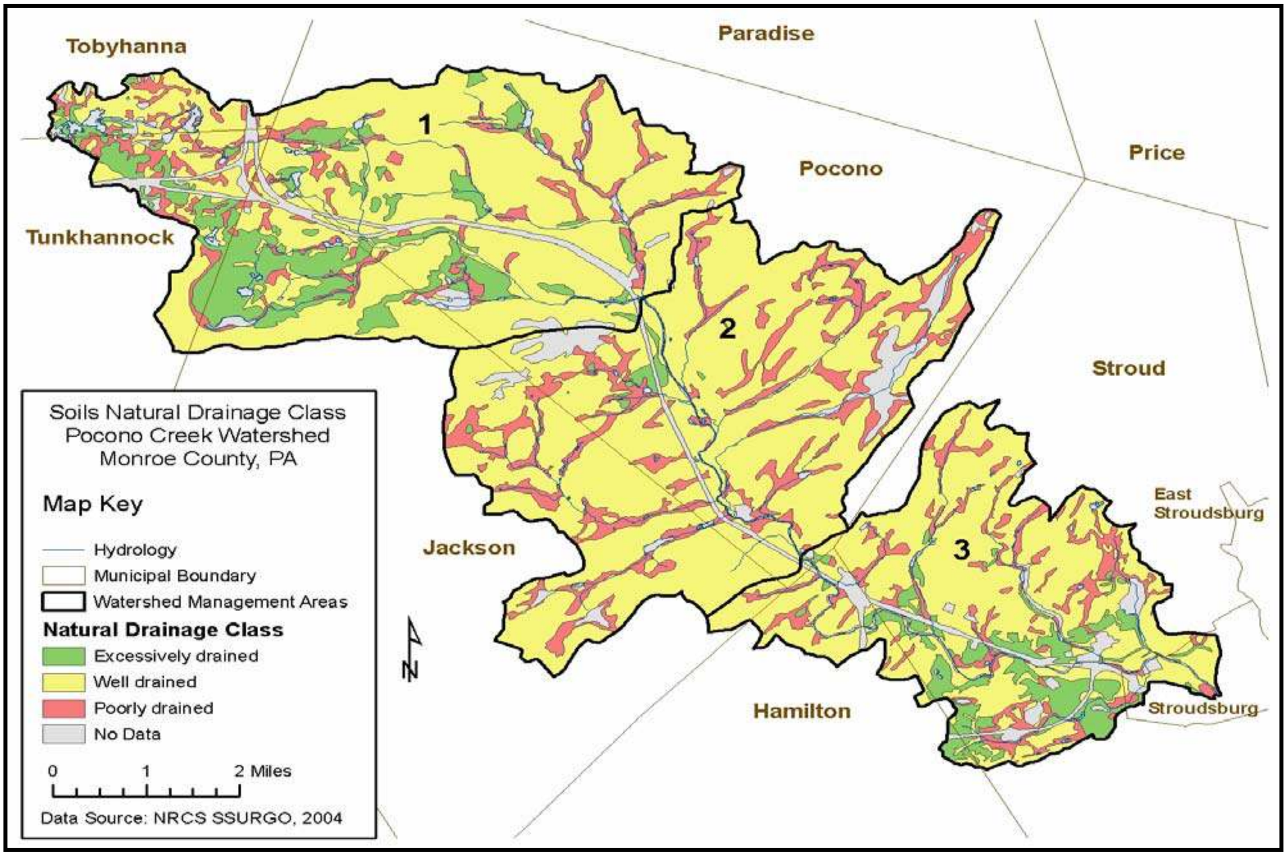
- **Poorly Drained:** This category includes poorly, somewhat poorly and very poorly drained soil. These soils are wet for significant periods of time. Water is removed so slowly that the soil is wet at shallow depths periodically or that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is shallow or very shallow and common or persistent. The soils are commonly level or depressed and frequently ponded. If rainfall is high or nearly continuous, slope gradients may be greater.

- **Well Drained:** This category includes well drained and moderately well drained soils. Water is removed from the soil readily but not rapidly or somewhat slowly during some periods of the year. Internal free water occurrence is moderately deep, deep or very deep and annual duration is not specified, but could be transitory or permanent. Natural drainage classes indicate the degree, frequency and duration of wetness and saturation.

Table 2.1: Natural Soil Drainage Classes in Pocono Creek Watershed.

Pocono Watershed Soils Natural Drainage Class	**NRCS Natural Drainage Class**
Excessively drained	Excessively well drained
Excessively drained	Somewhat excessively well drained
Well drained	Well drained
Well drained	Moderately well drained
Poorly drained	Poorly drained
Poorly drained	Somewhat poorly drained
Poorly drained	Very Poorly drained
Null	Null
DRBC, 2008	Sources: NRCS, SSURGO, 2004

Figure 2.4: Natural Soil Drainage Classes in Pocono Creek Watershed.



Surface runoff classification refers to the amount of water lost from an area by excess water flow over the land surface. Surface runoff differs from subsurface flow or interflow and moves laterally when conditions support free surface water. Figure 2.5 shows surface runoff classification for the Pocono Creek watershed. For this study, the six runoff classifications used by the NRCS are consolidated into three groups: high, medium and low (see Table 2.2).

Figure 2.5: Surface Runoff Classification for the Pocono Creek Watershed.

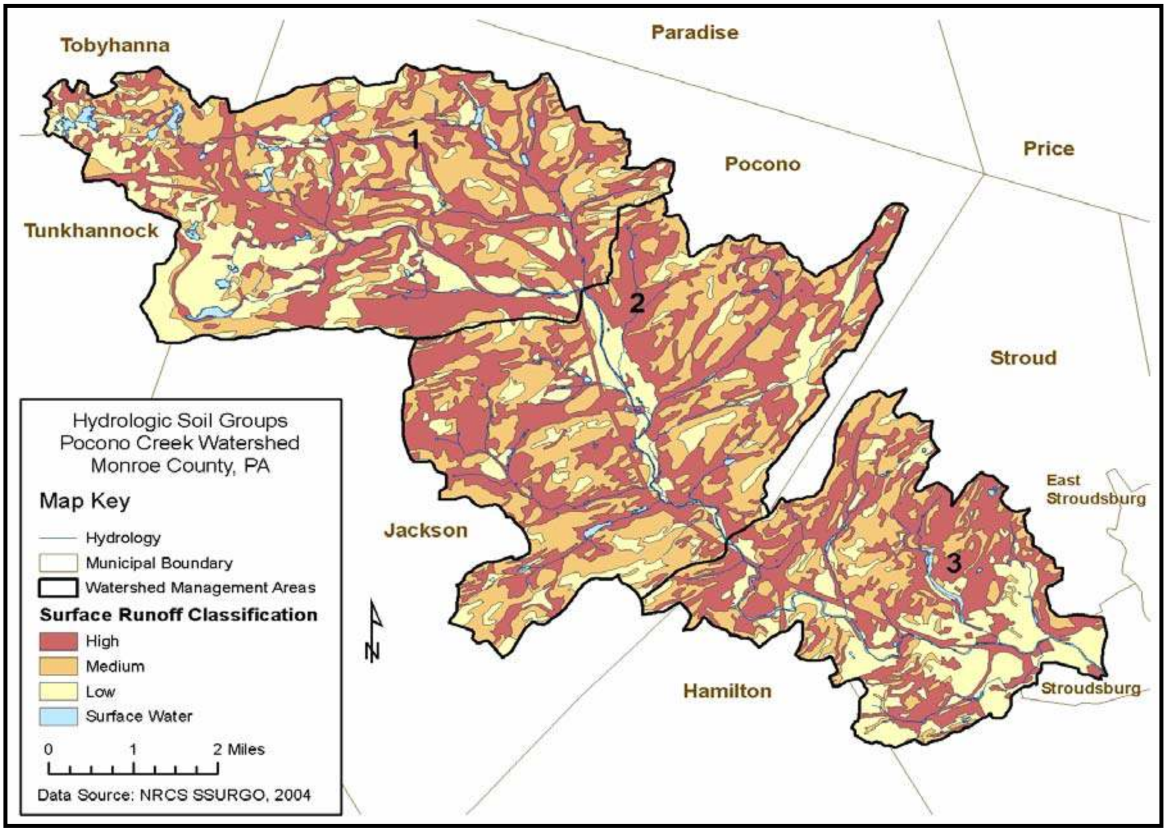


Table 2.2: Surface Runoff Classification for the Pocono Creek Watershed.

Surface Runoff Classification	NRCS Runoff Class
High	Very High
High	High
Medium	Medium
Low	Low
Low	Very Low
Low	Negligible
Null	Null
	Sources: NRCS, SSURGO, 2004

2.2.2 Hydrologic Soil Groups

Hydrologic soil groups classify soil types by their ability to infiltrate runoff. Hydrologic groups are used in equations to estimate runoff from rainfall. The U.S. soils classified into four groups defined below. Figure 2.6 shows hydrologic soil groups for the Pocono Creek watershed.

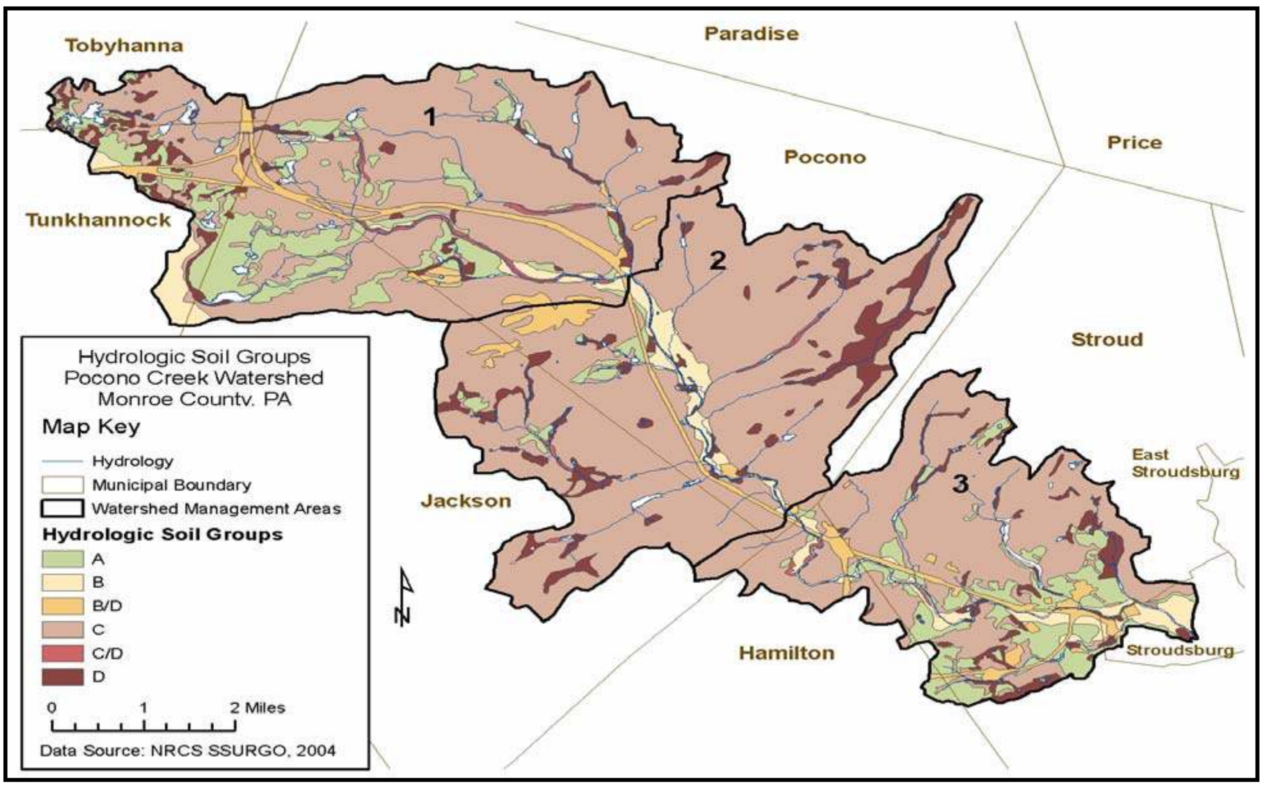
- A Soils-have low runoff potential and high infiltration rate when saturated. Often sandy and gravelly, deep, and well drained.

- B Soils-have moderate infiltration rate when fully wet, are moderately deep or deep, moderately well drained or well drained with fine to course textures.

- C Soils-have slow infiltration rates when thoroughly wet, consisting of soils that have a layer that impedes infiltration and are moderately fine or fine texture.

- D Soils- high runoff potential from a slow infiltration rate, with a layer of clay near the surface, and have a permanent high water table, or are shallow over nearly impervious bedrock or other material.

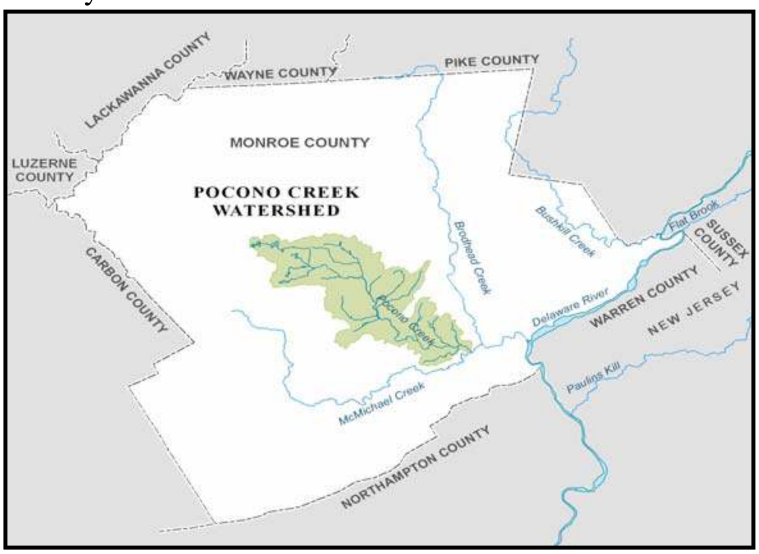
Figure 2.6: Hydrologic Soil Groups for the Pocono Creek Watershed.



2.3 Location

The Pocono Creek watershed is located in northeastern Pennsylvania in central Monroe County. The Delaware River is the county's eastern border from Sussex County, New Jersey and includes over 6000 acres of the Delaware Water Gap National Recreation Area (Figure 2.7). Positioned 75 miles and 90 miles respectively from the New York and Philadelphia metropolitan regions, the watershed is less than a 2-hour ride from either area. At the Delaware Water Gap, U.S. Interstate 80 crosses from New Jersey into Pennsylvania and parallels Pocono Creek (see Figure 2.8). Also paralleling Pocono Creek is State highway 611, the region's primary commercial artery that cuts through to the Pocono Plateau.

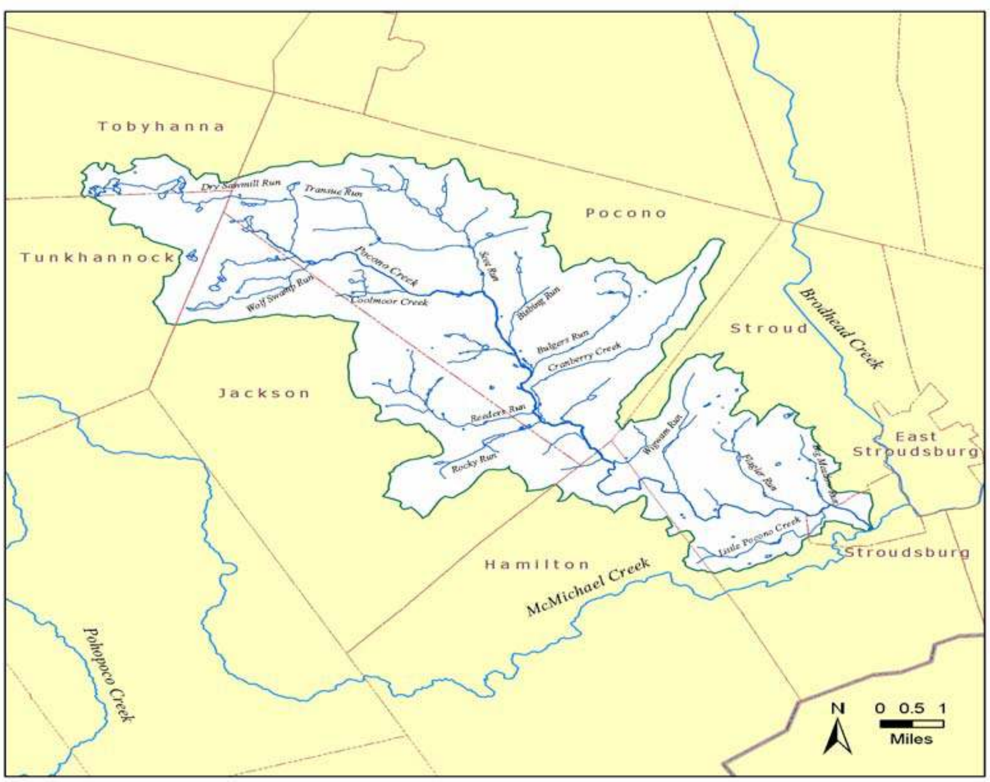
Figure 2.7: Pocono Creek Watershed in Monroe County, Pennsylvania.



The Pocono Creek watershed is generally rural in character. The headwaters area has abundant areas of open space, including state game lands, with intermittent pockets of residential development. The degree of development follows a typical east coast watershed development pattern, which is a progressively intensified build-up from the headwaters, i.e. the plateau, towards the confluence area. In the Pocono Creek watershed the headwaters drain to the southern most point of the watershed, Stroudsburg, a small urbanized town center that is the county seat. The lower 8 miles of Route 611 have water and sewer lines out of Stroudsburg. Figure 2.9 shows the seven municipalities that the Pocono Creek transects.

Figure 2.8: Route 80 overpass along the Pocono Creek. (Bob Limbeck, DRBC)

Figure 2.9: Pocono Creek Watershed and Municipalities.



2.4 Land Use

During the Pilot study, a windshield survey was completed to determine the distribution of the types of land use throughout the watershed. As shown in Table 2.3, the Pocono Creek watershed has a broad range of land uses including interstate, state and local roadways, an urbanized town center, a retail and commercial corridor, recreational and industrial areas, high, medium and low density residential areas, and open space, which comprises half of the watershed. Public water and sewer lines run from Stroudsburg about a third of the way up the watershed, along Route 611. The Pocono Creek watershed 2002 Pilot showed about 11% -12% impervious cover, with the Headwaters area with less than 10% while the Central area exceeded 10% and the Lower Pocono was over 20% imperviousness. Since the impervious surface study was completed, there has been additional development, especially along the Route 611 corridor.

Table 2.3: Distribution of Land Use in Pocono Creek Watershed, 2002.

Land Use	% of LU in Pocono Creek Watershed	% of Imperviousness from LU
Open Space	**50.7**	**0**
Low Density (< 5 units/acre)	**38.5**	**3.9**
Medium Density (2-4 units/acre)	**3.0**	**1.2**
High Density (> 4 units/acre)	**2.3**	**1.4**
Commercial/Roads/ Industrial	**5.5**	**5.5**
Total Watershed	**100**	**12**

Scientific and technical literature has established an association between impervious surfaces and impacts on waterways. Impervious surface area proportional to a watershed's area can be used as an indicator of aquatic health and biodiversity. Research at the Center for Watershed Protection shows that when the level of imperviousness within a watershed reaches 10%, the "health" of the stream starts to deteriorate. The next threshold is 15% when the degree of impact begins to accelerate, and when there is 25% impervious surface in a watershed, a stream can no longer support a diverse wildlife community (Schueler, 2000).

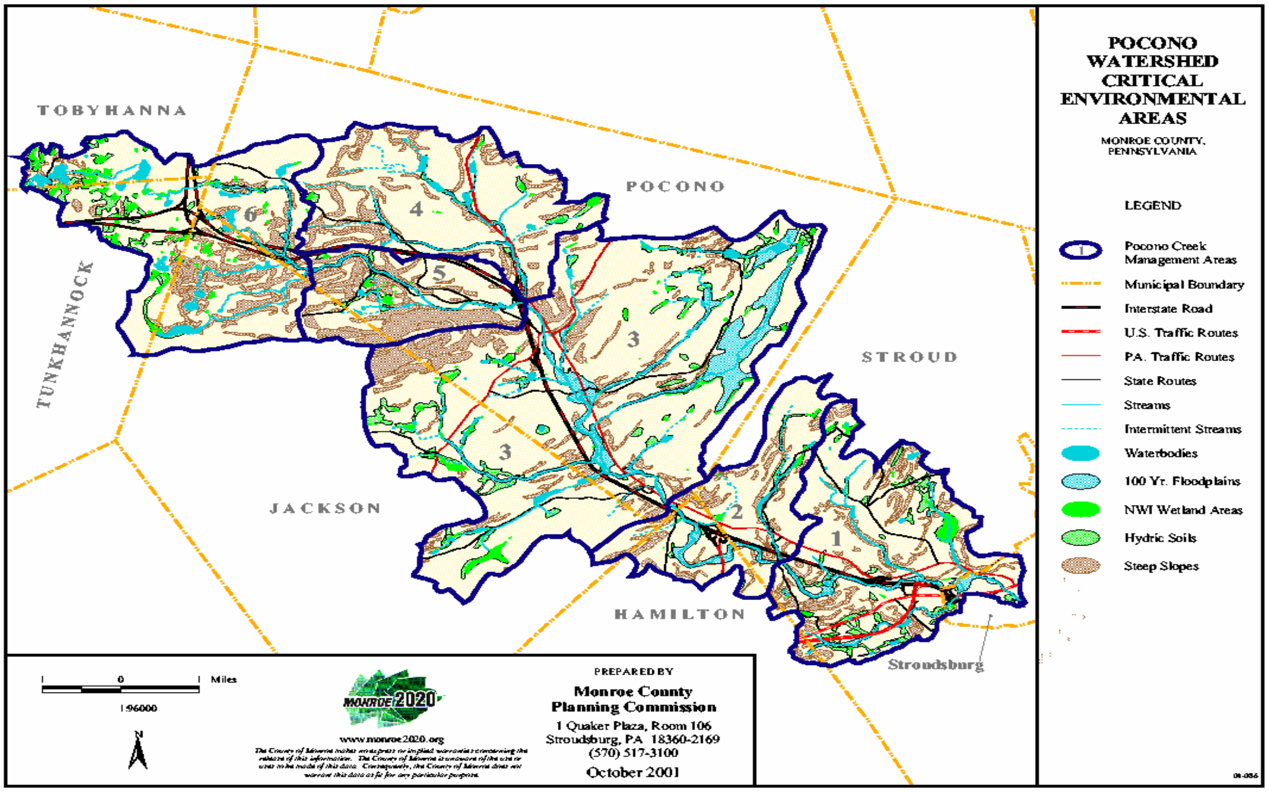
2.5 Critical Environmental Areas

The Pilot showed that approximately one third of the Pocono Creek watershed consists of Critical Environmental Areas (CEAs) (see Table 2.4). CEAs are sub-categories of land use designations that are ecologically, geologically or hydrologically sensitive to alteration. These areas of fragile ecology and biodiversity are critical to a watershed's hydrologic integrity. These high value areas provide critical hydrologic functions within the watershed, including maintaining ecological stability. CEAs that remain intact can recharge aquifers and maintain ecological flows, reduce stormwater runoff by retaining a watershed's natural drainage patterns, and protect water quality and water supplies. CEAs inside the Pocono Creek watershed include floodplains, wetlands, hydric soils, steep slopes (at or above a 17% grade), and water bodies (Figure 2.10).

Table 2.4: Critical Environmental Areas Acreage in Pocono Creek Watershed.

Pocono Creek Watershed's Critical Environmental Areas		
Total Acres in Pocono Creek Watershed 31,560		
Critical Area Type	**Acreage**	**% of Watershed**
Floodplain	1698	5.38%
NWI wetland	1330	4.21%
Nydric soil	2271	7.20%
Steep slopes	4824	15.29%
Water	331	1.05%
TOTAL	10,454	33.12%

Figure 2.10: Critical Environmental Areas in Pocono Creek Watershed.



2.6 Water Quality

The existing water quality in the Pocono Creek watershed is generally outstanding. Pocono Creek, as are most of Monroe County's streams, is designated by DEP as High Quality Cold Water Fishery (HQ-CWF) or Exceptional Value (EV) and is within the drainage area of DRBC's Special Protection Waters. The Pocono Creek's Wolf Creek qualifies as a Class A trout stream by the PAF&BC, based on the existing water quality that includes abundant cold, spring-fed flowing water in a silt free rocky channel.

Review of existing data during the Pilot study by Dr. Robert Traver, indicated that temperature in Pocono Creek that does not meet the statewide temperature standards on a regular basis. Although there is no state criterion for Dissolved Oxygen (DO), it is a parameter that reflects the health of a stream, especially trout streams, and is related to temperature. DO can be expressed as a percent of the saturated capacity of the waters, which is a function of temperature. A review of DO data shows DO deficiencies increase with increasing temperature. Low DO values indicate areas in the Pocono Creek where biological activity has "used up" the stream's oxygen faster then it can be replaced.

Chapter 3: Approach

The *Framework for Sustainable Watershed Management* (Framework) was designed to include fundamental disciplines necessary for integration of water resource management and economic development. Three main pillars are incorporated into the planning process for the Framework:

1. Science,
2. Planning and Policy, and
3. Education.

Each pillar is sequential, and provides the basis for the development of the next project stages. In the Framework scientific methods are used to: 1) identify or develop scientific techniques to evaluate the impact of future growth projections on the hydrology of the Pocono Creek watershed; 2) apply the technical findings to determine immediate practices that could be used within the watershed, doing what is possible within the current regulatory structure and socio-economic environment; and 3) design and implement an innovative outreach and education effort to enhance "watershed community" identity by using wild trout as the program focus.

The Framework utilizes integrated watershed management as the primary approach to sustainable watershed planning. This provides a unique and comprehensive approach that bridges gaps between natural environmental processes, existing multi-tiered laws and regulations, and land use objectives that support economic development.

The hydrologic integrity of a watershed is retained when water cycles over the landscape and through the subsurface geology without disruption. Watershed topographical and geological boundaries are used as fundamental planning units to balance natural hydrologic functions with future land use changes. The objective of the Framework is to keep or restore the connection between a watershed's hydrology and its aquatic habitat, both of which may be impacted by land use changes.

Currently, watershed planning focuses on non-point source pollution, an offshoot of stormwater management programs. However, the Framework recognizes that watersheds are highly complex systems that function in four dimensions (longitudinal, lateral, vertical and temporal) where the terrestrial processes of the water cycle take place. Watersheds are ecosystems where many functional hydrological processes take place (water collection, storage, discharge, pathways for water to travel, conduits for chemical reactions , and provides the biological elements of a habitat

(Black, 1997)). In order to retain the watershed's hydrologic integrity, flow paths must remain operable, soil structure must retain friability and porosity, and riparian vegetation needs to be protected or established.

The Framework encompasses social and economic concerns as well as natural resources. In the Poconos, the economic engine is the natural resource base, including land and water resources. Thus, the Pocono Creek watershed and its ecology support economic and social as well as environmental systems. Integrated Watershed Management brings together independent disciplines that ordinarily address only partial aspects of water management, such as stormwater and flooding, or water quality or wastewater, or economic development and infrastructure. Pennsylvania water quality programs are top-down permitting programs that attempt to minimize adverse impacts after local land use decisions have been made. In addition, water infrastructure decisions are made by agencies associated with economic and community development funding, and neglect to assimilate impacts from hydrologic changes into long term fiscal projections.

The Planning and Policy pillar of the Framework addresses sustainable approaches to water resource management at all levels of government, from local decision making at the municipal and county levels to federal and state jurisdictions. It looks at the linkages among overlapping regulatory sectors, such as land use, economic development, utilities and authorities, industrial and commercial, recreational and public health. The Education pillar of the Framework utilizes public participation and expertise from a broad range of stakeholders and coordinates decision-makers across the various sectors impacting water resources. It emphasizes a democratic process, where all stakeholders collaborate to establish water resource policies and make decisions in response to specific challenges.

Ultimately, sustainable communities, economic development, natural resource protection, and enhanced quality of life cannot be obtained unless integrated watershed planning is used for local and regional land use decisions. The benefits of resource based planning of the Framework include: predictability and consistency across programs and political boundaries, improved fiscal impact, focused open space initiatives, sustainable tourism, and focused infrastructure investment.

3.1 Science

The technical studies performed in this project examine the potential for alterations to baseflow from projected groundwater withdrawals and land use changes in the Pocono Creek watershed. Since trout are used by the PF&BC in the classification of high quality and exceptional value streams, and because the Pocono Creek's excellent water quality and abundant flows support propagating trout populations, trout are used as an indicator species in this project. See Table 3.1 for PF&BC trout waters classification.

Table 3.1: Pennsylvania Fish and Boat Commission Listings for Trout Waters Classification.

• **Class A Wild Trout Streams**: Streams that support a population of wild (natural reproduction) trout of sufficient size and abundance to support a long-term and rewarding sport fishery. The Commission does not stock these streams.
• **Stream Sections that support Natural Reproduction of Trout**: Stream sections supporting naturally reproducing populations of trout. A wild trout stream section is a biological designation that does not determine how it is managed; therefore, these streams may also be stocked with hatchery trout by the Commission.
• **Wilderness Trout Streams**: Management is based upon the provision of a wild trout fishing experience in a remote, natural and unspoiled environment where man's disruptive activities are minimized. Established in 1969, this option was designed to protect and promote native (brook trout) fisheries, the ecological requirements necessary for natural reproduction of trout and wilderness aesthetics. The superior quality of these watersheds is considered an important part of the overall angling experience on wilderness trout streams. Therefore, all stream sections included in this program qualify for the Exceptional Value (EV) special protected water use classification, which represents the highest protection status provided by the Department of Environmental Protection (DEP). *http://www.fishandboat.com/waters_trout.htm*

3.1.1 Studies Performed

In order to evaluate the potential effects of growth on groundwater, streamflow, and trout populations in Pocono Creek watershed, the technical team:

- Developed a distributed watershed hydrologic model that established current infiltration and runoff rates, potential changes of infiltration and runoff at build-out, and the degree of impact at current levels of development compared to a forested condition (predevelopment) (Hantush, 2006);

- Developed a 3-dimensional groundwater model to estimate the effects of potential reduction in recharge caused by land use changes and the effects of groundwater withdrawals on stream baseflow for projected build-out conditions (Sloto, 2008);

- Determined the Pocono Creek's hydro-ecological classification and the impact on the stream indices for the build-out scenario. Also, an attempt was made to relate flow indices to trout populations (Henriksen, 2006); and

- Assessed the degree of change to trout populations from altered baseflows (Cade, 2008)

3.1.2 Setting Environmental Planning Criteria

Over the past few decades, there has been increasing recognition by the scientific community that the flow regime is a major factor in determining the long term health and sustainability of a stream's aquatic ecosystem. Richter, et al. (1997) provides a substantial review of the accumulated research on the relationship between hydrologic variability and river ecosystem integrity. That research recognizes that the full range of natural intra- and inter-annual variation of hydrologic regimes and associated characteristics of magnitude, timing, duration, frequency, and rate of change are critical in sustaining the full native biodiversity and aquatic integrity of aquatic ecosystems (Poff, 1997). Richter goes on to recommend that in the absence of stream-specific flow – biology relationships, which is the case with Pocono Creek, initial flow targets should cover the full range of hydrologic variability associated with select hydrologic parameters. Richter suggests that a good, initial flow target would maintain the median of the flow metric of interest within the 25th percentile to 75th percentile range for that metric under reference conditions. This would represent the approximate unaltered flow condition. It is also recognized that the selection of the flow targets should take into account the ecological consequences of not achieving the target. For example, in high value ecosystems where one may want to reduce the risk that it will be impacted, a more restrictive percentile range (e.g., 35th to 65th percentile) could be selected. Conversely, if a higher degree of risk could be tolerated, one might select a broader percentile range (e.g., 5th to 95th percentile).

Henriksen accepted the Richter approach and recommended a 25/75 percentile range as an appropriate initial criterion for Pocono Creek. In view of the existing high ecological value of Pocono Creek, and the threat posed by the projected future land use change, the 25th percentile to 75th percentile range is considered an appropriate level of protection for Pocono Creek (Henriksen). We also recognize that it is important to implement an "adaptive management" approach to ensure that the quality of Pocono Creek is maintained. Such an approach would involve monitoring Pocono Creek and making appropriate adjustments to the management approach in response to what is learned from the monitoring data and other relevant future information.

3.1.3 Application of the Environmental Planning Criteria

A violation of the planning criteria occurs whenever the median for a hydrologic index value for a selected scenario falls outside of the inter-quartile (75/25 percentile) of the median for the reference condition scenario. For Pocono Creek, the study evaluates the impacts on streamflow and ecological integrity at a land use build-out condition compared to both existing land use conditions and a "hindcast" undeveloped forested watershed condition.

3.2 Planning and Policy

3.2.1 Development of Sustainable Watershed Management Strategies

The project planners have developed innovative approaches for watershed-based best management practices (BMPs) for on-the-ground projects, performed a review of the existing laws and regulations affecting water resource management, and established a long-term regional oversight group for water and natural resource protection that will integrate water resource concerns into land use and development decisions.

3.2.2 Watershed Management Areas

The management strategies address the "disconnect" between watershed planning and local land use decision making processes. In Pennsylvania, watershed planning must contend with the authority of "home rule," where the state constitution provides local municipalities full land use powers. Since watersheds are delineated by the geologic and geographic features of the terrain, a watershed often overlaps numerous municipalities. In response to this situation, Watershed Management Areas (WMAs) are established based on sub-watersheds that share similar natural, geographical and physiological characteristics as well as demographic and social conditions. For this study, three WMAs are formed: Headwaters, Transitional and Urban.

Using the WMA approach, area-specific strategies can be developed to address unique characteristics and needs, without imposing additional burdens on any area beyond its boundary. Therefore, decision makers can focus on water resource issues in the sub-regions contained in their municipality, instead of in the entire watershed. WMAs enable municipalities to partner with other municipalities in their WMA to manage water resources consistently. WMAs are developed to help limit the number of issues to be addressed by each individual municipality.

3.2.3 Regulatory Structure Review

In order to establish regulatory consistency for water resource management, it is essential to understand the labyrinth of regulations that involve or affect water. It is also necessary to know the full range of stakeholders in a watershed to be included in any collaborative effort to integrate sustainable watershed practices. Developing a new process for integrating the numerous elements of sustainable watershed management requires that shareholders understand the shortcomings of the existing approach, before they can devise an alternative process. The current juxtaposition of laws, policies, regulations, and rules of the different legal sectors that impacts water and its management includes agencies within all levels of government, and multiple agencies within each level of government. Frequently, within a single agency, multiple departments have policies, rules and procedures that can impact watershed integrity.

In an attempt to identify and analyze connections among the different sectors of government that regulate activities that affect watersheds, an overview of the regulatory structures has been prepared. These include laws for the environment, water quality, water supply, stormwater, infrastructure, land use, public health, conservation, recreation, silviculture, infrastructure and economic development.

3.3 Education

When pursuing a fully integrated watershed management program, it is necessary to establish broad-based support throughout the community. The Brodhead Watershed Association (BWA) initiated an innovative watershed outreach program to inform the public about the relevance of watershed management, ecological flows and land use to their environment, economy and community. In order to convey a simple message about the complex topic of sustainable watershed management, the “Develop Right, Save a Trout” campaign was developed. Laying the groundwork for future strategic marketing campaigns, the BWA, Monroe County Conservation District (MCCD), Monroe County Planning Commission (MCPC), and the Monroe County Commissioners partnered with the Pocono Arts Council (PAC) and launched, “Trout Trails and Tales” a watershed based community art project.

Local artists from the Poconos were engaged to decorate fifteen five-foot trout sculptures. Each trout was assigned a section of the “Trout Tale,” that told a story linking trout survival to clean, abundant water supply and to land use. Each trout sculpture was then placed in different locations throughout the watershed to help create a sense of “watershed communities.” A “Trout Trail Map” was developed to guide participants to the individual sites throughout the watershed.

The effort generated extensive media coverage about the need for abundant high quality cold water for trout, raised public awareness of the "plight of the trout" and was supported by contributions from numerous community businesses and groups.

3.4 Transferability

The intent of the EPA's Collaborative Science and Technology Network for Sustainability (CNS) is the development and demonstration of scientifically based, transferable, systems-oriented innovative technologies that are preventative in nature and can be transferred at community and regional levels. Effective transferability of a project's products relies upon their attractiveness to the potential user. Within this study, numerous scientific and planning products can be replicated, as describe in Section 3.4.2.

3.4.1 The Framework

The *Framework for Sustainable Watershed Management* is a transferable methodology for using science based decision making for watershed management. As a planning model the Framework can be adapted to local situations using the fundamental assumptions of integrated watershed management, overall technological processes, planning elements and multi-sector watershed community outreach. Such methods applied in a well coordinated watershed management effort can be used to protect water resources while managing growth.

3.4.2 Technical Products

Each of these technical studies listed below will be described in more detail in Chapter 4. The completed technical reports are found in the noted Appendices.

- <u>Distributed Hydrologic Model</u>**:** This model estimates effects of potential reduction in recharge caused by land-use changes using a Soil and Water Assessment Tool (SWAT) to simulate infiltration and surface flow for existing and projected build-out land use conditions (Appendix A).

- <u>Groundwater Model:</u> This model estimates effects of groundwater withdrawals on stream baseflow using MODFLOW- 2000 groundwater flow model to simulate groundwater flow for existing and projected build-out conditions (Appendix B).

- Hydro-ecological Integrity Assessment Process: This process identifies relevant stream class hydrologic indices for the watershed at a sub-regional level. Projections were made for build-out conditions and flow alterations outside a 75/25% confidence interval were determined to be significant (Appendix C).

- Linking Flow Indices to Trout Populations: This study utilized the flow statistics defined in the Hydroecological Integrity Assessment Process (HIP) to link stream classification and flow conditions with wild trout populations to predict the effects of flow alteration on trout populations. (Appendix D)

3.4.3 Planning Products

- Watershed Management Areas: This approach addresses the challenge of simultaneously engaging numerous municipal representatives within a watershed to collaborate on implementing watershed management strategies.

- Watershed Communities: This includes a watershed-wide identity among municipalities and residents where a shared understanding of sustainable watersheds promotes partnerships through geographically linked issues.

- Issues and Management Strategies: These tools for multiple municipalities within geographic proximity are used to identify hydrologic issues within their WMA and collaborate on selecting and implementing appropriate watershed management strategies for their shared area in a watershed.

- Regulatory Framework Analysis: Seeking consistency in water resource management is a challenge with the labyrinth of laws that address water uses. The analysis introduces the current juxtaposition of laws, policies, regulations, and rules of the different legislative sectors concurrently impacting water and its management in Pennsylvania, plus the role of various agencies within all levels of government regarding water resources. The analysis includes, initial overview of rules addressing water quality, water supply, stormwater, infrastructure, land use, public health, conservation, recreation, silviculture and economic development. A summary of agencies and departments engaged in water programs and regulations is included in Appendix E.

- Sustainable Watershed Stormwater Agency Model: A Stormwater Agency can be used to comprehensively integrate many areas that contribute to watershed hydrology so that growth can occur with minimal impact to the water cycle. Although a conceptual model at this time, it provides a possibility for sharing responsibility for land use components of a sustainable watershed program for municipalities within a watershed. The watershed community may then share the benefits of growth while enjoying protected headwater or other environmentally sensitive areas.

- Model Watershed Transfer of Development Rights: Through the Sustainable Watershed Stormwater Agency Model, watershed hydrologic integrity can be achieved more effectively by transferring development rights within a watershed so that urbanized areas can build at compact densities and forested and open space areas can be preserved. Developed areas would distribute the "added benefits" of development to designated areas that opted to retain the primary functional elements of a watershed's cycle (e.g., headwaters).

3.4.4 Education and Outreach Product

- Innovative Watershed-wide Outreach: Trout Trails and Tales was a watershed community art project that promoted the relationships between land uses, watershed hydrology and ecological flows by using five-foot fiberglass blanks decorated by local artists. Numerous children's programs and contests were also introduced throughout the event. This type of public message campaign can be used for any watershed using the watershed "symbol" of sustainability.

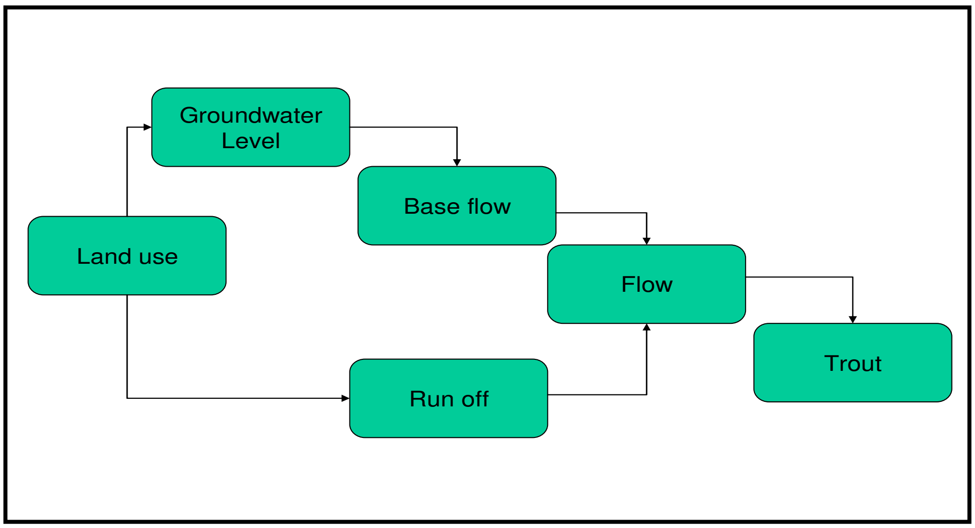
Figure 3.1: A Trout on the Trail. (P. V'Combe, DRBC)

Chapter 4: Technical Stage

4.1 Introduction

The technical stage of the Framework was designed to establish a scientific basis for developing water management strategies for the protection of baseflows in the Pocono Creek watershed. Water resource managers are concerned that existing groundwater levels and surface runoff will be affected by development, altering the existing ecological flow regime and resulting in reduced trout populations (see Figure 4.1).

Figure 4.1: Flowchart Linking Land Use Changes to Trout, an Economic and Environmental Indicator. (Borst, EPA-ORD)



As mentioned previously, this project seeks to develop a process that integrates watershed planning with scientific, policy, and educational outreach products in order to implement strategies for long-term in-stream and out-of-stream water management in the face of development pressures. The Framework's technical studies are designed to: a) establish the watershed's existing hydrologic character, b) determine the stream's existing flow characteristics; c) estimate potential future impacts on baseflows from unmanaged growth, d) determine extent and causes of base flow alterations, e) establish the linkages shared by watershed systems and hydrologic integrity to land use, and f) establish relationships between flow alterations and trout populations.

Trout are sensitive to the effects of streamflow alterations, and are currently used by PF&BC as an indicator of high quality stream habitat. Therefore, trout were also selected as an indicator species for this project. Trout populations depend on the availability of habitat under specific but variable flow conditions, which are a function of watershed hydrology. By identifying a watershed's hydrologic characteristics and processes influencing the hydrologic system, the impacts of land management changes can be evaluated. Furthermore, by managing development so that a significant proportion of the watershed's hydrologic function is maintained, trout populations may be sustained.

The technical objectives for the project are achieved through the development and application of two hydrologic models and a hydro-ecological assessment that determines stream classification type. The studies were undertaken by EPA-ORD, and the USGS-WSC, and USGS-Fort, with contributions from EPA-R3, DRBC and PF&BC. The studies evaluate the effects of growth and land use change on groundwater, streamflow, and the habitat of Pocono Creek. After a baseline characterization of the watershed's existing hydrologic functions, both models and the hydro-ecological classification process simulated existing and projected build-out scenarios and a "hind cast" scenario (i.e., a forested, pre-development condition). Changes between existing and projected conditions for baseflows are used to identify non-supporting flow conditions, when a projected shift in the flow exceeds the 25%-75% confidence interval of the baseline regime. The models and studies assess: a) existing flow conditions and stream classification, b) interactions between groundwater and surface water, and c) effects of development on streamflow characteristics and natural recharge patterns. It was determined that there is not enough data at this time to link the predicted changes in flow regime of Pocono Creek to percentage changes in the trout population.

4.2 Background Data and Analysis

The preparatory actions taken before development of the modeling studies are described below.

4.2.1 Data Collection

The EPA-ORD's Edison, NJ office supplied in-stream equipment and training to support the collection of flow data for the calibration of the distributed hydrologic model and the groundwater model. Automated logging equipment (YSI 6600 sondes) also recorded dissolved oxygen, pH, conductivity, water depth, water temperature and turbidity at three locations throughout the Pocono Creek watershed. In two locations installed flow meters (American

Sigma 950) recorded the depth and flow velocity that are used to estimate the flow rate in sub-watersheds. Tipping bucket rain gauges were installed at two locations to monitor and document total rainfall.

4.2.2 Build-out Projections

For existing and projected land use changes, the technical team used the build-out analysis performed by Monroe County Planning Commission for the 2003 Pocono Creek Pilot Study. The projected build-out map was created by applying maximum densities permitted by existing zoning ordinances within the watershed. The projected changes in distribution of land use types from the year 2000 to 2020 reflect a 70% decrease in combined forest and agricultural use and an increase of almost 41% in sprawling low density residential use. Projections show that transportation, commercial and industrial uses could increase 10 times by 2020. Figure 4.2 shows existing and build-out maps of the Pocono Creek watershed. Table 4.1 shows the percentage change in land use types from 2000 to build-out.

Figure 4.2: Pocono Creek Watershed Land Use for Year 2000 (top) and Projected Build-out (bottom).

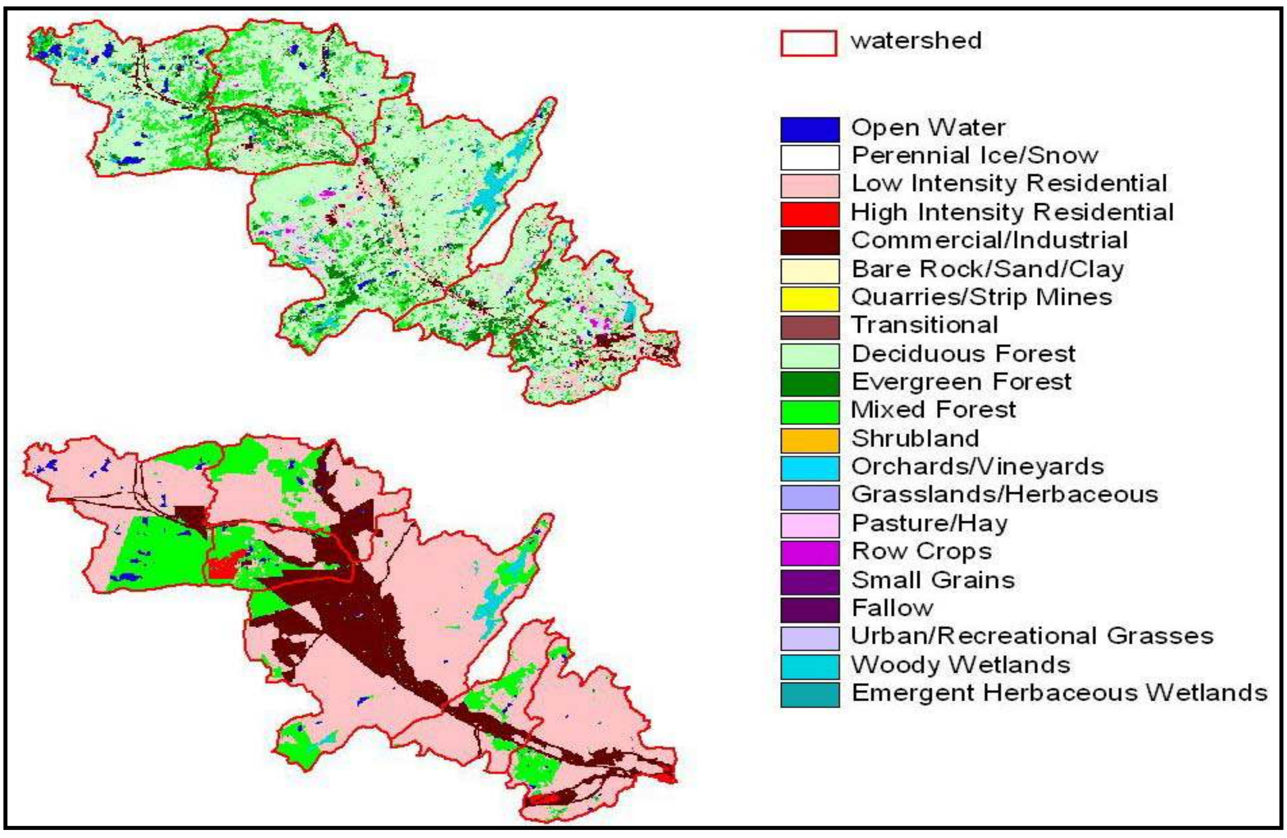


Table 4.1: Percentage of Land Uses Change from 2000 to Build-out.

Pocono Creek Watershed Land Use	2000	Build-out	Change
Forest	85.23	18.7	- 66.5%
Pasture/Crops	3.71	0.27	- 3.4%
Residential – Low Density	3.53	44.19	+ 40.7%
Residential- High Density	0.05	0.77	+ 0.7%
Residential – Medium Density	0	8	+ 8.0%
Commercial/Industrial/ Transportation	2.25	22.84	+ 20.6%
Water	1.43	1.43	0.0
Wet Lands	3.8	3.8	0.0
	100	100	

4.2.3 Existing Water Use

The DRBC performed a water demand analysis for the Pocono Creek watershed. DRBC has reviewed several sources of water use information, because no one source has a complete and current record of water use in the Pocono Creek watershed. Some of the data comes from DRBC's own records (e.g., Project Review) and others are obtained from external sources such as PADEP. The water use databases reviewed in this study are listed in Table 4.2.

Table 4.2: Water Use Data Reviewed.

Database Review	Source Agency
Project Review	DRBC
Water Charges	DRBC
Water Use Data System (WUDS)	PADEP
Act 220 Registration	PADEP

Pennsylvania's Act 220 program requires all water users that use more than 10,000 gallons per day (gpd) to register within the Act 220 database. Data from the 2003 calendar year were reviewed for this study, because it is the most complete dataset available. The Water Use Data System (WUDS) is another database in Pennsylvania. WUDS predates Act 220 and had a general reporting requirement of 100,000 gpd. WUDS data from 1999 were reviewed in this study, because it is the most complete year of records available in WUDS.

A limitation in the water use data review is that it generally does not include water users with an average use of less than 10,000 gpd. Furthermore, the Act 220 registration program commenced in 2003 and new registrants are still being added to the system, so it cannot yet be considered a complete inventory. However, by cross-checking several databases, it is likely that this assessment has captured all water users using greater than 100,000 gpd. and the vast majority of water users greater than 10,000 gpd. in the study area.

4.2.4 Water Data Analysis

The Act 220 and WUDS datasets provide the most complete database of water users for the study area. The databases provide numerous fields (attributes) of interest to this study, such as name, location, water source, category of water use, and monthly and annual total water withdrawals. The user inventory that was developed from the Act 220 and WUDS databases can be found in Table 4.4. These withdrawal points form the basis of the analysis and are plotted on Figure 4.3. Public water service areas are shown on Figure 4.4. Water demand can be broken down into sub-components for the purposes of this study. Water demand was analyzed to explicitly consider the following components:

- Annual Use
- Monthly Use
- Withdrawal Amount
- Consumptive Amount
- Groundwater Use
- Surface Water Use

Consumptive water use was estimated by applying a consumptive use coefficient to the withdrawal based on the type of use of the water. For example, public water suppliers were assigned a consumptive use coefficient of 0.1, meaning that 10% of water withdrawn is not returned directly to the watershed. A more detailed consumptive use estimate can be obtained by looking at discharges in relation to withdrawals. This type of analysis is data and time intensive and is beyond the scope of this investigation, but was carried out in a USGS study (Sloto and Buxton, 2006). An example of where the consumptive use coefficient approach may not reflect actual conditions is where a Public Water Supplier (PWS) withdraws water from a watershed (and may serve a service area in the watershed) but discharges its wastewater outside the watershed. From the perspective of the watershed, the use is 100% consumptive, but from a larger basin perspective, the consumptive use coefficient approach may be valid, as wastewater is returned to the system. Of course, the opposite scenario may occur, and water may be imported to the watershed. The USGS study (Sloto and Buxton, 2006) notes that "Penn Estates Utilities, Inc. operates one well for public-water supply in the Pocono Creek watershed. All water withdrawn from this well is exported from the watershed. It is the only export of water from the watershed." Act 220 registration data (for 2003) show that Penn Estates Utilities, Inc. has added an additional well. The findings of the USGS study (Sloto and Buxton, 2006) are incorporated in this study by assigning a 100% consumptive use factor to withdrawals for Penn Estates Utilities, Inc. Summary statistics for the watershed are shown in Table 4.3.

Table 4.3: Summary Water Use Statistics for Pocono Creek.

	Withdrawals			Consumptive Use		
All values MGD	Ground Water	Surface Water	Total	Ground Water	Surface Water	Total
JAN	0.347	1.447	1.794	0.162	0.318	0.481
FEB	0.322	0.183	0.504	0.139	0.040	0.179
MAR	0.355	1.352	1.707	0.151	0.297	0.449
APR	0.383	0.000	0.383	0.199	0.000	0.199
MAY	0.452	0.000	0.452	0.238	0.000	0.238
JUN	0.512	0.000	0.512	0.259	0.000	0.259
JUL	0.498	0.000	0.498	0.231	0.000	0.231
AUG	0.492	0.000	0.492	0.229	0.000	0.229
SEP	0.478	0.000	0.478	0.238	0.000	0.238
OCT	0.480	0.000	0.480	0.243	0.000	0.243
NOV	0.429	0.000	0.429	0.205	0.000	0.205
DEC	0.445	0.150	0.595	0.211	0.033	0.244
TOTAL	5.193	3.131	8.324	2.505	0.689	3.194

During the development of Act 220, a Geographic Information System-based Water-Analysis Screening Tool (WAST) was used to help in the process of identifying Critical Water Planning Areas. A Critical Water Planning Area may be designated where water demands are, or are projected to be, greater than supply. The results documented in the Act 220 WAST for the Brodhead Creek watershed report (Sayers and Barr, 2009) indicate that almost half of the pour points measured were less than optimal and 20% were currently showing net withdrawals significantly greater than the initial screening criteria, which may cause potential adverse aquatic resource impacts. The report prepared for Brodhead is entitled *Verification of Water-Analysis Screening Tool Results for the Brodhead Creek Watershed. Monroe and Pike Counties, Pennsylvania* and may be found in Appendix F.

Figure 4.3: Known Water Use Locations in the Pocono Creek Watershed.

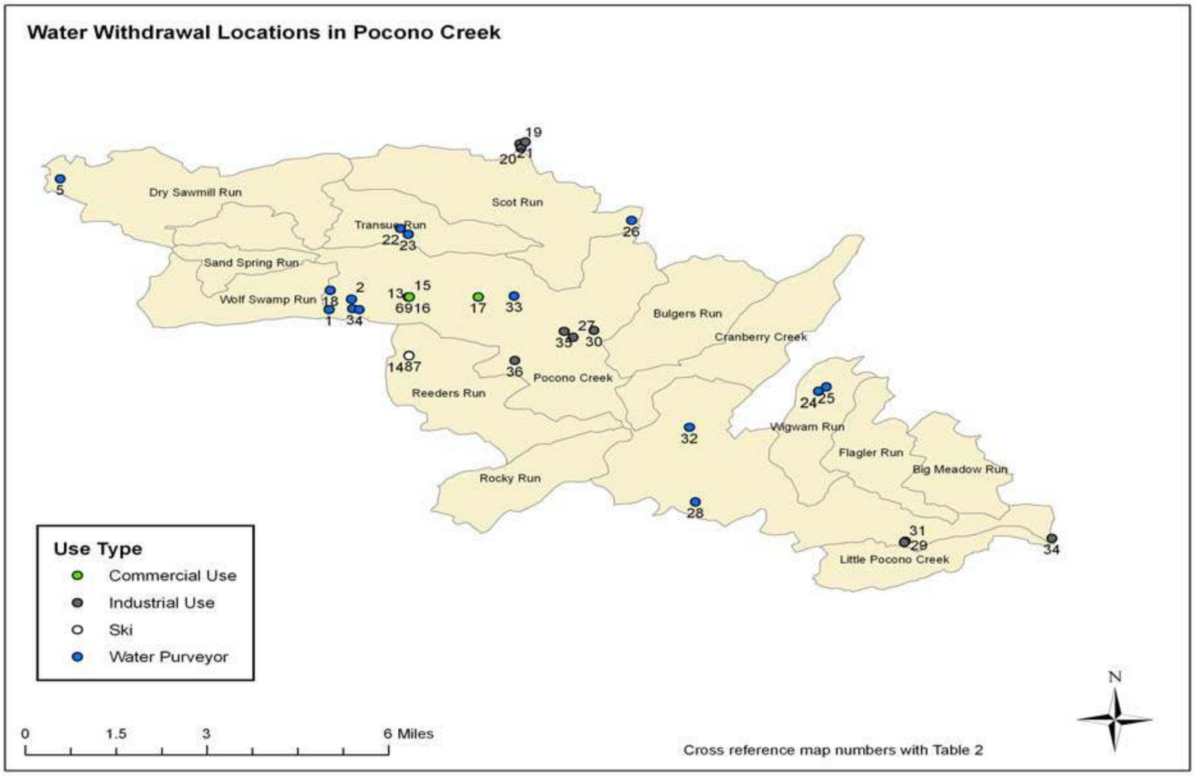
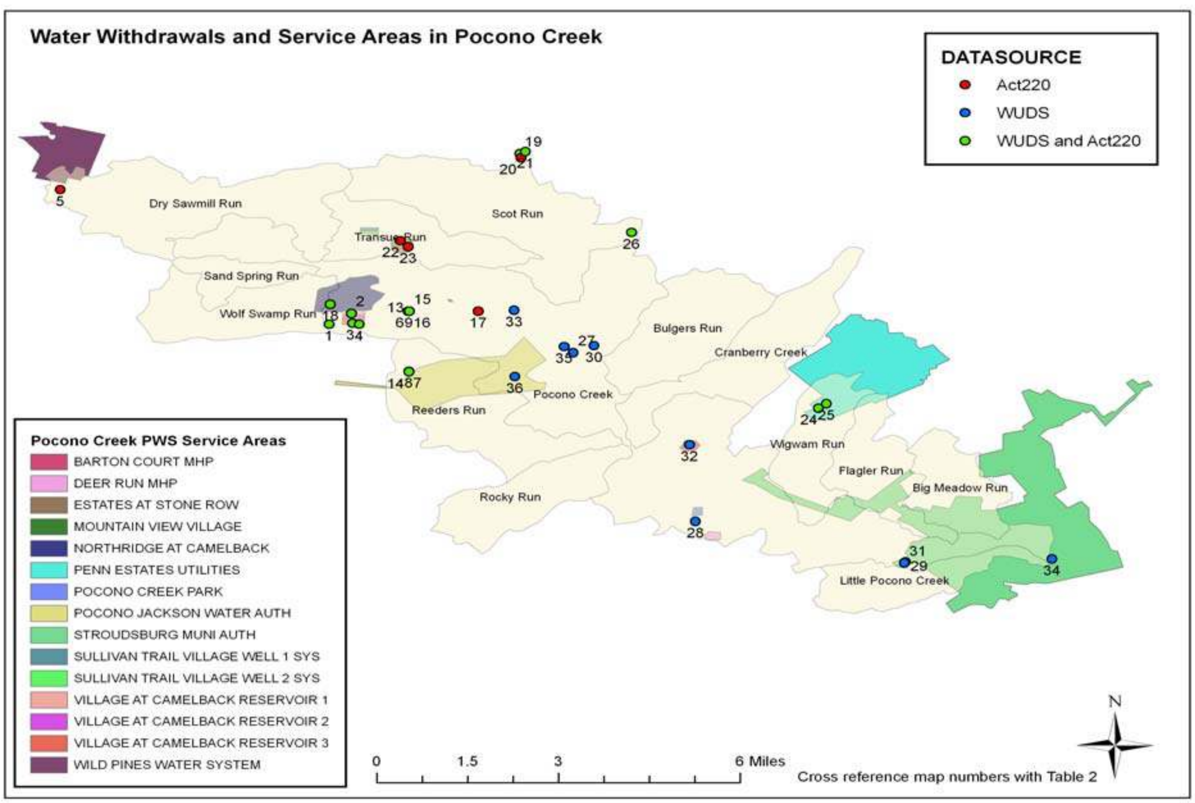


Figure 4.4: Public Water Service Areas in Pocono Creek.



4.2.5 Conclusions and Potential for Water Conservation

Water withdrawals in the Pocono Creek watershed are dominated by the surface water withdrawal by the Camelback Ski Corporation for snow-making activities. This withdrawal represents the only active surface water withdrawal in the watershed and it is only active during winter months. The remaining withdrawals are for the purposes of public supply, industrial and commercial use. No agricultural withdrawals have been identified for this watershed. A profile of monthly water use is shown in Figures 4.5 and 4.6. Due to the dominance of the ski-related withdrawal in the study area, the Pocono Creek watershed shows the unusual characteristic of having peak withdrawals (and consumptive use) during the winter months.

The potential for water conservation in the watershed can only be evaluated with additional information, such as a profile of the age of the housing stock and more detailed knowledge of the industrial and commercial activities that take place within the watershed. Plumbing fixtures and fittings in new construction must conform to federal, state and DRBC water conservation standards. These standards have been shown to reduce per capita water use, where the style of new construction is similar to old construction (i.e., similar socio-economic mix of housing stock).

Figure 4.5: Water Withdrawals in Pocono Creek.

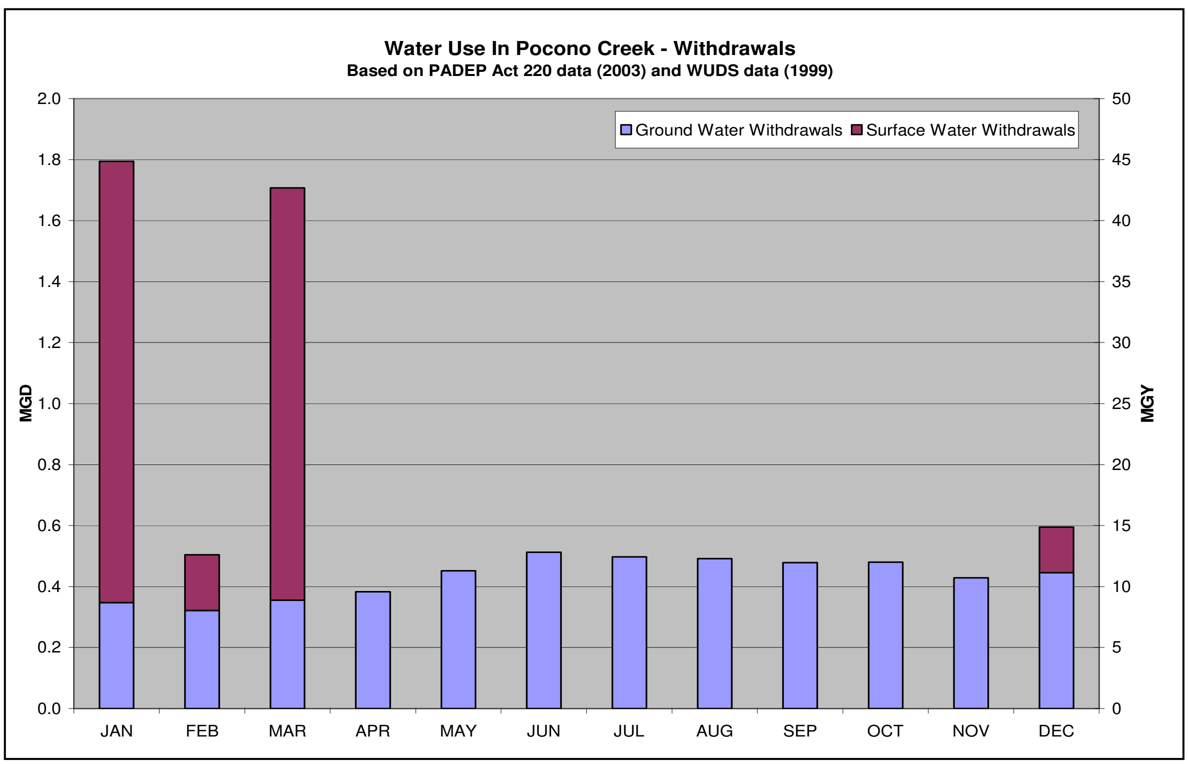


Figure 4.6: Consumptive Use in Pocono Creek.

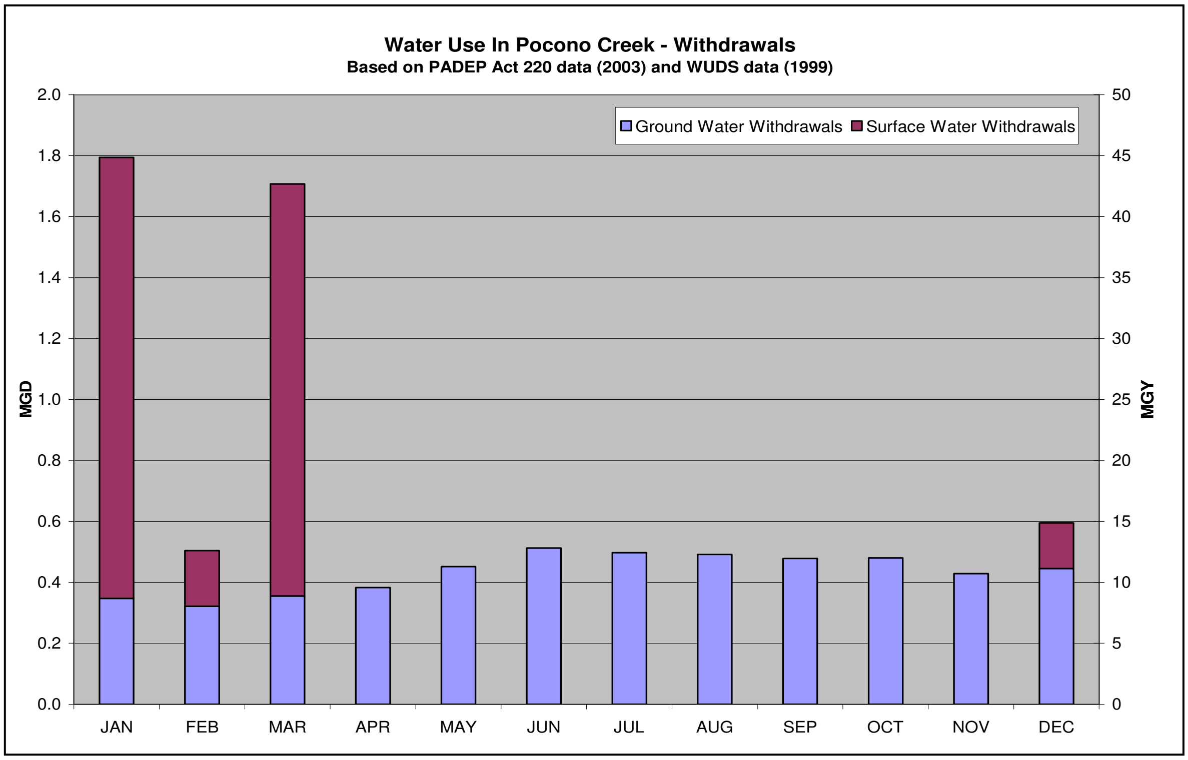


Table 4.4: Water Withdrawal Identified in Pocono Creek. (cross reference Figs. 4.3 & 4.4)

Map ID	Primary Facility Name	Sub Facility Name	Use Type	Source Type
1	VILLAGE AT CAMELBACK RESERVOIR 3	CLUSTER 2 WELL 4	Water Purveyor	Groundwater
2	VILLAGE AT CAMELBACK RESERVOIR 1	VILLAGE 2 WELL 1	Water Purveyor	Groundwater
3	VILLAGE AT CAMELBACK RESERVOIR 2	CLUSTER 7 2 WELL 3	Water Purveyor	Groundwater
4	VILLAGE AT CAMELBACK RESERVOIR 2	VILLAGE 7 1 WELL 2	Water Purveyor	Groundwater
5	WILD PINES WATER SYSTEM	WELL 1	Water Purveyor	Groundwater
6	CAMELBACK SKI AREA	WELL 9	Commercial Use	Groundwater
7	CAMELBACK SKI AREA	WELL 8	Commercial Use	Groundwater
8	CAMELBACK SKI AREA	WELL 5	Commercial Use	Groundwater
9	CAMELBACK SKI AREA	WELL 4	Commercial Use	Groundwater
10	CAMELBACK SKI AREA	WELL 10	Commercial Use	Groundwater
12	CAMELBACK SKI AREA	WELL 2	Commercial Use	Groundwater

Table 4.4 Continued: Water Withdrawal Identified in Pocono Creek. (cross ref. Figs. 4.3 & 4.4)

Map ID	Primary Facility Name	Sub Facility Name	Use Type	Source Type
13	CAMELBACK SKI AREA	WELL 7	Commercial Use	Groundwater
14	CAMELBACK SKI AREA	POCONO CK DIV	Ski	Surface Water
15	CAMELBACK SKI AREA	WELL 3	Commercial Use	Groundwater
16	CAMELBACK SKI AREA	WELL 6	Commercial Use	Groundwater
17	CAMELBACK SKI AREA	WELL 11	Commercial Use	Groundwater
18	CAMELBACK SKI CORP	WELL 1	Water Purveyor	Groundwater
19	AVENTIS PASTEUR INC	WELL 2	Industrial Use	Groundwater
20	AVENTIS PASTEUR INC	WELL 3	Industrial Use	Groundwater
21	AVENTIS PASTEUR INC	WELL 1	Industrial Use	Groundwater
22	STONE ROW POA	WELL 1	Water Purveyor	Groundwater
23	STONE ROW POA	WELL 2	Water Purveyor	Groundwater
24	PENN ESTATES UTILITIES	WELL 5	Water Purveyor	Groundwater
25	PENN ESTATES UTILITIES	WELL 6	Water Purveyor	Groundwater
26	MAPLE ROCK TRAILER COURT	WELL 1	Water Purveyor	Groundwater
27	BLUE BAY INC	WITHDRAW WELL	Industrial Use	Groundwater
28	POCONO CREEK PARK	WELL	Water Purveyor	Groundwater
29	BENNISON WOOD PRODUCTS INC	WITH WELL	Industrial Use	Groundwater
30	WRIGHTS CABINET SHOP	WELL	Industrial Use	Groundwater
31	POCONO TRUSS INC	WELL	Industrial Use	Groundwater
32	BARTON COURT MHP	WELL 1	Water Purveyor	Groundwater
33	MOUNTAIN VIEW VILLAGE	WELL	Water Purveyor	Groundwater
34	MONROE SILK MILLS	WITHDRAW WELL	Industrial Use	Groundwater
35	JIFFY PRINTING	WITHDRAW WELL	Industrial Use	Groundwater
36	POCONO RECORD	IMPOUNDM ENT RES	Industrial Use	Surface Water

4.3 Watershed Modeling

The foundation for this sustainable watershed management project is based on sound science and technology. The technical phase was performed to determine if intensive development, as currently allowed by local land use law, will impact existing water resources, affect propagating trout populations, and alter the existing hydrologic character of the watershed. In order to quantify the watershed's hydrologic responses to future development, three models and a statistical analysis were prepared. These steps include:

1) Development of a 3-dimensional groundwater model that simulates existing groundwater availability and flow conditions and then estimates the effect of a build-out land use scenario on recharge and the effect of groundwater withdrawals on stream base flow;
2) Development of a distributed watershed hydrologic model that establishes current infiltration and runoff rates, potential changes of infiltration and runoff at maximum build-out, and the degree of impact at current levels of development compared to a forested condition (predevelopment); and
3) Determination of the Pocono Creek's hydroecological classification and the impact on the stream indices for the build-out scenario. Also, an attempt was made to relate flow indices to trout populations.

Trout populations were selected as an indicator species for streamflow integrity and water quality since trout are: 1) sensitive to habitat disruptions, 2) used by the PADEP and PF&BC to classify high quality and exceptional value streams and 3) an important economic resource to the community since outdoor recreation is the largest economic generator of the region. A disruption in the trout populations would signal that the watershed's critical natural features and processes are not stable.

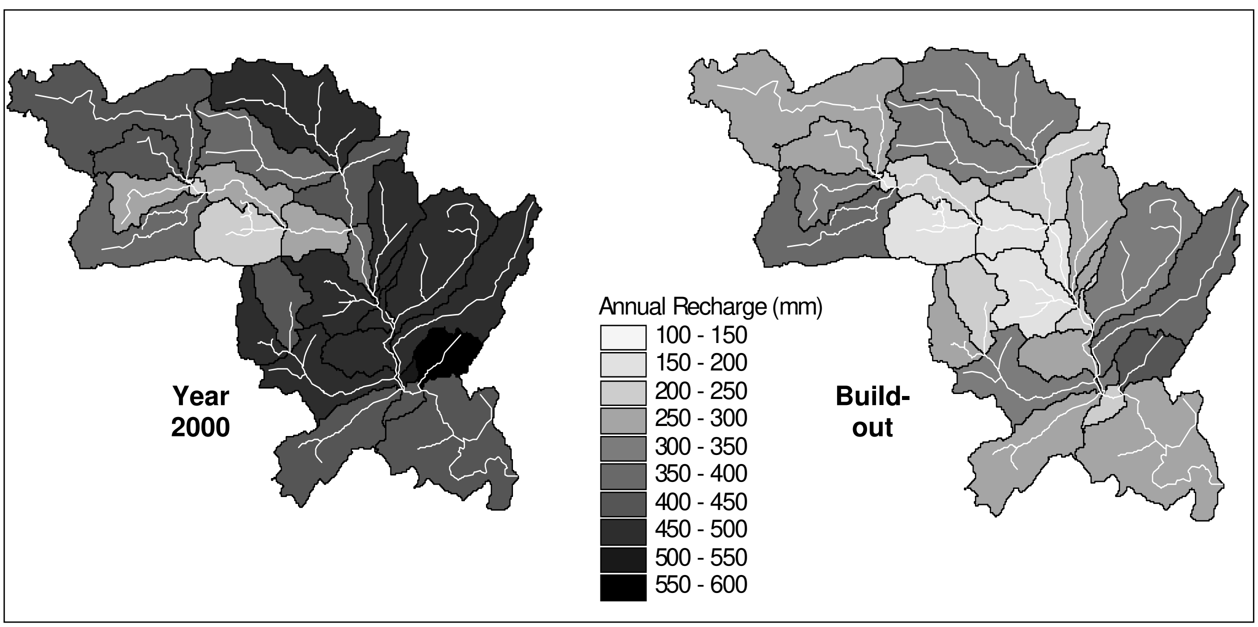
Protecting trout populations is a sustainable way to protecting the environmental and economic future of the region. Degradation of the water resources could cause a downward economic and social spiral from a loss of natural resources. Just as the miner's used canaries in the mines to indicate dangerous conditions, using trout in the Poconos can help protect critical conditions supporting the environmental quality of life and the basis of the economy.

The studies indicate that at a build-out scenario, on an average watershed-wide basis, groundwater recharge for the watershed is predicted to decline by 31% causing the average daily baseflow to be reduced by 31%. The seven day/ten year low flow (7Q10) is predicted to decline by 11%, and the monthly median daily flow is anticipated to be reduced by 10%. Monthly peak of daily flows and annual maximum daily flow are predicted to increase by 21% and 19%, respectively (Hantush, 2006). The predicted changes in streamflow show that that trout would experience a significant degree of flow alteration using the Range of Variability Approach (Ritcher, 1997).

Each of the four studies is included as appendices to this report. Highlights of each study are provided here. These highlights provide the context for the management strategies developed, as well as the basis of the innovative education and outreach effort.

1. Distributed Hydrologic Model, 2006 (Hantush and Kalin – EPA ORD Cincinnati)
The distributed watershed model by Hantush and Kalin was developed to characterize the role of hydrological processes that govern surface and subsurface water movement. EPA's Soil and Water Assessment Tool (SWAT) was used to model the hydrologic response of projected build-out of the Pocono Creek watershed by establishing the existing land surface interaction with precipitation and the effects of development on sub-basin responses to precipitation, infiltration and recharge. The model calculates the impact of projected urbanization on streamflow characteristics and identifies critical areas within the watershed having major contributions to changes in the streamflow. This model provides tools for environmental decision making for water resources planning and management. In addition to making model predictions of future flow conditions, the distributed hydrologic model assesses hydrologic impacts of various land use scenarios, such as watershed build-out (potential future conditions) or fully forested conditions (historic predevelopment conditions). The model calculated different recharge rates ranging from 6.11 to 22.66 in/yr (155 to 576 mm/yr) for all the sub-watersheds (see Figure 4.7).

Figure 4.7: Annual Groundwater Recharge Distributions in the Pocono Creek Watershed for Two Land Use Scenarios.



The results of this model study point toward significant changes in low as well as high flow regimes, should the Pocono Creek watershed experience land use changes consistent with the projected build-out in the watershed. Model simulations over a 20-year period predict that the build-out scenario would, on average:

- Reduce Daily Base Flow by 31%
- Reduce the 7Q10 (low-flow index) by 11%,
- Reduce the Monthly Median Daily Flow by 10%
- Reduce Watershed-averaged Groundwater Recharge by 31%
- Increase of Monthly Peak of Daily Flows by 21%
- Increase of Annual Maximum Daily Flow by 19%

The types of stream alterations in extreme storm events that were found are consistent with traditional development practices that increase impervious area and lead to urbanization. Urbanizing watersheds have the potential to impact ecosystem functions and processes, degrade water quality and ultimately stress trout populations.

The report concluded with the statement: "Informed management decisions may benefit from the identification of portions of the watershed that have the highest contribution to the reduction/increase in the quantity of interest. In a sense, preserving the land use of a particular area in the watershed can be considered as a best management practice (BMP)."

The simulated flow output generated by this model was used in the USGS groundwater flow model (MODFLOW) and the USGS-Science Center's Hydroecological Integrity Assessment Process (HIP). The USGS's 3-dimensionial groundwater study for this project (Sloto, 2008), used the SWAT model's sub-watersheds and their associated recharge rates as a spatial data set. USGS was able to establish recharge areas corresponding to the sub-watersheds, and then assign the sub-watershed recharge rates to the USGS model cells. The Hydroecological Integrity Assessment Process by USGS Fort Collin's Science Center (Henriksen, 2006) used the simulated daily discharges to determine changes in the statistical distribution of values of selected ecologically relevant hydrologic indices that match the timing of various life stages of brown trout (*Salmo trutta*) and brook trout (S*alvelinus fontinalis*) life history.

The distributed hydrologic model (DHM) as developed for this project by the U.S. EPA – ORD achieved the following objectives:

a. **Calibrated and validated DHM for Pocono Creek Watershed using Next Generation Weather Radar (NEXRAD) data against that based on surface rain gauge precipitation data:** Radar generated precipitation estimates from NEXRAD products were found to be useful as an alternative source of gage data. The NEXRAD precipitation estimates provided useful information about the spatial distribution of precipitation patterns. The application of NEXRAD data in this model showed that it can be a cost-effective alternative to costly and sparse rain gauge data.

b. **Predicted impacts of projected land use changes on annual average recharge distribution:** Spatial distribution of annual groundwater recharge rates were computed pre- and post - build out for use by the USGS MODFLOW Groundwater Model to simulate the impact of projected increase in groundwater withdrawals on base-flow reductions.

c. **Predicted impacts of projected land use changes on monthly median daily flows:** Monthly median daily flows were computed for pre- and post- build out scenarios to be used by the USGS Fort Collins for use for the Hydro-ecological Integrity Assessment Process.

d. **Evaluated model predictive uncertainty:** It is a common practice to calibrate and validate hydrologic and water quality models, but their forecasting abilities are rarely rigorously evaluated. In this modeling effort, the extra step of evaluating model error propagation was conducted using time series analysis and Monte Carlo (MC) type simulations.

e. **Computed the effect of urbanization on streamflow characteristics:** The impact of land-use changes on low, high, monthly average, and median flows were investigated, along with 95% confidence band of the computed changes in flow characteristics.

f. **Identified critical areas in the watershed:** In order to determine priority areas for management in the watershed, an index methodology was developed to rank seven sub-watersheds of the Pocono Creek watershed based on relative impact on hydrologic response to projected future scenarios.

A copy of the published final report can be found in Appendix A.

2. Three-Dimensional Groundwater Flow Model, 2008 (Sloto – USGS-WSC)
In order to evaluate the interactions between groundwater and surface water systems, the USGS PA Water Science Center developed and calibrated a three-dimensional, regional numerical groundwater flow model capable of simulating aquifer-stream interactions for this project. This work was jointly funded by USGS and EPA Region 3. The results from the flow model were used to estimate the effects of reduced recharge caused by land-use changes and additional groundwater withdrawals on stream base flow. The model is capable of simulating groundwater discharge to Pocono Creek with various recharge and pumping rates. The USGS MODFLOW-2000 groundwater-flow model was used to simulate current (October 2004) baseflow conditions; baseflow under recharge conditions associated with 2000 land use; and base flow under potential recharge with full build-out conditions in the watershed.

Two models were integrated to develop the 3 Dimensional Groundwater Model. The EPA-ORD's DHM provided aerial recharge values for 2000 land use and for a projected full build-out land use scenario. The USGS groundwater flow model was used to estimate the effect of reduced recharge from changes in land use and projected groundwater withdrawals on stream base flow. The study report describes the geology and groundwater flow system of the Pocono Creek watershed, and presents the results of numerical simulation of groundwater flow in the Pocono Creek watershed. The model includes an upper layer representative of the unconsolidated surficial glacial deposits that are directly connected to the stream system and a lower layer representing fractured bedrock. The surface water divide between the Pocono Creek watershed and adjacent watersheds are assumed to be a "no-flow" groundwater boundaries

The model predicted a decrease in simulated base flow ranging from 3.8 to 63 percent at the 27 streamflow measurement sites over the time horizon (2000 – build-out). Simulated base flow at USGS streamflow gaging station Pocono Creek above Wigwam Run near Stroudsburg, Pa. (01441495) decreased 25 percent. These findings generally agree with the EPA-ORD Distributed Watershed SWAT model (DHM), which estimates a 30.6-percent loss in base flow at the streamflow gauging station.

Groundwater withdrawals are simulated in Pocono Creek sub-watersheds for the year 2000 and at full build-out land-use conditions. For the build-out scenario in the Scot Run sub-watershed, simulated base flow decreased 44 percent. Build-out scenarios in the Cranberry Creek sub-watershed showed the simulated base flow of Cranberry Creek decreased 63 percent, the base flow of Bulgers Run decreased 60 percent, and the base flow of Laurel Lake Run decreased 96 percent from 2000 levels.

The groundwater and surface water systems are found to be well connected in the Pocono Creek watershed. In most areas, streams act as drains for the groundwater system and gain water. In some places, such as the lower part of Pocono Creek, some stream reaches may lose water and recharge the groundwater system. Where stream reaches gain water, streamflow is composed of groundwater discharge (baseflow) and surface (overland) runoff.

The quantity of groundwater discharged to streams is related directly to the elevation of the water table. Baseflow generally declines when groundwater levels decline and increases when groundwater levels increase. The time of lowest base flow generally coincides with the lowest groundwater levels. Precipitation from June through October generally produces little recharge and little increase in groundwater levels; most of the infiltrated precipitation replenishes soil moisture.

The "local-minimum hydrograph-separation" technique was used to separate the baseflow and surface runoff components of the Pocono Creek streamflow hydrograph. Baseflow is calculated to comprise up an average of 52 percent of streamflow. Baseflow was measured at 27 sites in the Pocono Creek watershed for the calibration of the groundwater flow model. The measurements were made 15 days after precipitation at the end of a long base flow recession period. The base flow measurements show that streams in the Pocono Creek watershed gained water between all sites measured except in the lower reach of Pocono Creek. During reconnaissance for measurement sites on September 14, 2004, Wigwam Creek lost all of its flow in this area and was dry at its confluence with Pocono Creek.

A copy of the published final report can be found in Appendix B.

3. Hydroecological Integrity Assessment Process – 2010 expected publication (Henriksen, Heasly, Terrell, Hartle, et. al.)

The Hydroecological Integrity Assessment Process (HIP) determines a watershed's baseline hydrologic conditions, establishes environmental flow standards, and assesses future streamflow conditions affected by surface and groundwater use, and land use alterations. HIP can be used to identify essential flow conditions that can be used in establishing flow criteria. USGS Fort Science Center in Fort Collins, Colorado conducted a HIP analysis for the Pocono watershed to predict the impact of land use changes on the streamflow conditions and related those streamflow changes to effects on trout populations.

The USGS Fort Collin's Science Center conducted a hydrologic classification for streams in the Pocono Creek watershed using the National Hydrologic Assessment Tool (NATHAT). Environmental flow standards and baseline hydrologic conditions were established, and proposed hydrologic alterations for build-out were assessed. The HIP identified ecologically relevant, stream-class specific hydrologic indices that characterize the five major components of the flow regime: magnitude, frequency, duration, timing, and rate of change. For this study, streamflow is considered a "master variable" that limits the distribution and abundance of trout. The simulated daily discharges from the distributed hydrologic model (Hantush), discussed above, were used to determine changes in the statistical distributions of values of selected ecologically relevant hydrologic indices that match the timing of various life stages of brown trout (*Salmo trutta*) and brook trout (S*alvelinus fontinalis*) life history.

The HIP compared 163 hydrologic indices from the mean daily flow data (20 year simulation period) for each of the sub-basins for three scenarios; existing conditions (baseline), current permitted zoning (build-out), and predevelopment or forested (hindcast) scenario. In the absence of definitive functional relationships between stream hydrologic characteristics and trout population success, 28 (out of the 168) indices were selected that quantified the types of flow events that would most directly impact trout populations; two groups of monthly flow indices – annual monthly median minimum monthly flows and annual median maximum monthly flows were used for all of the sub-basins, plus four additional indices describing frequency and duration of extreme events were also used: low flow frequency, low flow duration, high flow frequency, and high flow duration.

Since trout reproduction and their life cycles have evolved within the natural variability in a stream's flow regime, the integrity of the watershed's streams' flow characteristics are compared to the normal flow conditions throughout the life cycle of trout on a monthly basis. Changes in flow regime reflected by changes in the selected indices may directly or indirectly impact brook and brown trout habitat and populations, with the spawning, incubation, fingerling, and yearling life stages likely the most vulnerable. The time periods when each life stage is likely present is shown in Table 4.5.

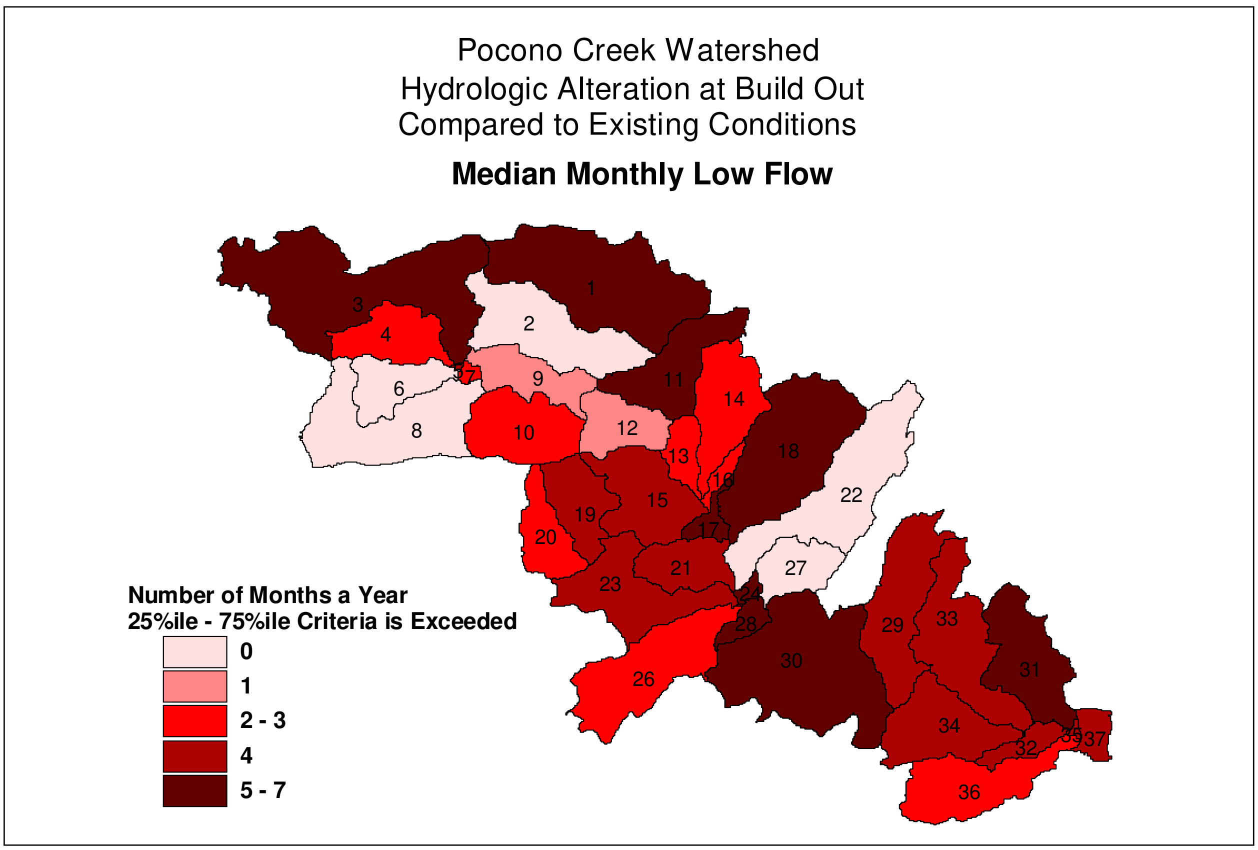
Table 4.5: General Life Stage Periodicities for Brook and Brown Trout in Northeastern United States ("X" represents approximately one week).

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Spawning									xx	xxxx	xx	
Incubation	xxxx	xx								xx	xxxx	xxxx
Fingerling		xx	xxxx	xx								
Yearling				xx	xxxx	xxxx	xxxx	xxxx	xxxx			

The analysis indicates that at build-out conditions, significant impacts on the 5 major components of flow (magnitude, frequency, duration, timing, and rate of change) are found in many sub-watersheds. Flow conditions that fall within the 75%-25% planning standards are guidelines for acceptable flow conditions. Since the effects of violations (impacts falling outside the 75-25% planning standards) have an accumulative impact on each life stage, all violations within a sub-watershed were counted for determining flow alteration impacts. Therefore, violations in a calendar month that occurs in more than one life history period are counted more than once.

The 12 median minimum monthly (low) flow guidelines: indices were violated in most of the sub-watersheds for the build-out scenario due to a decrease in the magnitude of monthly minimum flow. Planning standards, i.e., 75-25% variability range for median minimum monthly flows are violated during periods when non-adult trout life stages are present in 32 (86 percent) of the 37 sub-basins. There are as many as 9 violations in some sub-basins. (NOTE: Twenty-eight sub-watersheds have one or more months with violations during the spawning and incubation life stages.

Figure 4.8: Hydrologic Alteration of Pocono Creek Watershed at Build-out Compared to Existing Conditions for Median Monthly Low Flow. (App, EPA-R3)

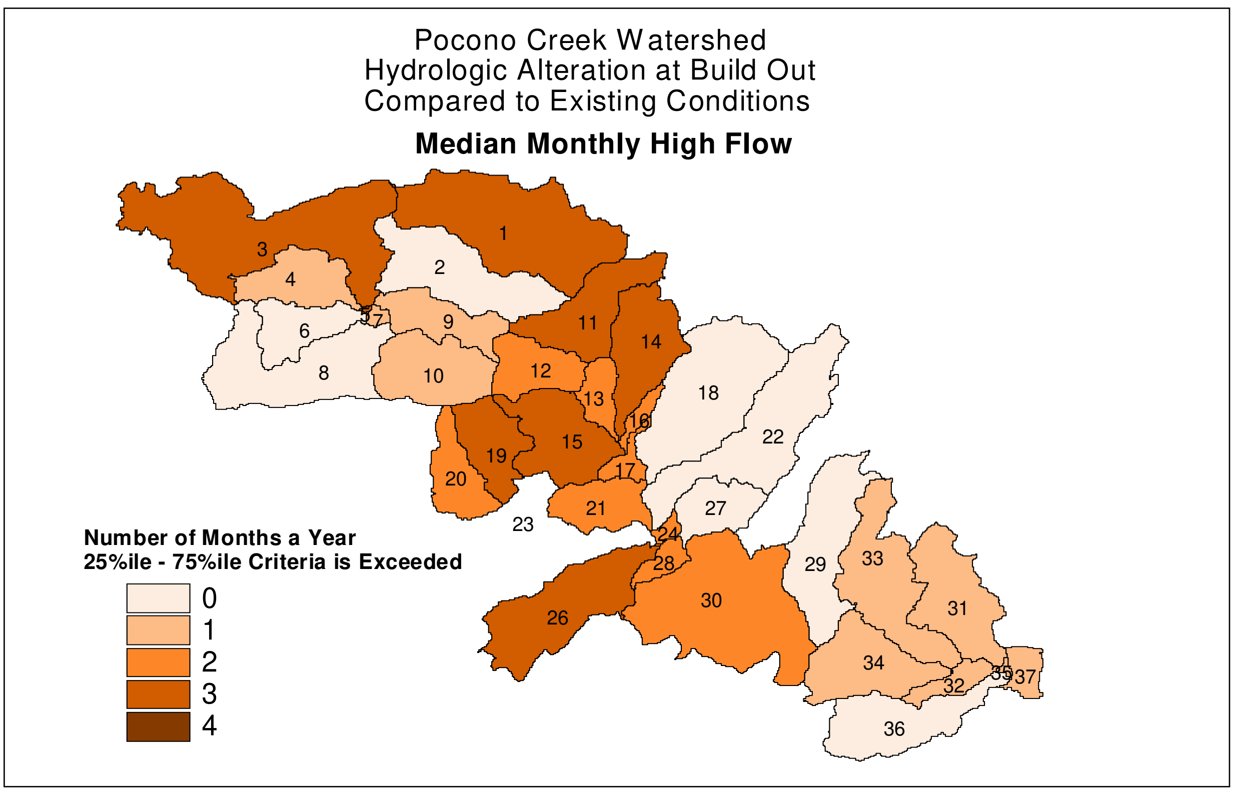


Twenty-nine sub-watersheds have one or more months with violations during the yearling life stage and eighteen sub-watersheds have one or more months with violations during the fingerling life stage. As shown on Figure 4.8, the largest number of months with violations for all of the sub- watersheds combined occurs during the incubation life stage (72 – 39% of 185 possible months), followed by spawning (48 – 43% of 111 months), yearling (41 – 18 % of 222 months), and fingerling (20 – 18 % of 111 months).

The 12 median maximum monthly (high) flow planning guidelines were violated in most of the sub-watersheds for the build-out scenario, as well. In all cases where median maximum monthly flow for build-out is outside the acceptable planning guidelines, it is due to an increase in the magnitude of monthly maximum flow. Violations for median maximum monthly flows occur during the spawning, incubation, and fingerling life stages. In contrast, twenty-eight of the sub-watersheds (76%) have one or more months when violations of the planning standards occurred during the yearling life stage.

Planning standards for at least one of four hydrologic indices addressing the frequency of low flow, frequency of high flow, duration of low flow, and duration of high flow are violated by the simulated flows in 32 of the 37 sub-watersheds for the build-out scenario.

Figure 4.9: Hydrologic Alteration of Pocono Creek Watershed at Build-out Compared to Existing Conditions for Median Monthly High Flow. (App, EPA-R3)



Nine of the sub-watersheds flows violated all four guidelines, ten of the sub- watersheds three of the guidelines, seven of the sub-watersheds two of the guidelines and six of the sub-watersheds one of these guidelines. In most cases, the change in the frequency of low flows events indicates an increase in the median number of low flow events per year. The same is true for the change in the frequency of high flow events (see Figure 4.9). In contrast, a violation of the duration of low flow events index indicates a decrease in the duration of low flow pulses. Most of the violations in the duration of high flow events index are also in the negative direction, i.e., simulated high flows do not last as long under the build-out scenario as during the baseline scenario.

A copy of the published final report is not yet available. At this time, the report is undergoing peer review. A place holder for the final product is reserved in Appendix C.

4. Linking Flow Indices to Trout Populations, 2008 (Cade- USGS)

In addition to estimating the impact of land use changes on the watershed's hydrology and groundwater, an important project goal is to relate the predicted streamflow changes to effects on the aquatic ecosystem. The objective of this evaluation is to compare long-term estimates of wild trout abundance with hydroecological indices for streams in Pennsylvania. For this second task, USGS - Fort Collins expanded on the initial Hydroecological Integrity Assessment Process (HIP) to link stream classification and flow conditions with wild trout populations. PADEP data for wild trout density and biomass (adult and young of year) within the Delaware River basin are linked to flow records for gauges on 42 streams in Pennsylvania. Non-linear patterns and high variability limit the inferences from these statistical models between flow indices and trout populations. Essentially, the researchers found that low to high biomass occurs across a large range of the hydrological indices considered. In addition, relationships between drainage area and trout biomass, with maximum biomass occurring at intermediate drainage areas, appear to strongly influence the observed relationships between biomass and hydrological indices. Such simple correlation studies limit ability to predict the effects of flow alteration itself, and more intensive studies for streams prior to and following hydrologic alteration are needed to better understand the expected response of the ecosystems to changes in stream hydrology.

The complete study is found in Appendix D.

4.4 Conclusion

The technical studies completed for the Pocono Watershed evaluate the impact of a build-out scenario on the integrity of the watershed's hydrology. The studies show that the effects of impervious surface on aquifer recharge and overland runoff will increase the number of high flow events, and prolong the number of low flow events. Projected withdrawals for water supply are predicted to reduce baseflows if development occurs as currently zoned and reduce streamflows that currently sustain trout. Although the studies are unable to make strong associations between specific altered flow conditions and sustaining trout populations, the scientific studies indicate a disruption to the watershed's hydrology under current zoning conditions that would alter streamflows supporting trout.

Chapter 5: Regulatory Overview of Rules, Laws & Policies Affecting Water Resource Management in Monroe County, PA

5.1 Background

Photo by P. V'Combe

In order to more effectively manage water resources, the Pocono region's predominant challenge is to re-organize the political and economic systems that affect water, land use and economic development so there is consistency throughout policy development, project implementation, and oversight. Monroe 2020 and the Pilot Pocono project support integration of economic development, environment protection, growth management, water management, planning and land use activities within a watershed context. Proper planning is needed to protect water quality, decrease potential impacts to streamflow, minimize stormwater impacts, and conserve groundwater for delegated uses. Examining the existing laws, regulations, policies and guidance in relation to these activities can provide insight as to where land use and water management may be better coordinated.

The Constitution of the Commonwealth of Pennsylvania (Article I, Section 27 - Natural Resources and the Public Estate) states that, "The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."

Yet protecting the remaining high quality waters in undeveloped regions of the state is a continuing challenge for natural resource managers. Waters continue to degrade, even with a plethora of protective legislation. Frequently, water regulations are often developed piecemeal and thus differentiate between related water issues, such as water quality, water supply, and flooding.

There are also many rules and regulations that indirectly affect watersheds and its hydrologic functions and resources, such as land use and economic development. The "shed" in watershed is the land that drains to surface water bodies. Changes to the landscape will eventually impact watershed hydrology if they do not consider the entire watershed in their planning. Currently, the primary focus of land use activities is not resource protection. The good news is that the problem seems to lay, not in land use or economic development projects per se, but "how" these activities take place. Replacing outdated approaches and techniques with more contemporary planning and development practices will go a long way to protect natural resources. These contemporary practices also enhance the land and its value.

The role of government in planning activities, land use and environmental regulations stems from the need to protect the public health, safety and general welfare of its citizens. Although land use and water resources are fundamentally linked, they are disconnected within the regulatory structures governing land use, water quality and water supply. These regulatory structures were developed independently to address public welfare concerns during different historical eras, with separate political intents. Land use laws, in Pennsylvania are constitutionally delegated to local municipalities. Infrastructure policies emerged in their current form out of the post-WWII era building boom, when populations were resettling in concentrated areas and centralized solutions (e.g., infrastructure) were appropriate. Environmental laws were initially established for public health purposes, focusing on sanitation and the containment of disease starting in the 1800s. Thus, waste disposal was a primary target for public health rules. Later, in the mid 1900's there was an evolution in policy directions and water became a highly valued natural resource and received federally mandated protection.

Economic expansion is an essential component to any vibrant social system, and is a major force in the development of regional character. The story of civilization is a tale of trade, commerce and business. The economy, pushed forward by technology, influences the manner of how places grow more than any other social influence. In the United States, progress is frequently defined as the amount of economic activity generated. Yet, economic trends are shifting from mid-20th century ideas of growth to a broader set of indicators that balance commerce with other priorities. In areas such as the Poconos, where the natural resource base is still abundant, and has become a regional market force, progress depends upon a model that allows for growth while protecting the regional economic engine, its natural resources.

Land use decisions, infrastructure projects, economic development, comprehensive planning and environmental programs take place within dissimilar and sometimes divergent spheres of society. These activities have different constituencies and a distinct body of statutes and policies that are enacted at multiple levels of government that spans through an aggregation of branches within departments throughout various commissions and agencies. Within Monroe County, planning, land use, infrastructure and water-linked programs alone, span across at least three federal agencies, one inter-state commission, four state departments (and up to four divisions within a department), two county commissions, seven local municipalities, and two regional authorities. Each administrative unit has separate bodies of laws, policies and programs, separate funding sources and is affiliated with different sectors of the community.

5.2 Regulatory Overview Purpose

There are a variety of legal instruments regulating water management, land use, economic development and infrastructure. The challenge is to systematically integrate the different areas of governance and society directly and indirectly affecting water and its management so that economic development can occur in such a way, that the region's water resources are protected while regional economic goals are met.

The regulatory overview that was completed for this project can be found in Appendix E. The overview is an assemblage of laws, policies, regulations and some of the agencies that impact water and its management in Monroe County, PA. The overview is not exhaustive, but provides insight into the regulatory range of areas impacting water; water quality, ecological flows, wastewater, economic development, infrastructure, regional planning, land use, and environmental planning. In order to effectively sustain the water resources of the Pocono Creek watershed, coordination is essential among the assortment of laws, regulations, policies, plans, and oversight. The information in Appendix E is intended as a reference for government officials, authorities, economic and community development sectors, the public and consultants in order to integrate complex management processes into a single regional vision and develop a process that meets the Pocono community's desired growth objectives.

There is a strong foundation for rational economic development and resource protection methods to be developed. Historically, Pennsylvania has been in the forefront of environmental and water protection measures, its Clean Streams Law being one of the first in the nation when it passed in 1937. However, Pennsylvania has regarded water resources as being separate and distinct from the surrounding environment, and as a result there is no comprehensive water management system. Pennsylvania's "Principles for Growth, Investment & Resource Conservation," or the Keystone Principles provide a trailblazing approach that supports rational and sustainable approaches connecting economic development and infrastructure investments in "greenfield economics."

A copy is included in Appendix E.

5.3 Summary

Many pieces of legislation and planning efforts influence water management in the Pocono watershed area. They include federal and state statutes and regulations (or officially adopted policies or plans), regional plans, and municipal ordinances, plans and policies. Ultimately, the way our water resources are managed depends on how water is viewed, either as private property that individuals are entitled to or as a common resource that needs to be protected for future generations. Understanding the federal, state, and local regulations and policies can present opportunities and challenges to managing our water resources. Some of the current challenges that water and land managers face exist because there is no comprehensive water management system. Changes are needed for local and state entities to gain control over their natural resources, so that decisions regarding water resources are made by the people of the Commonwealth rather than by outside interests or inconsistent court systems. Consistency in water resources management is needed to address conflicting land and water uses.

Sustaining water resources to meet multiple future objectives is dependant on understanding the link between the land use, geology, ground and surface water connections. Development to support economic viability historically has possessed a higher importance than protection of the environment. Careful planning and management of resources is often times misunderstood. If a comprehensive legal foundation within Pennsylvania is created to integrate and improve the existing framework, it will create a highway for a sustainable future. It would support economic growth at the regional, state and local levels while protecting the natural resources that we depend on for our survival.

The initial review of existing rules and regulations shows the following points need to be reconciled for a sustainable water management program to be effective:

- Watershed boundaries differ from municipal or state boundaries. Consistency and coordination is needed for water management purposes and the land use that affects water resources.
- Ground and surface water are connected, yet the laws that govern them are separate,.
- Some laws “suggest” that local or regional planning initiatives be “reviewed and be consistent with” other regulations and plans. However, some plans have not been developed yet and existing plans can be outdated or are not reflective of the current watershed condition.
- Only a fraction of comprehensive plans are enforceable.
- Some mandated ordinances are not required to be reviewed for consistency with approved plans.

- Depending on the financial situation of a county planning office or local municipality, they may not have staff to complete required reviews.
- Land use laws can be used to limit non-point source pollution from stormwater runoff, but are outside of the PADEP jurisdiction.
- Data collected is not consistent or easily shared among water resource management agencies and land use planning agencies or municipalities.
- PA Safe Drinking Water Act does not address local land use related to water infrastructure.
- Water Resources Planning Act (Act 220) does not regulate water infrastructure or provide legal protection to Critical Water Planning Areas that are identified through the State Water Plan.
- PA Sewage Facilities Act (Act 537) does not give PADEP authority to make permitting decisions or to deny private requests for revisions based on inconsistencies with local land use plans and ordinances.
- Water Rights Act of 1939 was designed to provide for review and regulation of surface water withdrawals by public water companies, municipalities, and power companies. It does not apply or relate to groundwater resources or groundwater withdrawals, nor are water infrastructure and land use concerns addressed. DEP does not regulate the amount of commercial and industrial withdrawals or other withdrawals than public water suppliers. River Basin Commissions are relied on to manage these issues.

Chapter 6: Development of Sustainable Watershed Management Strategies

The objective of the *Framework for Sustainable Watershed Management* is to protect existing high quality water resources in the Pocono Creek Watershed. An integrated and comprehensive approach to watershed management is necessary to meet watershed goals. This section outlines general approaches for the development of strategies addressing the watershed, ecological flows and water quality problems facing the Pocono Creek watershed. These strategies provide the basis for a comprehensive and integrated regional effort. The development of these strategies takes into account the following key findings discussed in previous sections:

- The Pocono Creek watershed in Monroe County has grown significantly and is predicted to continue to grow significantly over the next 30 years.

- Changes in land use associated with this growth will likely result in significant impacts on streamflows and flood frequencies, stream morphology and habitat, and water quality conditions if sufficient watershed management measures are not employed.

- Previous investigations and watershed assessments have found that streams in more developed watersheds are commonly impacted by changes in hydrology from increased impervious area. This suggests that streams in the Pocono Creek watershed will also be impacted by uncontrolled increases in impervious cover.

The Framework identifies four areas where the development of watershed management strategies needs to be directed: water resource protection, water resource restoration, water resource regulations and policies, and implementation of watershed management strategies. The Framework partners propose that the development of unique tools as templates for a broader management strategy development effort would allow for greater local and regional participation in an overall sustainable watershed management plan. These tools are designed to be used in a workshop setting that engages local municipalities along with other groups interested in contributing to the watershed management process for on-the-ground regional projects.

A primary purpose of the Framework is to integrate science as a basis for developing sustainable watershed management strategies. As mentioned previously, the Framework's architecture is supported by three sequential three pillars; technical, planning and policy, and outreach. Technical studies characterize the watershed's hydrology, define the interface between groundwater and surface water, establish the watershed's flow regime, and review its hydroecological integrity. Utilizing information from these studies, measures may be developed to implement the best management practices (BMP) throughout the watershed.

Sustainable watershed management is not just about environmental preservation. It requires incentives and coordination to engage local interests to work together to protect natural resources in the face of development pressures. Watersheds encompass numerous municipalities, each with independent authority over the land within their boundaries. Simultaneously engaging numerous local officials with the appropriate technical staff and authority to coordinate a comprehensive watershed plan beyond an individual municipality is a challenging notion. However, this project introduces a novel approach for coordinating local municipalities, by limiting the range and scope of watershed practices for each municipality. Technical support for multi-municipal grants to encourage economies of scale and shared resources to sub-watershed management can potentially provide the encouragement needed to sustain the interest of local officials.

The approach used in the Framework for sustainable watershed management includes two assumptions that address the critical moment that decision makers have arrived at regarding healthy waters and a sound economy in Monroe County and a watershed's natural hydrologic mechanisms:

1. The Precautionary Principle: The Framework rests upon the premise that it is economically rational, prudent and appropriate to protect the public from exposure to harm in the absence of absolute certainty regarding any adverse effects caused by significant alterations to a watershed's hydrologic functions. Therefore, when sufficient technical and scientific evidence exists to warrant concern, responsible public officials are encouraged to exercise the "Precautionary Principle." Lack of "absolute" scientific certainty should not be reason to delay strategies to prevent environmental degradation, damage to property or threaten the water resources, the primary regional economic driver. Decision makers in the Pocono region have reached a critical moment that necessitates pro-active measures to maintain the long term sustainability of its water resources. When a substantial body of scientific and technologic studies predicts serious consequences to the water resources, which in turn supports the economy, the exercise of a Precautionary Principle allows the communities to seek democratic alternatives to conventional approaches of growth and resource management.

2. Watershed Connectivity**:** Watershed connectivity as used in the Framework refers to the physical, landscape and systematic linkages within or between the hydrologic cycle functions within a watershed. Watershed connectivity recognizes that watersheds are four dimensional systems, with three spatial dimensions (longitudinal, lateral, and vertical) that function along a temporal pathway (Ward, 1989, Pringle, 2003). Watershed connectivity includes the functional capacity of the watershed landscape. It refers to the flow, exchange, and pathways of water,

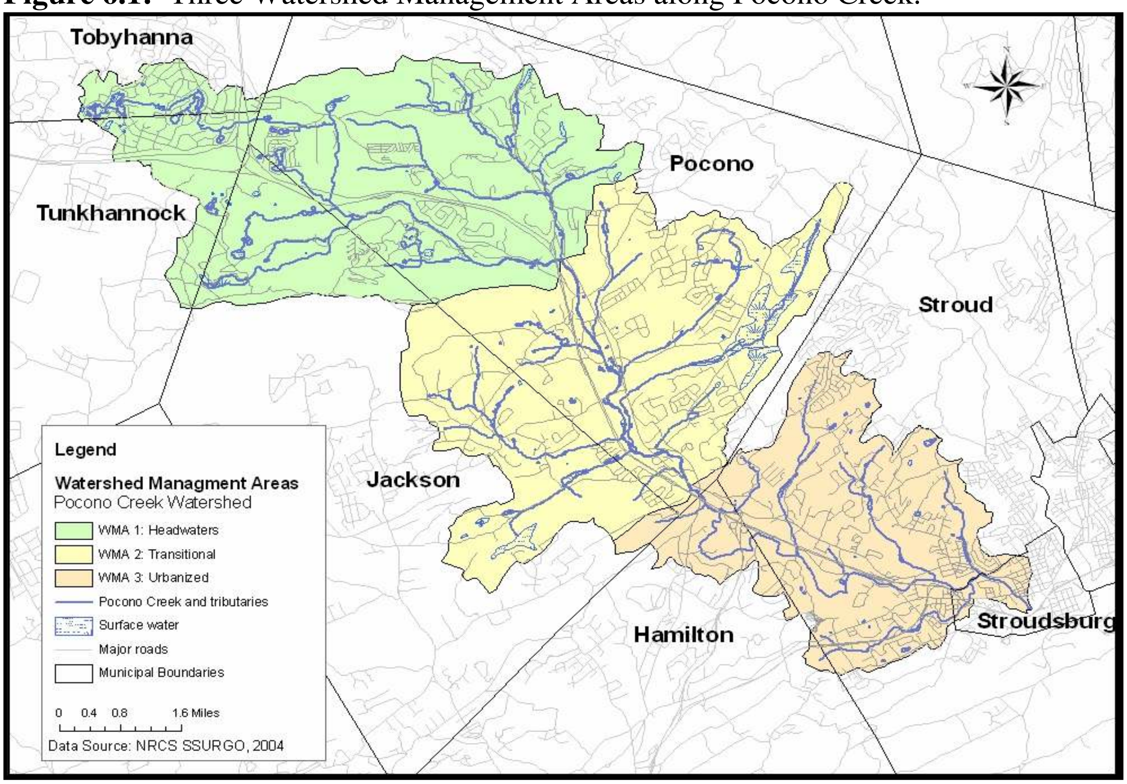
energy, matter, nutrients and organisms within a watershed. Decisions regarding water resources and land use made without watershed connectivity as a conceptual model can have unintended consequences.

6.1 Alternative Watershed Management Tools

<u>Watershed Management Areas</u>: This management tool was developed to engage a broad range of watershed communities as well as appropriate technical expertise to address specific watershed issues from a socio-economic and geographical perspective. A watershed management area (WMA) is a sub-watershed sharing common geography and socio-economic character. Figure 6.1 shows the three WMAs used in the study:

- WMA 1 – Headwaters
- WMA 2 – Transitional
- WMA 3 – Urbanized

Figure 6.1: Three Watershed Management Areas along Pocono Creek.



Traditional settlement patterns in linear watersheds along the East Coast reflect typical economic development stages of an area. Since the deepest waters and the strongest flows are desirable for transport and harnessing waterpower, many of the oldest towns and largest commercial cities in a watershed are found at the low end of a river valley corridor near the confluence with another stream. The Borough of Stroudsburg, for example, is at the base of the Pocono Watershed where the Pocono Creek meets the larger McMichaels Creek. From the 1840's to the 1900, Stroudsburg was one of the world's major producer of iron and steel, and the first city in the country to produce railroad ties. A tannery founded in 1820 utilized the constant water supply from the Pocono Creek, and by the mid-1800's there were at least 4 tanneries operating inside the watershed.

Frequently, the confluence area of East Coast watersheds is the initial area to be urbanized, and development continues upstream, becoming less dense as one travels away from the developed area. Typically, roads follow river valleys and development follows roads. The Pocono Creek is no exception, with both State Route 611 and Interstate 80 running north and south of the streambed, respectively. Development also tends to spread laterally as the river valley and its floodplain widens. The vertical ascent and lateral spread of settlement patterns in a watershed delays development in the upper reaches of a watershed, which can have steeper slopes and limited agricultural potential. As a result, these headwater regions tend to be more rural and forested. The areas between the urbanized lower watershed and the rural headwaters are transitional zones, which tend to become more developed over time.

Actively engaging multiple municipalities in a unified watershed management effort that has no regulatory enabling authority is a challenge. Cultivating a unified vision for a watershed among half-dozen or more municipalities is another challenge. Complicating the situation within a watershed is that municipalities located in the headwaters of a watershed may doubt there is anything in common with more developed downstream municipalities regarding water resources. Headwater towns typically get their water from wells and rely on septic systems for waste disposal, while the paved surfaces of the confluence city have public water, sewers and water and wastewater treatment infrastructure. One municipal official attending a watershed management plan meeting claimed to be "bewildered" because the number of issues throughout the watershed and potential solutions was "too much to consider."

Experience has found that sub-watersheds in the study area share similar natural, geographical and physiological characteristics as well as demographic and social conditions. In order to better organize the Management effort, three watershed management areas (WMA) were delineated in the Pocono Creek Watershed; headwaters, transitional and urban. WMAs are simply an organizing tool that feature similarities found within the sub-watershed areas and provide context for a municipality within the full watershed. WMAs are delineated along tributaries where geographic and land use transitions could be seen. Use of the WMA tool limits the number of issues addressed by each municipality.

WMAs allow for "bundles" of strategies to be developed for one area that specifically address that WMA's unique characteristics and needs, without imposing additional burdens on any municipality beyond its management area. Therefore, decision makers can focus on their own regions, instead of the entire watershed at all times. WMAs enable municipalities to partner with other municipalities in their WMA to manage water resources consistently. WMAs provide opportunities for municipalities to target priority issues in their WMA and formulate alternatives for their WMA. Examples of appropriate best management practices for WMA efforts can be found in Appendix H.

Watershed Communities: A community emerges out of the collective efforts of citizens participating with local officials on planning initiatives and local officials looking beyond their boundaries for the best interests of their hometown. A "sense of place" forms and common interests are identified. The character and the resources of this "place" become important.

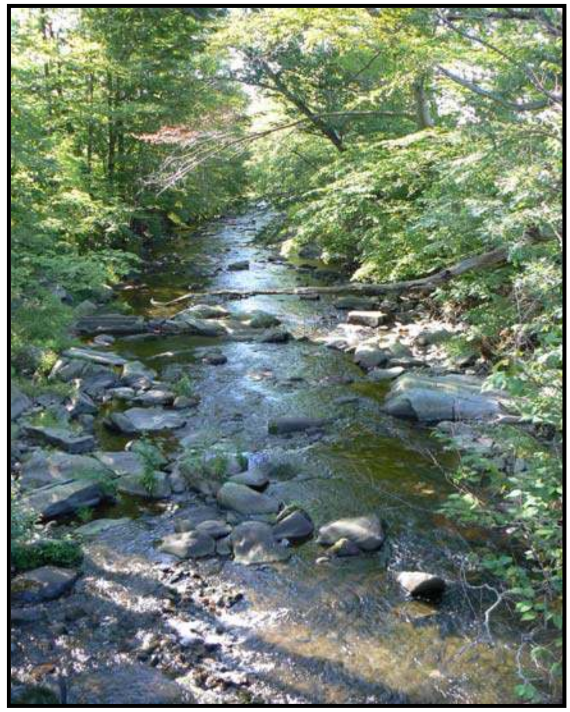
The municipalities within each WMA share similar geographical and socio-economic conditions. These "watershed communities" have the potential to create multi-municipal partnerships to implement management strategies and share resources. Watershed communities within the Pocono Creek watershed can achieve many of their goals through watershed management.

6.1.1 Pocono Creek Watershed Management Area Descriptions

6.1.1.1 WMA 1 - Headwaters

In WMA 1, the headwaters of the Pocono Creek drain the Pocono Plateau (BWA). WMA 1 is located mostly in Pocono Township (61%), with small areas in Jackson (19%), Tunkhannock (13%), and Tobyhanna Township (7%). The rolling, rocky hills are covered primarily with trees, shrubs, wetlands, and other forms of open space (69%). The development consists mostly of single family homes (low density residential) and covers about 25% of the area. Land development is somewhat limited by the shallow bedrock, rocky soil and glacial till. Two major transportation routes, Interstates 80 and 380 intersect just below the Emerald Lakes community. Some medium density residential development can be found, mainly vacation properties along Sullivan Train Rd, around Crescent Lake, and on Camelback Mountain. Commercial and light industrial areas are intermittently found along PA Rt. 611. Two of the largest commercial parcels are Great Wolf Lodge and The Crossings outlet mall. Less than 1 % of the WMA is high density residential, which is located adjacent to the Camelback ski area. Approximately one-third of the headwaters is protected by State Game Lands No. 38 and Big Pocono State Park. This state park is located at the summit of Big Pocono Mountain, the areas most dominant topographic feature formed by the Pocono Plateau escarpment, and serves as the divide between the Pocono watershed and the McMichaels Creek located to the west (BWA, 2005). Total impervious surface are for WMA 1 is approximately 7%. Surface water resources in WMA1 include the Pocono Creek and its tributaries, which include Dry Sawmill Run, Scot Run, Transue Run, Sand Spring Run, Coolmoor Creek, and Wolf Swamp Run. The largest, most notable lakes are Emerald Lake, Pine Tree Lake, and Brookdale Lake. Other surface water features that dominate the area are numerous small lakes, many natural glaciated lakes. Figure 6.2 shows Pocono Creek in WMA 1.

Figure 6.2: Headwaters of the Pocono Watershed – WMA 1. (P.V'Combe, DRBC)



6.1.1.2 WMA 2 - Transitional

The majority of the Transitional WMA 2 is also in Pocono Township (67%), with the remaining area (33%) in Jackson Township. The gradual, rolling topography is covered with forest and approximately 58% of the area is open space. Several villages, such as Reeders, Tannersville, and Bartonsville are centers of low density residential development. As in most of the Pocono watershed, commercial and light industrial development is limited to the Route 611 and Interstate 80 corridor. Total impervious surface for the WMA 2 is 10%.

Surface water resources include the Pocono Creek and its tributaries, which include Bulgers Run, Bisbing Run, Cranberry Creek, Reeders Run, and Rocky Run. The area has a few small lakes including Laurel Lake and Hunter Lake, and a large concentration of wetlands. The National Wetlands Inventory (NWI) map (1995) indicates 5% of WMA 2 is considered wetlands. Most notable among the wetland areas is the Tannersville Cranberry Bog, the most southern boreal bog on the eastern seaboard, which is protected by a preserve owned by The Nature Conservancy and by township open space. Figure 6.3 shows a commercial area amidst scenic vistas in WMA 2.

Figure 6.3: WMA 2 Included with Commercial Attractions and Beautiful Scenery. (Gusto)

6.1.1.3 WMA 3 - Urbanized

Urban WMA 3 is the most populated and developed. It includes the Townships of Stroud (80%), Hamilton (12%), Jackson (2%), and Pocono (1%); and Stroudsburg Borough (4%). Commercial and light industrial land uses are more wide-spread in this area, but concentrated along Rt. 611 and in the Borough of Stroudsburg, the cultural center and county seat of Monroe County. The borough's population was 5,756 at the 2000 census and is expected to grow as development in this area increases. The majority of the developed areas are low-density residential, but open space is limited to approximately 14% of WMA 3. Impervious surface is over 20%. Surface water resources of WMA 1 include Pocono Creek before its confluence with McMichaels Creek. The Pocono's tributaries in this area include Wigwam Run, Flagler Run, and Big Meadow Run, and Little Pocono Creek. Figure 6.4 shows the Borough of Stroudsburg in WMA 3.

Figure 6.4: Main Street, Stroudsburg – WMA 3.

6.2 Water Resource and Management Strategies Matrices

Sustainable watershed management seeks to protect existing high quality resources before they become impaired or degraded. The goal is to maintain the high quality water resources. Unfortunately, most watershed management efforts start after water impairments occur and mandatory or voluntary remediation programs are put into effect. Most pollution prevention programs are abatement efforts that attempt to reduce further pollution after a stream is already impaired.

During the stakeholder process, a workshop for targeted professionals and volunteers can introduce water resource issues to small groups with similar problems and generate input into the best management strategies for particular areas. Making sustainable watershed management an undemanding and straightforward process requires watershed managers to quickly engage and focus watershed communities concerning their role in a watershed-wide sustainability effort. Setting the groundwork for a sustainable watershed management effort includes providing workshop participants with appropriate materials that will expedite strategy development and encourage participant ownership of the watershed process.

In addition to maps and technical summaries, participants can be presented with a Water Resource Issues Summary Matrix (see example in Table 6.1), an outline of water resource issues for their consideration. This immediately provides a unified focus, elicits local expertise, and technical feedback. When presented in sub-watershed based WMAs, neighboring local municipalities may find they have the same issues and can begin to collaborate addressing those issues through a multi-municipal partnership. The Summary matrix would then be validated by each WMA participant, who would be asked to identify:

1. Primary and secondary water resource concerns in each WMA;
2. Management strategies most applicable for the WMA;
3. Resources they can share (equipment, technical support, materials, etc.) to implement management strategies.

An example of the type of matrix that can immediately focus WMA groups is found in Table 6.1.

Table 6.1: Example Water Resources Issues Summary for Pocono Creek Watershed.*

Watershed Management Area & Watershed Communities	Existing Primary Issue	Existing Secondary Issues	Potential Future Issues
WMA 1: Headwaters Pocono Twp Jackson Twp Tunkhannock Twp Tobyhanna Twp	Maintain Eco-Flows Water Supply Protection Area	Water Quality Channel Stability	Ecological Flows Water Quality
WMA 2: Transitional Pocono Twp Jackson Twp	Water Quality Water Resource Protection Area	Channel Stability	Ecological Flows Flooding
WMA 3: Urban Stroudsburg Borough Hamilton Twp Stroud Twp Jackson Twp Pocono Twp	Water Quality Flooding	Channel Stability	Ecological Flows

* The above WMA issues are illustrative of the types of WMA issues that may be found and not meant to be conclusive.

After participants agree on issues within their WMA, the Management Strategies Matrix can be introduced. The Management Strategies Matrix lists management practices most likely to address WMA issues. An example of the management strategies matrix that can assist WMA groups in choosing appropriate controls is found in Table 6.2.

Table 6.2: Example Management Strategies Matrix.

FOCUS	MANAGEMENT STRATEGY
WMA 1 HEADWATERS	**Conservation**
Eflow, WQ	Establish **model watershed ordinances** to prevent baseflow diminishment
Eflow, CS, WQ, Supply, RF	Inventory existing natural areas that can **protect groundwater recharge areas**
CS, WQ	**Preserve floodplain** as open space where feasible
Eflow, CS, WQ, Supply, RF	Manage all government properties consistent with Sustainable Framework goals
CS, WQ	Protect **riparian buffers** with ordinances
Eflow, WQ, Supply, RF	Encourage **rain gardens** to recharge and infiltrate to groundwater.
Eflow, CS, WQ, Supply, RF	Review and revise municipal ordinances to **minimize impervious surface** in new development
Eflow, Supply, RF	Encourage **water conservation** through reuse of grey water and education
Eflow, WQ, Supply, RF	**Preserve and protect Critical Environmental Areas**
WMA 2 TRANSITIONAL	**Buffers/Retrofits**
Eflow, CS, WQ, Supply, RF	Create incentives to protect existing **riparian buffers** on development sites, i.e. square footage bonuses where overall lot average is reduced
Eflow, CS, WQ, Supply, RF	Enforce **performance-based ordinances** and regulations throughout the watershed
Eflow, CS, WQ, Supply, RF	**Manage all government properties** consistent with Framework goals
Eflow, Supply, RF	Review and revise municipal ordinances **to minimize impervious cover** in new developments and retrofit projects.
Eflow, Supply, RF	Require new stormwater basins to be **curvilinear basins**, minimizing side slopes, and planted with native meadow species
Eflow, Supply, RF	Encourage **water conservation** through reuse of grey water and education
Eflow, Supply, RF	Design new buildings, home, and developments with **rain barrels, cisterns, and rain gardens**
Eflow, CS, WQ, Supply, RF	**Maximize infiltration** though use of pervious pavement, infiltration basins, subsurface infiltration beds, rain gardens, bioretention beds, dry wells, constructed filter, vegetated swales, vegetated filter strips and other BMPs (Low Impact Development).
Eflow, Supply, RF	Require **non-compaction zones** during construction of BMPs

Table 6.2 Continued: Example Management Strategies Matrix.

FOCUS	MANAGEMENT STRATEGY
WMA 3 - URBAN	**Retrofit**
WQ, CS, RF	Protect and enhance **riparian buffers** on all property types
Eflow, CS, WQ,Supply, RF	Develop a prioritized list, with costs and site maps of **recommended stromwater projects**
Eflow, CS, WQ,Supply, RF	Adopt **performance-based ordinances** throughout the watershed
Eflow, CS, WQ,Supply, RF	**Retrofit paved areas** with vegetated and infiltration BMPS, for example curb cuts, bioretention parking lot islands, tree trenches, rain gardens, etc.
Eflow, CS, WQ,Supply, RF	Require redevelopment efforts to **manage for stormwater** runoff
Eflow, CS, WQ,Supply, RF	**Manage all government properties** consistent with Framework goals
Eflow, CS, WQ,Supply, RF	Review and revise municipal ordinances **to minimize impervious cover** in new developments and retrofit projects.
Eflow, CS, WQ,Supply, RF	**Retro-fit stormwater basins** to extend detention, minimize side slopes, eliminate low flow concrete channels and be planted with native meadow species
Eflow, CS, WQ,Supply, RF	**Remove existing impervious cover** where feasible and replace with landscaping or other pervious materials
Eflow, CS, WQ,Supply, RF	**Restore natural hydrologic integrity** to improve natural conveyance and attenuation of flood flows within the stream channel, floodplain, and associated wetlands
Eflow, Supply, RF	Encourage **water conservation** of water through reuse of grey water and education
Eflow, CS, WQ,Supply, RF	**Maximize infiltration** though the addition of pervious pavement, infiltration basins, subsurface infiltration beds, infiltration trenches, rain gardens, bioretention beds, dry wells, constructed filter, vegetated swales, vegetated filter strips and other retrofit BMPs.
Eflow, CS, WQ,Supply, RF	**Restore** floodplains, wetlands, and other high value resource areas
Eflow, CS, WQ,Supply, RF	Provide local and affordable ways to **obtain rain barrels and native plants for rain gardens**

* Maintain Ecological Flows (Eflow); Channel Stability (CS); Water Quality (WQ); Water Supply Protection (Supply); Runoff/Flood (RF)

Chapter 7: Innovative Education & Outreach Effort

The third pillar of the Framework for Sustainable Watershed Management calls for novel approaches to actively engaging the public and critical watershed interests in the area of sustainable watershed management.

Monroe County is a planning savvy region. Its residents are very aware of the Monroe 2020 comprehensive planning activities by the county. Monroe County's Model Stormwater Ordinance for the Brodhead Creek and McMichaels Creek watersheds had extensive public input. The Board of County Commissioners established the Municipal Partnership Program to promote cooperation between the local and county governments to help successfully implement the Monroe County Comprehensive Plan with a coordinated multi-municipal strategy to guide growth. The Brodhead Watershed Association's (BWA) effort to protect and improve water resources in the Brodhead watershed, where the Pocono Creek is nested, has brought the Plan to the public's attention. During the Pocono Creek Pilot study, a goals process included a public participation element, and throughout the study, local municipal participation was very strong.

Many of the county's public participation efforts encouraged individuals to attend public meetings and information sessions or as volunteers on local projects. However, the traditional meeting format has been losing popularity as "planning fatigue" begins to affect area residents. Thus, much of the public participation is accomplished by a small active group of committed individuals, which needs to be expanded to achieve sustainable integrated watershed planning. This project sought to develop an innovative means to reach a larger population and extend the watershed project's visibility beyond the dependable core environmental constituency.

The complex nature of sustainable watershed management and its link to the economic vitality of this rural region requires broad support, as well as political will, for coordinated and cooperative government action. Providing an appropriate forum to educate the public, private businesses and elected officials about cooperative approaches for economic and watershed management is critical to long term success. Clearly, an innovative approach is needed to broaden public engagement in sustainable planning while significantly increasing public awareness about the protection of trout to the local economy – an approach that is fun, catchy and far reaching.

The Framework's Education and Outreach team goals are to:

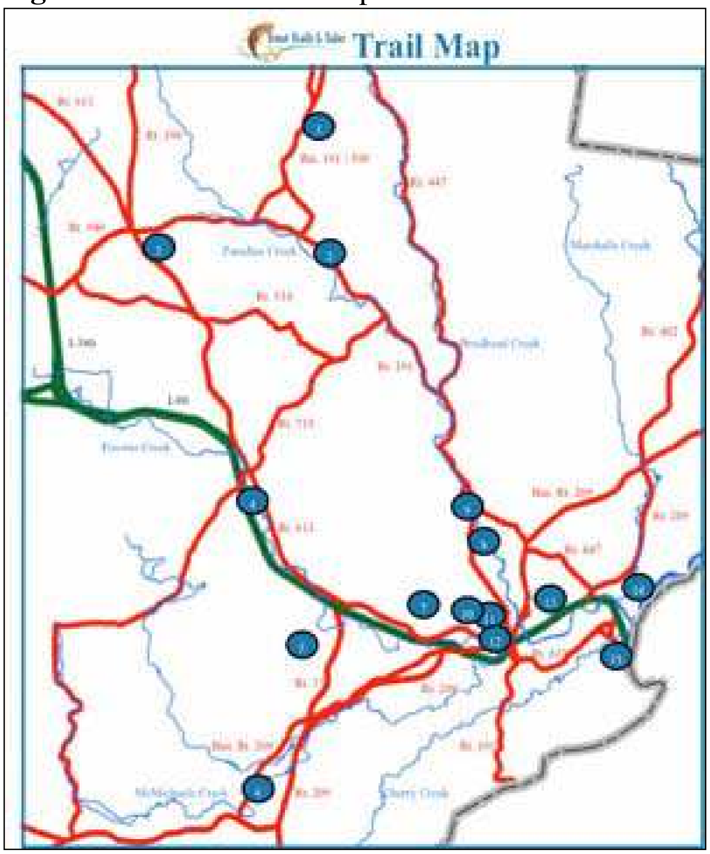
- Increase local municipal and general public engagement in sustainable watershed management planning,
- Elevate public awareness about the relationship between ecological flows and local trout populations,
- Cultivate the idea of a "watershed community,"
- Establish a connection between water quantity/quality and the local regional economy, and
- Establish the groundwork for future social marketing campaigns based on a *"Develop Right, Save a Trout"* theme.

To accomplish these goals the Brodhead Watershed Association President, Theresa Merli, initiated *Trout Trails and Tales* to raise the awareness of local residents and visitors about the need for environmental protection to protect trout populations. This community art effort was based on the popular fiberglass animal "parades" many cities and communities have initiated. Since June is National Rivers Month in Pennsylvania, June 2008 was selected as the appropriate time for project kick-off. Numerous additional partners were recruited for the event, included the Pocono Arts Council. Fifteen fiberglass trout were decorated by local artists and placed throughout the community, from early June to late August, for maximum exposure during the tourist season. A "message plaque" and stand was designed by the Monroe County Conservation District, constructed by welding and carpentry students of the Monroe Career and Technical Institute, and later affixed to each Trout statue.

Figure 7.1: A Young Visitor Reads the Trout Tale at the "Native Brookie" Mosaic Sculpture Site along the Trout Trail. (P. V'Combe, DRBC)

Each Trout presented one of the 15 segments of the "Trout Tale" that introduced the concepts of ecological flows, watershed hydrology, trout life and the regional economy, and suggested actions individuals can take to help maintain stream hydrology. Figure 7.1 shows one of the fifteen trout exhibits. The Trout Tale along with the featured statues can be found on the Trout Trails and Tale website at www.trouttrails.org or in Appendix I, "The Trouts' Tale."

Figure 7.2: Trout Trail Map.



Trout have been compared to the "coal miners' canaries" during education campaigns. The legend, widely understood by the public, refers to the early mining days when canaries, a species sensitive to oxygen in the air in underground mines, were used as an early warning system for workers. As long as the canary in a coal mine kept singing, the miners knew their air supply was safe, while a dead canary signaled danger. Trout are considered local indicator species, requiring adequate quantities of fresh, oxygenated waters. As long as there are trout populations in the streams, the water quality is considered good. The absence or disappearance of trout signals development of a water resources problem.

A Trout Trail Map (see Figure 7.2) was designed to encourage members of the community to discover individual trout throughout the Brodhead watershed. The Trout Trail was developed to take a "Trail Blaze" to various areas within the Brodhead watershed, including Pocono Creek from its headwaters in the Pocono Plateau to the confluence with the McMichaels Creek, in downtown Stroudsburg.

The Pocono Record, the regional newspaper, provided extensive coverage throughout the event. Contests encouraging children to "Follow the Trout Trail" to find the Trout of the Week were conducted. Hundreds of entries were received from children throughout the summer. Drawings for prizes were held throughout the summer and local water parks donated free passes for children ages 7 to 12.

The high visibility of the Trout Trail fiberglass statues and consistent coverage from the press has made the members of the Education and Outreach team confident that an increase in public awareness of the relationships among water quality, trout population and the local regional economy has been made. The effort also successfully established the groundwork for a future social marketing campaign based on a proposed *"Develop Right, Save a Trout"* theme. This effort will be a part of the "Next Steps" for the sustainability effort to bolster public support for smart growth initiatives, to continue to engage the development community and to foster local municipal implementation of Monroe 2020's strategies.

Chapter 8: Next Steps

8.1 Project Conclusions

After reviewing the technical studies, establishing planning principles, providing an overview of the regulatory framework, and developing a suite of watershed management strategies for the Framework for Sustainable Watershed Management study, the following conclusions are reached:

- Partners want to maintain the natural environment, as the region's primary economic engine and driver for recreational and tourism, and the basis for the residents high quality lifestyle;
- Natural resources in the region are supported by superior water quality;
- The Framework's technical studies strongly indicate that existing zoning in the Pocono Creek watershed allows for significant adverse impacts to the water resources. Several sub- basins in the lower confluence area of the creek currently show violations of flow criteria while others are approaching the impairment threshold;
- Inappropriate land uses in a sub-basin may adversely affect hydrologic integrity;
- Protecting existing high quality water resources is essential to protecting the natural resource base;
- Ecological flows support water quality criteria, i.e., aquatic uses;
- The Pocono Creek watershed is representative of many streams in the Brodhead watershed;
- Integrated watershed management efforts need to be provided and implemented on a greater scale than the Pocono Creek Watershed;
- The Pocono Creek Watershed is the correct scale for sub-watershed management strategies for the Brodhead Creek Watershed;
- Existing development practices and regulations will not protect the area's natural resources;
- Coordinating the span of regulatory control affecting sustainable watershed management requires systemic changes in numerous divisions of government at all levels;
- The design, use and correct application of innovative technology should be incorporated through permitting programs;

- Further review of the regulatory environment is needed including a review of permitting processes and linkages to overlapping rules for potential conflicts to sustainable water resources management;
- Yesterday's solutions are the basis of today's problems, and application of traditional water management practices are not suitable in the 21st century for regions wishing to retain a rural character;
- Soundly planned growth must occur through a coordinated strategy; sound growth will not occur within a single agency or sector;
- Education, promotion and outreach must be a continuous effort; and
- Water resource management must be implemented on a watershed scale.

8.2 Next Steps

The above conclusions provide the basis for the next steps of sustainable watershed management and economic development of the Pocono Creek watershed. Five critical tasks are identified as needing immediate attention:

1. **Organization:** New county and institutional organizations should be established to implement green infrastructure and sustainable economic development plan;
2. **Revitalization of Existing Plans and Programs:** Existing plans and programs are the most appropriate tools available and need to be revitalized and coordinated with latest information and data;
3. **Scale:** Programs must be scaled for efficient and effective results, using Pocono Creek as a model for more regional efforts;
4. **Review of Overlapping Regulations:** Further review of the overlapping regulatory and socio-economic sectors issues is essential;
5. **Continuous Education and Outreach:** Constant communication, outreach and education is needed to maintain the momentum gained by the Trout Tales program: and

8.2.1 Organization

In order to accomplish these tasks, an executive oversight group committed to regional sustainable growth is essential. Their mission would be to ensure that all interested parties have a voice in guiding future development in Monroe County that ensures the region's economic stability and growth while protecting its base of natural resources. This multi-sector stakeholder council would provide the leadership and opportunity necessary for collaboration among divergent interests and find joint directions that provide growth and "save a trout," at the same time. Such an endeavor requires a long-term effort and commitment, supported by broader partnerships. Sustainable economic and water resource management involves active representation with natural resource agencies, the Chamber of Commerce, and local politicians.

Existing models for executive oversight groups include: a county Economic Advisory Board, which was recommended by the Monroe County Commissioners' 2002 Economic Summit.(Monroe Commissioners); a Critical Area Advisory Committee (CAAC), which is required in PA Act 220 legislation for areas designated as Critical Water Planning Areas (CWPAs) (PADEP Guidance); a Stormwater Enterprise Agency, within the water and wastewater community to integrate planning, revenues and services as described in the recommendations to the Governor's Sustainable Water Infrastructure Task Force's August 2008 report.(Governor), and a public/private Sustainability Advocacy Board composed of a group of high-level leaders who would promote to the public and policy makers at all levels a system where rural goods and services are compensated through new relationships with local urban centers.

8.2.2 Revitalization of Existing Plans and Programs

Although there is a need to plan regionally and on a watershed basis, implementation occurs at the local level. Many local partners already possess the tools needed to steer prevailing development trends into a sustainable direction. These include *Monroe 2020,* the existing county comprehensive plan as well as the *Model Stormwater Quality Management Plan for the Brodhead/McMichaels Watersheds, Act 167 Plan*. Together, these plans, when properly implemented will support a new paradigm for development that achieves the county's sustainability objectives while meeting future housing, business, and retail needs. In addition, with the development of multi-municipal plans under Acts 67 and 68, there would be consistency throughout the region for design and permitting of development projects making the region attractive for business.

Concurrent with this project, the Commonwealth of Pennsylvania introduced the 2002 Act 220 legislation that produced the *State Water Plan, 2009,* including the *Principles,* , and the Governor's Sustainable Infrastructure Task Force published their findings (Governor). The State Water Plan assesses water needs and its goals and objectives echo those found in both the Monroe 2020 and the two Pocono Creek Watershed studies. Act 220 *Principles* (DEP) will direct the State's water resource management program for the next fifteen years. The Sustainable Infrastructure Task Force (Task Force) assessed the water infrastructure needs and recommends more efficient water infrastructure management that includes the maximization of innovative and nonstructural solutions. Both state efforts advocate watershed-based management approaches and integrated water resources management, natural resource protection. The Delaware Regional Water Resources Committee identified "connecting land use decisions and water resources management," as its primary regional goal.

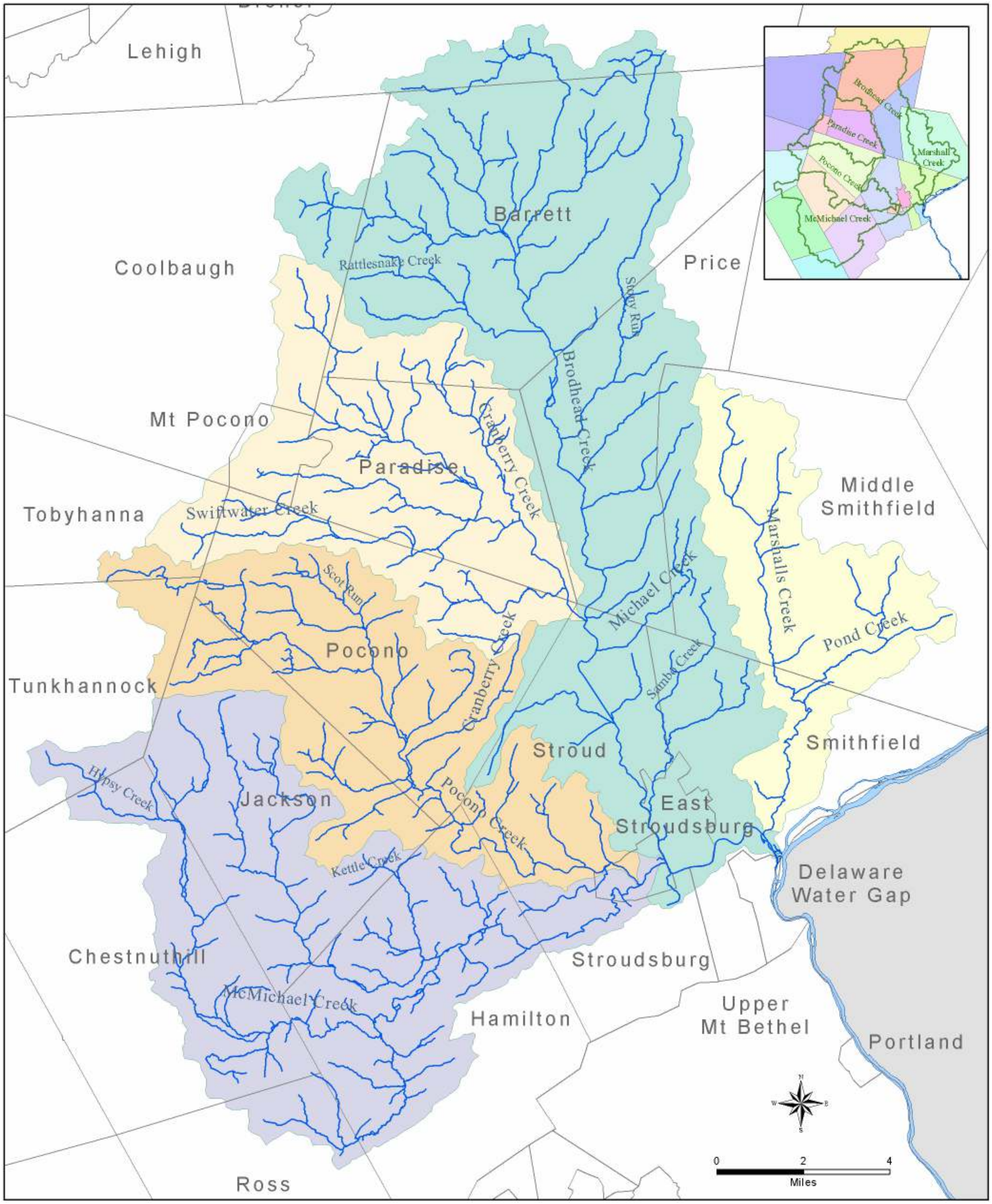
A brief description of the existing planning tools for economic development, environmental conservation, water management and land use policies referenced can be found in Appendix H. These tools can accommodate projected growth while preserving regional amenities and enhancing the quality of life for all Monroe County residents.

8.2.3 Scale

Watersheds have a natural hierarchy consisting of nested hydrologic units. The largest unit is a river basin that can be thousands of square miles. The smallest is a drainage area that can be as small as a tenth of a square mile. In-between are different orders of watersheds, and sub-watersheds. Each of these successively divided and sub-divided watershed levels have dynamic interactions and processes within its own level and between watersheds. Each scale is delineated by and connected to a specific landscape, and each watershed scale has a particular utility. The appropriate scale for water management planning is at a regional watershed scale, such as the Brodhead. However, it is at the local scale that sub-watershed programs developed for regionally linked systems would be implemented.

Shifting to regional planning and management at the Brodhead watershed scale would increase productivity, economies, effectiveness and efficiency. The 48 square mile Pocono watershed is a representative watershed for the 260 square mile Brodhead Creek Watershed within which it is nested (see Figure . Using the Pocono Creek Watershed as a "sustainable watershed laboratory" permits the development of numerous watershed assessment tools and processes as well as critical examination of watershed issues from scientific, social and political perspectives. All of the tools, methodologies, processes and studies may be transferred to other watersheds seeking to establish a sustainable watershed management program.

Figure 8.1: Brodhead Watershed with Sub-Watersheds.



8.2.4 Review of Overlapping Regulations

The review of the existing regulatory structure affecting water shows a complex and entangled network of rules and regulations established for particular segments of society at specific times in history for various reasons. Relationships between the laws for water, land use and infrastructure need to be understood. Becoming familiar with existing laws to protect rural economies and character, water resources, and natural resources is fundamental for a sustainable future.

The study's regulatory overview provides a foundation for further study and analysis of the implications of these complex issues and relationships. Initial examination sheds light on the types of policy questions that need to be addressed, including the following. What is the relationship between infrastructure and local zoning? Is infrastructure driving development or do existing local zoning and development practices increase the need for more infrastructure in rural areas? Can the authority for water supply and land use be separated without adverse consequences? The cumulative water use and discharge impacts on natural resources or designated aquatic uses cross into separate regulatory programs.

Shifting to a new sustainable organizational and management paradigm that operates at a regional scale will require collaboration of political entities working within natural system boundaries. Updating yesterday's solutions to solve today's problems requires continued development of new rules that allow sustainable practices to be implemented.

8.2.5 Continuous Education and Outreach

The fabulous success of the 3-month Trout Trails and Tale public outreach effort in the Pocono region bought the message about linkages between trout and land use, water quality, economic development and ecological flows to the general public, business community, local government officials, and visitors to the area. While highly successful this effort is just an initial effort that lays the ground work for a dual track social marketing effort.

Having broad-based multi-sector support for sustainable development and protection of ecological flows in the Poconos are the long term goals of the project. However, this can only be accomplished through a change in the existing governance paradigm. Broad based support includes persuading local officials, developers, long term residents, state officials in numerous jurisdictions, businesses and newly relocated residents from metropolitan centers that a new approach is in everyone's best interests.

Social marketing is designed to bring about social change using traditional commercial marketing techniques. "Selling" sustainability requires creating incentives to influence consumer behavior that support an alternative to the status quo. Identifying key "social influencers," is the first step. Social influencers are the equivalent of community role models, who are likely to be imitated by a broad range of peers. The broad based "audience" is currently a broad spectrum of interests, each holding their own perceptions to a proposed change. A strategic, incremental, scientific approach is needed in order to identify and target the primary influencers in the sustainability culture of the Poconos. Thus, the social influencers become the target audience.

Establishing the target audience's primary motivators provides the means to "Product Development." Collecting and analyzing behavior data about the target audience establishes the basis for defining specific desirable behavior change objectives. For instance, in the Chesapeake Bay, excessive nutrient runoff was killing the Maryland Blueclaw Crabs. Social research found that lawns are a significant source of the nutrients to the bay. Thus, "Lawn Lovers" were identified as the target audience. Lawn Lovers fertilize their lawns twice a year, as recommended by fertilizer producers. However, the second treatment is excessive and is being washed into Chesapeake Bay. Reducing the number of fertilizer treatments to a single application is important to reducing the nutrient load to the Bay. During the target audience identification studies, a very high correlation between Lawn Lovers and Crab Feasters was found. Crab Feasters consisted of the residential sector that highly valued patio life that included outdoor cookouts, where crabs were a highly valued part of the experience. Social marketers developed their message to address the Lawn Lover's lawn care in such a way it served the self interests of Lawn Loving Crab Feasters. The message was "Save the Crabs, so You Can Eat Them." Motivating the Lawn Lovers to apply fertilizer once a year would allow them to continue to have the outdoor patio lifestyle they highly valued.

Promoting the Product is essential. Once the Product is developed, it is only as good as it is "bought." Developing the most effective promotional materials, i.e. the right outreach and education programs, is essential to getting your Product sold. The goal is to create a promotion that has a positive impact on the targeted Audience. Product Placement is putting the product where it will be picked up by the targeted audience. Also, the "Price," had to be right -- the lower the cost to the Targeted Audience, the more successful the sales would be. Using the Chesapeake Lawn Lovers as an example again, another promotion produced coasters with the image of a crab and the message, "Save the Crabs, So You Can Eat Them," distributed by the better bistro and cafes throughout the Bay area and frequented by this clientele. Bartenders and staff were briefed on the coaster campaign and supporting postcard-sized fact sheets were available regarding single spring fertilizer application (note that it was found that Lawn Lovers are not big readers).

Implementing a social marketing effort after the Trout Trails and Tales effort is critical to maintaining the momentum of goodwill and interest. There is a growing desire by interested parties to continue exploring alternative futures and move towards a sustainable future ("Develop Right, Save a Trout."). Being presented with attractive alternatives has provided a means for participants to imagine a new reality, one that is attractive. Change is coming to the Poconos, and for the first time, there is a growing interest and belief that the change can provide more satisfying, healthy and attractive development patterns with new applications of urban design featured along business corridors and hamlets with conservation design projects supporting growth areas.

Regional skill base is also growing, thanks, in part to the Pilot and Framework projects, which developed innovative and trendsetting approaches to watershed planning as well as making contributions to the field of sustainable development management practices. However, a social marketing effort would require expertise beyond this skill base. The skill set for establishing psycho-social response dynamics, surveying, product development, pricing, promotion and placement are outside the traditional planners toolbox.

Nonetheless, the watershed partners have optimism, energy, tenacity and much creativity. The combined efforts of the Monroe County Conservation District, the Monroe County Planning Commission, and Brodhead Watershed Association for over 30 years has produced highly talented experienced "future makers," who have already had an impact at a state level and are national examples of persistence and leadership. The local partners have keen insight into the overall development processes, have reached "across the aisle" and initiated dialogue with potential challengers. The local partners find success in identifying and changing the processes that change the quality of live. Today, the local partners are poised to compel others to make choices that are in their own best interests and to bring a shared future into reality. In order to galvanize the community into action, the next steps towards a sustainable future require a social marketing effort to begin the new sustainability paradigm.

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"When the well is dry, we learn the worth of water" –Benjamin Franklin

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APPENDICES A-I