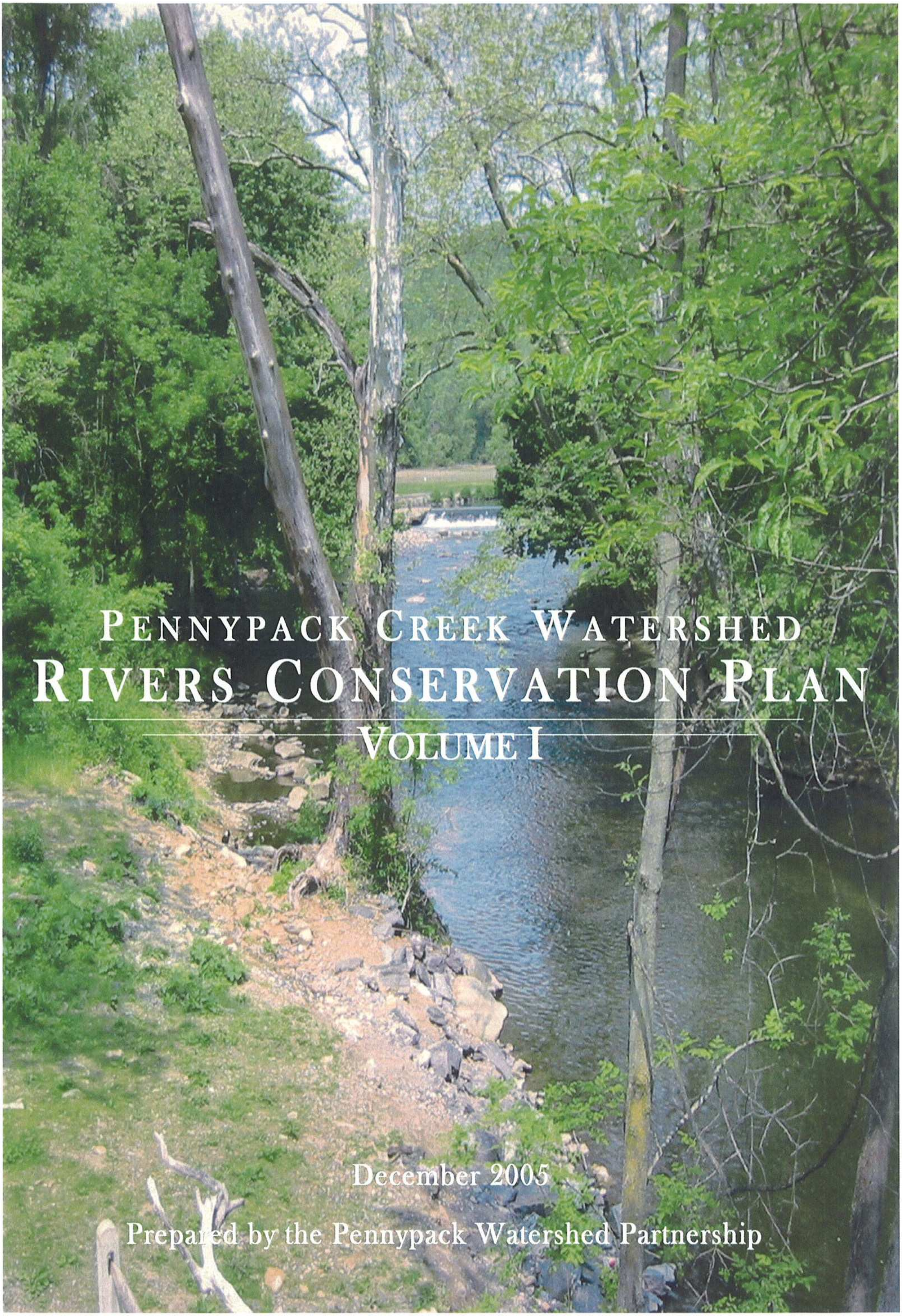

Pennypack Creek Watershed
Rivers Conservation Plan
Volume I

December 2005

Prepared by the Pennypack Watershed Partnership

Pennypack Creek Watershed River Conservation Plan

December 2005

Prepared for:
Philadelphia Water Department
Aramark Tower - 5th Floor
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FXB File No.
PA1605-01-002

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Pennypack Creek Watershed River Conservation Plan Executive Summary

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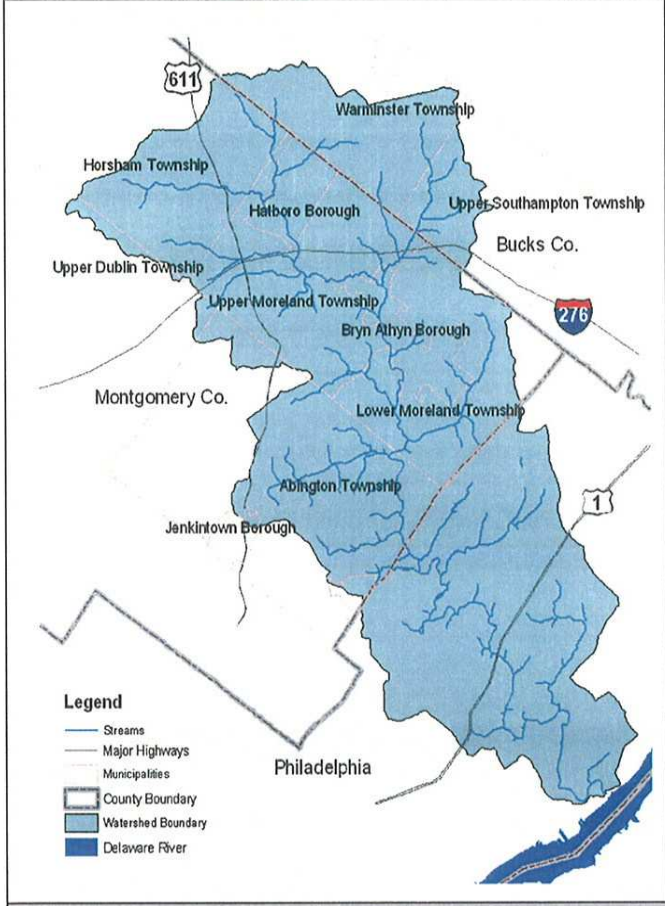
EXECUTIVE SUMMARY

PROJECT DESCRIPTION

The Pennypack Creek River Conservation Plan is one component of ongoing efforts being conducted by the Philadelphia Water Department and the Pennypack Watershed Partnership to improve water quality, the environment and the quality of life of watershed residents. The principle goal of the conservation plan is to reconnect people to the Pennypack Creek through a two year, community based planning process. The planning process includes forming a diverse group of watershed stakeholders to act as a steering committee for the plan, engaging the public in the planning process through outreach and educational events and researching current and projected environmental and cultural conditions in the watershed. The project team will then compile all of this information into a document that provides a work plan to improve the watershed environment and promote the enjoyment of the Pennypack Creek.



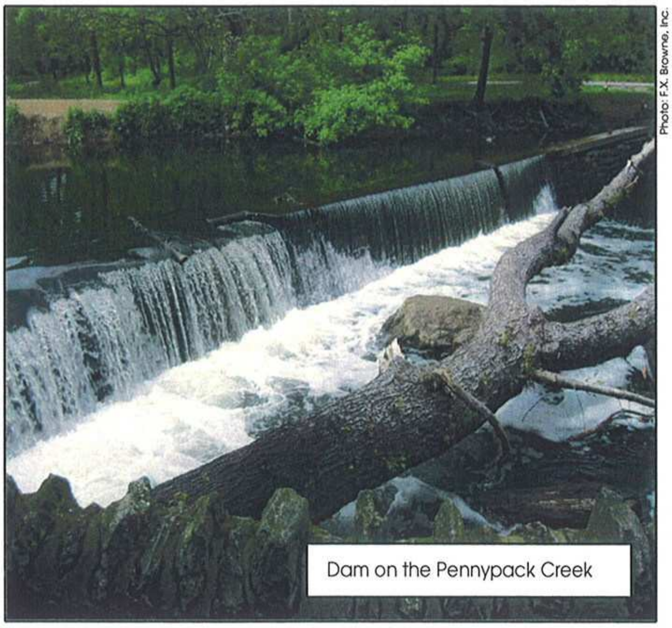
Data Source: Philadelphia Water Department (PWD)

Figure 1. Map of the Pennypack Creek Watershed

The Pennypack Creek has historically meant many different things to different people. The creek has been a faithful partner in our region's economic growth, creating wealth by powering mills and facilitating settlement by providing water and carrying away waste. The creek has also served as a recreation destination for thousands of people who come to streamside parks to fish, picnic or simply contemplate nature. Paradoxically, the Pennypack Creek has also served as an instrument of destruction as flood waters have claimed property and even lives. The Pennypack Creek River Conservation Plan attempts to consider the watershed's complex evolution and develop goals that will provide benefits for everyone who values the creek and its watershed. The goals of River Conservation Plans reflect the diverse interests, concerns and needs of the watershed residents, and will serve as a rallying point for a watershed community to improve their watershed. This River Conservation Plan is the first step in a comprehensive assessment of the Pennypack Creek Watershed that will culminate in a watershed management plan conducted by the Philadelphia Water Department in 2006 and 2007. Figure 1 shows the Pennypack Creek Watershed and its municipalities.

Information contained in this plan was gathered from existing studies as well as input from community members, key person interviews, a public survey and a number of workshops and neighborhood meetings. Analysis of Geographic Information System (GIS) data played a major role in the development of this plan and many GIS maps are included to enhance the understanding of the spatial relationships between watershed resources, opportunities and concerns. The fruits of existing planning efforts were also important to the development of the River Conservation Plan. Public participation from the Pennypack Park Master Plan, as well as the suburban community comprehensive plans, provides additional connections between this plan and the planning goals of the watershed stakeholders.

There are many opportunities to have a positive impact on the Pennypack Creek and its watershed and there are many organizations doing work to improve the watershed environment. Long term improvement, however, requires that anyone who lives, works or recreates within the watershed does their part to reduce negative impacts on the natural resources of the watershed while creating the momentum to improve the watershed community. This is the ultimate goal of the River Conservation Plan – to get people involved as a positive force to improve the watershed. This document and planning effort will serve as a guide to continue working toward that ultimate goal.



Dam on the Pennypack Creek

The River Conservation Planning process is funded in part by the Pennsylvania Department of Conservation and Natural Resource's (PA DCNR) Community Partnership Conservation Program. In 2003, the Philadelphia Water Department received a grant from the PA DCNR to conduct the plan. Other funding and in-kind services to conduct this plan have been provided by the Philadelphia Water Department, Fairmount Park Commission, Friends of Fox Chase Farm, Friends of Pennypack Park, Montgomery County Planning Commission, and the Pennypack Ecological Restoration Trust.

Public Outreach Efforts

The Pennypack Watershed Partnership conducted a number of public participation and outreach events throughout the two-year River Conservation Plan process. Public participation is central to accomplishing the goals of the plan. The following sections summarize the public outreach and education efforts.

Neighborhood and Community Meetings

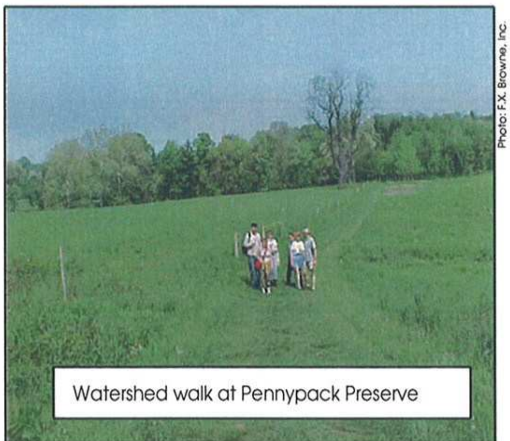
F. X. Browne, Inc., the Partnership's consultant for the River Conservation Plan, presented information concerning the Pennypack Creek River Conservation Plan at twenty community, civic association, school, municipal and environmental organization meetings between January 2004 and July 2005. Presentations included an introduction to the River Conservation Planning process and detailed ways that watershed residents could become involved in the development of plan goals and implementation projects.

Community presentations were given throughout the watershed from headwaters areas in Warminster and Horsham to the lower portions of the watershed in the Bustleton and Holmesburg neighborhoods of the city. These outreach efforts were successful at reaching watershed residents that may not typically be exposed to information regarding watershed planning. Table 1. is a list of the neighborhood and community groups which hosted conservation plan presentations.

Table 1. Neighborhood and Community Groups Hosting Conservation Plan Presentations	
Abington Environmental Advisory Committee	Pennypack Farm
Bucks County Trout Unlimited	Philadelphia Canoe Club
Bryn Athyn Borough Council	Rockledge Borough Council
Boys Scouts of America Council Round Table	Southeastern Montgomery County Trout Unlimited
Fox Chase Civic Association	Southampton Watershed Association
Friends of Fox Chase Farm	Upper Moreland Township Board of Supervisors
Friends of Pennypack Park	Upper Southampton Board of Supervisors
Greater Bustleton Civic League	William Tenent High School Environmental Science Classes
Holmesburg Civic League	William Tenent High School Biology Class
Horsham Township Board of Supervisors	Willow Grove Senior Center

Public Meetings

As part of the River Conservation Planning process, the Pennypack Partnership conducted four public meetings to inform the public about the River Conservation Plan and gather public input regarding planning efforts. The first public meeting for the Pennypack Creek River Conservation Plan was held in conjunction with the regular meeting of the Bucks County Chapter of Trout Unlimited in November 2004. The second public meeting was held in March 2005 at the Pennypack Environmental Center and featured a presentation



Watershed walk at Pennypack Preserve

by a Historical Consultant to the Philadelphia Water Department, Adam Levine. Mr. Levine presented information on the changing landscapes of the Pennypack Creek Watershed and how these changes affect the Pennypack Creek.

The Draft River Conservation Plan document was presented at a series of public meetings in September and October of 2005. The final River Conservation Plan document will be presented at the fourth meeting in December of 2005.

The public meetings have been well attended by people involved in the Pennypack River Conservation Plan process along with members of the general public. Approximately 20-30 people attended each meeting. Feedback regarding the planning efforts was positive and members of the public provided useful suggestions for the improvement of the plan document and public engagement process.

Workshops and Watershed Walks

The Pennypack Partnership conducted a series of watershed workshops and walks between September 2004 and May 2005. Educational efforts provided attendees an opportunity to learn about their watershed and encouraged citizens to participate in the River Conservation Plan process. The following is a list of watershed walks and seminars that were conducted:

Pennypack Watershed Walk, Fox Chase Farm, **July 13, 2004**

Watershed Wonders Festival, Pennypack Environmental Education Center,
September 18, 2004

Volunteer Stream Monitoring Presentation, Pennypack Environmental Education Center,
September 21, 2004

Homeowner Presentation on Watershed Protection, Pennypack Ecological Restoration Trust,
November 16, 2004 and April 26, 2005

Stream Restoration Presentation, Pennypack Ecological Restoration Trust,
April 7, 2005

Citizen Survey

F. X. Browne, Inc. conducted a statistically valid survey of watershed residents in Montgomery and Philadelphia Counties inquiring about the level of watershed awareness, park usage and environmental priorities of survey respondents. Two-thousand surveys were mailed to random addresses throughout the two county area of the watershed. The Bucks County portion of the watershed was not surveyed due to a lack of parcel data for Bucks County at the time the survey was conducted.

One-hundred and forty eight responses were returned. This equals a 7.5 percent survey return rate which is a typical response rate for a random survey of this kind. Survey results indicated that many respondents felt that water quality in the Pennypack Creek has improved over time (83% of respondents) and that water quality and conservation was an important issue affecting their quality of life (88% of respondents). Only 10 percent of respondents participate in watershed protection activities. Complete survey results are detailed in the Public Outreach and Participation report which accompanies the complete plan document.

Key Person Interviews

F. X. Browne, Inc. conducted 25 key person interviews during the River Conservation Planning Process. The goal of the Key Person Interviews was to capture in-depth observations and perceptions of watershed conditions and values from a diverse group of stakeholders. Interviewees were asked a series of questions regarding how they or their congregations, constituents, employees or organization members view and use the Pennypack Creek. Interviewees were also asked to identify needs for watershed improvement or valuable watershed resources. The interviews provided opportunities for a level of detailed input from stakeholders that may have been difficult to obtain through public meetings or other outreach events.

A number of prospective interviewees were selected from outside of the traditional pool of participants in watershed conservation activities and thus gave a more diverse view of the watershed. Interviewees included religious leaders, businesspersons, political leaders and public servants as well as environmental leaders.

Neighborhood and Block Interviews

F. X. Browne, Inc. scheduled ten work days to interview pedestrians in neighborhoods and shopping centers throughout the watershed. Pedestrians were asked brief questions about their perceptions of the Pennypack Creek and their usage of watershed open spaces and amenities. Interview results echoed many of the responses to the citizen survey.

Many respondents indicated that they were unaware of efforts being conducted to improve the watershed but would be interested in participating in watershed protection efforts if they knew more about the efforts and if these activities were appropriate for children. A number of respondents indicated they would be interested in activities that cleaned up the parks in the watershed. The majority of interviewees felt that the creek was not safe for swimming and many felt that there has been an increase in the amount of trash and litter in the parks and stream itself.

The neighborhood and block interviews collected information from a random and diverse pool of respondents. This effort ensured that input and concerns of the general public are included in the final River Conservation Plan document.

Issues, Concerns and Constraints

The Pennypack Creek Watershed, is home to many natural wonders and historic resources important to our region. Pennypack Park consists of 1,600 acres of natural and recreation lands that provide a green ribbon from the City's border with Montgomery County to the Delaware River. This park hosts a diversity of plant and animal species and affords residents a respite from urban life. Further upstream the Pennypack Preserve, owned and managed by the Pennypack Ecological Restoration Trust, is an example of the power of private citizens' efforts to protect the resources they care about. The preserve is the largest publicly accessible, private nature preserve in Montgomery County. Future plans to expand the greenways along the Pennypack Creek into the headwaters of the watershed and beyond are included in the Montgomery County Open Space plan. These are just some examples of the many active groups and efforts underway to improve the Pennypack Creek Watershed for everyone.

The relative health and condition of the Pennypack Creek Watershed is a reflection of the manner in which people use, develop and steward the land. Water quality, environmental, and even recreational conditions, are a result of historic and current land uses. Throughout the public outreach and participation process, and with critical input from the River Conservation Plan steering committee, common themes continually recur when people consider the Pennypack Creek.

Rapid conversion of the Pennypack Creek Watershed from agricultural lands to predominantly residential land uses, with the attendant construction of transportation infrastructure and commercial centers, is an often identified explanation for many of the Pennypack's ills. This rapid residential development is cited as the cause of stormwater management issues, flooding problems, water quality degradation as well as loss of biodiversity and open space. New federal, state and municipal regulations are attempting to stem the negative impacts of the land development process on the environment. Current planning efforts, such as the Montgomery County Open Space Plan and Open Space Bond issue, are working towards creating greenways throughout the watershed while protecting existing green fields.

Reducing the impacts of stormwater flows from existing development is another recurring theme encountered when discussing the Pennypack Creek. The creek shows many of the symptoms of a degrading urban stream: severe bank erosion, disconnection from its floodplain, low base flow followed by high storm flows and poor aquatic biodiversity. Many efforts are underway to address stormwater management ranging from homeowner education to university research studies. This conservation plan can play a major role in changing people's habits and attitudes about stormwater management.

Photo: Mike Wilson

Trout Unlimited Restoration Project In Lorimer Park

Historic schools, religious buildings and commercial sites are scattered throughout the watershed as a testament to the region's settlement and history of growth and commerce. These historic resources, along with evidence of Native American settlements, reinforce the notion that the Pennypack Creek Watershed, with its temperate climate, rolling topography, natural beauty and economic opportunities, is a great place to live, work and play.

WATERSHED CHARACTERISTICS

Home to more than 250,000 residents, the Pennypack Creek Watershed encompasses a 56-square mile region in southeastern Pennsylvania, an area dominated by the urban and suburban landscapes of northeast and suburban Philadelphia. Much of the watershed lies within the Piedmont region, a broad swath of land extending from Georgia to Massachusetts that separates the flat Atlantic Coastal Plain from the Appalachian Mountains. This is a land of transition; a pastoral landscape of narrow valleys, woodland streams, and forest-covered hills. It is also a land that has been heavily altered by sprawling cities, agriculture, and industry.

Photo: F. X. Browne, Inc.

Street intersection in Northeast Philadelphia

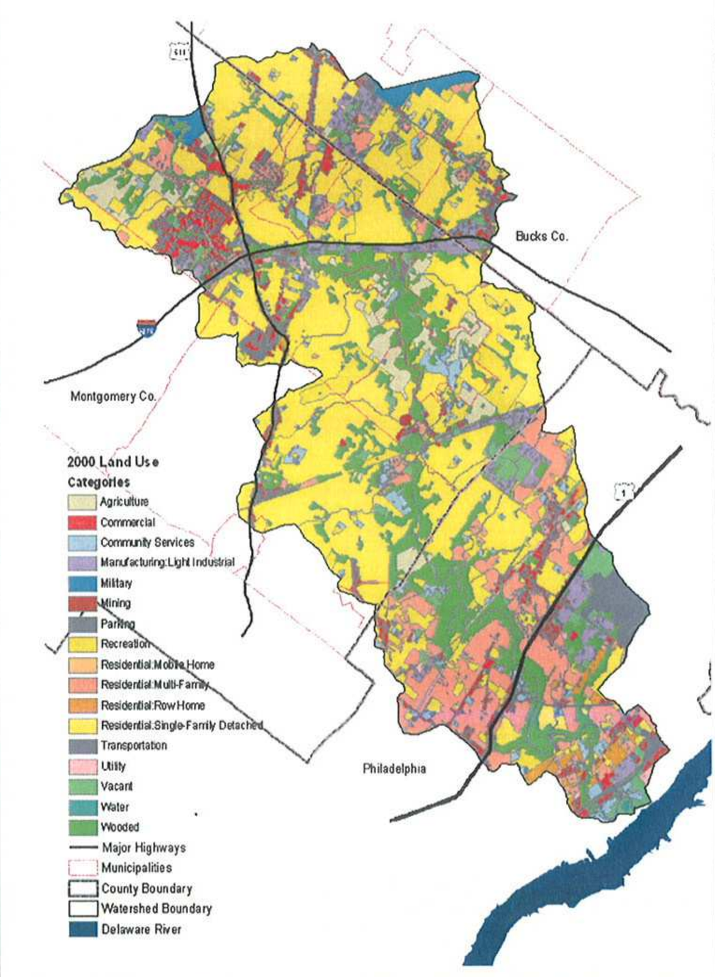
Like much of the northeastern United States, the climate in the Pennypack Creek Watershed is characterized by four distinct seasons with moderately cold winters and long humid summers. Although much of the forest within the Pennypack Creek Watershed has been removed to support agriculture and residential and commercial development, or altered by invasive species and nuisance deer, remnants of the hardwood forests that once covered the entire watershed can be found in places such as Lorimer and Pennypack Parks and the Pennypack Preserve.

The upper portions of the watershed are located in the northern suburbs of Philadelphia within Montgomery and Bucks Counties. Here, Pennypack Creek flows through several boroughs and residential communities including Willow Grove, Hatboro, Southampton, Horsham, Abington, and Bryn Athyn. Moving downstream, the main stem of the Pennypack Creek flows southeast through the Fox Chase, Bustleton, Rhawnhurst, and Holmesburg sections of Northeast Philadelphia before entering the Delaware River.

While sections of the watershed are covered by urban land uses including industrial and business parks, commercial shopping areas and suburban residential communities, much of the lower section of the Pennypack Creek is shielded from development by an interconnected greenway of forested lands, protected farms, and park land. This greenway includes more than 700 acres of protected lands managed by the Pennypack Ecological Restoration Trust; Lorimer Park, a 250-acre Montgomery County Park; and Pennypack Park, which is part of the renowned Fairmount Park System in the City of Philadelphia.

LAND USE

Land use in the Pennypack Creek Watershed is predominantly residential, characterized by single family detached residences in the upper and middle portions of the watershed and multi-family and row home areas in the lower section of the watershed. The majority of this development occurred in the suburban expansion after World War II but considerable suburban development has occurred in the headwaters and upper portions of the watershed over the last 20 years. Figure 2 presents land use within the Pennypack Creek Watershed as of 2000. The large areas of yellow on the map are indicative of the preponderance of residential land uses in the watershed.



Land use category	Acres	% of watershed
Single family detached	14,580	40.44
Wooded	5,190	14.39
Total Multi-family, row home, mobile home residential	4,234	11.73
Parking	2,042	5.66
Commercial	1,977	5.48
Recreation	1,605	4.45
Agriculture	1,346	3.73
Manufacturing	1,185	3.29
Vacant	1,172	3.25
Community Services	1,043	2.89
Transportation	867	2.41
Military	367	1.02
Water	217	0.60
Utility	207	0.58
Total Mining	25	0.07

Data Source: Year 2000 Land Use Data from Delaware Valley Regional Planning Commission

Figure 2. Year 2000 Land Use Map and Statistics for the Pennypack Creek Watershed
Single-family detached residences account for over 40 percent of the land use in the Pennypack Creek Watershed.

The second largest land use category in the watershed is wooded land (14 percent of watershed land). These wooded areas can be seen in Figure 2 as a green spine of parks and preserved land along the creek corridor through the lower and middle sections of the watershed. Parking and commercial land uses (11 percent of the watershed) contribute to the overall area of impervious surface in the watershed.

Parks, Recreation and Open Space

There are 2,650 acres of public park, recreation, and open space land in the Pennypack Creek Watershed. This equates to approximately 10 acres of recreational and open space land for every one thousand watershed residents. The distribution of regional open spaces and recreational lands, however, is largely in the middle and lower sections of the watershed, with Pennypack Park being the largest and most notable park at 1,600 acres. Figure 3 shows the municipal and county parks and recreation facilities in the watershed. It is important to note that the municipalities that are only partly in this watershed have other facilities, not presented in this table, that are available for residents' use. The lands of the Pennypack Preserve are also not included on this map even though it is open to public use. The preserve is privately owned by the Pennypack Ecological Restoration Trust and is not officially part of county or municipal park systems.

In addition to large areas dedicated to passive recreation (e.g., Pennypack Park and Lorimer Park, etc.) each municipality has neighborhood and community parks and schools that provide playgrounds, ball fields and courts to meet the active recreation needs of their residents. Each municipality also has recreation programs that provide recreational and cultural programming for residents. The City of Philadelphia offers the widest range of recreational programming of any municipality in the watershed through the 12 recreation centers operated by the Philadelphia Department of Recreation.

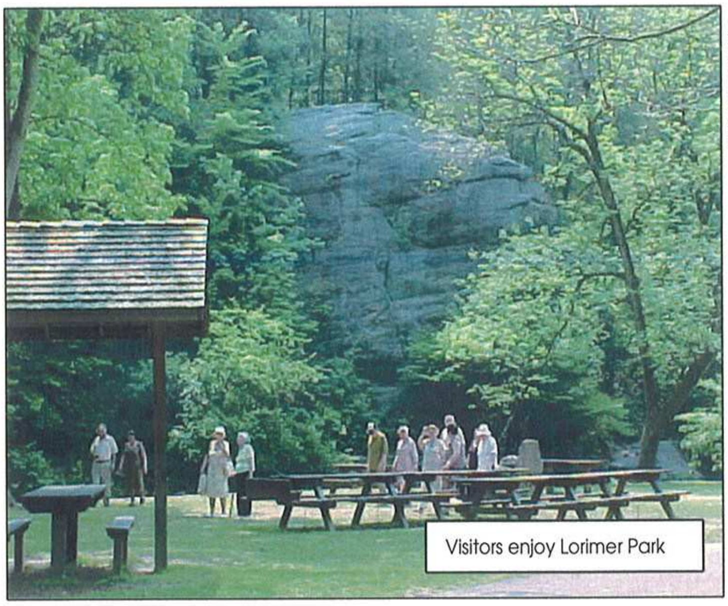
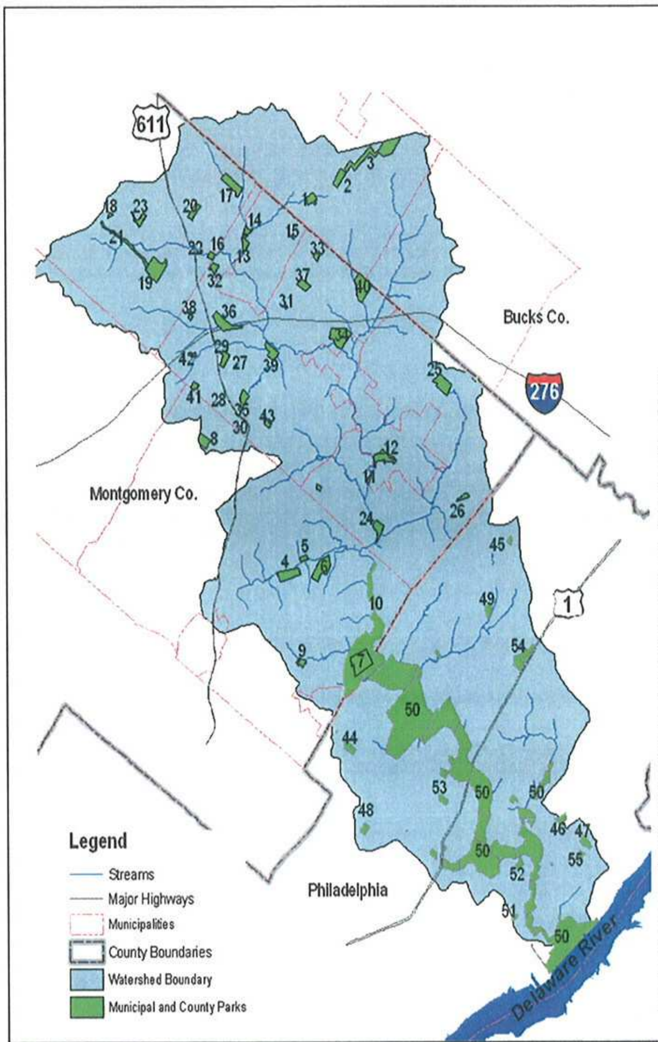


Photo: F. X. Browne, Inc.

Visitors enjoy Lorimer Park



Data Source: PWD, Municipal Open Space Plans, Recreation Plans

Key To Watershed Parks		
1. Crooked Billet Green	19.Lukins Park	37.Boileau Park
2.Parklands of Warminster	20.Meetinghouse Park	38.North Will Grove Park
3.Szymanek Park	21.PECO Trail	39.Terwood Park
4.Abington Bird Sanctuary	22.Pemmepecka Park	40.Frank Pillegi Park
5.Abington Game Preserve	23. Sawyers Way	41.Valley Green
6.Abington Game Preserve	24.Elkins Field	42.Whitehall Park
7. Butler Park	25.Lower Moreland Park	43.Woodlawn Park
8.Crestmont Park	26.Ridgeway Park	44.Fox Chase Playground
9. Fox Chase Manor Park	27.Brook Street Park	45.Gifford Playground
10.Lorimer County Park	28.Broughton Park	46.Holme Playground
11. Elsa Park	29.Buehler Park	47.Jacobs Playground
12.Bryn Athyn Borough Park	30.Cherry Street	48.Jardel Recreation
13.Hatboro Memorial Park	31.Dawson Manor Park	49.Lackman Playground
14.Eaton Park	32.Fair Oaks Park	50.Pennypack Park (Fairmount Park)
15.Tanner Playground	33.Fern Village Park	51.Rambler Playground
16.Blair Mill Park	34.Mason Mill Park	52.Ramp Playground
17.Clearbrook Park	35.Memorial Park	53.Rhawnhurst Playground
18.Jarrett Road Park	36.Mill Road Park	54.Robert Memorial Playground
		55.Trumbette Playground

Figure 3. Community and Sub-Regional Parks of the Pennypack Creek Watershed

Biological Resources

The biological communities of the Pennypack Creek Watershed, be they aquatic or terrestrial, flora or fauna, reflect the predominance of urban and suburban development throughout the watershed. Even large natural areas such as Pennypack Park and the Pennypack Preserve suffer from some degree of habitat disturbance either from encroachment of human uses, upstream water quality and habitat degradation or nuisance or invasive plants and animals.

Low aquatic macroinvertebrate diversity has been noted in the Pennypack Creek Watershed for at least 35 years and is an indicator of water quality and habitat stressors on the creek. More recently, non-native, invasive plant species, such as Japanese knotweed (*Polygonum cuspidatum*), mulitflora rose (*Rosa multiflora*) and porcelainberry (*Ampelopsis brevipedunculata*) among others, have been claiming large areas of natural lands in the watershed and contributing to declines in native plant and animal biodiversity in the watershed.

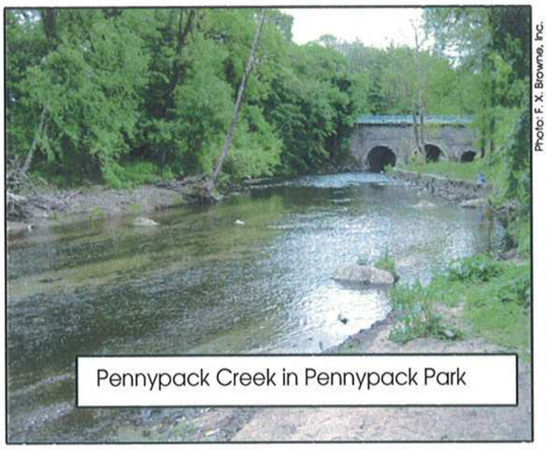


Photo: F. X. Browne, Inc.
Pennypack Creek in Pennypack Park

Large populations of white-tailed deer (*Odocoileus virginianus*) have also contributed to declines in native biodiversity in the watershed by denuding forests of understory vegetation and tree seedlings. Deer browsing on tree seedlings is preventing recruitment of new trees in woodlands. The removal of understory plant species by deer browsing reduces food sources and cover for a large number of native insects, birds and mammals.

The PA Fish and Boat Commission is leading an effort to restore populations of native fish species to the watershed. In 2004 the commission released 667,000 hickory shad fry into the creek in an effort to imprint the creek on these anadromous fish (fish that spend parts of their lives in the ocean and return to fresh water to spawn) so that they will return to the Pennypack Creek to spawn. The Fish Commission is supporting these stocking efforts with other cooperative efforts with the Fairmount Park Commission and the Southeast Montgomery County Chapter of Trout Unlimited to remove or mitigate obstacles to fish passage along the length of the Pennypack Creek.

Water Resources

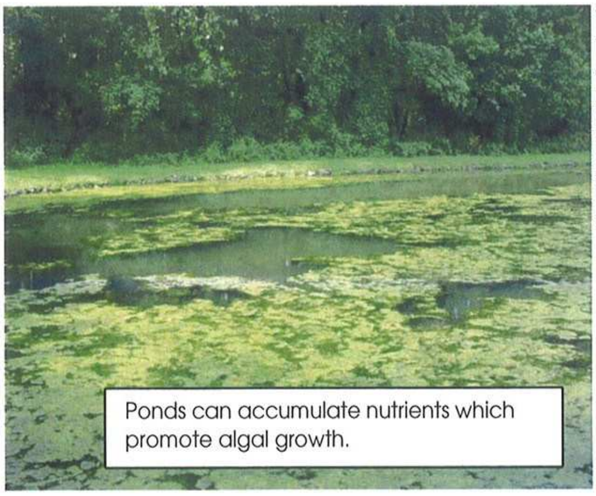
Water resources include both surface and ground water resources. Surface water resources include lakes, ponds, streams, and wetlands, while groundwater resources consist of water stored within porous bedrock called aquifers.

Sustainable water resources are essential for the success of all human societies and provide a nearly endless potential suite of uses ranging from active and passive recreation, industrial cooling and production, food production, irrigation, power generation, flood conveyance, and drinking water. Watershed residents and other users value water resources for the direct and indirect uses they provide. As a society, we also value water resources for their inherent ecological value, their mysterious beauty and for the tremendous variety of life they support. The beauty of a free flowing stream or still fog on a glacial lake has been captured in picture and song for centuries. Many of the world's great scenic landmarks (the Grand Canyon, Crater Lake, Niagra Falls) are either the result of or center around water resources. Even the term water resources, for all its utility, somewhat undermines the true value of rivers, lakes, and wetlands.

Surface Water Resources

The Pennypack Creek Watershed covers 56 square miles and contains 79 miles of surface water streams. The Pennypack Creek's headwaters lie in Horsham Township in Montgomery County and in Warminster Township, Bucks County. The watershed includes approximately 61 ponds occupying 38 acres of land and 502 acres of wetlands. Figure 4 is a map of the ponds and wetlands in the watershed.

A Philadelphia Water Department and Temple University study of ponds in the watershed revealed that 90 percent of the first order streams in the Montgomery County portion of the watershed contain ponds. This statistic indicates that dammed or altered first order streams are the norm in the Pennypack Creek Watershed. These ponds affect water quality and natural stream flows by concentrating nutrients, promoting the growth of algae, and raising water temperatures.



Ponds can accumulate nutrients which promote algal growth.

Photo: Philadelphia Water Department

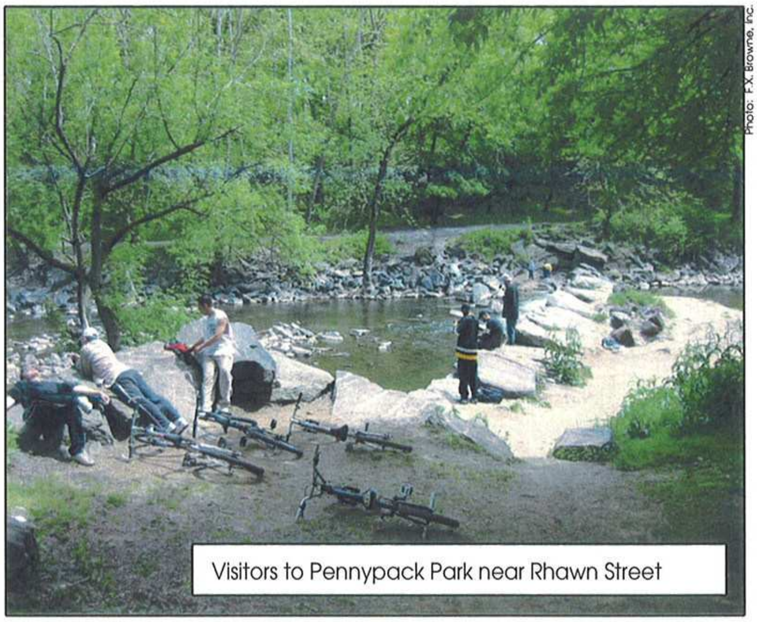
According to the National Wetlands Inventory, the Pennypack Creek Watershed contains approximately 502 acres of wetlands. The National Wetlands Inventory is a service of the U. S. Fish and Wildlife Service that identifies wetlands from aerial photographs. These wetlands are not field verified and may contain data errors or inaccuracies. Field verifications are necessary for determination of jurisdictional wetlands. The large majority of wetlands in the watershed are riverine or riparian wetlands found along the mainstem of the Pennypack Creek. Important areas of wetlands can be found on the Pennypack Preserve, in Pennypack Park, and at the confluence of Meadow Brook with the Pennypack Creek in Abington Township.

Water Quality

A number of biological assessments and water quality studies have been performed on the Pennypack Creek since the 1960s. Major studies include monitoring by the Pennsylvania Department of Health and the PA Department of Environmental Protection (PA DEP) in the 1960s and 70s, habitat assessments conducted as part of the Pennypack Park Master Plan, and ongoing biological and water quality monitoring by the Philadelphia Water Department and the PA DEP.

PA DEP monitoring has determined that approximately 82 percent of the Pennypack Creek's stream miles are impaired and have subsequently been listed on the Pennsylvania 303d list of impaired waters. According to the DEP *Watershed Restoration Action Strategy for the Poquessing and Pennypack Creek Watersheds*, 66 of the 79 stream miles do not support the biological communities protected by the Clean Water Act. The report indicates that the majority of impairment is due to urban stormwater run-off, water flow variability and flow and habitat alterations. Other recent studies of the creek echo the PA DEP's findings and identify stormwater runoff and fluctuations in stream flow as the primary challenge to protecting and restoring the stream's ecosystem.

The Pennypack Creek, although much improved as a result of the implementation of the Clean Water Act, is still challenged by nutrient contributions from wastewater treatment plant discharges and from non-point source pollution. Watershed residents, in their goal to improve water quality and stream biology, need to take a holistic approach to achieving these improvements by working closely with municipal officials to ensure that all point sources are meeting their permit requirements (and that the funding is there to support plant operators in this endeavor) in addition to educating citizens on the causes and effects of stormwater runoff pollution and the measures that citizens can take to minimize polluted runoff.



Visitors to Pennypack Park near Rhawn Street

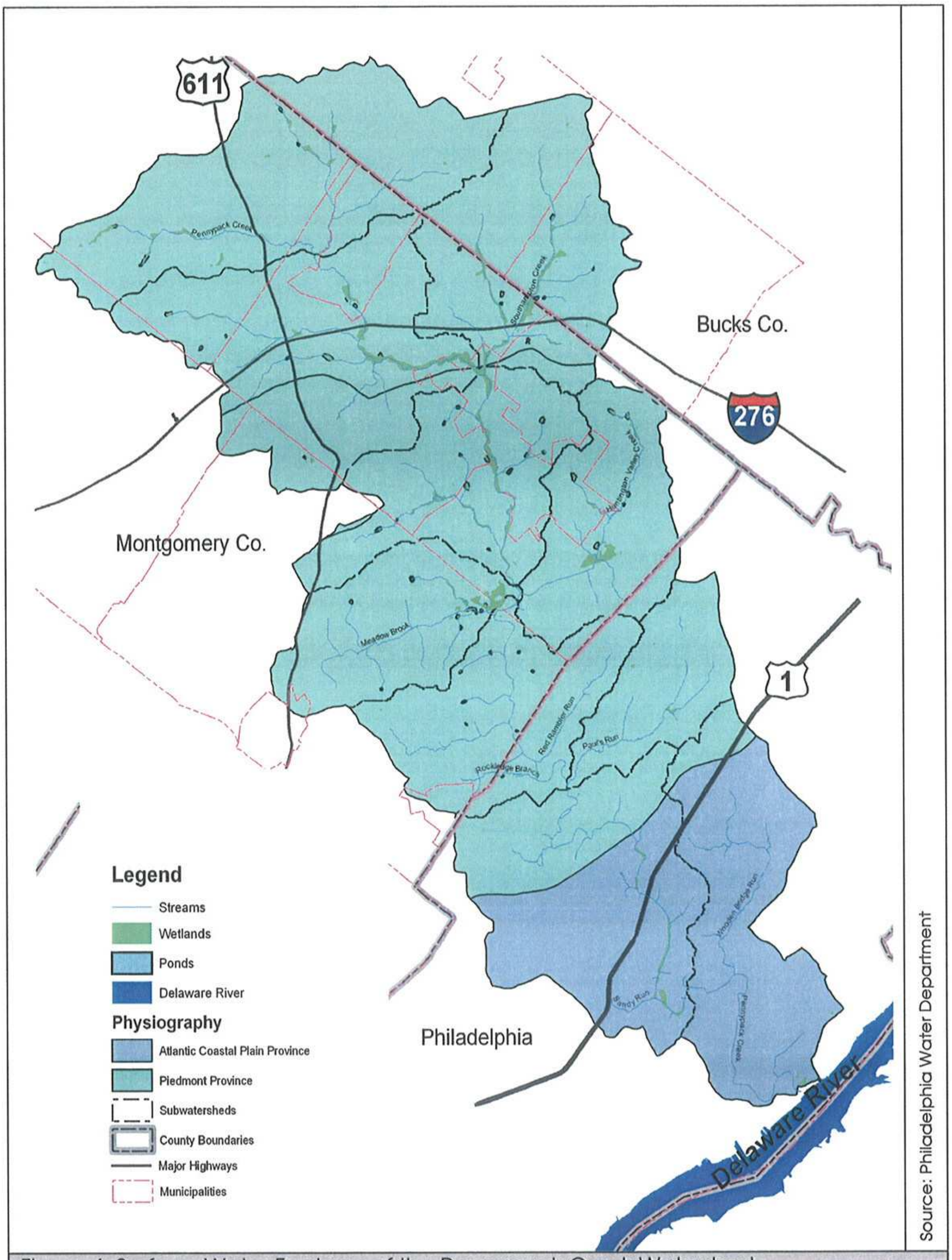


Figure 4. Surface Water Features of the Pennypack Creek Watershed.

Cultural and Historic Resources

The Pennypack Creek Watershed is rich in historic, archaeological and cultural resources. There are 43 buildings and structures either listed or determined to be eligible for listing on the National Register of Historic Places as well as 19 archaeological sites with completed Pennsylvania Archaeological Site Surveys. These sites document Native American habitation, diverse religious groups that settled the area and important milestones in the region's commercial and industrial past. Many cultural resources become threatened by development, redevelopment or infrastructure improvement projects. Cultural and historic sites reveal the importance of the Pennypack Creek and its resources to prehistoric and contemporary residents of the watershed alike and as such, attempts to preserve these unique resources should be included in conservation efforts.

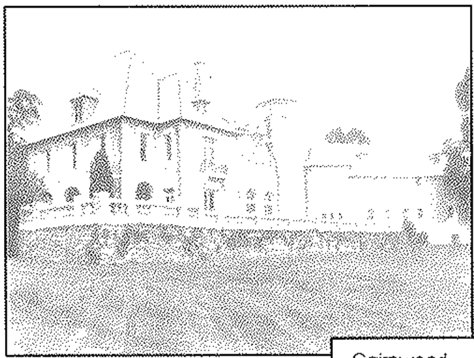


Photo: PHMC

Cairnwood

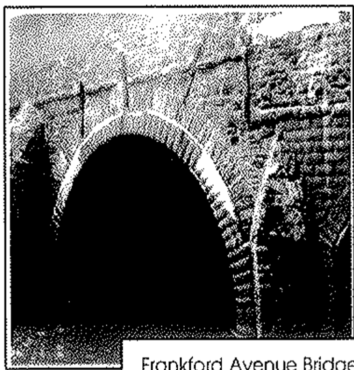


Photo: PHMC

Frankford Avenue Bridge


Photo: PHMC

Knowleton

Goals and Objectives

The Goals and Objectives of the River Conservation Plan were developed by the plan steering committee, collected from public input and culled from existing and ongoing planning and restoration efforts. Goals and Objectives will continue to be developed through the public meeting process and will reflect public comment and reaction to the draft plan documents.

The following is a list of the goals of the Pennypack Creek River Conservation Plan. These goals will serve as a framework for the development of management options that can be implemented by watershed stakeholders, in order to improve the Pennypack Creek Watershed.

- Improve stream habitats and aquatic resources
- Improve in-stream flow conditions
- Improve water quality and reduce pollutant loads
- Improve and protect stream corridors
- Address flooding
- Enhance and improve recreational opportunities
- Enhance quality of life for watershed residents
- Improve stewardship, communication and coordination among watershed stakeholders and residents

Management Options

The management options for the Pennypack Creek River Conservation Plan are being developed by the plan steering committee and through input from watershed stakeholders and participants in the public outreach and education efforts. The purpose of the management options is to develop a list of positive actions that watershed stakeholders can implement to improve the health, environment, historical, cultural and economic resources of the Pennypack Creek Watershed. Table1 is a Preliminary Management Option Matrix that presents the action items that have been developed to date. The management options will be further developed through the River Conservation Planning process and public input.

The River Conservation Planning Team continued to accept input regarding management options until the publication of the Final River Conservation Plan. Through the course of the planning process, the steering committee will prioritize these options and identify primary and supporting partners to implement these action items.

Many of the identified Management Options will support more than one of the Plan's Goals. In these cases the Management Options are included under the most appropriate goal.

Table 1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Goal 1. Improve Stream Habitat and Protect Aquatic Resources				
Planning & Data Gaps	• Develop comprehensive stream bank and stream channel stability assessment • Adopt consistent natural resource protection ordinances for all watershed municipalities	• Work with Meadowbrook Country Club to improve natural riparian corridor	PWD, SEMCTU, TU Municipalities, CPC,PEC	• 2005-2006
Implementation	• Improve in-stream habitats through dam removal and habitat enhancement projects • Daylight buried and piped stream channels where feasible • Restore geomorphic stability through active channel restoration • Implement stream and riparian restoration recommendations of FPC Pennypack Park Master Plan	• Huntingdon Pike Dam • Restore day-lighted section of the Sandy Run • Lorimer Park Adopt-A- Stream project	FOPP, FPC, PAFBC, PERT, PWD, SEMCTU	• On-going habitat restoration projects
Monitoring	• Monitor successes of habitat and species restoration efforts through agencies, volunteers and non-profit organizations	• Monitor success of PA Fish and Boat Commission Shad restoration and dam removal program • Continue PWD Biomonitoring efforts	DRKN, FOPP, FPC, PAFBC, PWD, SEMCTU	• On-going
Education	• Work with PA DOT and municipalities to ensure proper bridge and culvert design for new and redevelopment	• PA Turnpike repairs	DVRPC, Municipalities, PA DOT, PEC, PWD	• 2006-2007
Goal 2. Improve In-stream Flow Conditions				
Planning & Data Gaps	• Develop headwater protection ordinance to assist municipalities with protection of headwater streams • Ensure enforcement of municipal natural resource protection ordinances • Identify and prioritize stormwater BMPs for retrofits that promote infiltration and reduce stream flow variation during storm events	• All municipalities	PEMA, CCD, CPC, Municipalities	• 2006-2008

Table 1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Implementation	• Encourage large institutional landowners to implement porous pavement, infiltration trench and other on-site infiltration demonstration projects • Retrofit stormwater BMPs for biological water treatment and longer detention times • Remove headwater ponds	• Willow Grove Mall	SEMCTU, PAFBC, Korman Corp. Municipalities, PEC, PWD, TU	• 2005-2006 • On-going
Monitoring	• Establish additional flow monitoring stations on the creek	• Establish flow monitoring stations in rapidly changing sub-watersheds such as the Pennypack Headwaters	SEMCTU	• 2006-2008
Education	• Work with county conservation districts and municipal EACs to Implement rain barrel, rain garden and green roof workshops • Develop and present stormwater management workshops for homeowners, builders and municipal officials		CCD, Municipalities, PWD	• On-going
Goal 3. Improve Water Quality and Reduce Pollutant Loads				
Planning & Data Gaps	• Develop Act 167 Plan • Adopt and implement NPDES Phase II Regulations • Collect fecal coliform monitoring data to characterize sources of coliform, including wet weather sampling • Develop BMP database, including location, ownership and maintenance needs • Develop long term monitoring and maintenance plans for new and existing stormwater BMPs in the watershed		CCD, CPC, Municipalities, PWD, TU	• On-going
Implementation	• Institute stormwater BMP maintenance and monitoring program • Continue to take actions to reduce the occurrence of combined sewer overflows	• All municipalities and City of Philadelphia	CPC, Municipalities, PWD, TU	o On-going

Table 1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Monitoring	• Implement aggressive monitoring program to track sewer infrastructure leaks and illegal cross connections • Conduct additional water quality monitoring on the watershed to characterize pollutant loading sources • Monitor water quality changes in BMP retrofits	• City of Philadelphia • All municipalities	CHD, DRKN Municipalities, PWD, Utilities	o 2006-2008
Education	• Develop homeowner's manual for pond owners in headwaters to improve water quality • Develop BMP demonstration site map and informational materials for municipalities and developers		CPC, CCD, DRKN Municipalities, PWD, TU	o 2006
Goal 4. Improve and Protect Stream Corridors				
Planning & Data Gaps	• Develop and implement deer management plans for natural areas • Develop invasive species management plans for natural areas and parks • Develop watershed wide open space/riparian corridor protection plan • Create inventory database of riparian landowners to be used for outreach and education and research • Adopt woodland protection ordinances, in watershed municipalities, that limit removal of existing vegetation and update standards for tree replacement with species that were removed from the development site • Develop tree protection standards to be used by municipalities to protect existing trees and woodlands on development sites	• Lorimer Park, municipal parks and open spaces	FPC, CPC, CPD, PERT, NLT, PEC, Municipalities	o On-going
Implementation	• Conduct landowner outreach and education programs to promote better riparian land management • Improve upstream/downstream connectivity by protecting existing green corridors and promote new green corridors through easements, land acquisition and donations • Actively remove non-native invasive plant species from riparian areas and restore riparian habitats by revegetating with native plant species	• All along Pennypack Creek and tributaries	CCD, FPC,PAFBC, PWD	o 2007-2010

Table 1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Monitoring	• Track annual statistics of open space acquired, easements donated and acres of land preserved in a common database		GSA, CPC	• On-going
Education	• Hold workshop for golf courses, homeowners, corporations and apartment building managers and other large riparian landowners on stream and riparian management.		CCD, CPC, Municipalities, PEC	• Immediately
Goal 5. Address Flooding				
Planning & Data Gaps	• Update flood emergency management plans • Develop mechanism for the removal or reconfiguration of log and woody debris jams to reduce erosion and flooding		FEMA, Municipalities, PEMA	• Immediately
Implementation	• Buy out flood prone properties to promote green river corridors • Enforce floodplain protection ordinances • Implement recommendations of Temple University Floodplain Study		FEMA, Municipalities, PEMA, PADOT	• On-going
Monitoring	• Track permitted floodplain encroachments and variances granted to allow development in the floodplain		CPC, Municipalities	• 2006
Education	• Create clearinghouse of municipal information for repairing flood damage, protecting floodplains and floodplain best management techniques		CPC, PEMA	• 2006
Goal 6. Enhance and Improve Recreational Opportunities				
Planning & Data Gaps	• Develop maintenance and management plans for existing recreational facilities and open spaces • Investigate opportunities for new active and passive recreational facilities in the watershed • Update recreation plans to reflect demographic changes	• Investigate further development of park at the mouth of the Pennypack Creek for interpretive center and environmental education	CPC, CPRD, FPC, GSA, Municipalities, PDR	• 2006-2009

Table 1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Implementation	• Implement access and trail improvement recommendations of FPC Pennypack Master Plan • Continue recreational facility upgrades and maintenance • Acquire additional community open space	• Implement Newtown Rail Trail and other identified trail linkages • Significantly upgrade Pennypack Valley Park between Torresdale Ave. and State Road to reconnect park to Delaware River	CPC, CPRD, FPC, GSA, Municipalities, SEPTA CPC, CDC, CPRD, FPC, Municipalities, PDR	• 2006-2010 • On-going
Monitoring	• Conduct surveys to gauge public interest in proposed trail networks and connections	• Bucks and Montgomery Counties	GSA, CPC	• 2006
Education	• Market watershed's recreational amenities through development of brochures, maps and other educational materials		CPC, CDC, CPRD, FPC, Municipalities, PDR	• On-going
Goal 7. Enhance Quality of Life for Watershed Residents				
Planning & Data Gaps	• Identify opportunities to improve stream access, especially in upper watershed where connection to stream is lost		GSA, CPC, Municipalities	• On-going

Implementation	• Conduct regular stream clean-ups
	• Conduct regular trail maintenance activities
	• Ensure environmentally sensitive redevelopment of Willow Grove Naval Air Base, should it close
	    • Set aside land for recreation
	    • Protect natural communities identified in the Natural Areas inventory
	    • Use innovative BMPs for stormwater management
		• Coordinate watershed wide clean-up day
		• Develop Adopt-A-Stream Program
			SEMCTU, PERT, FOPP, PWD
			
			CPC, Municipalities DCED
				• 2006
				
				• On-going

Monitoring	• Conduct series of surveys and public outreach events to evaluate success of River Conservation Plan implementation projects		PP	• 2009

Table 1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Education	• Implement environmental education and program outreach to minority and immigrant groups • Implement program similar to National Institute of Health, educating people about health benefits of walking , running and bike riding in a natural setting	• Northeast Philadelphia and other areas with large immigrant populations	CHD, CPRD, FPC, PERT	• 2006-2009
Goal 8. Improve Stewardship, Communication and Coordination Among Watershed Stakeholders and Residents				
Planning & data Gaps	• Hold workshops to reduce municipal miscommunication and promote regional planning • Create an organization or other mechanism for plan implementation • Create a watershed information clearing house or web site that promotes and coordinates stewardship activities		CPC, FPC, PEC, PWD, PP	• 2006

Implementation	• Promote education about buried segments of Sandy Run—similar to Wingohocking Mystery tour in Germantown
	• Develop a small scale map, brochure, or tour booklet to educate populace about watershed and reconnect headwater communities to the stream
	• Develop or implement accredited stewardship program or curriculum that meets state education standards
	• Target developers for education programs
	• Name unnamed tributaries in the watershed
	• Implement education program for residents about location, function and value of streams in their communities
	• Hold annual event to promote watershed issues
	• Present open space preservation education programs
	    • Tax benefits
	    • Tools for municipalities
	    • Benefits and methods
		• Implement Adopt-A-Stream Program	CPC, CCD, PP, PWD, PEC	• On-going

Monitoring	• Create recognition program such as municipal ecology awards to promote environmental stewardship and good ordinance development
	• Review accomplishments of plan in 5 years for
	    • Watershed Impact
	    • Implementation
			CPC, CCD, GSA, PP, PWD, PEC
			
			PP, PWD, PPSC
				• 2006
				
				• 2010

Table 1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Education	• Develop and distribute education materials • Implement "Rediscover Your Watershed" Program (history, connections to natural environment		CPC, CCD, PP, PWD, PEC	• On-going

Abbreviations: CCD, County Conservation Districts; CDC, Community Development Corporations; CHD, County Health Departments; CPC, County Planning Commissions; CPRD, County Parks & Recreation Departments; DCED, Department of Community and Economic Development; DRKN, Delaware River Keeper Network, FEMA, Federal Emergency Management Agency; FPC, Fairmount Park Commission; FOPP, Friends of Pennypack Park; GSA; Green Space Alliance; NLT, Natural Lands Trust; PA DOT, PA Department of Transportation; PAFBC, PA Fish& Boat Commission; PEC, Pennsylvania Environmental Council; PEMA, PA Emergency Management Agency; PERT, Pennypack Ecological Restoration Trust; PP, Pennypack Partnership; PPSC, Pennypack RCP Steering Committee; PRD, Philadelphia Department of Recreation; PWD, Philadelphia Water Department; SEMCTU, Southeast Montgomery Country Trout Unlimited; SEPTA, Southeastern PA Transportation Authority; TU, Temple University

CHAPTER 1
INTRODUCTION

1.1 Acknowledgements

The Pennypack Creek River Conservation Plan Project Team would like to thank the following individuals that played key roles in the development of this plan. The team would also like to thank the people who generously donated their time to grant key person interviews and the community and neighborhood groups who hosted RCP project presentations.

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1.2 Project Description

The Pennypack Creek River Conservation Plan is one component of ongoing efforts being conducted by the Philadelphia Water Department and the Pennypack Watershed Partnership to improve water quality, the environment and the quality of life of watershed residents. The principle goal of the conservation plan is to reconnect people to the Pennypack Creek through a two year, community based planning process. The planning process includes forming a diverse group of watershed stakeholders to act as a steering committee for the plan, engaging the public in the planning process through outreach and educational events and researching current and projected environmental and cultural conditions in the watershed. The project team will then compile all of this information into a document that provides a work plan to improve the watershed environment and promote the enjoyment of the Pennypack Creek.

The Pennypack Creek has historically meant many different things to different people. The creek has been a faithful partner in our region's economic growth, creating wealth by powering mills and facilitating settlement by providing water and carrying away waste. The creek has also served as a recreation destination for thousands of people who come to streamside parks to fish, picnic or simply contemplate nature. Paradoxically, the Pennypack Creek has also served as an instrument of destruction as flood waters have claimed property and even lives. The Pennypack Creek River Conservation Plan attempts to consider the watershed's complex evolution and develop goals that will provide benefits for everyone who values the creek and its watershed. The goals of River Conservation Plans reflect the diverse interests, concerns and needs of the watershed residents and will serve as a rallying point for a watershed community to improve their watershed and take a comprehensive look at their creek for the first time.

Information contained in this plan was gathered from existing studies, as well as input from community members, key person interviews, a public survey, workshops, neighborhood meetings and a stream visual assessment conducted by volunteers and staff of the Philadelphia Water Department Office of Watersheds. Analysis of Geographic Information System (GIS) data played a major role in the development of this plan and many GIS maps are included to enhance the understanding of the spatial relationships between watershed resources, opportunities and concerns. The fruits of existing planning efforts were also important to the development of the River Conservation Plan. Public participation from the Pennypack Park Master Plan, as well as the suburban community comprehensive plans, provides additional connections between this plan and the planning goals of the watershed stakeholders.

There are many opportunities to have a positive impact on the Pennypack Creek and its watershed and there are many organizations doing work to improve the watershed environment. Long-term improvement, however, requires that anyone who lives, works or recreates within the watershed does their part to reduce negative impacts on the natural resources of the watershed while creating the momentum to improve the watershed community. This is the ultimate goal of the River Conservation Plan – to get people involved as a positive force to improve the watershed. This document and planning effort will serve as a guiding document to continue working toward that ultimate goal.

This plan is organized by presenting the Issues, Challenges and Resources of the Pennypack Creek Watershed in Chapters Two through Seven. Chapter Eight contains the Goals and Management Options that were developed by the River Conservation Plan Steering Committee and through the Public Outreach process. The purpose of the Goals and Management Options is to protect and improve existing resources of the watershed and to address the issues and concerns affecting the watershed, its environment and communities. As such, Chapter Eight represents the culmination of the two-year River Conservation Planning effort and is a must read chapter in this report.

The River Conservation Planning process is funded in part by the Pennsylvania Department of Conservation and Natural Resource's (PA DCNR) Community Partnership Conservation Program. The Philadelphia Water Department received a grant from the DCNR to conduct the plan in 2003. Other funding and in-kind services to conduct this plan have been provided by the Philadelphia Water Department, Fairmount Park Commission, Friends of Fox Chase Farm, Friends of Pennypack Park, Montgomery County Planning Commission, and Pennypack Ecological Restoration Trust.

CHAPTER 2
THE PENNYPACK CREEK WATERSHED

INTRODUCTION

Street intersection in Northeast Philadelphia

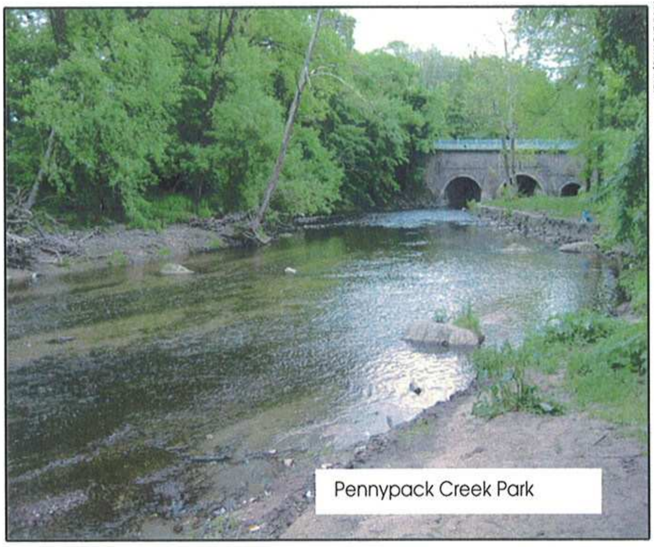
F.X. Browne, Inc.

Home to more than 250,000 residents, the Pennypack Creek Watershed encompasses a 56-square mile region in southeastern Pennsylvania, an area dominated by the urban and suburban landscapes of northeast and suburban Philadelphia. Much of the watershed lies within the Piedmont region, a broad swath of land extending from Georgia to Massachusetts that separates the flat Atlantic Coastal Plain from the Appalachian Mountains. This is a land of transition; a pastoral landscape of narrow valleys, woodland streams, and forest-covered hills.

Like much of the northeastern United States, the climate in the Pennypack Creek Watershed is characterized by four distinct seasons with moderately cold winters and long humid summers. Although much of the forest within the Pennypack Creek Watershed has been removed to support agriculture and development, or altered by invasive species and nuisance deer, remnants of the hardwood forests that once covered the entire watershed can be found in places such as Lorimer Park and Pennypack Creek Park.

The upper portions of the watershed are located in the northern suburbs of Philadelphia, within Montgomery and Bucks Counties. Here, the Pennypack Creek flows through several boroughs and residential communities including Willow Grove, Hatboro, Feasterville, Horsham, Abington, and Bryn Athyn. Moving downstream, the main stem of the Pennypack Creek flows southeast through the Fox Chase, Bustleton, Rhawnhurst, and Holmesburg sections of Northeast Philadelphia before entering the Delaware River.

While sections of the watershed are covered by urban land uses including industrial and business parks, commercial shopping areas, dense city residential developments, and affluent suburban residential communities, much of the lower section of the Pennypack Creek is shielded from development by an interconnected greenway of forested lands, protected farms, and park land. This greenway includes more than 700 acres of protected lands managed by the Pennypack Ecological Restoration Trust; Lorimer Park, a 250-acre Montgomery County Park; and Pennypack Creek Park, which is part of the renowned Fairmount Park System in the City of Philadelphia.



Pennypack Creek Park

F.X. Browne, Inc.

2.1 PHYSICAL SETTING

Describing the physical setting of a watershed involves describing the character of the landscape itself. The natural characteristics of landscapes can be described in many ways including basic landform (e.g., mountains vs. flat plains), topography, location (and therefore climate), the soils that have developed on the landscape, the geology of the rocks that underlie the landscape, and the vegetation that covers the landscape.

Because much of the Pennypack Creek Watershed has been profoundly influenced by the activities of humans, its physical and cultural landscapes are fundamentally interconnected. The soils, vegetation, animal communities, and topography that characterize the watershed today are in many cases very different from those that characterized the watershed before European settlement.

Physiography

Physiography describes the character, appearance, and natural history of landscapes. Examples of physiographic forms include mountains, ridges, plateaus, canyons, and coastal plains. The physiography of an area integrates the sum total of various processes that act upon the landscape including the erosion and movement of soil and rock by wind, rivers and streams, oceans, and glaciers; the formation of mountains through tectonic upheaval and volcanic activity; and the deposition of sediments within large waterbodies.

In the United States, areas with similar landforms have been mapped into broad regions referred to as physiographic provinces, and smaller designations called physiographic sections. The lands within a particular province are similar with respect to elevation, topography, underlying geology, and landscape formation. The Commonwealth of Pennsylvania is divided into seven physiographic provinces as shown in Figure 2.1.

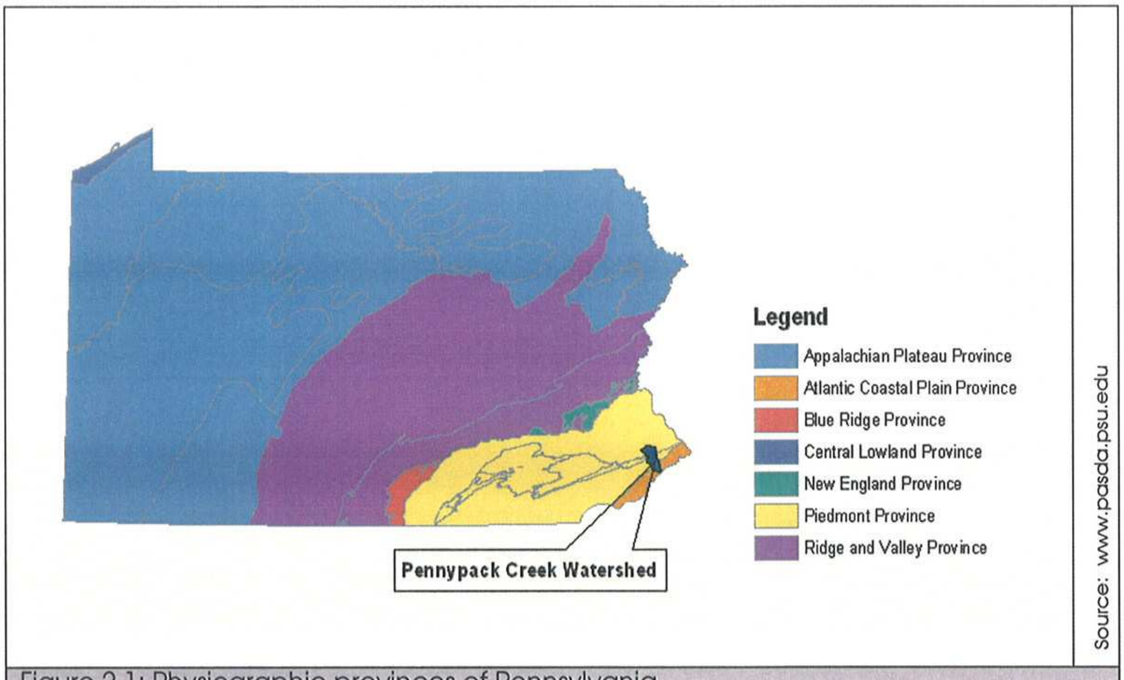


Figure 2.1: Physiographic provinces of Pennsylvania
The Pennypack Creek Watershed is located within the Atlantic Coastal Province and the Piedmont Province.

As shown in Figure 2.2, a large majority (approximately 73%) of the Pennypack Creek Watershed, including the upper and middle portions of the watershed, is located within the Piedmont physiographic province. Piedmont literally means "foot hills" and is a term generally used to describe transitional landscapes that occur between plains and mountain chains. Piedmont landforms typically consist of low rolling hills separated by complex networks of stream and river valleys. The Piedmont physiographic province specifically refers to the region of the eastern United States that separates the Appalachian Mountains from the Atlantic Coastal Plain. The Piedmont physiographic province stretches from Georgia to Massachusetts.

Much of southeastern Pennsylvania consists of Piedmont land forms, with the exception of the far southeast corner where the tidal portion of the Delaware River is surrounded by a sandy, flat coastal plain. This area is part of the Atlantic Coastal Plain physiographic province, which covers most of the eastern coast of the United States. The lower-most portions of the Pennypack Creek Watershed lie within the Atlantic Coastal Plain. This portion of the watershed includes parts of the Philadelphia neighborhoods of Holmesburg, Upper Holmesburg, Torresdale, Pennypack Woods, Bustleton, Rhawnhurst, Mayfair, and Lexington Park. The portion of the Northeast Philadelphia Airport located within the Pennypack Creek Watershed is also located within the Atlantic Coastal Plain.

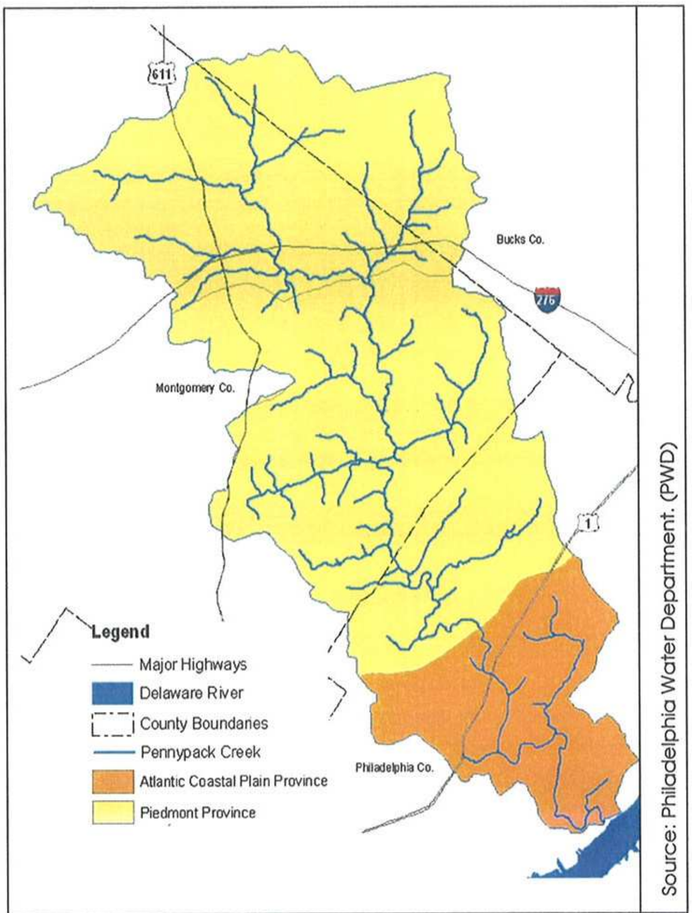


Figure 2.2: Physiographic Provinces of the Pennypack Creek Watershed

The Pennypack Creek Watershed is located in the Atlantic Coastal Plain Province and the Piedmont Province.

Physiographic sections demarcate finer scale variations in land form. Within the Pennypack Creek Watershed, the Piedmont physiographic province is divided into two physiographic sections, the Gettysburg-Newark Lowland section and the Piedmont Upland section. The Gettysburg-Newark section, which occupies most of central and upper Bucks and Montgomery Counties is generally characterized by gently rolling hills and is differentiated from the Piedmont Upland section mostly on the basis of underlying geology. The Gettysburg-Newark section is characterized principally by sedimentary rocks, such as sandstone and shale. The Piedmont Uplands are underlain by older, harder metamorphic rocks, such as gneiss and schist.

Geology

All landscapes on earth are underlain by rock. The character, arrangement, and location of various rock layers underneath the thin soil covering of the earth surface are as important as the landforms that characterize the landscape surface. Indeed, geologic characteristics strongly influence soil characteristics and water chemistry; influence the type and location of land uses that can occur on a particular landscape; dictate the structure and characteristics of groundwater aquifers and influence the development and characteristics of surface landforms.

Bedrock underlying the Pennypack Creek Watershed ranges from sedimentary rock found in the upper reaches of the watershed, to metamorphic rock found in the central portions of the watershed, to recent deposits of unconsolidated sand and gravel, which are found at the mouth of the watershed (Figure 2.3: Geology of the Pennypack Creek Watershed).

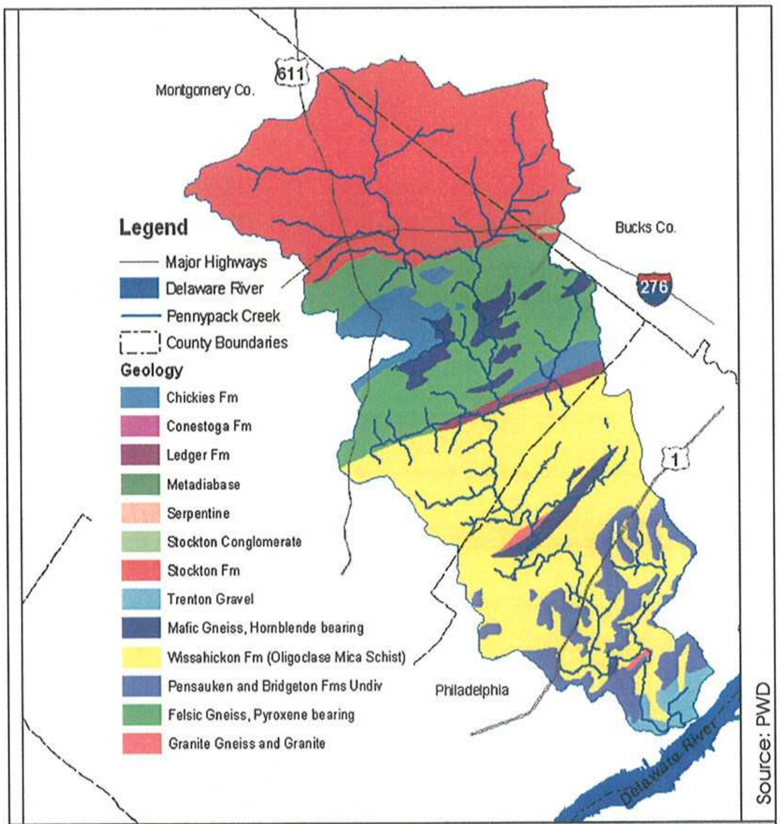


Figure 2.3: Geology of the Pennypack Creek Watershed

The Wissahickon Formation and the Stockton Formation underlie the majority of the watershed.

Bedrock in the northern portion of the watershed, including Warminster, Horsham, Upper Dublin, Upper Southampton, northern Upper Moreland Townships and Hatboro Borough, consists of a thick layer of sedimentary rock, referred to as the Stockton Formation, which was formed during the Triassic Period (248-206 million years ago). The Stockton Formation consists of layered beds of red sandstone and shale that are thousands of feet thick. Some of these layers are permeable and contain significant groundwater aquifers. The sedimentary rocks of the Stockton Formation are more susceptible to weathering than harder, metamorphic rock. Consequently, soils overlaying the Stockton Formation tend to be more fertile than soils overlaying metamorphic formations and historically supported rich forest communities.

In contrast to the sedimentary rock of the Stockton Formation, the bedrock underlying the central portions of the watershed consists of older metamorphic rock, some of which was formed over 540 million years ago during the Precambrian Era. The oldest rocks in the watershed are the mafic and felsic gneiss formations that occur within portions of Abington, Upper Moreland, and Lower Moreland Townships, as well as Bryn Athyn Borough. These are hard rocks that are highly resistant to weathering and lack the permeable qualities of sedimentary rocks.

Moving south, the watershed is underlain by Wissahickon Schist. Schist is another type of metamorphic rock, which is formed through chemical alteration of shale, a common sedimentary rock. Wissahickon Schist is commonly found within the stream valleys of Philadelphia, most notably in the deeply cut Wissahickon Creek Gorge, where large outcroppings of schist are visible. Schist is more prone to weathering than gneiss, but is significantly harder than sedimentary rocks such as sandstone and shale. Like gneiss, schist formations have low porosity and are generally not associated with significant aquifers.

Towards the lower section of the watershed, schist formations are covered in places by geologically recent deposits of unconsolidated sand, gravel, silt, and clay. The presence of these deposits correlates with the transition from the Piedmont to the Atlantic Coastal Plain. These deposits include the Pennsauken and Bridgeton Formations, which were deposited during the Tertiary Period (lasting from 67 to 2 million years ago). As the Pennypack Creek nears the Delaware River, the Pennsauken and Bridgeton Formations are underlain by a still younger deposit of sand and gravel commonly referred to as Trenton Gravel. These deposits contain the eroded particles of rock formations found in the upper Delaware River basin, which have been transported to and deposited in the lower reaches of the Delaware River. These gravel deposits can be as thick as 100 feet and are found adjacent to as well as beneath the Delaware River channel. Trenton Gravel deposits extend from Trenton, New Jersey to Darby Creek in Philadelphia. Trenton Gravel deposits contain high-yielding, shallow aquifers that are particularly susceptible to groundwater contamination due to high permeability.

Ecoregion

Ecoregions represent land areas that share similar land uses, climate, soils, topography, geology, and natural vegetation. They provide another, perhaps more holistic, way to describe the watershed landscape by combining physical and ecological characteristics. Omernick (1987) defines three levels of ecoregions for North America: Level I, which divides the continent into 15 broad regions based on large scale variations in climate, vegetation, and land form; Level II, which further divides the Level I divisions into 52 regions; and Level III, which includes 120 ecoregions. More recently, Level IV Ecoregions have been developed, which reflect regional, more nuanced variations in ecological and physical characteristics.

Level III Ecoregions

Figure 2.4 shows the relationship of the Pennypack Creek Watershed to Level III ecoregions of the Eastern United States. The Pennypack Creek Watershed is located within the Northern Piedmont and Middle Atlantic Coastal Plain Level III ecoregions. The Middle Atlantic Coastal Plain is a low, nearly flat plain typically containing many swamps and marshes with poorly drained soils and corresponds with the Atlantic Coastal Plain physiographic province. The low lying Philadelphia neighborhoods of Holmesburg and Torresdale are located in this region. Here, urban development has significantly changed natural topography, drained wetlands and radically altered the original ecosystems.

The sections of the watershed in Montgomery and Bucks County along with the northern neighborhoods of Philadelphia are located within the Northern Piedmont ecoregion. Again, this designation corresponds with the boundaries of the Piedmont physiographic province discussed earlier in this chapter. This region transitions between the flat plains of Middle Atlantic Coastal Plain and the mountains of the Ridge and Valley and is characterized by low rounded hills and open valleys. Historically, the vegetation in this region was dominated by Appalachian Oak Forest, but expanding urbanization has drastically altered native vegetation communities.

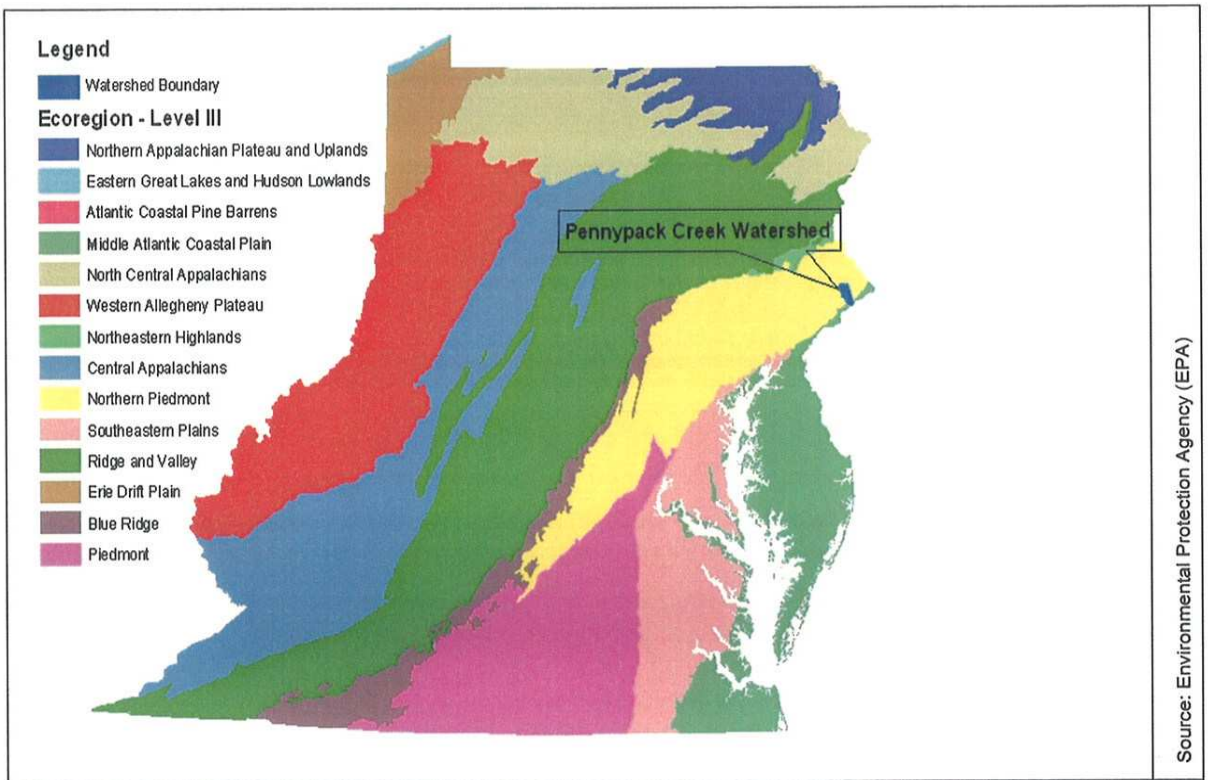


Figure 2.4: Level III Ecoregions
The Pennypack Creek Watershed is located in the Northern Piedmont and the Middle Atlantic Coastal Plain Ecoregions.

The climate in the Northern Piedmont Ecoregion is considered humid continental, with cold winters and hot summers. There is an average of 170 to 210 days without a killing frost. The annual average temperature is 55°F, ranging from an average of 77°F in July to 32°F in January. The average precipitation is 40.9 inches per year. Soils within this region are deep, well-developed and, in general, fertile.

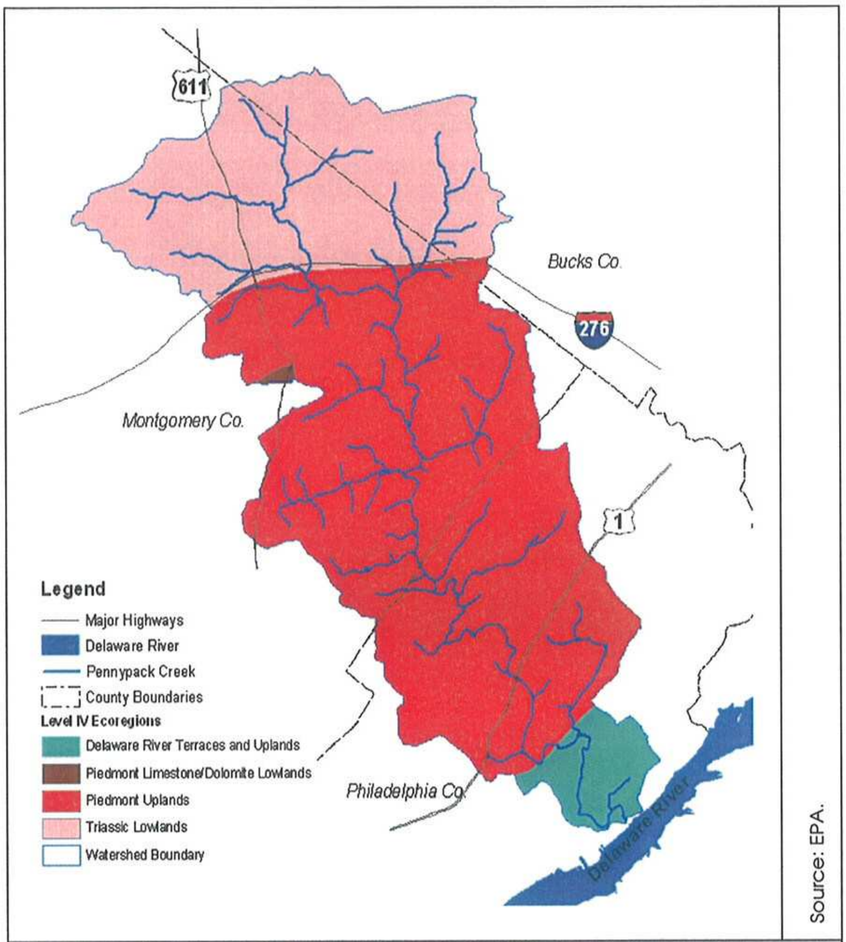


Figure 2.5: Level IV Ecoregions

The Pennypack Creek Watershed is located in the Delaware River Terrace and Uplands, the Piedmont Limestone/Dolomite Lowlands, the Piedmont Uplands and the Triassic Lowlands Ecoregions.

LEVEL IV ECOREGIONS

The portion of the Pennypack Creek Watershed located in the Level III Northern Piedmont Ecoregion is further divided into three Level IV ecoregions: the Triassic Lowlands, Piedmont Uplands, and the Piedmont Limestone/Dolomite Lowlands (Figure 2.5).

The headwaters of the watershed (Warminster, Upper Southampton, Horsham, Upper Moreland Townships and Hatboro Borough) are located in the Triassic Lowlands. The region is an undulating plain with wide ridges and broad, nearly level valleys and corresponds to the portion of the watershed within the Gettysburg-Newark physiographic section and the portion of the watershed underlain by the Triassic rocks of the Stockton Formation. The local relief is lower than the Piedmont Uplands region which lies to the south. The soils in the Triassic Lowlands ecoregion are fertile and have historically supported productive farms. The predominant natural vegetation is the Appalachian Oak Forest, which is dominated by white and red oaks.

Between the headwaters and the mouth of the watershed lies the Piedmont Uplands Level IV Ecoregion, which includes portions of Abington, Upper Southampton, Upper Moreland and Lower Moreland Townships, Bryn Athyn, and Rockledge Boroughs along with the Philadelphia neighborhoods of Somerton, Bustleton, Fox Chase, Rhawnhurst, and Oxford Circle. The majority of the Pennypack Creek Watershed is located within the Piedmont Uplands Level IV ecoregion. The major distinctions between the Triassic Lowlands and the Piedmont Uplands include differences underlying geology and degree of elevation change from hill to valley (relief).

The Piedmont Uplands ecoregion is bordered to the southeast by the Delaware River Terraces and Uplands Level IV ecoregion, which is part of the Mid-Atlantic Coastal Plain Level III ecoregion. The border between these two regions is commonly referred to as the Fall Line, an abrupt change in elevation that creates steeply sloped streams, exposed bedrock, cascades and waterfalls. The Fall line creates a physical barrier that blocks the passage of some lowland calmwater fish species to Piedmont stream networks. Underlying geology within the Delaware River Terraces and Uplands is characterized by deposits of sand and gravel including the Pennsauken and Bridgeton Formations and Trenton Gravel deposits discussed above. Because of the intense urbanization that characterizes much of the Delaware River Terraces and Uplands Ecoregion within southeastern Pennsylvania, the natural vegetation and landscape has been severely altered. The soils in the Delaware River Terraces and Uplands Ecoregion are less fertile than in the headwaters of the watershed but still capable of supporting agriculture.

There is a small intrusion of Piedmont Limestone/Dolomite Lowlands in Abington Township along the western border of the watershed. The carbonate bedrock has been weathered over time producing a nearly level surface with sinkholes, caverns and disappearing streams. This region has the most fertile soils in the watershed. The limestone provides a high yielding aquifer, but the solution channels that form in limestone formations reduce water filtration and increase the risk of groundwater contamination.

Soils

Soil characteristics can exert a great influence on the way in which land is utilized and developed. Different soil types exhibit varying characteristics with regard to erodability, drainage potential and suitability for development and building foundations. Certain soil types are particularly suited for agriculture and forestry. These "prime agriculture soils" are rapidly disappearing from southeastern Pennsylvania because their characteristics (well drained and found on level topography) also make these soils good places to build homes and businesses.

Soil Characteristics

Soils are generally named or grouped into types based on their unique set of characteristics. A soil's characteristics are a result of how the soil was created and evolved. There are five primary factors that influence how a soil develops its particular characteristics. The factors are:

Parent material: A soil's parent materials are the minerals or organic components that break down to form the soil. Minerals are present in underlying geology or in sediments transported by wind, water, volcanoes or even glaciers. Organic material is contributed to soils through deposition of decaying plant and animal matter and waste.

Climate: Weathering facilitates the break down of parent material into soils through the processes of freezing, thawing, wetting and drying. These processes coupled with a region's temperature and humidity influence soil characteristics.

Living organisms: Both plants and animals affect soil characteristics by adding and extracting organic matter and minerals from the soil. Living organisms also help to break down, mix and enrich soil through activities such as tunneling (moles, etc.), spreading roots (vegetation) and extracting nutrients from soil particles (earthworms and fungi).

Topography: Topography or the slope of land influences soil characteristics mostly through the influence of erosion and moisture. Well drained soils are generally found in sloping areas, while moist, poorly drained soils are generally found in low lying areas where water collects. Erosion can transport the topsoil or even subsoil leaving behind weakly developed soils.

Time: It takes hundreds of years of cycles of freezing and thawing and wet and dry seasons to form soils from parent materials. The vast amount of time it takes to form soils is one of the reasons that soil conservation is so important and why the rate at which native soils are being converted to "Urban or Made Land" is so alarming.

Soil Associations

The soils in the Pennypack Creek Watershed generally belong to one of seven soil associations. These soil associations change from the headwaters region of the watershed to the confluence of the creek with the Delaware River.

The soil associations from the headwaters region to the mouth are presented in Table 2.1

Table 2.1: Soil Associations of the Pennypack Creek Watershed

Lawrenceville-Chalfont-Doylestown association: These soils are deep, moderately well drained to poorly drained soils formed in windblown silt deposits on undulating uplands.

Lansdale-Penn-Readington association: These soils are deep and moderately deep, well drained and moderately well drained soils underlain by shale and sandstone on rolling uplands.

Made land-Glenelg-Chester association: This association is characterized as deep to moderately deep, well drained soils underlain by schist and gneiss, located on undulating uplands.

Manor-Glenelg-Made land association: Soils of this association are moderately deep to deep, well drained soils underlain by schist and gneiss. They are micaceous soils located on hilly uplands.

Urban land-Chester association: These soils are well drained located in the City of Philadelphia on nearly level to sloping land forms.

Urban land-Howell association: This association is found along the Delaware River in Philadelphia. The soils are well drained and found on level to gently sloping topography.

Edgemont-Manor association: There is a small area of this association in the southern portion of Montgomery County. Soils of this association are moderately deep to deep, well drained soils underlain by quartzite and quartz schist found mainly on ridges.

Source: USDA

Soil characteristics

Over 53% (19,113 acres) of the soils in the Pennypack Creek Watershed are classified as Urban, Made Land or other disturbed soil group. Urban or Made land are those soils whose characteristics have been altered due to disturbance from earthmoving, compaction or the construction process. Often these soils are overlain by buildings, roads or other infrastructure. The drainage and erosion characteristics of disturbed soils are highly variable but generally these soils are not ideal for stormwater infiltration or groundwater recharge.

Hydrologic Soils Groups (HSGs) designate a soil's capacity to infiltrate water. The soil's HSG classification relates to the minimum rate of water infiltration for bare soil after wetting. Soils are classified as A, B, C, or D, with group A soils being well drained and suitable for infiltration and group D soils being poorly drained or having a seasonally high water table. There are no HSG A soils in the Pennypack Creek Watershed (Figure 2.6). Table 2.2 presents the infiltration rates associated with each of the HSG and the percentage of the watershed with these soils. A table detailing all of the soil groups found in the watershed, their HSG, drainage and erosion potentials and total acres can be found in Appendix A.

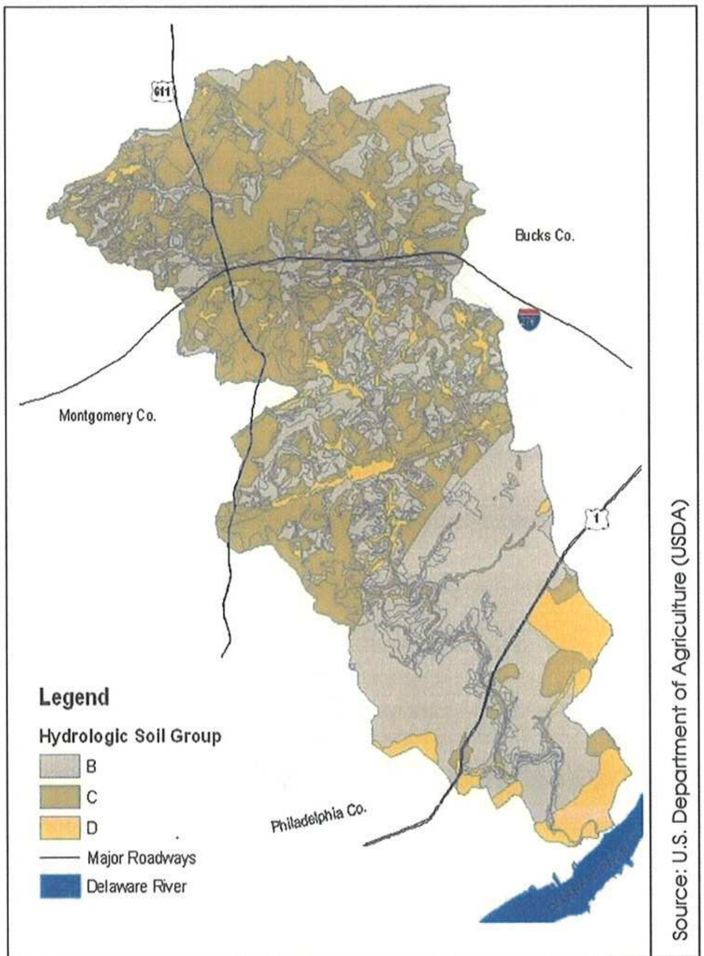


Figure 2.6: Hydrologic Soil Groups of the watershed
This figure shows that many of the soil groups in the headwaters of the watershed are poorly drained.

Due to the high percentage of poorly drained soils in the watershed, opportunities for infiltration stormwater Best Management Practices (BMPs) and groundwater recharge are important to identify and preserve in order to improve stream baseflow and stormwater quality. A lack of stormwater infiltration opportunities makes the utilization of BMPs, such as treatment wetlands and bioretention basins, which improve water quality, critical to improving this watershed's ecological health.

Large areas of poorly drained soils are found in the headwaters of the watershed. As a result the Pennypack Creek is flashy in nature and carries a large amount of stormwater run-off even in areas where natural groundcover still exists. The poor water infiltration characteristics of these headwater soils promote stormwater run-off. Paradoxically, since the geomorphology of the Pennypack Creek evolved in response to these poorly drained soils, the creek may be less susceptible to hydrologic changes due to increases in urban stormwater runoff than streams that flow through well drained areas. This is because the stream systems in the Pennypack Watershed are naturally adapted to poorly drained soil characteristics and associated flashy runoff patterns. Percentages of better drained soils (HSG B) increase lower in the watershed; however this section of the watershed is more densely developed and much of the development in this area (Upper and Lower Moreland, Abington and Philadelphia), occurred before widespread implementation of stormwater BMPs. Soils in this section of the watershed are largely covered with impervious surfaces or compacted to point where they no longer exhibit favorable drainage characteristics.

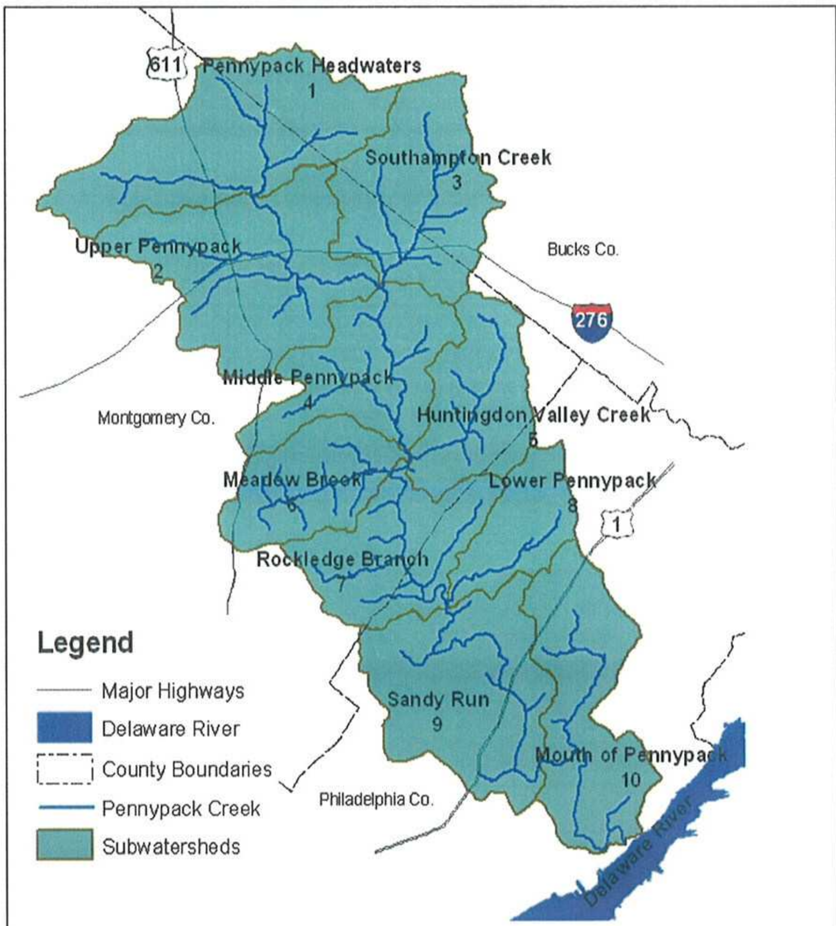
Table 2.2: HSG Infiltration Rates

HSG	Infiltration Rate	HSG % of watershed
A	>0.3 inches / hour	0
B	0.15-0.3 inches / hour	43%
C	0.05-0.15 inches / hour	45%
D	< 0.05 inches / hour	12%

Source: USDA Hydrology Handbook

DRAINAGE CHARACTERISTICS

Pennypack Creek Watershed is located within the Delaware River basin and is bordered by the Neshaminy Creek, Poquessing Creek, Wissahickon Creek, and Tacony-Frankford Creek. The Pennypack Creek Watershed encompasses approximately 56.4 square miles of land. Subwatersheds further divide this 56 square mile drainage area into 10 smaller drainage areas, which range from 2.6 to 8.2 square miles in size (Figure 2.7). Drainage characteristics are discussed in more detail in Chapter 4.



Sub-watershed	Area (mi)
1	8.2
2	8.0
3	3.9
4	5.1
5	4.9
6	6.2
7	7.3
8	4.1
9	2.7
10	6.0
Total	56.4

Source: PWD and Delaware Valley Regional Planning Commission (DVRPC)

Figure 2.7: Subwatersheds of the Pennypack Creek

2.2 Cultural Setting

Location

The Pennypack Creek Watershed is located in southeastern Pennsylvania and drains portions of Montgomery and Bucks Counties and the City of Philadelphia (Figure 2.9). The watershed is located within the Delaware River basin and bordered by the Neshaminy Creek and Poquessing Creek watersheds to the north and east and the Wissahickon and Tacony-Frankford Creek watersheds to the west.

The 56-square mile watershed includes part or all of eleven different municipalities in Bucks and Montgomery Counties and the City of Philadelphia (Figure 2.8). The Montgomery County municipalities in the watershed are Horsham, Upper Moreland, Upper Dublin, Lower Moreland, and Abington Townships; and Hatboro, Rockledge, Bryn Athyn, and Jenkintown Boroughs. The Bucks County municipalities are Warminster and Upper Southampton Townships. Philadelphia neighborhoods within the watershed are Somerton, Bustleton, Fox Chase, Rhawnhurst, Oxford Circle, Mayfair, Lexington Park, Winchester Park, Pennypack Woods, Aston-Woodbridge, Holmesburg, Upper Holmesburg, and Torresdale.

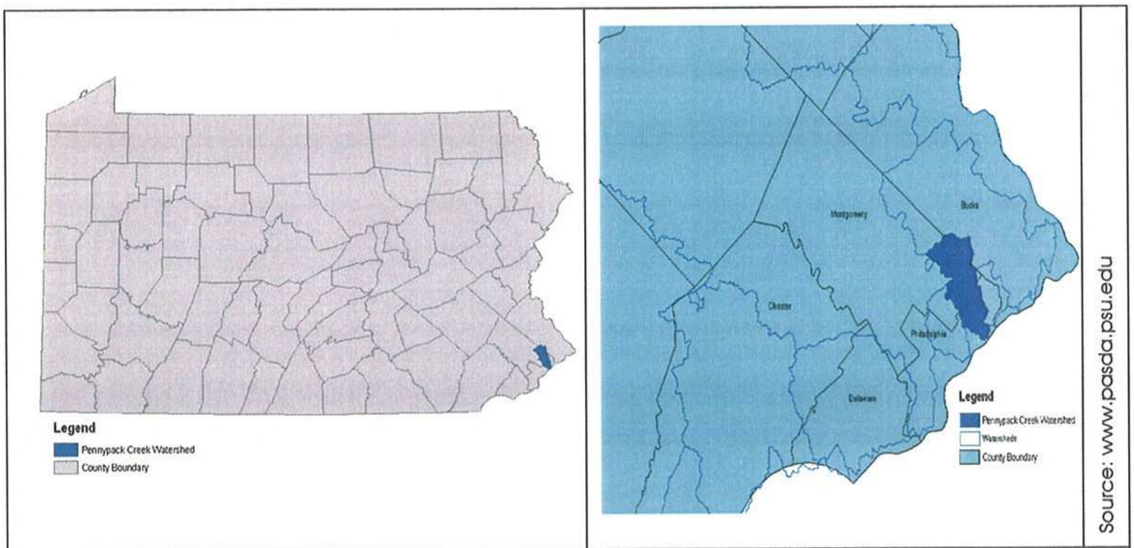


Figure 2.8: Location of the Pennypack Creek Watershed

The Pennypack Creek Watershed is located in within the Delaware River Basin in Southeastern Pennsylvania.

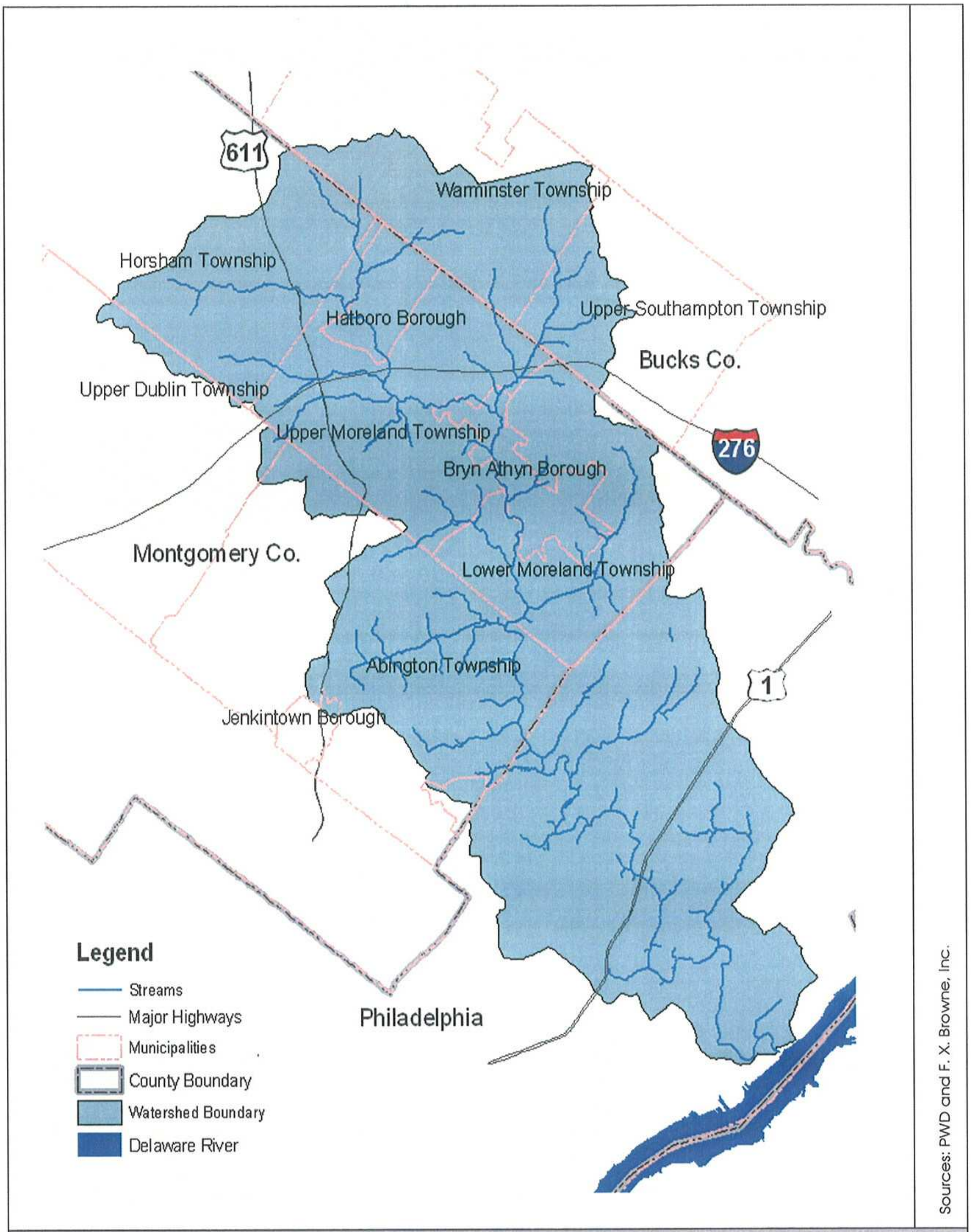


Figure 2.9: General Location Map of the Pennypack Creek Watershed

The Pennypack Watershed includes portions of three counties and 12 municipalities, making intermunicipal cooperation critical to the Rivers Conservation Planning process.

Cultural History

The cultural history of the Pennypack Creek and its tributaries offer insight into how the watershed came to look like it does today. Many of the current watershed land-uses are rooted in historic settlement patterns and transportation routes, some even pre-dating European settlement.

Early History & Settlement

American Indian Settlement

Prior to European settlement, the Pennypack Creek Watershed was inhabited by the Unami band of the Lenape or Delaware Indian tribe. The Unamis were not a politically cohesive group but shared common language and cultural characteristics. Tribal governments consisted of three sachems or captains, one from each of the three matrilineal clans: Turtle, Wolf and Turkey. The head sachem was always elected from the Turtle clan and usually controlled no more than a few villages.

> **A Trip Down Memory Lane: Old Kings Highway**
>
> The bridge over the Pennypack at Frankford Avenue has a history that dates back as far as the early settlers. The Lenni-Lenape had a trail that marked the spots where crossing the Tacony, Pennypack and Poquessing creeks was the easiest. In 1682, William Penn petitioned for the path to be widened for passage of carts and carriages to conduct business between the Schuylkill and Neshaminy Rivers.
>
> The improved trail became known as the Kings Highway. Later a bridge was completed in 1697. This bridge, constructed with a tax on each male resident, either in money or its equivalence in labor, is still in use today (Lake, 1996 and Rambling Along the Pennypack).

The Lenape Indians lived in villages and relied on agriculture as the primary form of sustenance. Men of the tribe supplemented the food supply through hunting and fishing. The Lenape managed the stands of climax forest in the region through burning, which created open fields for farming and controlled understory within the forest, increasing forage for deer and access to the woods for security.

The Lenape left a lasting imprint on the region. Lenape trails formed the rudimentary foundations for many roads and highways still in use today and through their names of natural features. According to John Heckwelder, historian of local Native Americans, the Lenape name for the Pennypack was Peme-peck or Pennapecka, meaning "deep, dead water," or "water without much current" (Natural Lands Restoration and Environmental Education Program (FPC), 1999). Places throughout the Delaware Valley, such as Neshaminy, Poquessing, Wissahickon and Pennypack, all have origins in the Lenape language.

Early European Settlement

The Swedes and Dutch were the first Europeans to settle in the Philadelphia area during the first half of the 17th century, followed by the British in the late 1600s. By 1683, William Penn had negotiated the purchase of all of the land in the Pennypack Creek Watershed from the local Lenape Indians. As more European settlers moved into the colony the native Indians continued to relocate north and west. By the early 1720s, the Lenape had almost disappeared from what are now Bucks, Montgomery and Philadelphia counties.

In 1681, King Charles II of England granted William Penn a charter for 40,000 square miles of land in America. Penn hired Thomas Holme as Surveyor General. Holme arrived in what is now the City of Chester in July of 1682 and began looking for the best location for the City of Philadelphia. He decided on the area of land between the Delaware and Schuylkill Rivers because of the access to the rivers for trade and protection from Indian attacks provided by the rivers. William Penn later arrived in September of 1682. Happy with Holmes' decision, he paid

Holmes with 1,646 acres of land that was located north of the Pennypack Creek. Peter Rambo, a friend of Penn, was given over 1,000 acres of land which included the areas now known at Holmesburg, Tacony, and Wissinoming (FPC, 1999). Peter Rambo is believed to be the first European settler in the Pennypack Creek Watershed. Holmesburg is named for John Holme, a cousin of Thomas Holme, who purchased the land from Rambo (McNeill, 1963).

Penn rethought the ways both cities and farm areas should be constructed and managed. He believed farms would be more productive if individual families farmed small plots of land (approximately 250 acres), rather than working together to farm large common fields. This caused large plots of land to be subdivided into smaller tracts and sold to small farmers (FPC, 1999).

In the early 1700s, villages in the Pennypack area were connected by a network of plantations. A road system was needed to support the ever-expanding population and economy. Trails through the woods were developed into a road system, including toll roads. Although the roads provided a connection for goods to pass from the outlying areas to the city, they further fragmented the forests and disturbed wildlife habitats (FPC, 1999).

As Europeans settled the watershed, agriculture and milling operations moved up the Pennypack valley. The Creek and its tributaries were dammed many times for grist and textile mill operations. Three early towns to arise around these mills and to bring the commerce of the watershed area to Philadelphia were Holmesburg, Bustleton and Somerton.

Growth and Development

City Expansion

Heavy industrial development in the watershed began in the mid-1800s. Iron mills and tool factories replaced the agrarian fields and grist mills. Two historically significant industries operated in the Pennypack Watershed; the Disston Saw Works and Tacony Ironworks. The Disston Saw Works moved to the Pennypack Creek Watershed in 1872 and produced tools for agriculture, timbering and the U.S. military. More significantly, John Disston purchased land around his factories to provide affordable housing for his workers, and facilitating the development of the watershed. The Tacony Iron Works opened in 1881. The foundry produced such important products as the structural supports for the dome of City Hall in Philadelphia and the large statue of William Penn (Lake, 1996). The Tacony Ironworks was located right on the banks of the Pennypack Creek. This mill and others like it all along the stream have left long lasting impacts on the watershed. Other prominent industries including the Rowland Spade and Shovel Factory as well as a prominent axe factory were also located along the banks of the Pennypack.

Expanding industry put major stresses on the waterways. More than 30 dams were placed across the Pennypack Creek, along with numerous waterwheels. Tributaries in unwanted areas were frequently "fixed" by simply covering them or filling them (FPC, 1999). USGS conducted a study to attempt to locate areas of fill in a section of Philadelphia (Chirico, 2000). Figure 2.10 shows the areas within the Pennypack Creek Watershed that the GIS analysis found to have possible or probable fill. These areas may previously have been stream channels or wetlands. Today, Sandy Run, one of the significant tributaries of the Pennypack Creek within the City of Philadelphia, now flows in a storm sewer system below the Rhawnhurst section of the City.

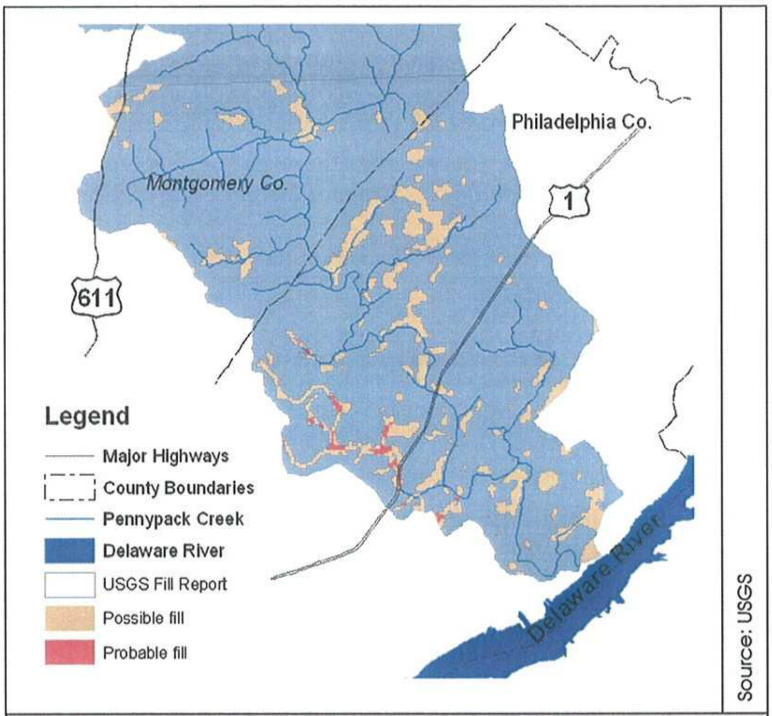
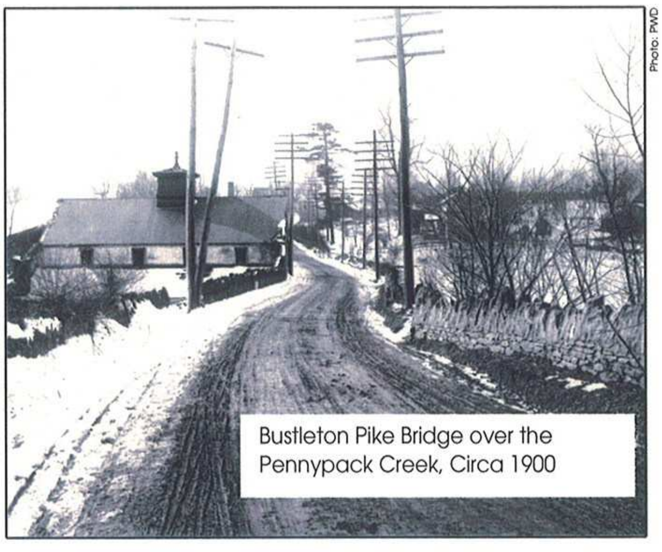


Figure 2.10: Locations of possible fill and probable fill within the USGS study area located in the Pennypack Creek Watershed.

Tan color shows area that have Possible fill or "an area where more than 5 feet of positive topographic change has been calculated or where topographic maps indicate a historical stream channel or low area that no longer exists." Red color shows areas that have Probable fill or "an area where more than 5 feet positive topographic change has been calculated and topographic maps indicate the presence of historical stream channel.

Conversion of forested land into agricultural land had substantial impacts on the area's waterways. Historical accounts note dramatic decreases in stream flows after clearing for agricultural and industrial purposes (FPC 1999). Increases in both channel and land erosion introduced vast quantities of sediment into streams in the watershed. Much of this sediment was subsequently deposited in the stream channels and floodplains, a process that caused stream elevations to rise with time. Much of the sediment deposition was concentrated behind mill dams, where slow water velocities diminished the creek's ability to move sediment. In many areas of the Piedmont, several feet of post-settlement deposition can be seen in the soil horizons of the streambanks. Excess sediment also filled in streamside wetlands and larger riverine wetlands.

As many areas of the watershed began to convert from agricultural land uses to urban land uses, increases in runoff caused streams to downcut through post-settlement sediment deposits, leaving streambeds highly channelized and much lower than the floodplain bank elevations. This process of sedimentation and subsequent downcutting has had serious consequences for stream ecosystems in the Pennypack Creek Watershed. For instance, there are currently few large riverine wetlands remaining in the watershed because they were destroyed by sedimentation, down cutting, filling, and reduced base flows (FPC, 1999).



Bustleton Pike Bridge over the Pennypack Creek, Circa 1900

By the middle of the 19th century, community members and government officials in the Philadelphia area began to realize the profound impact of human activity and land use changes on water resource quality. Organized protection of the city's water resources and open spaces began in 1855 with a city ordinance that initiated the forerunner of the present Fairmont Park system. At this time, the city was experiencing problems as a result of its rapid growth, including a serious shortage of potable water. A concerted effort was made to protect the watershed that supplies the city to ensure clean water and also to provide recreation facilities for the growing middle class (FPC, 1999).

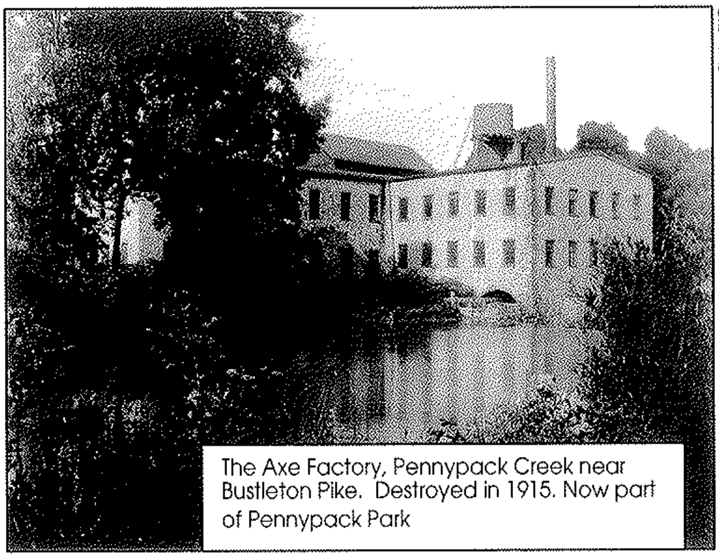


Photo: PWD

The Axe Factory, Pennypack Creek near Bustleton Pike. Destroyed in 1915. Now part of Pennypack Park

At the turn of the century, much of the Pennypack Creek Watershed was still agricultural. The Village of Bustleton (now the Bustleton Section of Northeast Philadelphia) was still very much a rural town in 1900. As the City of Philadelphia expanded into the Pennypack area, city planners decided that the main stem of the creek should be protected as park land. Thus, the Pennypack Creek avoided the fate of several creeks that once drained earlier developed areas of the city. In many of these areas, including vast sections of north, west, south, and central Philadelphia, creeks were straightened, filled, and piped to make way for expanding city grids.

In 1905, the City passed an ordinance for the creation of the Pennypack Creek Park. Over the next 20 years, the City purchased and protected significant parcels of land along the creek, many of them former industrial sites. Many of the large industries along the creek were demolished to make way for the park.

During the early part of the 20th century, sanitary and storm sewer flows within expanding communities were typically combined into a single sewer system. This system resulted in direct sanitary sewage discharges into streams during large storm events when the capacity of these systems was exceeded.

Most communities in the Pennypack Creek Watershed are served by separate sanitary and storm sewers, but leaks and illegal cross connections between sanitary and storm sewer systems still contribute pollution to the stream. In the spring of 1954, the Health Department banned swimming in the Pennypack Creek, due to elevated fecal coliform levels. Due to continued water quality problems and concerns for public safety the creek has never been approved for swimming.

Early Suburban History

With the advent of the railroad and trolley cars, it became possible for wealthy residents of Philadelphia to move out of the city and commute to the city. In the late 1800s, strong suburban communities began to develop around rail and trolley stations. These transportation improvements facilitated the development of Northeast Philadelphia and surrounding first ring suburbs. The invention of the automobile, and more significantly the availability of affordable automobiles due to improvements in assembly line technology, further promoted suburban development. The completion of the Frankford Elevated rail line to Bridge Street, the paving of Roosevelt Boulevard to Holme Circle and the construction of the Tacony-Palmyra Bridge in the 1920s all facilitated the conversion of northeast Philadelphia into a suburb allowing people to live outside the traditional city neighborhoods and commute easily to work. New homes were built in Mayfair between 1926 and 1939 that were different from the traditional row homes of Philadelphia. These homes had garages instead of backyards. Outward expansion of development into the headwaters of the Pennypack Creek was now underway.

After World War II, federal housing policy and programs designed to assist economic development further encouraged people to move to the suburbs and out of traditional city neighborhoods. Programs such as the GI Bill and Housing Act of 1949 encouraged new construction over the renovation of homes by tying construction standards to home financing. These programs essentially made buying new homes easier and more affordable than buying and renovating existing homes within urban areas. These programs and policies combined with aging housing stock, loss of manufacturing jobs and a desire for more private open space facilitated an outflow of people from the city beginning in the 1950s and began to affect first ring suburbs and older boroughs in the 1970s. New malls, such as the Roosevelt Mall at Roosevelt Boulevard and Cottman Avenue, also changed the way people socialized by drawing shoppers away from traditional commercial centers thus further exacerbating economic conditions in Philadelphia and surrounding older boroughs (Lake, 1996).

Brief histories of each of the suburban communities are presented in this section.

Abington Township

Abington Township was settled in the 1680s by Quaker settlers who purchased land from William Penn. The Township was incorporated in 1704 and was crossed by many important transportation routes including York and Easton Roads. Early transportation routes made villages, such as Rydal, Jenkintown and Rockledge, important commercial centers.

The township was served by the North Pennsylvania Railroad in the 1870s and trolley lines in the late 1800s. These modes of transportation, along with the important roadways made Abington an important Philadelphia suburb.

Bryn Athyn Borough

Bryn Athyn Borough incorporated out of Moreland Township in 1916. A strong sense of religious community was the impetus for the creation of this borough whose name means "hill of cohesion" in Welsh.

The major land uses in the Borough have historically been religious institutions such as the Academy of the New Church, the Bryn Athyn Church School and the New Church College. These institutions give Bryn Athyn a measure of open spaces not available in the surrounding municipalities.

Hatboro Borough

Hatboro was established as a village in 1705, when the first residents built homes along the Pennypack Creek. Hatboro's location at the crossroads of York, Horsham and Byberry roads made it an important commercial and industrial center on the route from New York to Philadelphia.

Hatboro incorporated as a borough out of Moreland Township in 1870. Rail service in 1871 fueled both population and industrial growth of the town. The Borough experienced its greatest growth during the 1920s and 30s but continued to gain population until the 1980s when many boroughs and older suburbs in the Philadelphia region began to lose population to surrounding communities.

Horsham Township

Horsham Township was settled by Quakers in the 1680s as part of William Penn's original land grant. The Township was incorporated in 1711 and later became home to Pennsylvania's colonial governor, William Keith. Keith was responsible for the creation of the Easton Road, which linked Philadelphia with the City of Easton. Horsham's early commercial center, Horshamville, was centered at the cross roads of Horsham and Easton Roads.

The North Pennsylvania Railroad's service to Hatboro in the 1870s virtually linked the two communities as residential development spread out from the train station into Horsham along Horsham-Hatboro-Byberry Road. Horsham was served by trolley lines in the late 1800s but Horsham remained largely an agricultural community through the 1940s. The two regional Naval Air Stations (Willow Grove and Johnsville) attracted some residential development to the township but much of the municipality's growth has occurred since the 1970s as people have continued to migrate from Philadelphia and other first ring suburbs.

Rockledge Borough

The area that is now Rockledge borough was mostly agricultural until the 1880s. An influx of residents from the Fox Chase neighborhood of Philadelphia led to the incorporation of the Borough out of Abington Township in the early 1890s. Proximity to the city and rail and trolley service made the borough an important early suburb of Philadelphia.

Upper and Lower Moreland Townships

The townships of Upper and Lower Moreland were originally part of the 9,815 acre parcel of land purchased by Dr. Nicholas More from William Penn in 1682. At that time, the land was completely covered by stands of forest and was cleared for agriculture. The Pennypack Creek was the center of the township's commercial ventures, and by the early 1700s the creek supported 10 grist mills, 3 saw mills, a fulling mill, 5 tanneries and a distillery.

With the creation of Montgomery County in 1784, residents of the lower section of Moreland Township petitioned to remain part of Philadelphia County. As a result, 3,700 acres were annexed by Philadelphia and later incorporated into the city.

In the 1870s, the North Pennsylvania Railroad Company connected the city of Philadelphia with the Lehigh Valley. All along the rail line settlements arose around rail stations. In Moreland, the settlements of Betharyes, Fulmor and Heaton and Willow Grove were served by the railroad.

With the advent of the automobile and improvements to traditional coach and carriage routes, such as Easton Road, more families were able to move out of the city to Moreland. The township experienced great gains in population from the 1920s through the 1950s leaving the Morelands as two of the more densely populated townships in Montgomery County.

In 1961, Moreland Township was separated into the townships of Upper and Lower Moreland.

Upper Southampton Township

Like the rest of the Pennypack Creek Watershed, Upper Southampton was part of William Penn's original land grant and was surveyed by Thomas Holme. By 1685, Southampton was recognized as a township and was settled by Quaker farmers.

Agriculture dominated the township through the 1800s and the market towns of Davisville and Southampton sprouted at major crossroads. Rail service came to the village of Southampton in the 1870s and made it possible for residents to commute into Philadelphia.

Proximity to Philadelphia and rail access led to a population boom in the township in the early 1900s. In response to this population growth the township split into Upper and Lower Southampton Townships in 1929. Upper Southampton remained largely an agricultural community until another population boom after World War II. By the 1970s, farming land had been largely consumed by residential development.

Warminster Township

Warminster Township was originally part of William Penn's land grant from King Charles II. In 1711, the township was formed by separating from Southampton Township. In its earliest days, Warminster Township was an agrarian community with villages (Hartsville, Warminster, Johnsville and Ivyland) that served as commercial centers where local goods were bought and sold and products from the area were repackaged and transported on to Philadelphia. The North Pennsylvania Railroad served these villages in the 1870s and encouraged their growth.

In 1939, the Brewster Aircraft Company began building airplanes for the Federal Government and in 1943 the government built 1,200 housing units in Warminster Heights to support the war effort. The U.S. Navy acquired the factory in 1944 and was one of the region's largest employers until the Naval Air Warfare Center was closed in 1996.

Population growth of Warminster Township mostly occurred in the 1950s, 60s, and 70s. Residential development was fueled by the automobile, among other reasons, and subdivisions sprung up along the townships major thoroughfares. Since the1980s, Warminster Township has been losing population and faces many of the challenges of first ring suburbs in the Philadelphia metropolitan region.

Social/Economic Profile

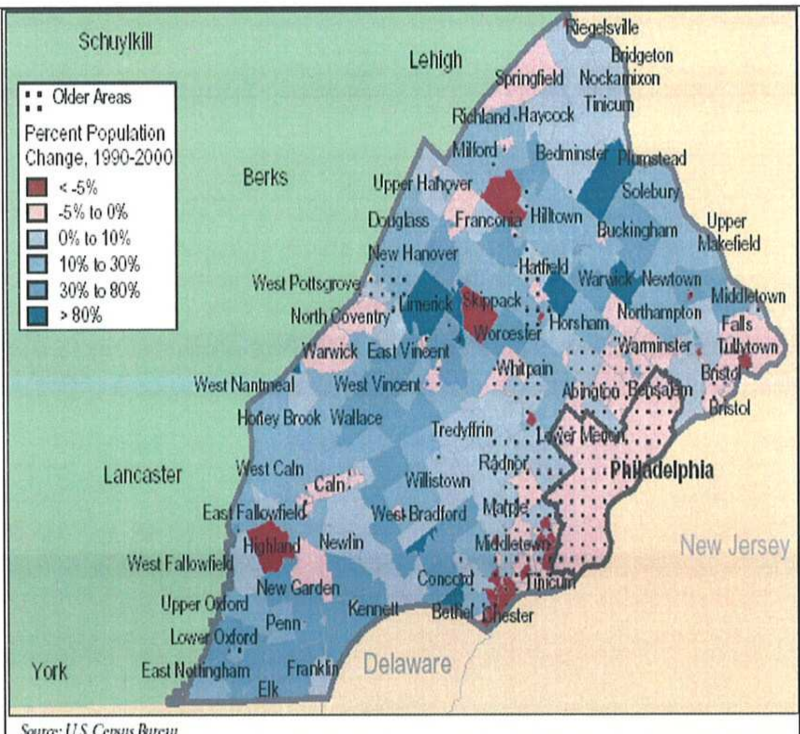
According to the 2000 Census, the Pennypack Creek Watershed is home to more than 250,000 residents. The density, racial characteristics, and economic profile of these residents vary widely across the watershed. This section of the plan summarizes population and economic trends occurring in the watershed to identify changing issues facing the watershed and its residents.

Like much of the Greater Philadelphia area, the Pennypack Creek Watershed is experiencing a population shift from the City of Philadelphia and its first ring suburbs to more rural communities. Table 2.2 shows the population change from 1990 to 2000 for the Philadelphia neighborhoods and municipalities in the watershed and compares them to the city and counties as a whole. Overall, Bucks County has seen a 9.4% increase in population but the Bucks County townships within the watershed have experienced population declines. Population in Bryn Athyn Borough in Montgomery County increased significantly more than the

County average. Older boroughs such as Rockledge Borough and first ring suburbs such as Lower Moreland Township experienced a decrease in population.

The Brookings Institution Center on Urban and Metropolitan Policy recently released a report entitled "Back to Prosperity: A Competitive Agenda for Renewing Pennsylvania", which summarizes important trends in the population dynamics and movements across Pennsylvania. Figure 2.11, excerpted from the Brookings Report, shows the recent trends in population movement in southeastern Pennsylvania. These trends continue to show movement out of the city and from older boroughs and first ring suburbs. More detailed analysis of recent land uses in the Pennypack Creek Watershed is presented in Chapter 4 of the report.

Table 2.2 presents aggregated changes in population from 1990 to 2000 for municipalities and Philadelphia neighborhoods located partially or entirely within the Pennypack Creek Watershed. While there is a general trend of population decline in the urbanized portion of the watershed, some neighborhoods including Rhawnhurst and Oxford Circle have experienced moderate population growth. Many suburban municipalities including Rockledge Borough, Hatboro Borough, Abington Township, Lower Moreland Township, and Upper Moreland Township have experienced negative and flat levels of growth. The notable exception is Horsham Township, in which the headwaters of the Pennypack Creek are located, where populations have increased by nearly 10% in the 1990s.



Source: The Brookings Institution Center on Urban and Metropolitan Policy

Figure 2.11: Percent Population change Across the Philadelphia Metropolitan Area, 1990-2000

The trends that are occurring in the Pennypack Creek Watershed are consistent with the Philadelphia area.

Tables 2.3 and 2.4 present additional demographic data for municipalities and Philadelphia neighborhoods located entirely or partially within the Pennypack Creek Watershed. As the tables show, populations within most areas became more diverse during the 1990s, although Caucasians still comprise the majority of the population in all municipalities and neighborhoods. Within the Philadelphia portion of the watershed, the Caucasian population decreased by ten percent while African American, Hispanic and Asian populations grew more rapidly. In some cases, minority populations have increased dramatically. Minority populations of nearly every race/ethnic group have also increased significantly in virtually every suburban municipality within the watershed. It is important to note that increases in the category "Other" are partly due to changes in the definitions of race used by the U.S. Census Bureau between 1990 and 2000, rather than the apparent influx of this category of people into the watershed. Figure 2.12 presents maps that indicate the relative percentage of the largest three racial groups in each of the ten sub-watersheds. The maps show that Pennypack Mouth sub-watershed in the City of Philadelphia is the most racially diverse of the sub-watersheds.

Table 2.3: Population Changes from 1990 to 2000 in Municipalities and Philadelphia Neighborhoods Located Partially or Entirely within the Pennypack Creek Watershed.

County	Municipality	1990 Population	2000 Population	% Change
Bucks County		541,174	597,635	9.4
	Upper Southampton Twp.	16,076	15,764	-2.0
	Warminster Twp.	32,832	31,383	-4.6
Montgomery County		678,111	750,097	9.6
	Abington Twp.	56,322	56,103	-0.4
	Bryn Athyn Borough	1,081	1,351	20.0
	Hatboro Borough	7,382	7,396	0.2
	Horsham Twp.	21,896	24,232	9.6
	Lower Moreland Twp.	11,768	11,281	-4.3
	Rockledge Borough	2,679	2,577	-4.0
	Upper Moreland Twp.	25,313	24,993	-1.3
City of Philadelphia		1,585,577	1,517,550	-4.5
	Bustleton	31,073	31,313	0.8
	Fox Chase	19,775	20,032	1.3
	Holmesburg / Torresdale	25,325	26,408	4.1
	Mayfair	34,012	33,514	-1.5
	Oxford Circle	49,231	51,681	4.7
	Pennypack / Academy Gardens	26,397	25,788	-2.4
	Pennypack Park	662	652	-1.5
	Rhawnhurst	27,019	28,212	4.2
	Somerton	32,634	32,867	0.7
	West Torresdale	32,746	30,595	-7.0

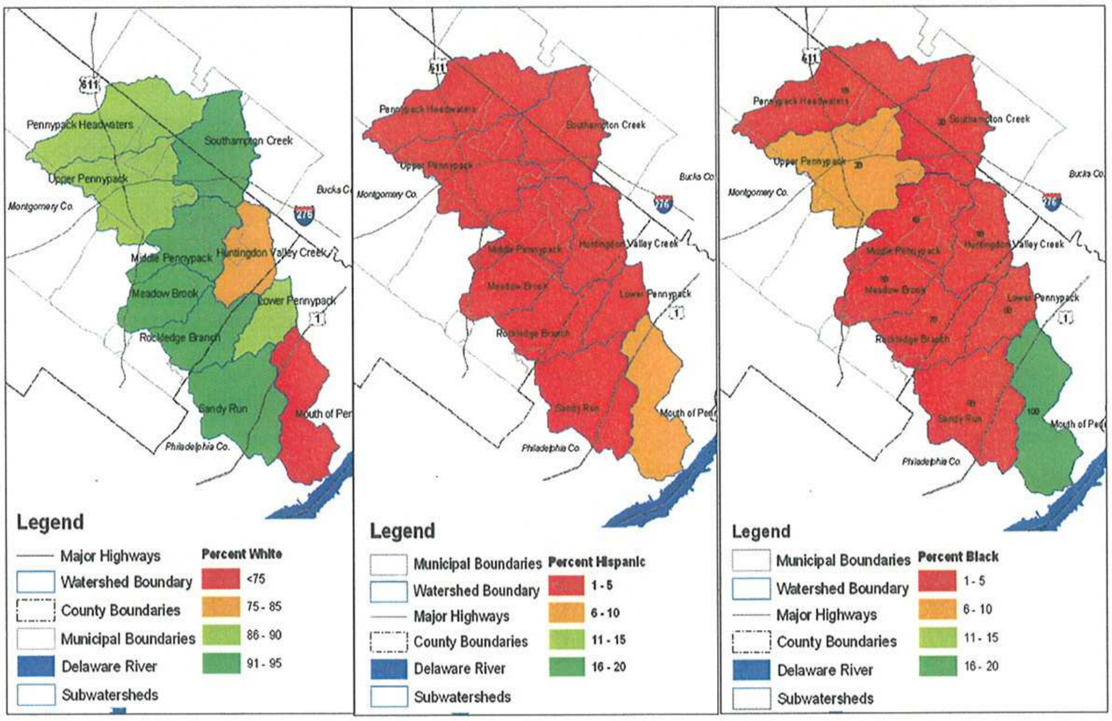
Sources:1990 and 2000 Census Data

Table 2.4: Population by Race/Ethnic Group in Municipalities in the Pennypack Creek Watershed, 2000

County	Municipality/Neighborhood	Caucasian	African American	Hispanic	Asian	Am. Indian	Other
Bucks County		557,751	21,552	14,005	15,538	2,114	7,202
	Upper Southampton Twp.	15,348	144	127	284	29	64
	Warminster Twp.	28,889	1,216	1,454	753	85	886
Montgomery County		655,447	60,052	15,300	32,767	2,798	8,502
	Abington Twp.	47,700	6,431	883	2,026	201	459
	Bryn Athyn Borough	1,316	19	9	19	1	6
	Hatboro Borough	7,112	161	107	88	15	63
	Horsham Twp.	21,935	989	387	1,243	83	216
	Lower Moreland Twp	10,808	71	103	400	14	52
	Rockledge Borough	2,541	2	15	31	4	16
	Upper Moreland Twp.	22,895	1,197	432	854	100	235
City of Philadelphia		703,584	672,162	128,928	74,435	4,073	90,441
	Bustleton	27,257	1,091	1,019	2,198	*	327
	Fox Chase	18,472	499	620	558	*	270
	Holmesburg / Torresdale	17,470	7,069	1,590	485	*	968
	Mayfair	31,910	575	888	347	*	298
	Oxford Circle	39,180	4,354	4,981	4,056	*	2,611
	Pennypack / Academy Gardens	21,847	2,089	1,119	1,031	*	391
	Pennypack Park	637	3	18	40	*	3
	Rhawnhurst	21,947	1,027	1,311	1,209	*	552
	Somerton	27,798	1,280	1,044	2,770	*	366
	West Torresdale	27,536	1,686	887	629	*	305

* No data available

Source: 1990 and 2000 Census Data



Source : 2000 Census data

Figure 2.12: Percent of Different Race/Ethnic Groups in Various Subwatersheds within the Pennypack Creek, 2000. The 2000 Census data were clipped to the sub-watershed boundaries. Equal population density throughout Census blocks was assumed so population data in Census blocks split along the boundary were adjusted by percentage of the block within the watershed boundary.

Economic conditions also vary widely throughout the watershed. Median income per household and median home values for each municipality and Philadelphia neighborhood located partially or entirely within the Pennypack Creek Watershed are presented in Table 2.5. In general, both median incomes and median home values are higher in suburban municipalities than in the City of Philadelphia. All Philadelphia neighborhoods within the watershed have higher median income and higher median home values than the average values for the City of Philadelphia. Median incomes and home values for the Montgomery County communities in the watershed are generally higher than the county averages with the exception of Hatboro and Rockledge Boroughs.

Like most municipalities in the Philadelphia Area, median home values in the Pennypack Watershed area have increased dramatically in the last several years. For instance, a recent article in the Philadelphia Inquirer ("City home-cost median near $100,000", April 17, 2005), reported that home values in Oxford Circle increased by 29% from 2003 to 2004 and had the highest sales volume anywhere in the City of Philadelphia over that period.

Table 2.5: Median Household Income and Median Home Values for the Municipalities and Philadelphia Neighborhood Located Partially or Entirely Within the Pennypack Creek Watershed, 2000.

County	Municipality/Neighborhood	Median Household Income	Median Home Value
Bucks County		$59,727	$163,200
	Upper Southampton Twp.	$59,493	$175,800
	Warminster Twp.	$54,375	$160,500
Montgomery County		$60,829	$160,700
	Abington Twp.	$59,921	$142,100
	Bryn Athyn Borough	$68,646	$215,800
	Hatboro Borough	$44,901	$135,100
	Horsham Twp.	$61,998	$167,700
	Lower Moreland Twp	$82,597	$233,600
	Rockledge Borough	$47,958	$122,300
	Upper Moreland Twp.	$50,454	$143,400
City of Philadelphia		$30,746	$59,700
	Bustleton	$36,402	$112,021
	Fox Chase	$37,084	$99,736
	Holmesburg / Torresdale	$35,984	$77,460
	Mayfair	$37,291	$70,228
	Oxford Circle	$37,210	$65,314
	Pennypack / Academy Gardens	$39,636	$88,386
	Pennypack Park	$58,665	$120,930
	Rhawnhurst	$34,855	$91,577
	Somerton	$41,771	$113,907
	West Torresdale	$48,275	$92,160

Source: 2000 Census Data.

Philadelphia neighborhood data summarized by the Cartographic Modeling Laboratory at the University of Pennsylvania. http://www.cml.upenn.edu/

POPULATION CENTERS

Population density varies significantly throughout the Pennypack Creek Watershed. Population density is highest within the City of Philadelphia neighborhoods of Fox Chase, Rhawnhust, Mayfair and Holmesburg (Figure 2.13). The middle portion of the watershed is much less densely populated due to the prevalence of protected lands including Pennypack Park, Pennypack Preserve and institutional landuses, such as Academy of the New Church and the Bryn Athyn Church School in Bryn Athyn Borough. Institutional uses occupy more land than residential uses in the borough, making Bryn Athyn atypical of the more densely populated boroughs in the watershed. Population density in the upper Pennypack Creek Watershed has been increasing since the 1980s.

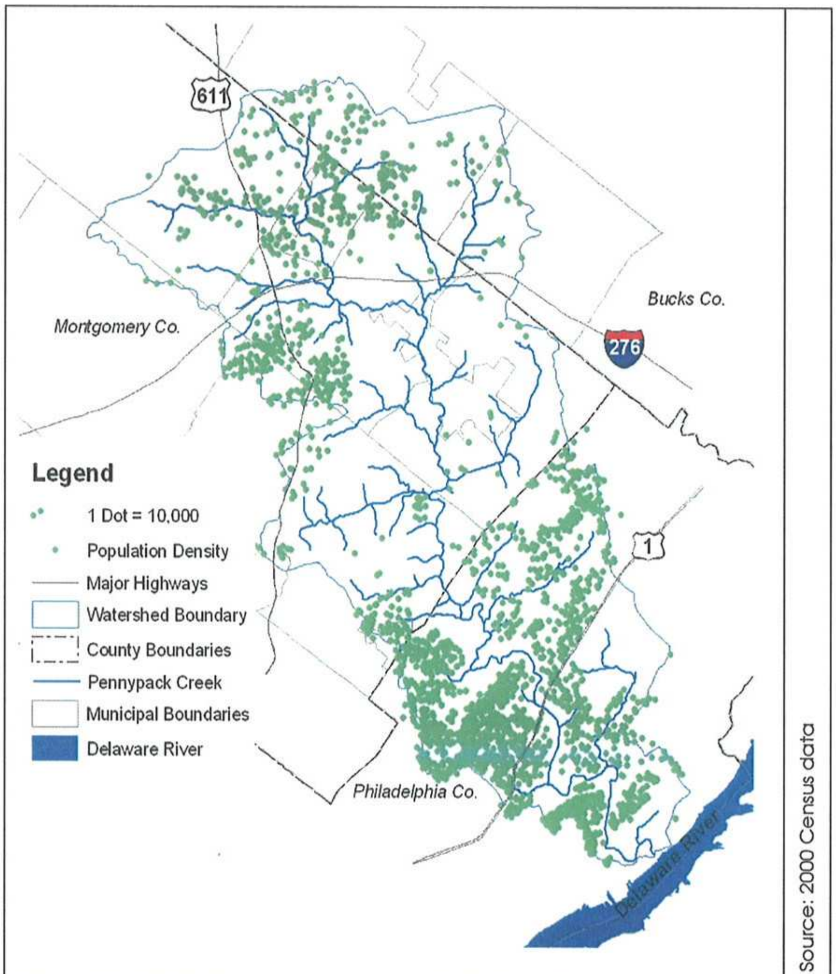


Figure 2.13: Population Density within the Pennypack Creek Watershed, 2000.

Population is most dense near the Pennypack Creek in Philadelphia.

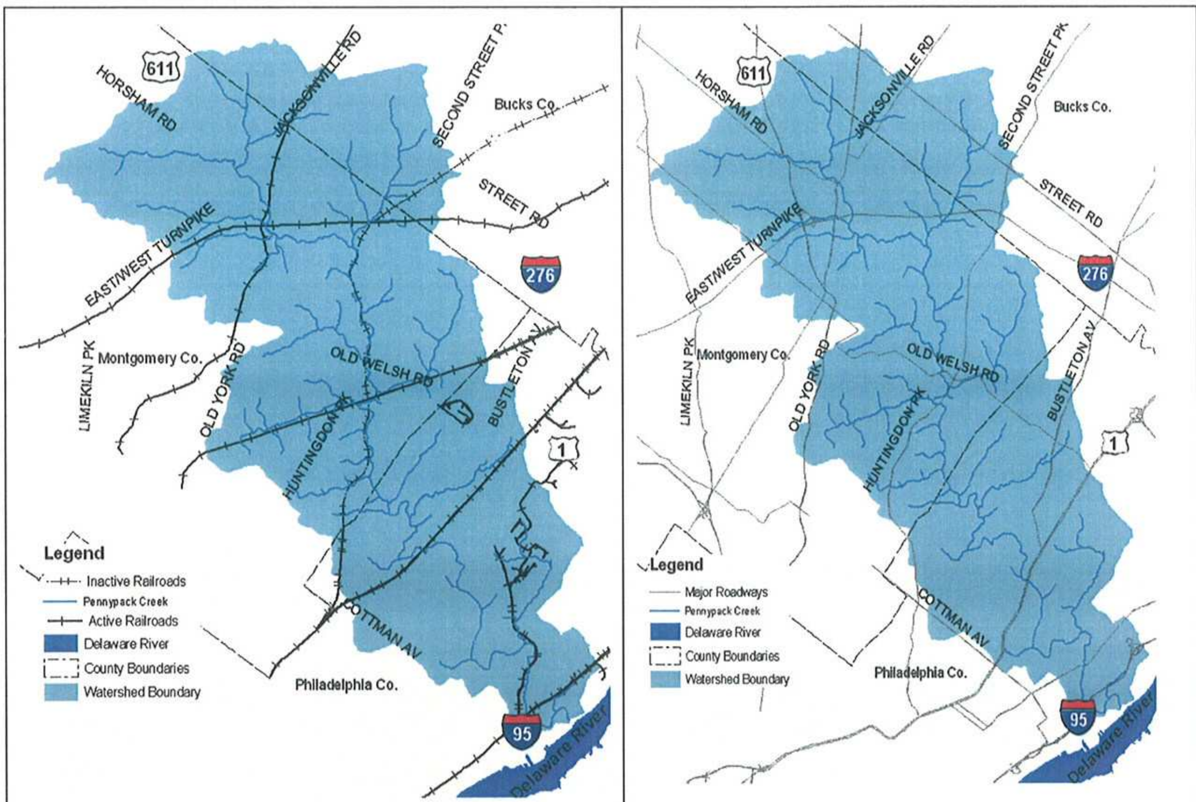
Transportation Facilities

Transportation has shaped the growth and development of the Pennypack Creek Watershed. As a result, there is a significant amount of transportation infrastructure in the watershed. Large interstate highways (I-95, I-276, and US-1) dissect the watershed and move tens of thousands of people through the watershed on a daily basis. State roads move local traffic but are becoming more and more congested. Public transportation serves the watershed communities but not as extensively as it once did. The Southeastern Pennsylvania Transportation Authority (SEPTA) R2, R3 and R8 regional rail lines provide access between Philadelphia and suburban communities. An unused SEPTA line runs through Lorimer Park along the Pennypack Creek (Figure 2.14). The active rail lines are the R2 Warminster, R3 West Trenton and R8 Fox Chase Rail Lines. The lower portion of the watershed is serviced by

Table 2.6: Bus Routes in the Pennypack Creek Watershed.

Route 1	NE Phila to Wissahickon Transportaion Center /54th St & City Ave
Route 18	Cedarbrook to Fox Chase
Route 24	Southampton to Frankford Transportation Center
Route 26	Germantown to Olney and Frankford Transportation Center
Route 28	Tacony to Fern Rock Transportation Center
Route 55	Doylestown/Willow Grove to Olney Transportation Center
Route 66	Torresdale to Frankford Transportation Center
Route 67	Bustleton and Franklin Mills Mall to Frankford Transportation Center
Route 70	Torresdale and Tacony to Fern Rock Transportation Center
Route 77	Chestnut Hill/Jenkintown to NE Phila
Route 80	Olney Transportation Center to Horsham
Route 84	Franklin Mills/Somerton to Frankford Transportation Center
Route 88	Pennypack Woods/Holy Redeemer Hospital to Frankford Transportation Center
Route 310	Horsham Breeze
Route 311	Commonwealth Breeze

Source: www.septa.org



Source: PWD and www.pasda.psu.edu

Figure 2.14: Transportation Routes within the Pennypack Creek Watershed.

the Market-Frankford Elevated and the R7 Trenton Lines.

In addition to regional rail service, several bus routes provide public transportation access throughout the watershed. Table 2.6 shows the Route numbers and bus routes for the bus lines that run through the watershed.

Employment Centers

There are a variety of employment opportunities within and in close proximity to the Pennypack Creek Watershed. Like the watershed's demographics, the region's largest employers have changed over time. Health care, finance and service industries have replaced the military as the largest employers in the watershed, with Abington Hospital being the largest single employer. Table 2.7 and Figure 2.15 detail the top employers in the watershed and the number of people that are employed at each location.

The major sources of employment in the City of Philadelphia are educational, health and social services (26.0%), professional, scientific, management, administrative, and waste management services (10.5%) and retail trade (10.4%). The main sources of employment in the Montgomery County area are educational, health and social services (21.6%), manufacturing (15.0%), professional, scientific, management, administrative, and waste management services (12.9%), retail trade (11.3%), finance, insurance, real estate, and rental and leasing (10.0%). The primary sources of employment in Bucks County are educational, health and social services (19.6%), manufacturing (15.5%), retail trade (13.3%), professional, scientific, management, administrative, and waste management services (10.7%).

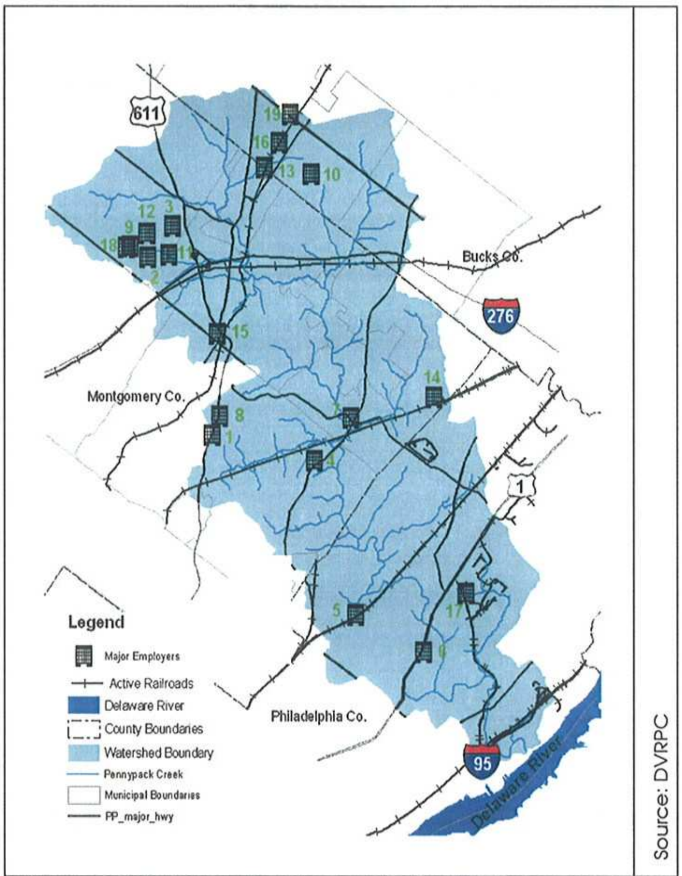


Figure 2.15: Major Employers in the Pennypack Creek Watershed.
The numbers on the figure correspond to the employer descriptions in Table 2.7.

Table 2.7: Major Private Employers Located within the Pennypack Creek Watershed

Employer	Location	Number Employed
1. Abington Memorial Hospital	Abington Township	4,251
2. United Parcel Service	Horsham Township	3,500
3. Prucare of Philadelphia	Horsham Township	1,600
4. Holy Redeemer Hospital and Medical Center	Abington Township	1,500
5. A.P. Orleans Vocational Center	Philadelphia	1,330
6. Nazareth Hospital	Philadelphia	1,150
7. Holy Redeemer Health System	Abington Township	1,000
8. PNC Bank Corp.	Abington Township	801
9. Quest Diagnostics, Inc.	Horsham Township	800
10. Warminster Hospital/Tenet	Warminster Township	610
11. GMAC Mortgage Corp.	Horsham Township	517
12. Penn Mutual Life Insurance	Horsham Township	500
13. ABB Automation Co.	Warminster Township	490
14. Toll Brothers, Inc.	Huntingdon Valley	400
15. U.S. Security Guards	Abington Township	300
16. W. Atlee Burpee Co.	Warminster Township	250
17. DEB Shops, Inc.	Philadelphia	200
18. Envirosource, Inc.	Horsham Township	100
19. Averstar, Inc.	Warminster Township	60

Source: DVRPC

CHAPTER 3

ISSUES, CONCERNS, CONSTRAINTS AND OPPORTUNITIES

3.1 Urban streams: Reclaiming a lost Greatness

The study of urban streams in American cities is a dichotomy between a glorious past and a largely forgotten present. One would be hard pressed to name a major American city that did not owe a great debt to the rivers and streams that flow through them. Indeed, in almost every city, urban streams have played a critical role in paving the way for economic development—providing power for new industries, water for growing towns and cities, and a means of moving raw materials and finished goods to and from market.

Paradoxically, it is the heavy hand of growth and prosperity that has left many of our urban streams in shambles. Today, in many cases, our urban streams have become forgotten arteries; receptacles for trash, sewage and stormwater; captured, buried, and straightened by the cities they once helped to build. Only when heavy rains come are we reminded of our streams as they flood our homes, businesses, and roadways.

But in some places, where foresight or good fortune has preserved our city streams, we see their great potential. They are places where the rush of water can whisk one away from the rigors of urban life, where children can learn to fish or discover a new world teaming with life. Our streams are green ribbons of life that weave and connect distant communities and serve as a rallying point that can provide a new breath of hope for troubled neighborhoods. They are portals into the exploits and undertakings of past generations. They can provide food or refreshment on a summer day, or provide the perfect backdrop for a romantic walk or a family picnic.

Restoring our urban streams involves first reinventing our concepts of how these streams can make our cities better places to live. Many urban streams no longer play the central role in commerce, navigation or power generation they once did (although some do), but still play critical roles in providing safe drinking water, stormwater conveyance, recreation opportunities, and natural habitats for an array of aquatic life. To this end, managing our city streams is as much about getting people excited about the potential as it is about cleaning up pollution. It is about learning to see our streams in a new way - different, but no less great than when they once helped cities rise. Apathy is indeed the enemy.

Starting with the premise that every city stream can be a resource to the people that live near it, we can begin to take aim at the problems that plague our city streams. Before we can do this however, we must begin to understand how the mere presence of a city landscape surrounding a stream begins to disrupt and alter a stream's delicate ecological balance.

The History of Impact

As many American cities developed, both direct use of stream channels for industry and commerce (e.g., dredging for navigation, damming of streams for milling, etc.), landscape changes (e.g., paving of roads, replacement of natural drainage ways with storm sewers, construction of bridges, etc.), and disposal of human and industrial waste products combined to negatively impact nearby streams and rivers. In many cases, these and other factors drastically diminished the ability of urban streams to sustain aquatic life and provide the full suite of uses and benefits to urban residents.

Many urban streams in the United States have a disturbance history that extends hundreds of years. During this time, many of these streams have been straightened, filled, dredged, and/or piped to accommodate new development or to facilitate drainage. Other streams have been dammed to provide flood control, hydroelectric power, and recreational benefits. In the northeastern United States, the predominance of milling operations in the 1700s and 1800s placed hundreds of small mill dams on small-to-medium sized streams. Many of these structures remain today. Bridges that traverse streams often produce local scale instability and bank erosion problems and can exacerbate flooding problems. Much of the riparian, or streamside, forest and vegetation that surrounds natural streams is removed along urban streams, resulting in banks that are more susceptible to erosion. Removal of riparian forests also results in increased warming of stream water by sunlight and a reduction in woody debris inputs, which are a fundamental habitat feature of urban streams.

Because the physical form of a stream channel (e.g., width, depth, meander pattern) is calibrated to handle the amount of water and sediment delivered to the channel, modifications to landscapes that alter water and sediment transport can produce stream systems that are geomorphically unstable. Actively adjusting streams often widen and downcut, introducing large volumes of sediment into the stream channel. This process can further destabilize or degrade downstream reaches. Unstable streams often lack the physical habitat diversity and year-round flow required to support a diverse assemblage of biological organisms.

Physical changes to streams within urban landscapes are accompanied by equally damaging changes to water chemistry. Pollutants including nutrients, sediment, pathogens, hydrocarbons, and heavy metals are generated within urban landscapes and transported readily via stormwater drainage systems to urban streams.

Water withdrawals for drinking water, commercial and industrial use, and irrigation also alter the timing, volume, and quality of water delivered to urban streams. Effluent from wastewater treatment plants, industrial facilities and construction sites carry additional sources of pollution. Although many of these discharges are now regulated under the Clean Water Act, there are many illegal and illicit discharges, as well as permitted discharges that are in frequent violation of water quality standards.

In many cities, stream water and habitat quality decreased to the point where many streams became viewed as extensions of the man-made city infrastructure rather than as natural ecological systems – mere conduits for the elimination of wastewater or canals for the movement of materials. The management of stream systems reflected this limited view of the purpose and function of urban streams. Often, stream systems were modified to enhance a specific purpose, or to eliminate a particular ill to the detriment of many other potential functions. For instance, many urban streams that functioned as wastewater conduits were buried and converted into underground sewers. Streams that played important navigational roles were straightened, lined, or fitted with navigational locks and dams to enhance their ability to convey large cargo ships. In this and other ways, the early "management" of stream channels further impeded the ability of the stream system to support even the most basic level of aquatic life.

Many of these outcomes are the result of a development policy that failed to recognize the innate and intimate connection between land management and water resource quality, that maximized short-term use of water resources for specific purposes while failing to provide long-term sustainability, and that sought to control the negative effects of flooding streams primarily through structural engineering.

3.2 MOVING FORWARD – A NEW PARADIGM FOR URBAN STREAM MANAGEMENT

Today, we are developing new ways to approach urban streams that are based on a paradigm of integrated, sustainable, watershed-based water resources management. Watershed-based management recognizes the profound linkage between landscape processes and stream resources and therefore concentrates on land management as the principle vehicle for attaining and maintaining healthy streams. Integrated management seeks to create natural-like stream systems that offer the fullest range of uses and benefits to the largest possible range of user groups. Sustainable management means that managers provide these uses and benefits over time with a minimum amount of active interference.

Urban streams are used and valued by a number of different groups in sometimes widely differing ways. Common uses and values of urban streams include:

Active Recreation – use of a stream or stream corridor for boating, watersports, swimming, biking, fishing or similar activity

Passive Recreation – use of a stream or stream corridor for streamside walking, natural observation, meditation or similar activity

Power Generation – the use of streamwater for cooling or heat rejection

Navigation – movement of cargo to upstream and downstream destinations

Potable Water – use of stream water for drinking and bathing

Non Potable Water – use of stream water for irrigation, cleaning, and other non-potable uses

Property Values – the influence of a stream on the resale value of a home or business

Flood conveyance – the ability of a stream to transmit flood waters from source to mouth

Waste disposal – the ability of a stream to dilute, degrade, and transport industrial, residential, and commercial waste products

Urban streams that emulate the form and physical processes of natural stream channels will provide the most benefits to the widest range of groups for the lowest cost over time. Some of these fundamental attributes include:

- **Water quality** – stream water that is free of pollutants (including elevated temperatures) that diminish the ability of aquatic organisms to live and reproduce
- **Geomorphic stability** – a stream channel that does not rapidly change its width, depth, slope, or pattern over time
- **Longitudinal and lateral connectivity** – a stream channel that permits the free movement of aquatic and riparian organisms upstream and downstream along the stream channel and adjacent riparian areas, and which is hydrologically connected to its floodplain
- **Habitat diversity** – a stream channel that contains the full range of in-stream, riparian and benthic (bottom) habitats and a variety of water depths and velocities; in forested areas – a supply of in-stream woody debris
- **In-stream flows** – a stream channel that supports sufficient year-round flow to permit the persistence of diverse aquatic communities
- **Flood conveyance** – a stream channel and floodplain that is capable of transmitting flood waters without excessive damage or flooding

In urban environments, a set of stressors diminish the ability of a stream system to maintain these fundamental attributes. In many cases, multiple stressors act in concert over time to diminish multiple attributes. Urban stressors can be roughly divided into three categories: Point Source Discharges, Landscape Change Stressors, and Stream Corridor Stressors.

- **Point Source Discharges:** This set of stressors includes point discharge of pollutants and waste materials from residential, commercial, and industrial areas. Common examples of point source discharges include industrial waste discharges and wastewater treatment plant discharges.
- **Landscape Change Stressors:** This set of stressors includes modifications to the natural landscape including changes in topography, removal of vegetation, alterations to native soils, paving, and installation of artificial drainage systems that result in alterations to natural drainage patterns and/or transmission of non-point source pollution.
- **Stream Corridor Change Stressors:** This set of stressors includes alterations to stream corridors including the removal of riparian vegetation; the constriction of bridges, dams and other structures that restrict, constrict, or otherwise alter streamflow; and the straightening, burying, or lining of stream channels.

It is important to realize that impacts to urban systems often occur through a sequence of stress causing events that starts within an Ultimate Stressor (e.g., the ultimate or root cause of the problem, etc.) which in turn produces Intermediate Stressors and finally Proximate Stressors (e.g., the apparent or obvious cause of the problem, etc.). Stressor analysis involves understanding the complex chain of stressors that ultimately negatively influence natural functions and attributes. Such analysis often illustrates the linkages between stream management and larger socio-economic patterns and trends. For this reason, sustainable stream management often involves working with a larger set of groups and institutions working to effect large-scale socio-economic changes in urban environments.

Effective and sustainable management of urban stream systems involves a participatory, iterative process that involves many steps including:

- Understanding how various groups use and value or could **potentially** use and value a stream,
- Understanding the linkages between uses and values and the functions and attributes that make these uses and values possible,
- Evaluating the stream's current condition in terms of functions and attributes,
- Understanding how various stressors are combining to undermine functions and attributes,
- Developing a cohesive management plan that uses available resources to increase uses and values by enhancing natural functioning,
- Developing organizational, public relations, political, financial, and technical resources to implement the management plan,
- Developing a plan for on-going monitoring and evaluation, and
- Building awareness, excitement, and momentum through educational and outreach programs

In the following Chapters, this report will explore how the Pennypack Creek is used and valued by various watershed stakeholders. The collection and analysis of public participation data collected during the two-year RCP process, including citizen surveys, key person interviews, and feedback obtained during neighborhood and public meetings, played a key role in our ability to understand how the Creek is used and valued. We will also explore ways in which the uses and values of the Creek might be enhanced through actively managing the creek's watershed and corridor.

We will also spend considerable time exploring ways in which various stressors (i.e., entities or actions that stress or negatively affect the value or uses of a natural resource) alter the natural functioning of the creek and thus the ability of the creek to provide for existing or potential uses and values.

Finally, we will explore ways in which various actions including monitoring, educational programs, stream restoration projects, and landscape restoration might be used to improve the natural functioning of the Pennypack Creek and ultimately the uses and values of the Creek.

3.3 URBAN STREAM MANAGEMENT CHALLENGES

Before we proceed with the development of a Rivers Conservation Plan, let us consider some of the unique management challenges associated with urban streams in general, and the Pennypack Creek in particular. Keep these ideas in mind as you read through the rest of the report chapters.

Developing a Common Vision

Urban streams mean many things to many different groups of people and it is nearly impossible for one resource to meet all needs. One example of how various groups value the Pennypack Creek differently involves perceptions of the creek between city and suburban residents. Within the City of Philadelphia, the Pennypack Creek flows through Pennypack Creek Park, which is extensively used as a recreational resource by area residents. The wide, natural areas surrounding the creek protect nearby residences from flooding. The Creek is also much larger in these areas and is capable of supporting many species of game fish. By contrast, reaches of the Pennypack Creek in the Hatboro area are much smaller, support limited recreational use, lack recreational access or significant natural buffers, and have routinely caused flooding problems. Naturally, residents within the City of Philadelphia are more likely to use and value the Pennypack Creek as a resource than residents near and in the Borough of Hatboro. The results of the RCP Citizen Survey reinforce this conclusion. Survey results showed that City of Philadelphia residents were almost three times as likely as suburban residents to visit the creek daily or weekly.

Developing a common vision for an urban stream is a difficult and demanding undertaking. However, while the uses and values provided by urban streams may sometimes be in opposition, often the needs of many groups can be accommodated by restoring natural form and function to the stream system. In the Pennypack Creek Watershed, developing a common vision for the future of the creek is a key challenge.

50,000 Pounds of Cure

Often, the management of urban stream systems is hampered and restricted by severe physical, financial, and political constraints. In highly developed watersheds, large-scale restoration efforts can be extremely costly because they require retrofitting of existing facilities, disturbance of existing buildings and utilities, extensive permitting, and public buy-in. For example, large portions of the Sandy Run, a major tributary of the Pennypack Creek that flows through the Rhawnhurst section of Philadelphia, have been buried and piped in large combined sewers. While daylighting Sandy Run would dramatically improve the natural functioning of that stream, the feasibility of this management option is limited by virtually insurmountable financial, technical, and political challenges.

Finding creative ways to work with regulatory authorities, funding agencies and local watershed groups to find cost-effective restoration approaches continues to be a critical challenge in many urban watersheds including the Pennypack.

Finding Ways to Reach People

Watershed management is based on the concept that what happens on the landscape affects our streams and waterways. In urban environments, this means that meaningful improvements in water quality can require widespread voluntary behavior changes among tens of thousands of watershed residents. Watershed management and stream health are important, but secondary issues to many urban residents. Many folks do not know what a watershed is, and for those who live on the outskirts of the watershed, making the connection between their actions and a stream that is many miles away is difficult.

Making the real connection between water resource quality and people's quality of life is also a fundamental challenge for urban watershed managers. Drinking water quality and recreation value are two issues that resonate with urban residents, because they provide a tangible use and benefit for the average person. Finding creative, effective ways to raise awareness about watershed issues in a media saturated world is also a challenge. Often watershed groups rely on "low cost" methods of advertising including flyers, newsletters, and piggybacking onto existing events (e.g., local community fairs, community group meetings). Finally, effectively engaging various minority groups in watershed restoration efforts is an emerging challenge.

What Do We Do Next?

Most of the potential for new open spaces is gone. There is pavement as far as the eye can see. Most of the developments were built with minimal or no stormwater control. Streams are eroding and downcutting, not to mention flooding. What do we do next? Do we invest more funds into monitoring the stream to figure out exactly what is wrong with the stream? What about an intensive public outreach campaign? Will that really make a difference? Maybe we should conduct a stormwater retrofit at the local church. Developing a cohesive management strategy that balances the concept of prioritization (figuring out which management options among many will be most effective), with the concept of opportunity (which management options may be most possible because of public acceptance, political momentum, funding, etc.), is a critical, often overlooked, step in watershed restoration efforts.

There are highly technical methods for prioritizing restoration sites based on risk analysis, cost/benefit analysis and other methods. However, the technical merit of a particular project (e.g., pounds of pollutant removed) compared with project cost should not be the sole determinant of a project's priority. Other factors that should be considered include landowner cooperation, public relations potential, and educational benefit. For instance, a particular project may be a priority because it forges an alliance with a particular landowner, or result in a high-profile media coverage of watershed issues. These projects may be just as, if not more important than, projects that are low cost/high benefit from a purely technical perspective.

Geographic information systems (GIS) can be an invaluable tool for collecting, analyzing, and managing site data that can be used to prioritize restoration efforts.

The Upstream/Downstream Conundrum

Most of the obvious, tangible benefits associated with streams occur when streams reach a certain critical size. Larger streams can support diverse recreational and commercial fisheries; can be used for navigation, power generation, and a source of drinking water; and can support a variety of recreation uses. Larger streams also are more likely to negatively affect communities, principally through flooding. Either way, residents living adjacent to or near larger streams are more likely to have a strong opinion about their local stream. Paradoxically, people living adjacent to and near larger rivers exert a proportionally small influence on the quality of the river system.

Small streams, by contrast, offer little in the way of tangible societal benefits. Residents living adjacent to or near these small streams, in headwater reaches of a watershed, are often not even aware of the stream's existence, and if they are aware, they are unlikely to value the stream in any strong way. These residents tend to live tens of miles from the larger, more actively valued and used stream segments. Paradoxically, it is these upstream watershed residents that exert a disproportionately large influence on the quality of the entire stream system.

The spatial disconnect between those who most acutely influence streams (upstream residents) and those who most intensively use and value streams (downstream residents) is an important paradox to recognize when managing urban stream systems.

Getting Real

Setting realistic management goals for urban stream management is important. Most urban streams cannot attain water quality, habitat quality, or aquatic diversity equivalent to that of a pristine stream draining an undisturbed landscape. However, many urban streams can support a diverse array of aquatic life, provide exceptional recreational opportunities, and can strive to achieve water quality sufficient to support swimming and to provide sources for drinking water.

Setting achievable goals is a critical aspect of effectively managing urban water resources including the Pennypack Creek.

Thinking Watershed, Reacting Locally

Watersheds range in size from small headwater drainages to the massive land areas that drain to our largest rivers. Because smaller watersheds are almost always a part of one or more larger watersheds, management of these smaller watersheds should and must advance the management of the larger watersheds to which they contribute. Incorporating management goals of larger watersheds may significantly change the way a smaller watershed is managed. For instance, in many smaller streams nutrient enrichment is not a serious problem. However, nutrient enrichment (and therefore nutrient management) is often of paramount concern in larger rivers and estuaries. Often, the management of nutrient loads in smaller streams is critical to managing the quality of the larger downstream resource. Therefore, the explicit inclusion of nutrient reduction strategies in management plans for smaller watersheds is critical for the management of nutrient pollution in large rivers and estuaries. The recognition that a smaller watershed is not a self contained unit, but is often part of a larger management effort, is critical to the success of large-scale watershed management efforts.

The Pennypack Creek drains into the Delaware River Estuary. As such, the management of the Pennypack Creek and its watershed must address not only the uses and values associated with the Pennypack Creek, but also the management goals and objectives that have been developed for the Delaware River and the Delaware Estuary. In particular, the Pennypack Creek Rivers Conservation Plan should advance the goals and objectives of the Delaware River Basin Commission's *Comprehensive Plan for the Delaware River Basin* and the Partnership for the Delaware Estuary's *Comprehensive Conservation and Management Plan.*

Active vs. Passive Management

Historical approaches to stream "management" have typically involved engineering-intensive attempts to control and regulate streams. Today, we are realizing that certain natural stream processes including flooding and natural rates of erosion are characteristic of healthy stream systems and do not need to be regulated. Rather, we are beginning to take a more passive approach to stream corridor management. For instance, rather than building flood control structures to prevent the flooding of homes and businesses located with the floodplain, we are taking steps to remove development from the floodplain and to strongly regulate new development in active floodplains.

Reaching Across Boundaries

Approaches to minimizing the scope and intensity of future landscape and stream corridor changes involves regulating land use. In Pennsylvania, the Commonwealth devolves statutory authority to regulate land uses to individual municipal governments. This statutory authority is defined and regulated by the Municipal Planning Code (MPC). Within the limits of the MPC, each municipality in the Commonwealth can adopt and enforce a set of land use regulations.

From a watershed perspective, locally-based land use regulation presents difficult challenges. First, locally-based land use regulation simply means that the lands within a single watershed are subject to many different sets of laws. Affecting change in land use regulation to improve watershed protection throughout a watershed therefore means that watershed managers must work with many jurisdictions independently. Achieving uniformity in land use regulation across a watershed is exceedingly difficult. The RCP considers challenges associated with effective land use regulation in the Pennypack Creek Watershed in more detail in Chapter 4.

Reaching across boundaries also means breaching racial, cultural, and social boundaries. A successful urban watershed management effort must reach out to all watershed residents. In the Pennypack, minority residents are underrepresented in watershed management efforts and must be more effectively engaged in future efforts.

Working Together for Change

Managing an urban stream involves a great many endeavors including public relations; public education and outreach activities; fund raising; scientific data collection, management and analysis; engineering assessment and design; political advocacy; legal challenges; coalition building, and so forth. No one single group possesses the depth and breadth of human, financial, and organization resources to effectively accomplish all of the tasks associated with an effective watershed management effort. Even if they did, watershed management is essentially a team sport.

Working together for change means bringing a diverse suite of organizations and individuals together around a common banner. However, it is not enough to have a number of engaged groups working in a particular watershed. Implementing strategies to share data, equipment, and other resources among groups in a watershed enhances the effectiveness of each group as well as the watershed effort as a whole. Each group brings a particular set of skills, knowledge, and abilities to a watershed management effort. As such, part of an effective management plan is collectively figuring out how each group's contribution can be most effectively used to achieve management goals.

In the Pennypack Creek Watershed, there is no shortage of active groups working in various ways to improve the creek. These groups include the Philadelphia Water Department, Friends of Pennypack Park, Fairmount Park Commission, Temple University Center for Sustainable Communities, the Southeast Montgomery Chapter of Trout Unlimited, and the Pennypack Ecological Restoration Trust. The major challenge is to find ways for these groups to combine forces to achieve common goals, share knowledge, ideas, and input, and to develop synergies that will allow each group to better achieve its own mission within the context of a large watershed effort.

3.4 Watershed Management in the Pennypack Creek Watershed

Humans have exerted both positive and negative influences on the Pennypack Creek Watershed since before the settlement of the region by Europeans. Native Americans cleared forested lands for agriculture, settlement and game management. Europeans brought more intensive land uses and dammed the Pennypack Creek in many places. More recently, efforts to restore and protect the Pennypack Creek have been implemented. Throughout the region's history, efforts to influence the nature of the creek have reflected the manner in which people view and value the Pennypack Creek as a resource.

Past Efforts

The most notable historical efforts to protect the Pennypack Creek and its watershed have been through the preservation and acquisition of natural landscapes. The three primary organizations responsible for the preservation of large areas of natural lands in the watershed have been the Fairmount Park Commission, Pennypack Ecological Restoration Trust and Montgomery County.

Fairmount Park Commission

Some of the earliest efforts to preserve natural lands in the watershed were implemented by the City of Philadelphia in order to provide protection for sources of drinking water and preserve open space opportunities for city residents. The Fairmount Park Commission was established by an act of the city assembly in 1867. Today the Commission is responsible for the 63 neighborhood and regional parks that comprise Fairmount Park.

The commission began purchasing land that would become Pennypack Park in 1905. By 1929, the commission had acquired most of the 1,600 acres of open space that is Pennypack Park today.

In 1996, the commission received a grant from the William Penn Foundation to restore the natural lands in its charge and enhance or create environmental education programs within the park system. Fairmount Park Commission's Natural Lands Restoration and Environmental Education Program (NLREEP) was created within the commission to administer the grant and promote this mission. NLREEP contracted with the Academy of Natural Sciences in 1997 to formulate restoration plans for the natural areas in Wissahickon, Cobbs Creek, Fairmount, Franklin Delano Roosevelt, Tacony Creek, Pennypack Creek and Poquessing Creek Parks. These plans have been the basis for ongoing restoration efforts in the city portion of the Pennypack Creek Watershed. Examples of NLREEP restoration projects in the watershed include the creation of intertidal wetlands at the mouth of the creek, invasive plant species control and riparian buffer restorations.

Following the completion of the grant, NLREEP was transformed to the Environment, Stewardship and Education Division. The ESED program continues to implement restoration projects identified in their park management plans as well as assuming new project objectives. The program has become a regional example of ecologically sound land management and restoration efforts and continues to exert positive influences on the Pennypack Creek Watershed.

Pennypack Ecological Restoration Trust

The Pennypack Ecological Restoration Trust (Trust) was founded in 1970 to preserve natural lands in the rapidly developing portion of eastern Montgomery County. The Trust protects natural lands through land donations, purchase and acquisition of conservation easements. Today the Trust has assembled 720 acres of meadows and woodlands in the Pennypack Creek Watershed, making the Pennypack Preserve the largest privately owned nature preserve in Montgomery County that is open to the public.

The Trust enhances its land preservation goals through environmental education, ecological restoration, research projects and environmental stewardship. The Trust sponsors annual stream clean-ups and volunteers are involved in invasive species control efforts. The Trust plays a major role in restoring and enhancing existing protected lands in the watershed and develops innovative land management techniques that promote biodiversity through the region.

MONTGOMERY COUNTY

The Montgomery County Open Space Program has provided funds to facilitate the preservation of approximately 240 acres of natural lands, parks and open space in the Pennypack Creek Watershed since 1993. The program has provided almost $3 million dollars in grant monies to leverage other sources of funding to preserve critical open spaces.

Montgomery County Department of Parks also owns and maintains the 250-acre Lorimer Park, in Abington Township, which serves as an important greenway link along the Pennypack Creek to protected parks lands within the City of Philadelphia.

In 2004, Montgomery County passed an additional $150 million open space bond referendum. This bond will help the county to continue to support open space preservation efforts in the county and Pennypack Creek Watershed.

Current Efforts

All of the organizations mentioned in the previous sections are participating in on-going efforts to protect the environment of the Pennypack Creek. These groups continue to be a source of inspiration for current and future efforts to protect the Pennypack Creek Watershed.

Currently, major efforts to enhance the water quality and environment of the Pennypack Creek Watershed have been undertaken by the Philadelphia Water Department (PWD) and Temple University Center for Sustainable Communities.

PHILADELPHIA WATER DEPARTMENT OFFICE OF WATERSHEDS

PWD Office of Watersheds is a major force working for the improvement of the entire Pennypack Creek Watershed. In addition to sponsoring this River Conservation Plan, PWD's efforts include diverse projects and studies ranging from urban watershed management seminars to stream restoration projects to watershed management plans.

The PWD implemented a five-year biomonitoring program in 2002 to assess the water and habitat quality in the streams that flow through the city and ultimately influence the water quality of the City's sources of drinking water. PWD also monitors the creek for chemical and other water quality parameters. Initial monitoring efforts established baseline data for the department to compare future monitoring data. PWD has been using these data to support water quality enhancement projects that have also exhibited benefits for the habitat and environment of the watershed.

PWD has commissioned a study of all of the wetlands in the watersheds in the city. The study will map wetlands throughout the watershed and will identify candidate sites for wetland creation to treat stormwater run-off. This study will be a valuable tool in identifying and protecting existing wetlands and promoting good use of created wetlands for stormwater management in the future.

In addition to these studies, the PWD has been participating in other watershed protection efforts with partner organizations. The department has joined efforts with the ESED program to sponsor the removal of the Frankford Avenue and Rhawn Street dams to enhance stream habitat, allow anadromous fish passage and restore the free flowing Pennypack Creek. The department sponsors countless educational programs regarding watersheds and watershed management throughout the city as well as supporting habitat restoration and water quality projects throughout the Pennypack Creek Watershed.

TEMPLE UNIVERSITY CENTER FOR SUSTAINABLE COMMUNITIES

The Temple University Center for Sustainable Communities is currently conducting two significant flooding and environmental assessment studies in the Pennypack Creek Watershed; a Pennypack Floodplain Analysis Study and a Regional Environmental Vulnerability Analysis (REVA). The floodplain analysis study will result in the updating of hydrologic and hydraulic models for different rainfall events in the watershed. These models can be used to update Federal Emergency Management Agency (FEMA) floodplain maps and help to identify areas that may be vulnerable to flooding and flood damage. The results of this study will have a tangible impact on the manner in which municipalities in the watershed manage stormwater, and presents a glimpse into future flow conditions of the Pennypack Creek if stormwater management techniques are not improved as the headwaters of the watershed are developed.

The REVA study will use ecological assessment, indicators, modeling, and GIS analysis to evaluate the effects of urbanization on the stream system, evaluate various scenarios for action and implications of these decisions and link the results to state-wide indicators of environmental quality. This study will be a pilot study used to determine the efficacy of the REVA process and its transferability to other watersheds.

ACTIVE GROUPS AND ORGANIZATIONS

There are a number of other volunteer groups and organizations that are working to preserve and maintain the quality of natural lands and habitats in the Pennypack Creek Watershed. Examples include:

<u>The Friends of Pennypack Park</u>: The Friends have been sponsoring stream clean-ups of the Pennypack Creek, assisting with trail maintenance and volunteering for natural area restorations since 1987. The organization supports historical and environmental education efforts and publishes a comprehensive map of the trails of Pennypack Park.

<u>Southeastern Montgomery County Chapter of Trout Unlimited</u>: The chapter organizes volunteer stream clean-ups, educational programs and habitat restoration projects. The Pennypack Creek is the Chapter's home creek and they have provided thousands of volunteer hours to enhance the environment of the creek since the 1990s. The chapter has applied for grant funding to remove the Huntingdon Pike Dam, on the Pennypack, and open the stream up to fish passage upstream from Lorimer Park.

<u>Southampton Watershed Association</u>: Founded in 2003, the association has sponsored educational efforts, stream visual assessments and a riparian buffer planting project in the Southampton Creek Watershed, a tributary to the Pennypack Creek.

<u>PA Fish and Boat Commission</u>: The Fish and Boat Commission stocks trout in the Pennypack Creek and has recently reintroduced hickory shad to the creek. The commission has provided funding for dam and stream obstruction mitigation to promote the return of shad and other anadromous fish to the Pennypack Creek Watershed.

CHAPTER 4
LAND RESOURCES AND IMPACTS

4.1 Land Use Patterns

The concept of watershed management is rooted in the notion that what happens on our landscapes is reflected in the quality of our streams, lakes and wetlands. The conversion of natural landscapes to human-influenced landscapes changes the amount, timing, and quality of water flowing into our streams and rivers. As landscapes develop, the potential for pollution and negative impacts to water resources increases, but so do opportunities to interact with water resources in a positive manner. More than 250,000 residents live within areas that drain to the Pennypack Creek. Thousands of other people enjoy the Pennypack Creek as a recreational resource, or drink water that comes, in part, from the Pennypack Creek. Still, thousands more travel through the watershed to and from work, or to visit friends and family who live within the watershed. Particularly in highly urban areas, how we collectively live upon the landscape has profound consequences for the integrity of our waters. Understanding how, where, and why land is used and managed within the Pennypack Creek Watershed is an integral part of the Rivers Conservation Planning process.

Regional Land Use Trends

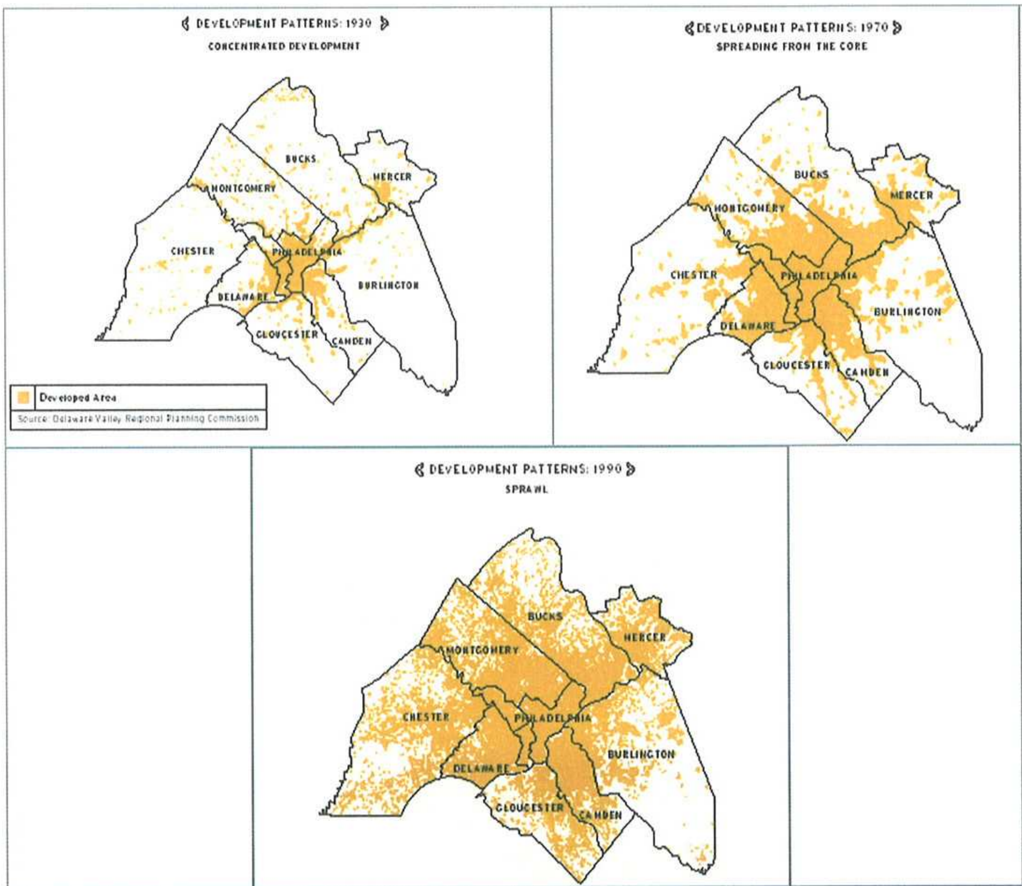
As discussed in Chapter 2, urban development in the Pennypack Creek Watershed began in the City of Philadelphia in the1800s, and then moved outward and upstream into suburban areas in the 1900s as transportation improved and housing demands changed. The outward expansion of the Philadelphia Metropolitan Area (PMA) has continued over the last two centuries, a trend that continues today. This section examines how urban expansion is occurring within the PMA and what forces are shaping the regional landscape.

The PMA encompasses two states and nine counties and, with over 6 million residents, is the 6th largest metropolitan area in the United States and the 43rd largest metropolitan area in the world. As shown in Figure 4.1, the land area occupied by development (urban and suburban land uses) within the PMA has increased dramatically over the last 75 years. In general, the rate of land conversion from natural and agricultural lands within the PMA has far outpaced increases in population. In fact, between 1982 and 1997 the amount of developed land in the Philadelphia Metropolitan area increased by 33% while the population grew by only 3% (Metropolitan Philadelphia Policy Center, 2001). Between 1970 and 1990, the amount of residential land in the region increased by 146 square miles or 29%, while undeveloped lands decreased by 299 square miles over the same time period (Figure 4.2) (DVRPC, 1994). During this time period, the region's population actually decreased by 3.6%.

Vast increases in land consumption without corresponding population growth suggest that most of the land consumption in the PMA is occurring as current residents living in high density population centers (e.g., inner ring suburbs and cities, etc.) relocate to newly constructed lower density developments. This is classic "urban sprawl"; haphazard, land intensive regional growth that typifies urban expansion in many major metropolitan areas throughout the United States. In the PMA, there are a number of economic and cultural factors that continue to drive this process. First, the presence of inexpensive land and less stringent controls on land development in ex-urban areas create favorable economic conditions for new housing development. At the same time, higher taxes, aging infrastructure, high real estate costs, traffic congestion and concerns about school quality and safety, create incentives for many city and inner suburban residents to consider relocating to development on the urban fringe. The expansion of interstate and regional highways into outlying rural areas means that those wishing to escape the real or perceived shortcomings of urban living can do so and still remain in commuting distance from major job centers.

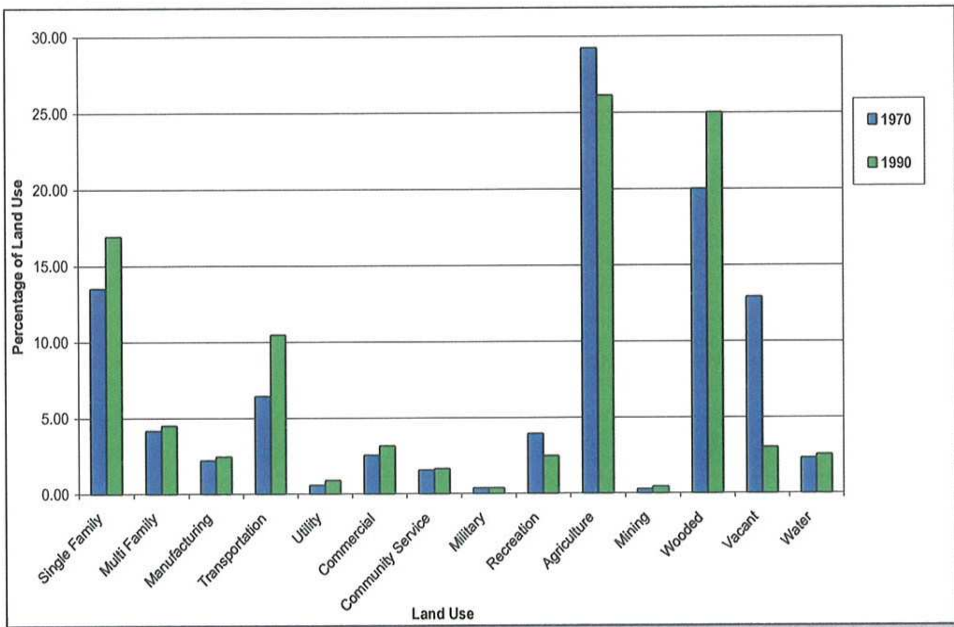
Despite the efforts of numerous conservation and planning groups promoting sustainable regional growth management strategies that focus on revitalizing existing developed areas while restricting growth in outlying areas, sprawl-type growth continues to characterize the mode of urban expansion in the PMA. One major hurdle to regional growth management is the politically-decentralized decision-making landscape in the region. While regional plans that advocate smart growth and new urbanism (a planning theory that encourages more compact development) have been developed, most land use regulation, planning, and decision-making still occurs on the municipal level. Implementing "regionalism" through collective local decision making is a huge challenge for the region.

Recently, however, several significant regional initiatives have been formed to promote more sustainable and less land intensive growth patterns within the PMA. Two groups, the Green Space Alliance and the newly minted Delaware Valley Smart Growth Alliance, represent exciting partnerships among various public, private, and non-profit groups to bring a more regional perspective on issues of open space protection and urban planning to the PMA. On the academic side, The Temple University Center for Sustainable Communities in Ambler is conducting applied research in many aspects of sustainable regional development. At the state level, recent amendments to the municipal planning code, which provides statutory authority for individual municipalities to plan for new growth, have improved the ability of neighboring municipalities to develop and implement multi-municipal planning agreements.



Source: Flight or Fight: Metropolitan Philadelphia and its Future. The Metropolitan Philadelphia Policy Center

Figure 4.1: Urban Expansion within the Philadelphia Metropolitan Area from 1930 to 1990.



Source: Delaware Valley Regional Planning Commission (DVRPC) "Land Use in the Delaware Valley 1970-1990, Analytical Report No 2.

Figure 4.2: Comparison of Land Use Changes from 1970 to 1990 within Montgomery, Bucks and Philadelphia Counties.

Land Use in the Pennypack Creek Watershed (1995-2000)

The Pennypack Creek Watershed is largely located in mature, built-out inner ring suburbs and Philadelphia neighborhoods that have been fully developed for 50 years or more. In a regional context, many of these areas are now slowly losing population to rapidly growing outer ring suburbs.

Not surprisingly, overall land use changes in the Pennypack Creek Watershed were modest between 1995 and 2000 (see Table 4.1 and Figure 4.3). However, while land uses are not changing dramatically within the watershed, substantial amounts of land were converted from wooded and agricultural use to single family residential and commercial uses from 1995-2000. Much of this land conversion took place in Horsham Township, where residential growth was greater than that in the rest of the watershed.

Land use in the Pennypack Creek Watershed is dominated by residential areas (52%) (DVRPC, 2000). Residential land use consists primarily of multi-family or row homes within the Philadelphia sections of the watershed, while residential land use in suburban areas is dominated by lower-density single family detached housing.

Wooded and recreational lands cover about 16% of the watershed, but are highly concentrated around the main stem of the Pennypack Creek in the central and lower portions of the watershed. These areas include the 720 acre Pennypack Preserve protected by the Pennypack Ecological Restoration Trust; Lorimer Park, a 250-acre Montgomery County Park, and the 1600-acre Pennypack Creek Park, which is part of the City of Philadelphia's Fairmount Park System. Smaller woodlands and parks are scattered throughout the watershed. Recreation lands also include several golf courses including Huntingdon Valley Country Club and Philmont Country Club.

Commercial land uses cover about 6.5% of the watershed and are found along most of the major roadways that transect the watershed including SR611, SR263, and SR532, where numerous strip malls, car dealerships and shopping outlets dot the landscape. Several large business parks located in the northwest portion of the watershed, in Horsham Township, also contribute significantly to the commercial land uses in the watershed. Additionally, two large indoor malls, Willow Grove Mall and Roosevelt Mall, are located within the watershed. Parking areas make up an additional 4.5% of the watershed and are primarily associated with commercial areas, although some parking areas are associated with apartment complexes and manufacturing areas.

Manufacturing and light industrial uses make up 3.6% of the current land uses in the watershed. The majority of these areas occur along two freight railroad lines that run east/west along the central and upper tiers of the watershed; in industrial parks located in Upper Southampton and Warminster Townships; and in northeast Philadelphia, just south of Roosevelt Blvd. (US-1) and adjacent to the Northeast Philadelphia Airport.

Transportation uses comprise 2.4% of the watershed and are largely associated with the Northeast Philadelphia Airport, which is located south of US-1 (Roosevelt Blvd.) in northeast Philadelphia.

Table 4.1: Comparison of Land Use in the Pennypack Creek Watershed, 1995-2000

Description	1995		2000		Land Use Change (1995-2000)	
	Acres	% of Watershed	Acres	% of Watershed	Acres	% Change
Residential - Single Family Detached	13,971	38.8%	14,580	40.4%	609	2%
Wooded	5,628	15.6%	5,190	14.4%	-437	-1%
Residential - Multi-Family, Row and Mobile Home	4,556	12.6%	4,235	11.7%	-321	-1%
Parking	1,690	4.7%	2,042	5.7%	352	1%
Commercial	2,329	6.5%	1,978	5.5%	-352	-1%
Recreation	1,476	4.1%	1,605	4.5%	129	0%
Agriculture	1,620	4.5%	1,346	3.7%	-274	-1%
Manufacturing	1,289	3.6%	1,186	3.3%	-104	0%
Vacant	970	2.7%	1,172	3.3%	202	1%
Community Services	821	2.3%	1,044	2.9%	222	1%
Transportation	874	2.4%	867	2.4%	-7	0%
Military	361	1.0%	368	1.0%	7	0%
Water	279	0.8%	218	0.6%	-61	0%
Utility	175	0.5%	208	0.6%	33	0%
Mining	-	0.0%	25	0.1%	25	0%

Source: DVRPC Land Use Data, 1995 and 2000.

Note - some data have been reclassified to account for changes in land use categories between 1995 and 2000.

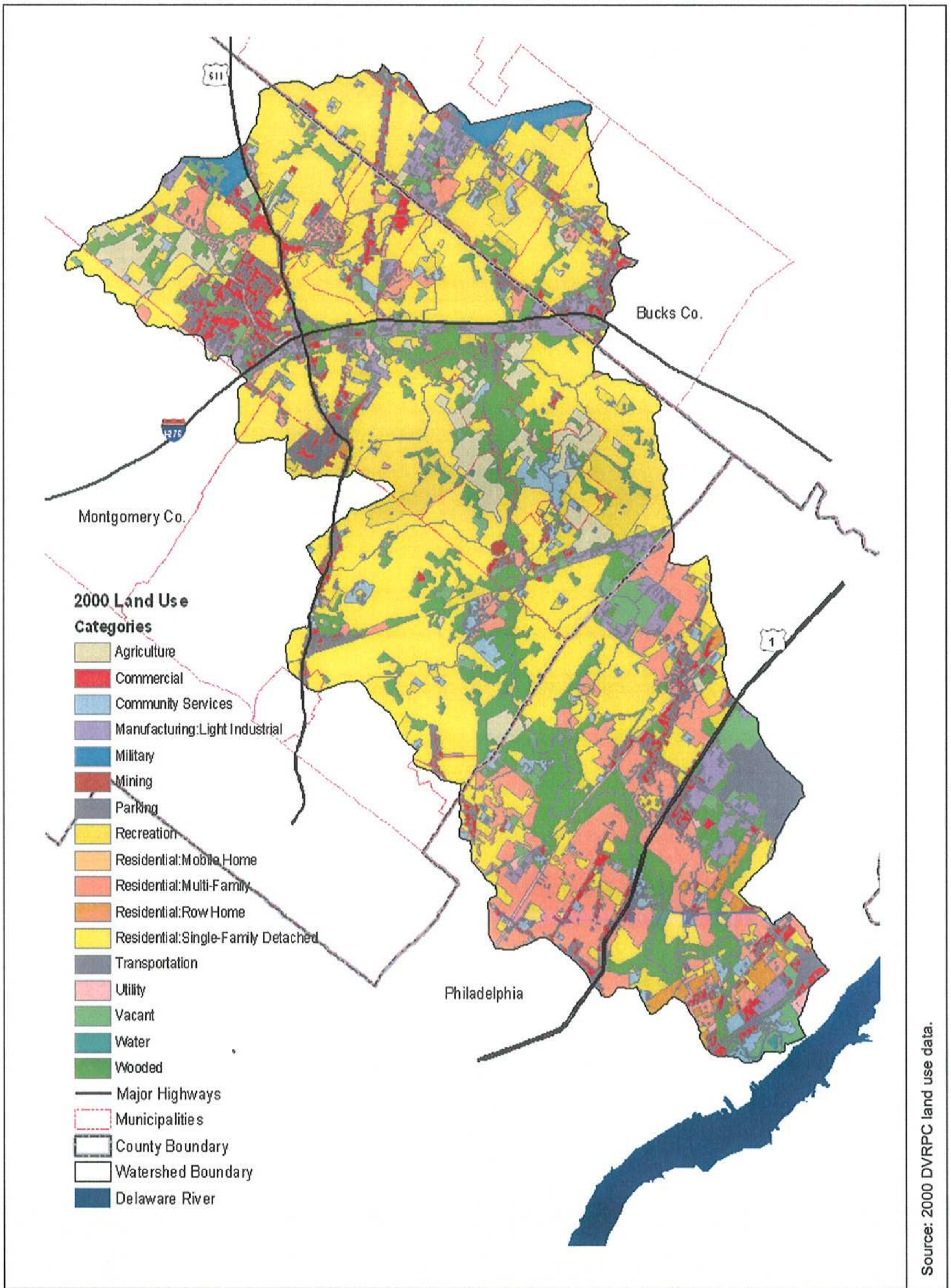


Figure 4.3: Land Use within the Pennypack Creek Watershed, 2000

Residential land uses occupy over 50 percent of the Pennypack Creek Watershed.

Table 4.2: Percentage of DVRPC 2000 Land Use Categories Occurring within Various Subwatersheds in the Pennypack Creek Watershed

Subwatershed Name	Subwatershed No.	Land Use Category (percent of total)													
		Agriculture	Commercial	Community	Manufacturing	Military	Mining	Parking	Recreation	Total Residential	Transportation	Utility	Vacant	Water	Wooded
Pennypack Headwaters	1	7	6	1	<1	4	<1	6	2	59	<1	1	2	<1	9
Upper Pennypack	2	1	12	2	4	<1	<1	12	3	50	2	1	2	1	11
Southampton Creek	3	3	4	2	5	3	<1	6	6	57	1	<1	3	<1	10
Middle Pennypack	4	14	2	3	<1	<1	1	1	8	47	<1	<1	1	1	22
Huntingdon Valley Creek	5	9	1	5	4	<1	<1	3	15	49	<1	<1	4	<1	10
Meadow Brook	6	<1	3	3	<1	<1	<1	5	3	69	<1	<1	1	<1	15
Rockledge Branch	7	3	1	4	1	<1	<1	2	2	56	<1	<1	4	1	26
Lower Pennypack	8	1	5	3	5	<1	<1	6	3	63	<1	1	5	<1	7
Sandy Run	9	<1	6	3	1	<1	<1	5	4	54	2	1	2	1	21
Mouth of Pennypack	10	<1	8	5	8	<1	<1	6	3	30	16	1	9	1	13

Source: DVRPC 2000 Land Use Data

The Mouth of the Pennypack sub-watershed has a large share of the watershed's commercial, transportation, and manufacturing resources, while the Headwaters, Meadow Brook, and Lower Pennypack all have between 58 and 70 percent of their land area committed to residential uses. Surprisingly, large areas of the Middle Pennypack subwatershed are still devoted to agricultural and wooded lands. Table 4.2 identifies the percentages of each land use for the ten sub-watersheds in the Pennypack Creek Watershed.

Projected Changes in Land Use

Despite the largely built-out nature of the watershed, as Table 4.3 shows, there are significant quantities of land area (including agricultural lands, vacant lots, privately-owned recreational lands including golf courses, and forested lands) that are not permanently protected via deed restriction, conservation easement or other protection vehicle. These lands total more than ten-percent of the total watershed area and are distributed throughout the ten sub-watersheds.

Given the current demand for developable land in the PMA and the substantial increases in single family residential land use in the watershed from 1995-2000, there is a strong possibility that much of the remaining open lands within the watershed will be incrementally converted to residential and/or commercial land uses over the next 25-30 years. Further, if regional growth management strategies take hold, much of the growth now occurring around the urban periphery will instead be accommodated within and around existing inner ring suburbs and urban areas. Many regional land use plans, including the DVRPC's *Horizons: The Year 2025 Plan for the Delaware Valley* and the *Montgomery County Comprehensive Plan 2025,* identify areas within the Pennypack Creek Watershed as future growth centers for the region. Under these plans, much of the open land remaining in the middle and lower Pennypack Creek Watershed may be needed to support regional growth needs.

It is unlikely that the lands identified in our analysis will be either completely developed or completely protected. In reality, some lands will be converted to more active uses, while some lands will be permanently protected or conserved for passive use. Collectively, the watershed community faces critical decisions about how limited resources available for open space protection can best be used to protect vulnerable lands and water resources while still providing an ample source of lands to accommodate regional growth needs. The challenge of balancing the need for regional growth control with the local goals of improving and conserving the Pennypack Creek and its surrounding landscape must be addressed in the light of reconciling regional priorities with local priorities.

Table 4.3: Land Area within the Pennypack Creek Watershed that is not Protected or Preserved as Open Space

Subwatershed	Area (acres)	Municipality	Area (acres)
1 Pennypack Headwaters	905	Abington Township	931
2 Upper Pennypack	649	Bryn Athyn Borough	541
3 Southampton Creek	771	Hatboro Borough	70
4 Middle Pennypack	940	Horsham Township	807
5 Huntington Creek	914	Lower Moreland Township	1,152
6 Meadow Brook	432	Philadelphia	1,262
7 Rockledge Branch	630	Rockledge Borough	1
8 Lower Pennypack	357	Upper Dublin Township	21
9 Sandy Run	275	Upper Moreland Township	909
10 Mouth of Pennypack	478	Upper Southampton Township	207
		Warminster Township	442
Total (acres)			6,351

Source DVRPC 2000 Landuse Data

This table is based on DVRPC 2000 land use data and parks GIS data from PWD. All the agriculture, recreation, wooded and vacant land use areas determined from aerial photographs were combined into a layer of currently undeveloped land. Areas of land that are already protected, such as parks, land trust and preservation easement lands, or other undeveloped land that is unlikely to be developed, such as cemeteries were subtracted from the land use data. The product of this analysis shows areas that are currently "unofficial" open space such as farms, private property, or vacant lots, that could be purchased and preserved as open space. Conversely, these areas could be converted into additional housing or commercial developments if they are not protected. This analysis does not evaluate whether the open space is located in critical natural resource area that may preclude development due to a local nature resource protection ordinance. Golf courses were included in the land available for development as many courses in the region are being converted to housing or selling portions of their land for development of "country club estates" Unless these courses are preserved by easement or other preservation strategy, they are available for development.

4.2 Land Use Regulations

Previous sections examined present-day land use, as well as trends in land use change, within the Pennypack Creek Watershed and in the region at-large. As mentioned earlier, land use decisions are largely regulated at the municipal level in Pennsylvania, which makes regional planning difficult. This section of the report provides some insight into the ways local municipalities in Pennsylvania can influence land use decisions within their borders and how municipal land use regulation can be used to protect water resources.

Zoning

Zoning ordinances are used by communities to divide or separate incompatible land uses. The goal of zoning ordinances is to protect the health, welfare and property values of the zoned communities by ensuring that certain building, development and land use standards are maintained within the zoning areas.

Early zoning regulations were enacted to protect city residents from the unhealthy and degraded living conditions presented by living in proximity to heavy industry or sources of pollution. These industries were consistently located within poor and disadvantaged neighborhoods and had serious implications for the life expectancy of these populations.

Zoning regulations are intended to implement the municipal comprehensive plan, shaping the way a community grows and develops while protecting important natural and cultural resources.

Each municipality in the watershed has enacted a zoning ordinance. Each zoning ordinance is different but generally offers similar restrictions regarding land use issues and protection of water and natural resources.

Subdivision and Land Development Ordinances

Subdivision Regulations and Land Development Ordinances (SALDO) are land use controls that guide how land is divided into two or more parcels for development. SALDOs typically describe the procedures the subdivider must follow to obtain approval from local government, the criteria for the design of the development, and the construction standards for public improvements in and around the subdivision.

SALDOs help to ensure that new development is integrated into the existing infrastructure of a community and that new infrastructure improvements meet standards. Examples are the requirements placed on intersection lines of sight and the availability of water and sewer service.

Land Protection

Zoning and SALDO ordinances are utilized by local governments as tools to protect their water and natural resources. Table 4.4 presents an inventory of the natural resource protection measures currently being utilized by the watershed's municipalities.

The inventory reviewed whether the municipality utilized the following ordinances:

Riparian Buffer: Riparian buffer ordinances protect stream corridors and vegetation by prohibiting development and certain activities within a fixed distance from the stream bank. These ordinances often divide the corridor into zones with stricter prohibitions being enforced closer to the stream banks.

Wetland and Watercourse Protection: These ordinances protect buffer zones around wetlands and watercourses. These ordinances often protect intermittent or other small waterbodies in watershed headwaters areas.

Floodplain Regulations: All of the municipalities in the watershed are required to have floodplain ordinances in order to qualify for Federal Emergency Management Agency Flood Insurance. Floodplain ordinances can often go beyond the minimum federal requirements to further protect floodplains from development and encroachment.

Stormwater Ordinances: Stormwater ordinances are an opportunity for municipalities to protect their water resources from non-point source pollution. All of the municipalities in the Pennypack Creek Watershed have ordinances that require that the peak storm flows from developing sites be less than or equal to the peak flow of water that left the site before it was developed. Some municipal ordinances, and new requirements under the federal National Pollutant Discharge Elimination System (NPDES) Phase II stormwater regulations, will require that stormwater best management practices improve water quality or infiltrate a portion of the stormwater back into the ground, as well as meet post development peak flow requirements.

Erosion and Sediment Control: Erosion and Sediment Control ordinances help to ensure that sediment and erosion are properly managed when earth moving or development exposes soil to erosive forces. State law requires that measures be taken to protect water bodies from receiving sediment-laden run-off; county government also has regulations regarding the management of sediment and erosion controls. The municipal ordinance can add an additional layer of protection to the management of development sites.

Protection of Restrictive Soils: Soils can be as important a resource as a waterbody or forest. Often soil characteristics will have great influence on the vegetation that can grow on a site, how the site drains or holds water, or even if a site is good for agriculture. Municipal ordinances can protect unique or restrictive soil types to ensure that development occurs in the most appropriate place. Alluvial soils are protected by all of the municipalities in the watershed.

Steep Slope Protection: Steep slopes, usually slopes >15%, increase erosion hazard and require extensive earthmoving and engineering to make sites suitable for development. Steep slope ordinances generally require that a percentage of a steeply sloped area be left undeveloped and in natural groundcover.

Woodlands Protection: Large wooded or forest tracts of land are important natural resources for protecting water quality, wildlife habitat and aesthetic quality of a community. Woodland protection ordinances generally restrict a percentage of a site from being cleared for development in order to conserve large contiguous wooded areas. Responsible forestry practices are usually excluded from regulation under forest protection ordinances.

Cluster Development Ordinances: A cluster development ordinance allows a developer to reduce lot sizes and cluster homes on a portion of the development site in order to protect larger tracts of community open space or natural resources.

Special Protection Districts: Some communities in the Pennypack Creek Watershed have special development districts that require >50% of land be left undeveloped in order to gain approval for that type of development. Municipalities also have resource protection zoning that requires larger lots than the typical subdivision or large areas of protected open space in order for approval of a development.

When viewed comprehensively and if enforced, municipal resource protection ordinances can do an effective job of maintaining the quality of a community's natural resources. Since water resources rarely follow municipal boundaries, complete watershed protection is beyond the control of any one community and must be comprehensively enforced in a cooperative manner.

Table 4.4 Natural Resource Protection Ordinance Review for Municipalities within the Pennypack Creek Watershed

Category	*Bryn Athyn Borough*	*Hatboro Borough*	*Abington Township*	*Horsham Township*	*Lower Moreland Township*	*Upper Moreland Township*	*Upper Southampton Township*	*Warminster Township*	*Philadelphia*
Ordinance reviewed	SALDO Zoning	SALDO Zoning	SALDO Zoning	SALDO Zoning	SALDO Zoning	SALDO Zoning	SALDO Zoning	SALDO Zoning	Stormwater Zoning
Riparian buffer	No	100 ft Stormwater management	No	Riparian Corridor Conservation District 75ft.	No	No	No	No	Yes
Wetland protection	No	100% and 50 ft. buffer	Yes	100% and 25-50 ft. buffer	No	No	Yes	Yes	Yes
Water course, lake, pond protection	No	Intermittent stream protection	Intermittent stream protection	Intermittent stream protection, lakes and ponds	Intermittent stream protection	No	Intermittent stream protection	Intermittent stream protection, lakes and ponds	Yes
Floodplain regulation	Floodplain Conservation District	Floodplain Conservation District	Floodplain Conservation District	Floodplain Conservation District	Floodplain Conservation District	Floodplain Conservation District	Yes	Floodplain Conservation District	Yes
Percent protected for 100-yr floodplain	100%	100%	100%	100%	100%	100%	100%	100%	100%
Limit development on 100 yr floodplain fringe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stormwater ordinance	No	SALDO Act 167 standards	Yes	SALDO, Act 167 standards	SALDO	SALDO	SALDO	SALDO Act 167 standards	Act 167 Standards
Runoff equals pre and post development	No	Yes	Yes	Yes requires groundwater recharge	Yes	Yes	Yes	Yes	Yes
Ersosion and sediment control	Yes SALDO Clean Streams Law	Yes SALDO	Yes SALDO Clean Streams Law	Yes SALDO Clean Stream Law	Yes SALDO	Yes SALDO	Yes SALDO	Yes SALDO Clean Stream Law	Yes
Restrictive soils	100% on alluvial soils	100% on alluvial soils	100% on alluvial soils	100% on alluvial soils	100% on alluvial soils	100% on alluvial soils	100% on alluvial soils	100% on alluvial soils	100% on hydric soils

Table 4.4 Natural Resource Protection Ordinance Review for Municipalities within the Pennypack Creek Watershed

Category	*Bryn Athyn Borough*	*Hatboro Borough*	*Abington Township*	*Horsham Township*	*Lower Moreland Township*	*Upper Moreland Township*	*Upper Southampton Township*	*Warminster Township*	*Philadelphia*
Steep slope protection	Steep Slope Conservation District on slopes >15%	70% natural cover on slopes >15% 80% natural cover on slopes > 25%	Steep Slope Overlay District on slopes >25%	70% natural cover on slopes >15% 80%natural cover on slopes > 25%	Setback from slopes >15%	Steep Slope Conservation District 70% natural cover on slopes >15% 80% natural cover on slopes > 20%	70% natural cover on slopes >10% 80% natural cover on slopes > 15% 85% natural cover on slopes > 25%	70% natural cover on slopes >8% 70% natural cover on slopes > 15% 85% natural cover on slopes > 25%	Yes on slopes > 25%
Woodlands protection	No	50%	Yes	50%	No	No	No	70%	No
Tree protection zone	No	No	Yes	Yes	Yes	Yes	Yes	No	No
Cluster development ordinance	Yes	No	Yes	No	Yes	No	No	No	No
Transfer of development rights	No	No	No	No	No	No	No	No	Yes
Special District that preserves >50% open space in new development	75% in Natural Preservation District	No	75% in Land Preservation and Cluster Development Districts	No	60% in Cluster Development 80% in Adult Community	No	No	No	No

Ordinances for the suburban municipalities were reviewed for the presence of standard natural resource protection ordinances. Ordinances for Jenkintown and Rockledge Boroughs and Upper Dublin Township were not reviewed due to lack of surface water features draining into the Pennypack Creek Watershed or the small area of the municipality within the watershed. The Philadelphia Stormwater Management Ordinance is in Draft Form and is expected to be adopted in the fall of 2005.

4.3 Open Space and Recreation

Although much of the land within the Pennypack Creek Watershed has been converted from natural to urban uses, there are still significant areas of protected green space areas providing a variety of different uses to the residents of the area. These areas include golf courses, municipal parks, privately-owned tracts of forested land, and land preserved by private land trusts and municipalities (see Figure 4.4). In total, the Pennypack Creek Watershed contains more than 4,000 acres of park lands, recreational lands, and protected open space, which is approximately 11 percent of the total watershed area. Of particular note is the significant greenway that extends along the main stem of the creek from its confluence with the Delaware River to the middle portions of the watershed. This unique feature creates a streamside landscape that affords tremendous recreational and scenic resources within a highly urbanized setting and is one of the truly outstanding resources that characterize the watershed. Away from this central greenway, particularly in the headwater regions of the watershed, a system of connected green spaces has not been established. Rather, green spaces within these areas include smaller, more isolated parcels, community parks, golf courses, and school campuses.

A variety of programs and organizations promote the acquisition of open spaces in southeastern Pennsylvania, including several regionally-active private land trusts, county open space funding, and state open space funding through the Pennsylvania Department of Conservation and Natural Resources. Recently, the GreenSpace Alliance, a consortium of private and public organizations engaged in land conservation throughout the region, has established priorities for land conservation.

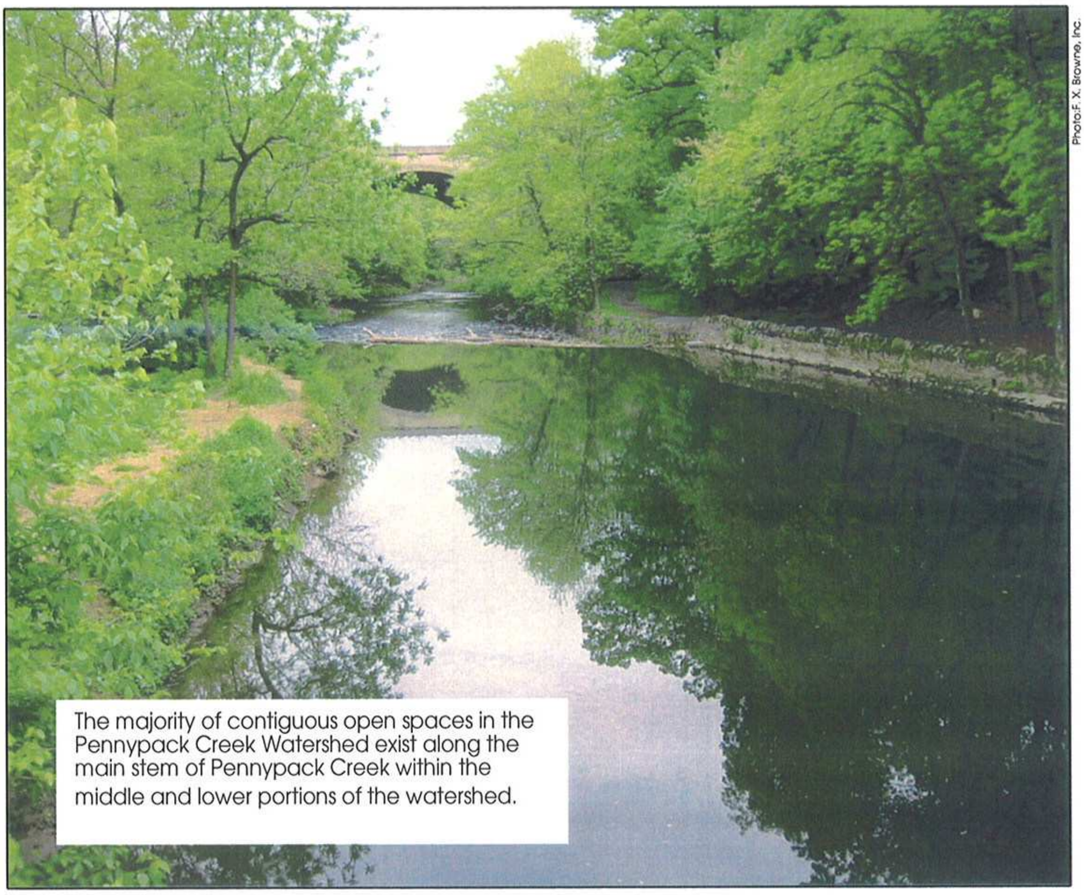


Photo:F. X. Browne, Inc.

The majority of contiguous open spaces in the Pennypack Creek Watershed exist along the main stem of Pennypack Creek within the middle and lower portions of the watershed.

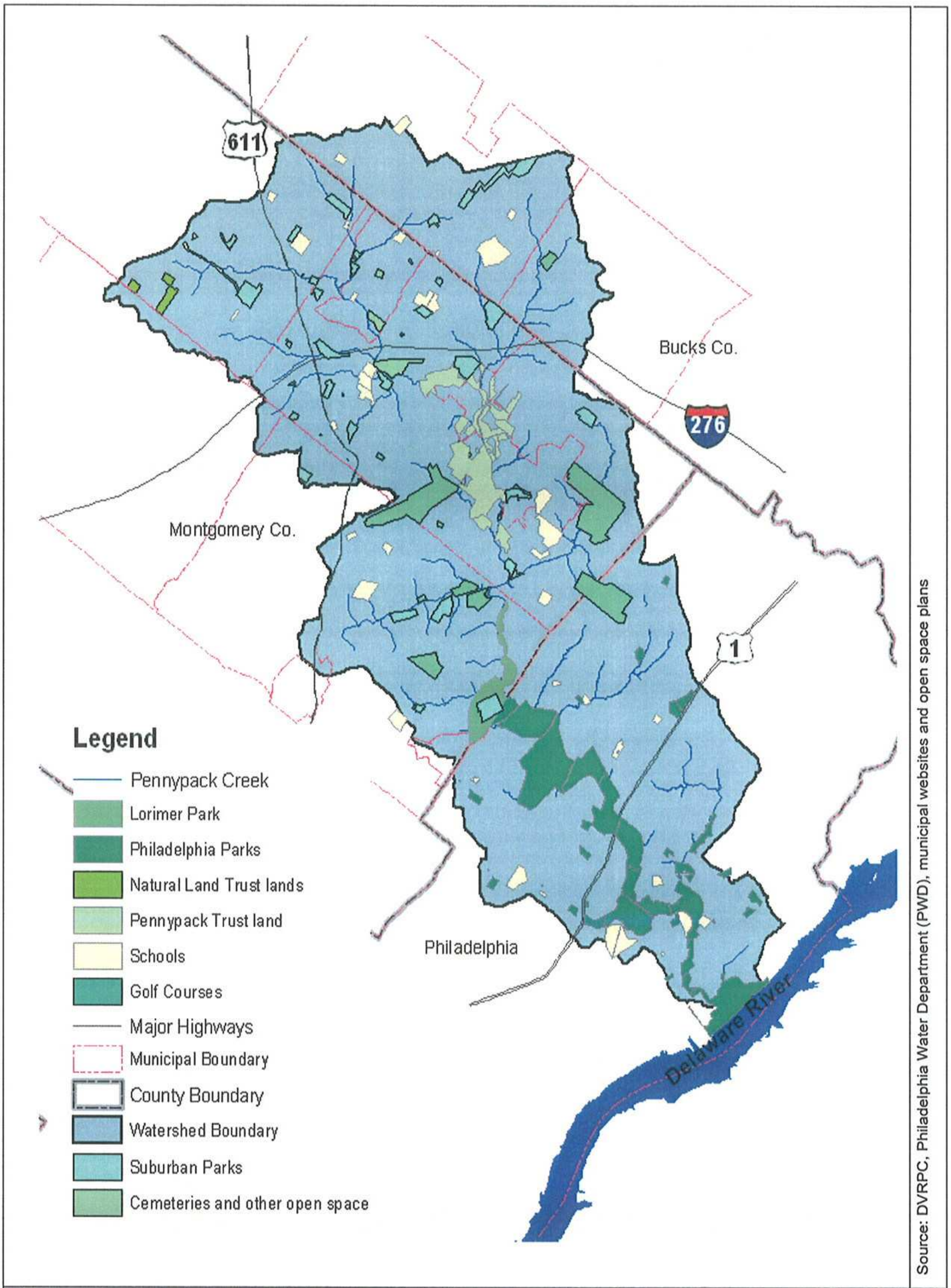
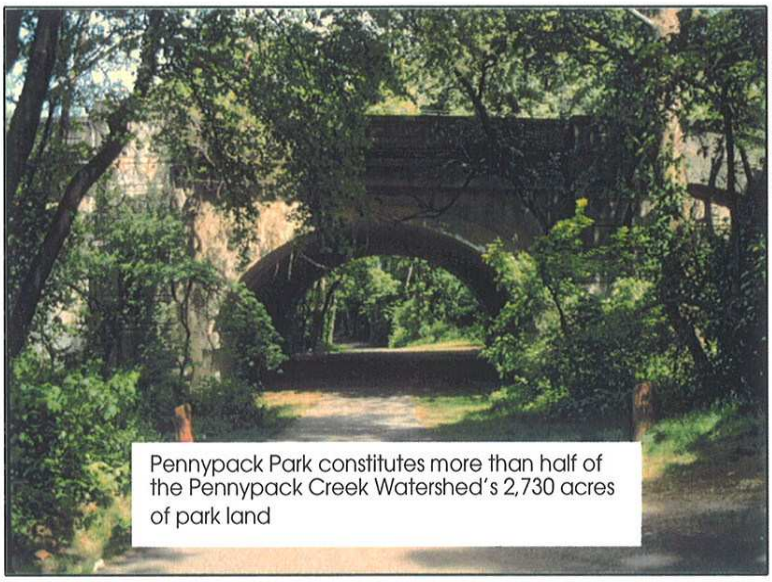


Figure 4.4: Open Spaces Within the Pennypack Creek Watershed, 2000

The Pennypack Creek Watershed contains a wide variety of open spaces including school campuses, community parks, regional parks, golf courses, cemeteries, and permanently protected natural lands. Note: map does not include all township and borough dedicated open space

Parks



Pennypack Park constitutes more than half of the Pennypack Creek Watershed's 2,730 acres of park land

Photo: Fairmount Park Commission

The Pennypack Creek Watershed contains approximately 2,730 acres of park land (Table 4.5). The majority of these lands are contained within two sub-regional parks, the 1,600 acre Pennypack Park, which is part of the City of Philadelphia's Fairmount Park System, and Lorimer Park, a 250-acre Montgomery County Park located in Abington Township. Both Pennypack Park and Lorimer Park are located in the lower portions of the watershed, along the main stem of Pennypack Creek. Together, with the protected lands of the Pennypack Preserve, Pennypack Park and Lorimer Park form a nearly contiguous greenway that stretches from the confluence of the Pennypack Creek with the Delaware River into the central portions of the watershed. A network of trails located throughout this greenway provides excellent opportunities for walking, hiking, biking, and bird watching, as well as access to the Pennypack Creek for fishing.

The remainder of the park land within the watershed is spread among 51 municipal parks. These parks provide a variety of passive and active recreation facilities for watershed residents. Many of the parks are relatively small, municipally-owned parks that provide significant active recreation resources but offer minimal natural habitat. These parks are scattered throughout the watershed and are often located in the midst of areas otherwise dominated by residential, commercial, and industrial land uses. Particularly in the suburban portions of the watershed, opportunities to travel between parks via trail systems are limited.

Blair Mill Park in Horsham Township

Photo: Horsham Township

Pennypack Creek Park - A Natural City Oasis

Situated among a tightly-packed labyrinth of Northeast Philadelphia's neighborhoods and busy commercial throughfares, Pennypack Park encompasses some 1,600 acres of forests, streams, wetlands and meadows. The Park surrounds the main stem of the Pennypack Creek throughout its entire eight mile length within the City of Philadelphia. The Park includes miles of paved and unpaved trails that lead visitors through a rich array of natural landscapes, including upland and floodplain forests, meadows, farm fields, and wetlands. The Park is also home to the Pennypack Environmental Center, whose professional staff provides a variety of interpretive programs for park visitors, school groups, and others.

Photo: F. X. Browne, Inc.

Fox Chase Farm provides a unique agrarian dimension to Pennypack Park

Also located within the Park is Fox Chase Farm, a working educational farm located within the City of Philadelphia and Abington Township. The Park also features several historical sites including the Ury House, Gwynne's Mill (Verree Mills), and the Krewstown Road Bridge.

Phoyo: Fairmount Park Commission

Pennypack Environmental Center provides interpretive programs for school groups and the general public

Established in 1905, the Pennypack Park is owned and administered by the Fairmount Park Commission, which conducts an active trail maintenance and natural lands restoration program within the Park. Friends of Pennypack Park, a volunteer organization, provide assistance with park management activities including stream clean-ups and trail maintenance.

The land for the park was acquired by the City over a 20 year period, beginning in 1905. The establishment of the park required the dismantling of several large factory complexes, which at the time lined the banks of the Pennypack Creek. The park's mere existence is a tribute to the rapidly evolving urban planning movement of the day, which began to recognize the great value of preserving natural stream corridors within otherwise congested cities. Streams flowing through adjacent areas of north Philadelphia that were developed only decades earlier were straightened, piped, and paved over.

Lorimer County Park - Linking City and Suburbs

At 250 acres, Lorimer County Park is the second largest park in the Pennypack Creek Watershed after Pennypack Park. Lorimer Park provides streamside picnic facilities including a large pavilion. The park also features large grass fields and several hiking trails.

Photo: F. X. Browne, Inc.

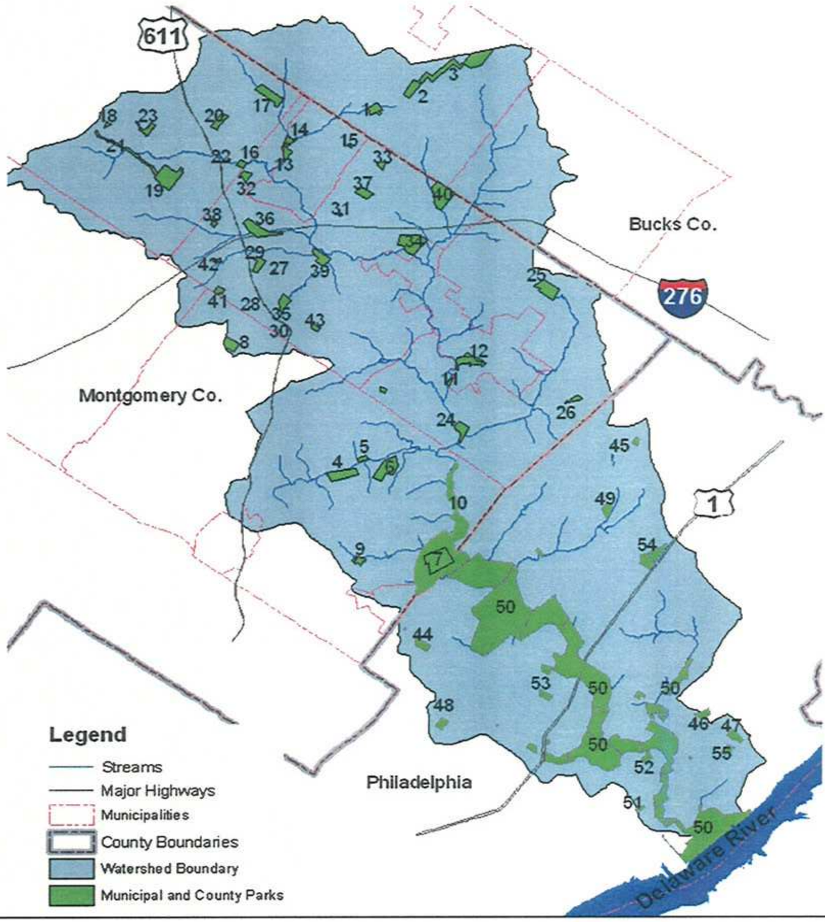
Photo: F. X. Browne, Inc.

Lorimer Park is the site of an exciting, grassroots stream restoration effort. With the help of the Pennsylvania Fish and Boat Commission, the Southeast Montgomery County Chapter of Trout Unlimited is installing habitat enhancement structures within the Pennypack Creek as it flows through Lorimer Park.

Lorimer Park is a critical link between the trail network in Pennypack Park and the proposed trails in the Montgomery County Open Space Plan.

Photo: Mike Wilson

Table 4.5 Community and Sub-Regional Parks of the Pennypack Creek Watershed



Key To Watershed Parks		
1. Crooked Billet Green	19. Lukins Park	37. Boileau Park
2. Parklands of Warminster	20. Meetinghouse Park	38. North Will Grove Park
3. Szymanek Park	21. PECO Trail	39. Terwood Park
4. Abington Township Bird Sanctuary	22. Pemmepecka Park	40. Frank Pillegi Park
5. Abington Township Game Preserve	23. Sawyers Way	41. Valley Green
6. Abington Township Game Preserve	24. Elkins Field	42. Whitehall Park
7. Butler Park	25. Lower Moreland Park	43. Woodlawn Park
8. Crestmont Park	26. Ridgeway Park	44. Fox Chase Playground
9. Fox Chase Manor Park	27. Brook Street park	45. Gifford Playground
10. Lorimer County Park	28. Broughton Park	46. Holme Playground
11. Elsa Park	29. Buehler Park	47. Jacobs Playground
12. Bryn Athyn Borough Park	30. Cherry Street	48. Jardel Recreation Center
13. Hatboro Memorial Park	31. Dawson Manor Park	49. Lackman Playground
14. Eaton Park	32. Fair Oaks Park	50. Pennypack Park (Fairmount Park)
15. Tanner Playground	33. Fern Village Park	51. Rambler Playground
16. Blair Mill Park	34. Mason Mill Park	52. Ramp Playground
17. Clearbrook Park	35. Memorial Park	53. Rhawnhurst Playground
18. Jarrett Road Park	36. Mill Road Park	54. Robert Memorial Playground
		55. Trumbette Playground

Source: DVRPC, PWD, municipal websites and open space plans

Protected Land

Continued removal of green space has motivated many environmentally-minded individuals to donate funds to facilitate land preservation. Two land trust organizations, Pennypack Ecological Restoration Trust and Natural Lands Trust, maintain active land holdings within the watershed. Through donations and grants, the Natural Lands Trust and the Pennypack Ecological Restoration Trust have protected over 700 acres of land in the Pennypack Creek Watershed.

Pennypack Creek as it flows through protected lands of the Pennypack Ecological Restoration Trust

The watershed also includes many acres of township owned community open space. These spaces include stormwater detention basins and open spaces within planned residential communities.

Private Recreational Lands

Green space encompasses much more than just preserved parks. Other privately-owned green space, including cemeteries and golf courses, provide grass and wooded areas allowing rainwater to recharge groundwater rather than immediately running off into surface streams. The Pennypack Creek Watershed has almost 850 acres of privately owned green space in golf courses and cemeteries that help infiltrate stormwater runoff (Table 4.6).

Table 4.6 Permanently Protected and Privately Owned Open Spaces within the Pennypack Creek Watershed

Organization	Size (acres)	Location
Permanently Protected Open Space - 740 Acres		
Natural Lands Trust	205*	Lower and Upper Moreland Townships, Horsham Township, and Bryn Athyn Borough
Pennypack Ecological Restoration Trust	720*	Lower and Upper Moreland Townships and Bryn Athyn Borough
Privately Owned Open Spaces - 715 Acres		
Golf Hollow Golf Club	22	Upper Southampton Township
Huntingdon Valley Country Club	248	Upper Moreland and Abington Township
Island Green Country Club	182	City of Philadelphia and Lower Moreland Township
MeadowBrook Country Club	75	Abington Township
Philmont Country Club	302	Lower Moreland Township
Rydal Country Club	63	Abington Township
Carson-Simpson Farm Day Camp	60	Upper Moreland Township
College Settlement Day Camp	235	Horsham Township
Willow Grove Day Camp	63	Upper Moreland Township
Cemeteries	30	Various Locations

Source: DVRPC, PWD, country club and camp websites.

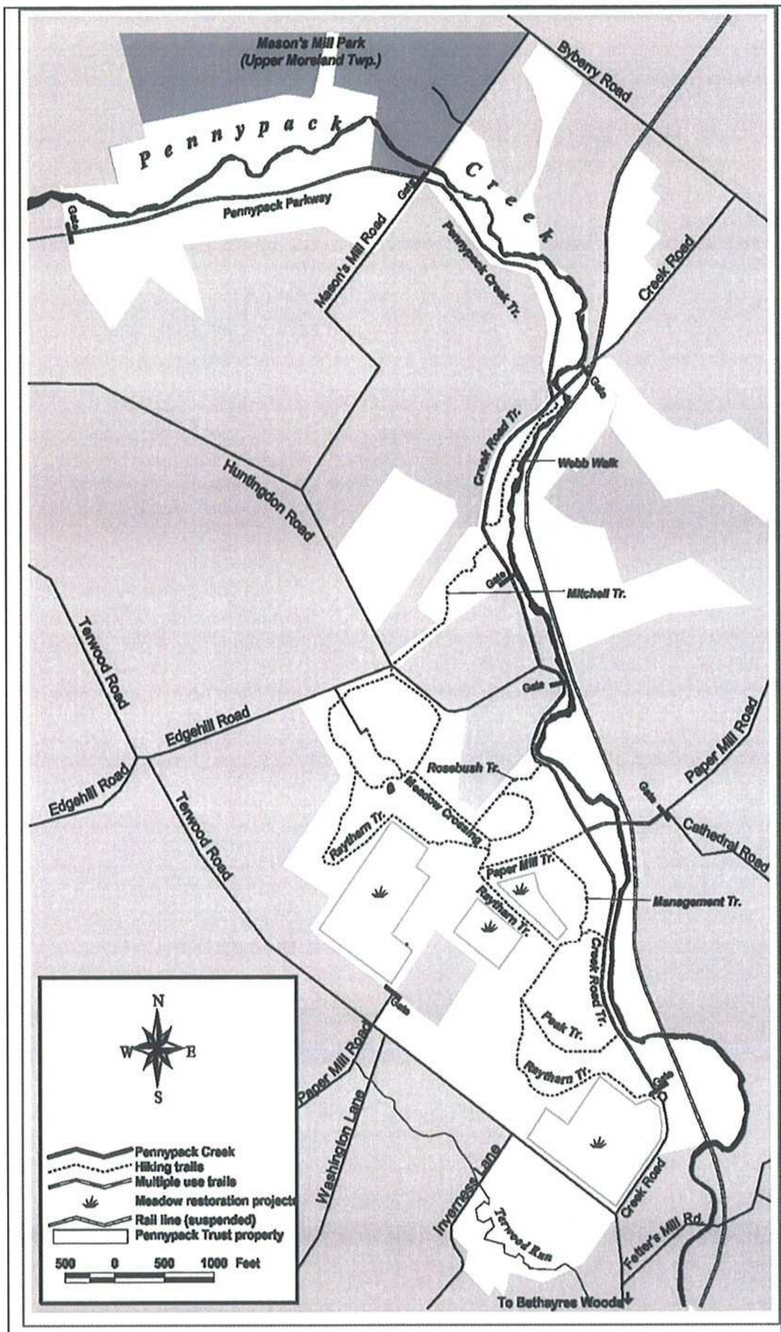
*Certain parcels are protected by both Natural Lands Trust and the Pennypack Ecological Restoration Trust. Therefore, the total acreage of permanently protected open space is less than the sum of the Natural Lands Trust and Pennypack Ecological Restoration Trust acreage.

Pennypack Ecological Restoration Trust - Land Protection and Stewardship

Founded in 1970, the Pennypack Ecological Restoration Trust is dedicated to protecting, restoring, and preserving the lands of the central Pennypack Valley. Today, Trust lands total more than 700 acres of woodlands, wetlands, and meadows. The Trust maintains more than eight miles of multi-use trails that are accessible to the general public. The Trust also features a visitor center and gift shop.

Photo: Joanne Dahme

The Trust provides a variety of hiking opportunities for areas residents



Source: Pennypack Ecological Restoration Trust

Figure 4.5: Pennypack Ecological Restoration Trust Trail Map

Land Management

Beyond owning land, the Trust maintains a staff of nine professionals that maintain trails, restore and enhance natural habitats, and conduct interpretive programs. The Trust's staff enhances existing natural communities through active planting projects, invasive plant monitoring and removal, stream clean-ups, and nuisance wildlife control.

4.4 Critical Areas

Industrial and commercial land uses can have a great impact on the health of the water system and also on the surrounding neighborhoods. An industrial or manufacturing facility may occupy a small area relative to the watershed as a whole and have very little or no impact when operated correctly, but if a facility is not in compliance with regulations, it can have a wide-reaching effect on water quality. There are a variety of different sites in the Pennypack Creek Watershed that are EPA regulated facilities.

Land Fills

There is one landfill located in the Pennypack Creek Watershed. Bethayres Reclamation Corporation is located at 2310 Terwood Drive, Huntingdon Valley. This facility is permitted to discharge to water, but is has not reported any toxic releases, does not handle hazardous waste, and has not reported any air releases. The landfill is in compliance with its permits.

Hazardous Sites

Waste Sites

There are a variety of different regulated producers of air, water and land waste throughout the watershed. Figure 4.6 shows the location and classification of these sites.

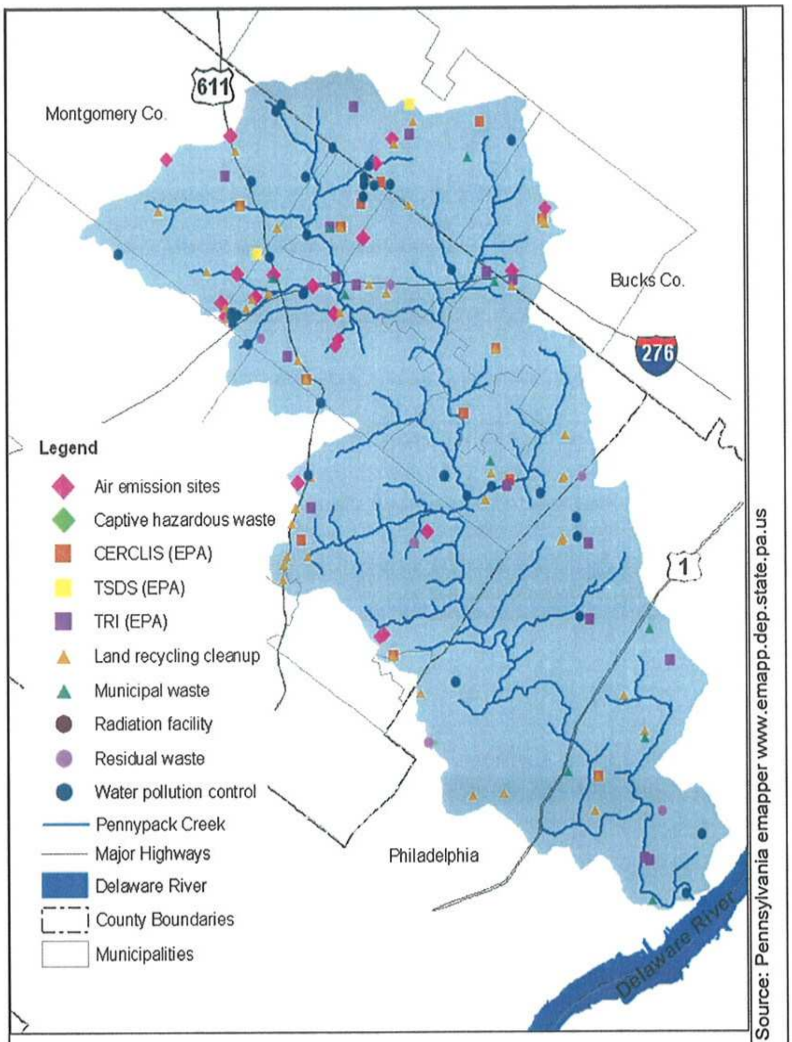


Figure 4.6: Location of critical areas in the Pennypack Creek Watershed.

There are two Resource Conservation and Recovery Act (RCRA) sites in the watershed, identified in Table 4.7. This act was originally enacted in 1976 and regulates the generation, storage, transportation and disposal of hazardous substances. Specifically, both of these sites are classified as Treatment, Storage or Disposal Sites or TSDS. One of these sites is on the National Priority List (NPL) and both are in compliance with federal regulations. The NPL is a federal list of hazardous disposal sites which prioritizes the clean-up or remediation of the worst sites based on the quantity and toxicity of wastes, the number of people at risk from the site, and vulnerability of groundwater contamination from the site.

There are 24 sites that are in the hazardous waste clean-up site tracking system known as the Comprehensive Environmental Response, Compensation, and Liability System (CERCLIS) (Table 4.8). The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), frequently referred to as the Superfund Act, was enacted in 1980 to deal with abandoned hazardous waste sites. Of the 24 CERCLIS or Superfund sites in the watershed, only three are on the NPL. Information regarding these sites can be accessed on the EPA's Envirofacts webpage at http://www.epa.gov/enviro/index.html by searching for the site by its identification number.

The Emergency Planning and Community Right to Know Act of 1986 (EPCRA) requires that certain types of manufacturing facilities submit annual reports of the chemicals released called Toxic Release Inventory forms. There are 17 locations in the watershed that file TRIs (Table 4.9). All of these are in compliance with federal regulations.

Table 4.7: Resource Conservation and Recovery Act sites in the Pennypack Creek Watershed.

TRI EPA ID	Site Name	County
PA6170024545	Naval Air Development Center	Bucks
PAD064362940	Conversion Systems Research Lab	Montgomery

Source: www.emapper.dep.pa.us.

Table 4.8 : CERCLIS Sites Located in the Pennypack Creek Watershed				
CERCLIS EPA ID	Site Name	County	NPL Status	Site Incident
PA0002289247	Holland Emergency Response	Bucks	Not On The NPL	
PAD077060358	Abar Corp	Bucks	Not On The NPL	
PA0000283945	Casey Village Area TCE/PCE Plume	Bucks	Not On The NPL	
PA0000766923	Castrol Industrial N A Incorporated	Bucks	Not On The NPL	
PASFN0305402	Creek Road Sand Blasting	Bucks	Not On The NPL	
PA0000076224	Derewal Property	Bucks	Not On The NPL	
PAD002345817	Fischer & Porter Co.	Bucks	Currently On The Final NPL	
PA0000585901	Warwick Twp Real Estate - Aka - Andela	Bucks	Not On The NPL	
PAD000436436	Ambler Asbestos Piles	Montgomery	Deleted From The Final NPL	Non-Oil Spill
PAD002348324	Cognis Corporation	Montgomery	Not On The NPL	
PASFN0305536	Cordus Property Site	Montgomery	Not On The NPL	
PAN000305604	Huntingdon Valley Country Club Sheen Site	Montgomery	Not On The NPL	
PAN000305861	Bryn Athyn Mercury	Montgomery	Not On The NPL	Non-Oil Spill
PA0000800698	E.W. Cannelley Painting	Montgomery	Not On The NPL	
PA0001015130	Hatboro Tank Farm	Montgomery	Not On The NPL	
PAN000305975	Horsham Mercury Site	Montgomery	Not On The NPL	
PAD039017694	Raymark	Montgomery	Currently On The Final NPL	
PAD987388188	Stockton Aquifer	Montgomery	Not On The NPL	
PA6170024545	Naval Air Station Joint Reserve Base Willow Grove	Montgomery	Currently On The Final NPL	
PASFN0305557	Sunoco Gasoline Spill	Montgomery	Not On The NPL	
PA5170090018	Naval Inventory Control Point	Philadelphia	Not On The NPL	
PAD981738800	Solly Ave Midnight Dump Site	Philadelphia	Not On The NPL	
PASFN0305481	Heintz Division Kelsey Hayes Company	Philadelphia	Not On The NPL	
PASFN0305401	Reliable Oil Fire E.R.	Philadelphia	Not On The NPL	

Source: www.emapper.dep.pa.us.

Table 4.9: Toxic Release Inventory sites in the Pennypack Creek Watershed.

TRI EPA ID	Site Name	County
18966WRMNSCOUNT	Warminster Fiberglass Co.	Bucks
18974RFRSH300JA	Refreshment Machinery Inds.	Bucks
19006BSTKCCOUNT	Bostik Findley Inc.	Montgomery
19006DRVRCREDLI	Drever Co.	Montgomery
19040PCKLS2940T	Tyco Electronics Corp.	Montgomery
19040RCHRD330SO	Procter & Gamble Mfg. Co.	Montgomery
19044DRXLNPOBOX	Drexel Ind. Inc.	Montgomery
19044FRCHL723DR	Loral Defense Sys.	Montgomery
19090FRMSN1FORM	Forms Inc.	Montgomery
19090NVFCM525DA	Nvf Co.	Montgomery
19090SPRGL3900W	Allegro Microsystems W.G. Inc.	Montgomery
19115PPRMN9800B	Pm Co.	Philadelphia
19116SNDMYONESA	Sandmeyer Steel Co.	Philadelphia
19136CHSFKASHBU	Chas. F. Kellom & Co. Inc.	Philadelphia
19136MRRLL7700S	Merrill Lumber Co. Inc.	Philadelphia
19154KNGSB10385	Kingsbury Inc.	Philadelphia
19154PPSCLROSSE	Pepsi Bottling Group	Philadelphia

Source: www.enviromapper.dep.pa.us

CHAPTER 5
WATER RESOURCES AND IMPACTS

INTRODUCTION

Water resources include both surface and ground water resources. Surface water resources include lakes, ponds, streams, and wetlands, while groundwater resources consist of water stored within regions of porous bedrock called aquifers.

Sustainable water resources are essential for the success of all human societies and provide a nearly endless potential suite of uses ranging from active and passive recreation, industrial cooling and production, food production, irrigation, power generation, flood conveyance, and drinking water. Watershed residents and other users value water resources for the direct and indirect uses they provide. As a society, we also value water resources for their inherent ecological value, their mysterious beauty and for the tremendous variety of life they support. The beauty of a free flowing stream or still fog on a glacial lake has been captured in picture and song for centuries. Many of the world's great scenic landmarks (the Grand Canyon, Crater Lake, Niagara Falls) are either the result of or center around water resources. Even the term water resources, for all its utility, somewhat undermines the true value of rivers, lakes, and wetlands.

In addition to providing benefits and values, water resources can also negatively impact individuals and societies, particularly if they are not managed properly. Flooding rivers cause millions of dollars of property damage each year. Eroding rivers often cause road wash outs, bridge scour, exposed sewer pipelines, and damage to other buried infrastructure. These impacts collectively cost societies billions of dollars per year. Dam failures and floods also extract a human toll, killing and injuring thousands of people across the globe. Unsupervised and unsafe recreational activities in and around water also result in the death and injury of many individuals. One need only recall the devastating hurricane season of 2005 to understand the power of water.

This section of the report focuses on the surface water resources of the Pennypack Creek Watershed. The first few pages of the section present a basic overview of the watershed's surface water resources. Later portions of the chapter discuss the ways in which surface water resources are used and valued in the Pennypack Creek Watershed and the degree to which surface water functions are impaired by human activity.

In 2004, volunteers and staff from the Philadelphia Water Department Office of Watersheds conducted a stream visual assessment of the entire length of the main stem of the Pennypack Creek. These visual assessments provide valuable first hand descriptions and locations of issues facing the watershed and exceptional watershed amenities. The visual assessment reports and maps of the assessment reaches with pictures are presented in Appendix B of this report and serve as a useful supplement to the analysis of stream corridor resources presented in this chapter.

5.1 Physical Description

Drainage Characteristics

Approximately 56 square miles of land drain to the Pennypack Creek. This watershed area can be subdivided into smaller units or subwatersheds – for instance the land area that drains to Sandy Run, a tributary to the Pennypack Creek, is the Sandy Run subwatershed. Although there are many ways to subdivide the Pennypack Watershed into smaller drainage units, we have delineated a total of ten subwatersheds, which are presented in detail in the next section.

Subwatersheds are a fundamental organizing unit of a watershed. Like cities and towns, each subwatershed has a unique character and an identity all its own in terms of its drainage area, land use, political location, physical land characteristics, land, water, cultural, and biological resources, stakeholders, and management issues. Accordingly, each subwatershed must be managed and considered somewhat differently.

Subwatershed Portraits

This section of the report provides an overview of the ten subwatersheds that comprise the Pennypack Creek Watershed.

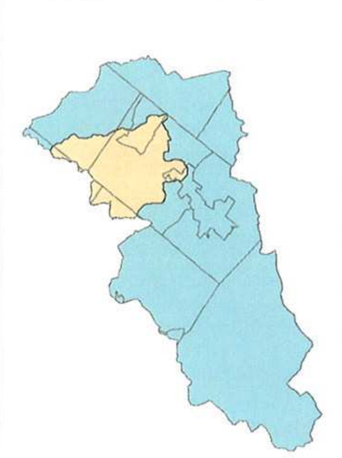
Photos: F.X. Browne, Inc.

Typical views of the Pennypack Creek Watershed include (from left to right)
Willow Grove Mall, Raytharn Farm and compact development in Northeast Philadelphia

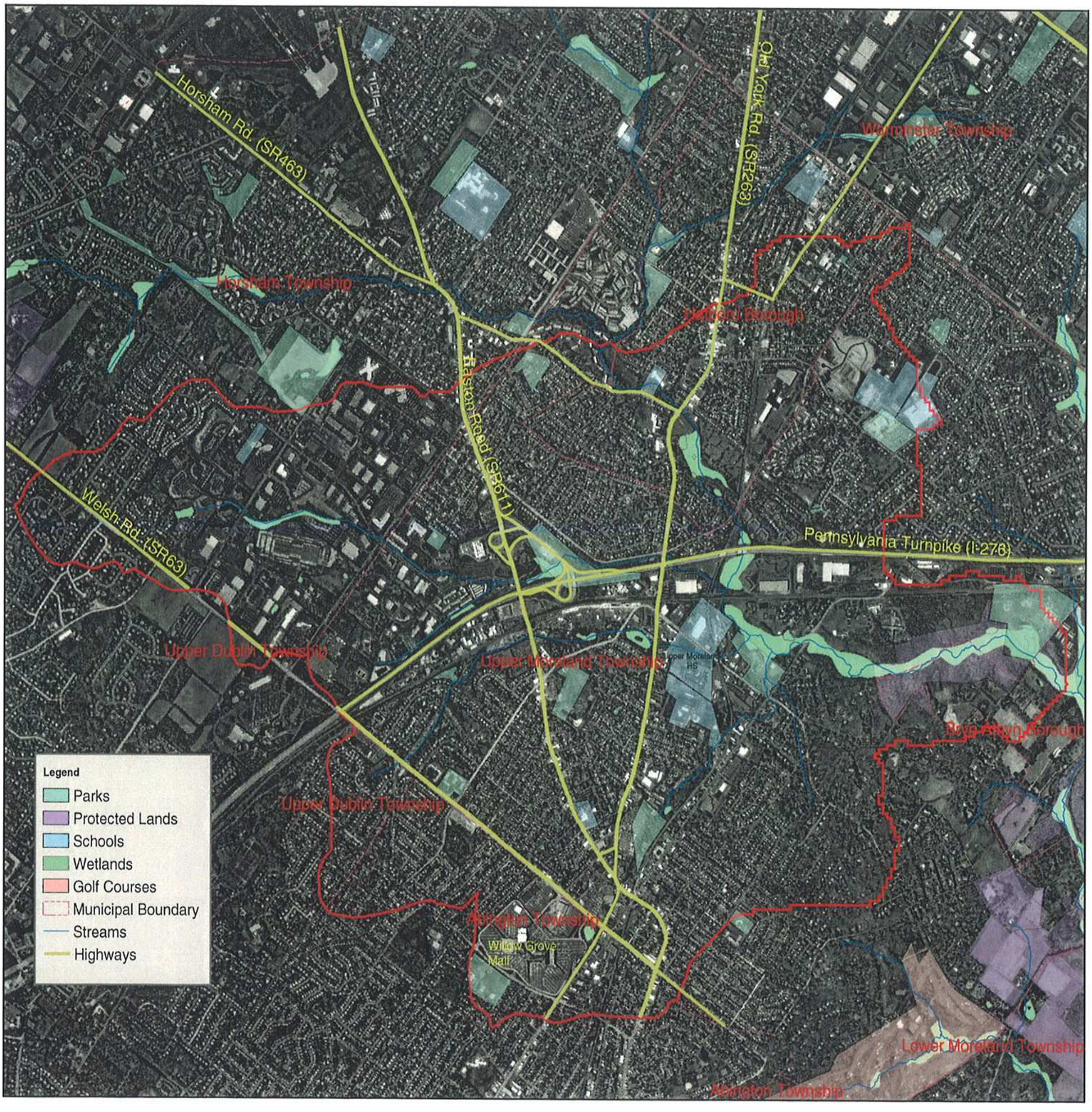
Subwatershed 2 *Upper Pennypack*

__Drainage area__ 7.95 sq. miles __Stream miles__ 10.70

__Location__ — Upper Moreland Township (60%), Horsham Township (15%), Hatboro Borough (11%)
__Physiography__ — Gettysburg-Newark Lowland Section (70%), Piedmont Upland Section (30%)
__Ecoregions__ — Level III: Northern Piedmont (100%), Level IV: Triassic Lowlands (51%), Piedmont Uplands (47%),
__Geology__ — Stockton Formation (62%), Felsic Gneiss (25%), Chickies Formation (14%)
__Soils__ — Moderately poorly drained (74%)
__1995 Land use__ — Residential (48%), Commercial services (11%), Wooded (11%), Parking (10%), Light manufacturing (5%)



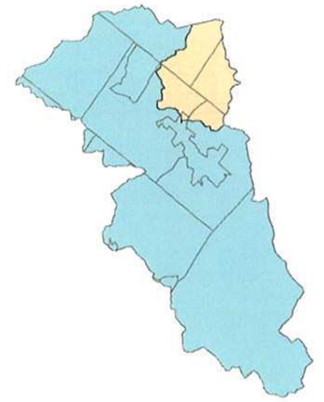
Area of Detail



Subwatershed 3 *Southampton Creek*

<u>Drainage area</u> 6.19 sq. miles <u>Stream miles</u> 8.49

<u>Location</u> — Warminster Township (34%), Upper Southampton Township (31%), Upper Moreland Township (23%), Lower Moreland Township (11%)
<u>Physiography</u> — Gettysburg-Newark Lowland Section (95%), Piedmont Upland Section (5%)
<u>Ecoregions</u> — Level III: Northern Piedmont (100%), Level IV: Triassic Lowlands (84%), Piedmont Uplands (16%),
<u>Geology</u> — Stockton Formation (89%), Felsic Gneiss (9%)
<u>Soils</u> — Moderately poorly drained (53%), Moderately well drained (43%)
<u>1995 Land use</u> — Residential (58%), Wooded (11%), Light manufacturing (6%), Parking (5%), Recreation (5%)



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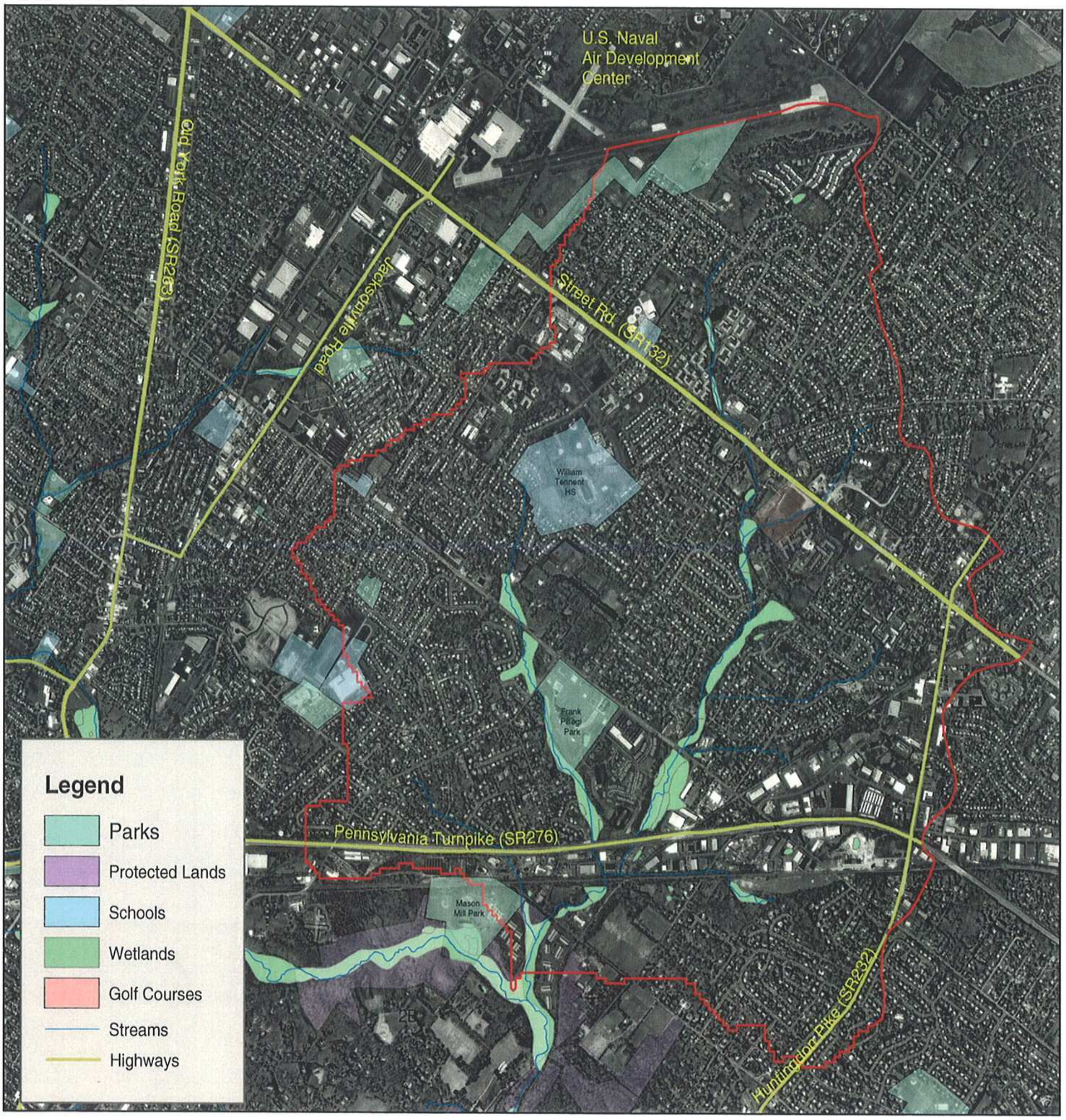
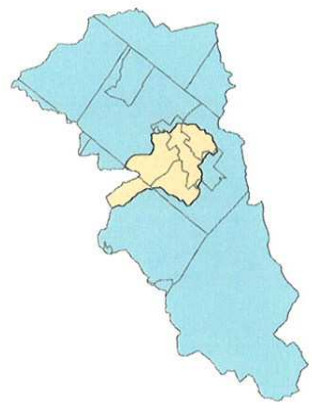


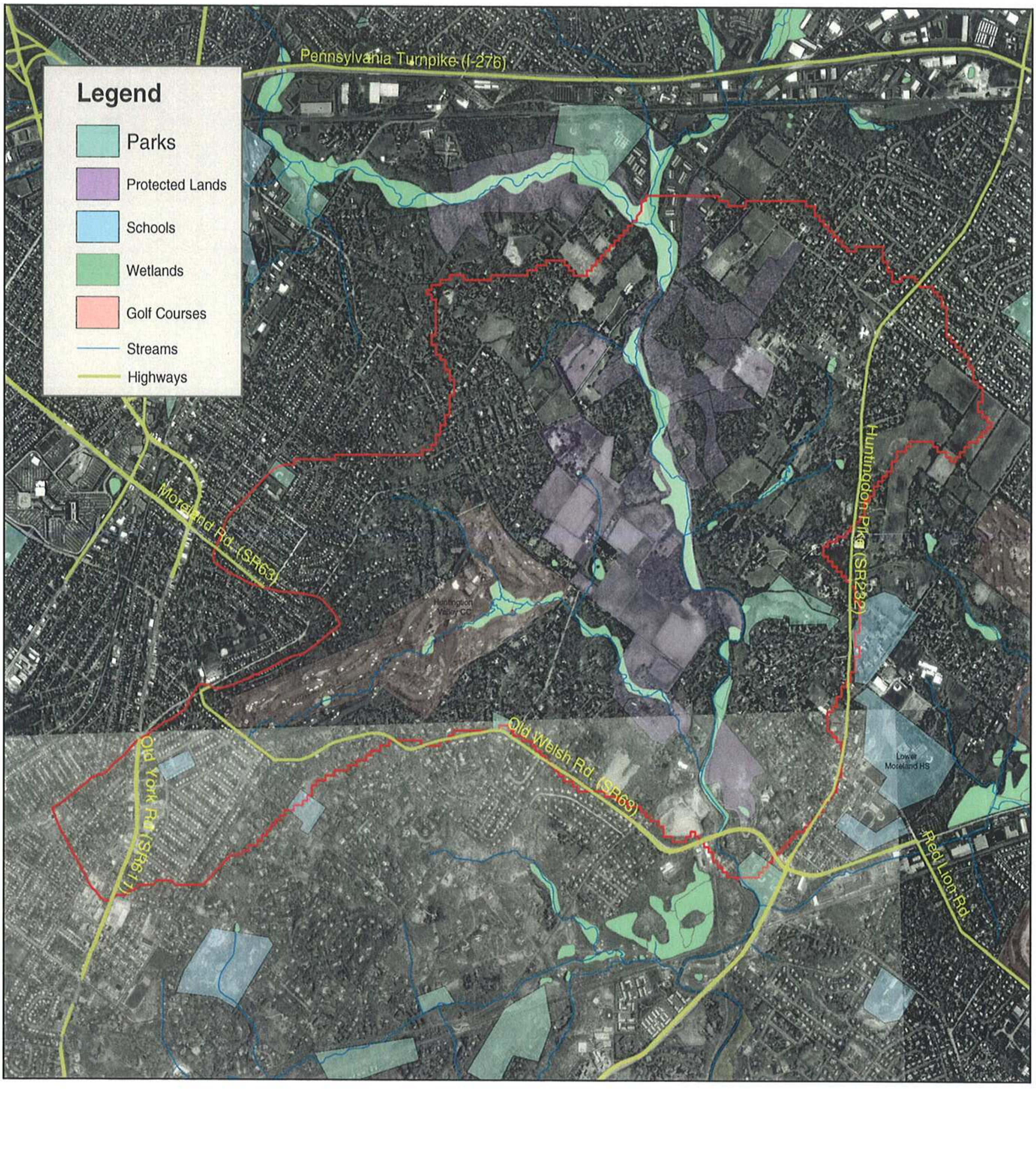
Subwatershed 4 *Middle Pennypack*

<u>*Drainage area*</u> 5.14 sq. miles <u>*Stream miles*</u> 9.58

<u>*Location*</u> — Lower Moreland Township (36%), Upper Moreland Township (29%), Bryn Athyn Borough (21%), Abington Township (14%)
<u>*Physiography*</u> — Piedmont Upland Section (99%)
<u>*Ecoregion*</u>s — Level III: Northern Piedmont (100%), Level IV: Piedmont Uplands (100%)
<u>*Geology*</u> — Felsic Gneiss (63%), Mafic Gneiss (24%), Chickies Formation (12%)
<u>*Soils*</u> — Moderately well drained (50%), Moderately poorly drained (38%)
<u>*1995 Land use*</u> — Residential (42%), Wooded (30%), Agriculture (16%), Recreation (6%)



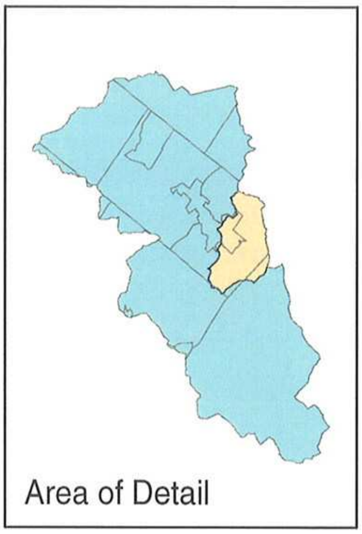
Area of Detail

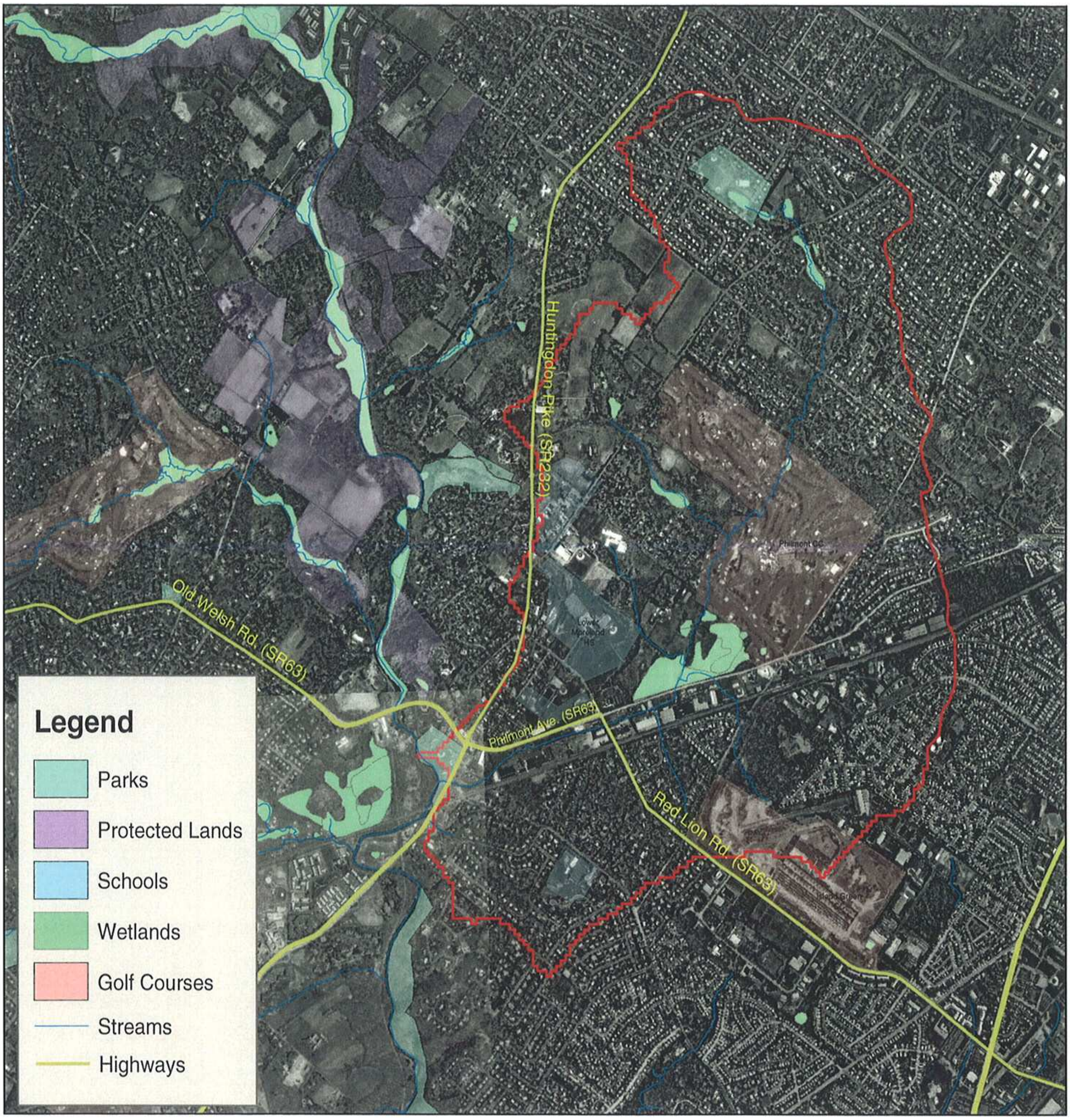


Subwatershed 5 *Huntingdon Valley Creek*

Drainage area 4.14 sq. miles Stream miles 6.18

Location — Lower Moreland Township (78%), Bryn Athyn Borough (15%), City of Philadelphia (7%)
Physiography — Piedmont Upland Section (100%)
Ecoregions — Level III: Northern Piedmont (100%), Level IV: Piedmont Uplands (100%)
Geology — Felsic Gneiss (39%), Wissahickon Formation (32%) Chickies Formation (15%)
Soils — Moderately poorly drained (51%), Moderately well drained (42%)
1995 Land use — Residential (49%), Recreation (15%), Wooded (11%), Agriculture (10%)

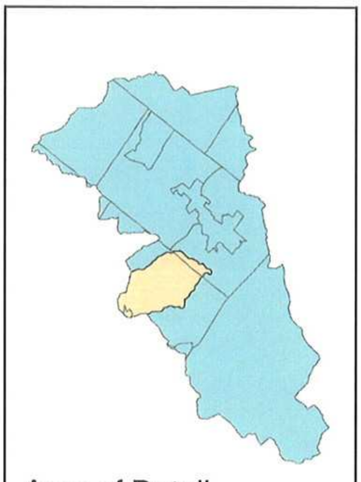


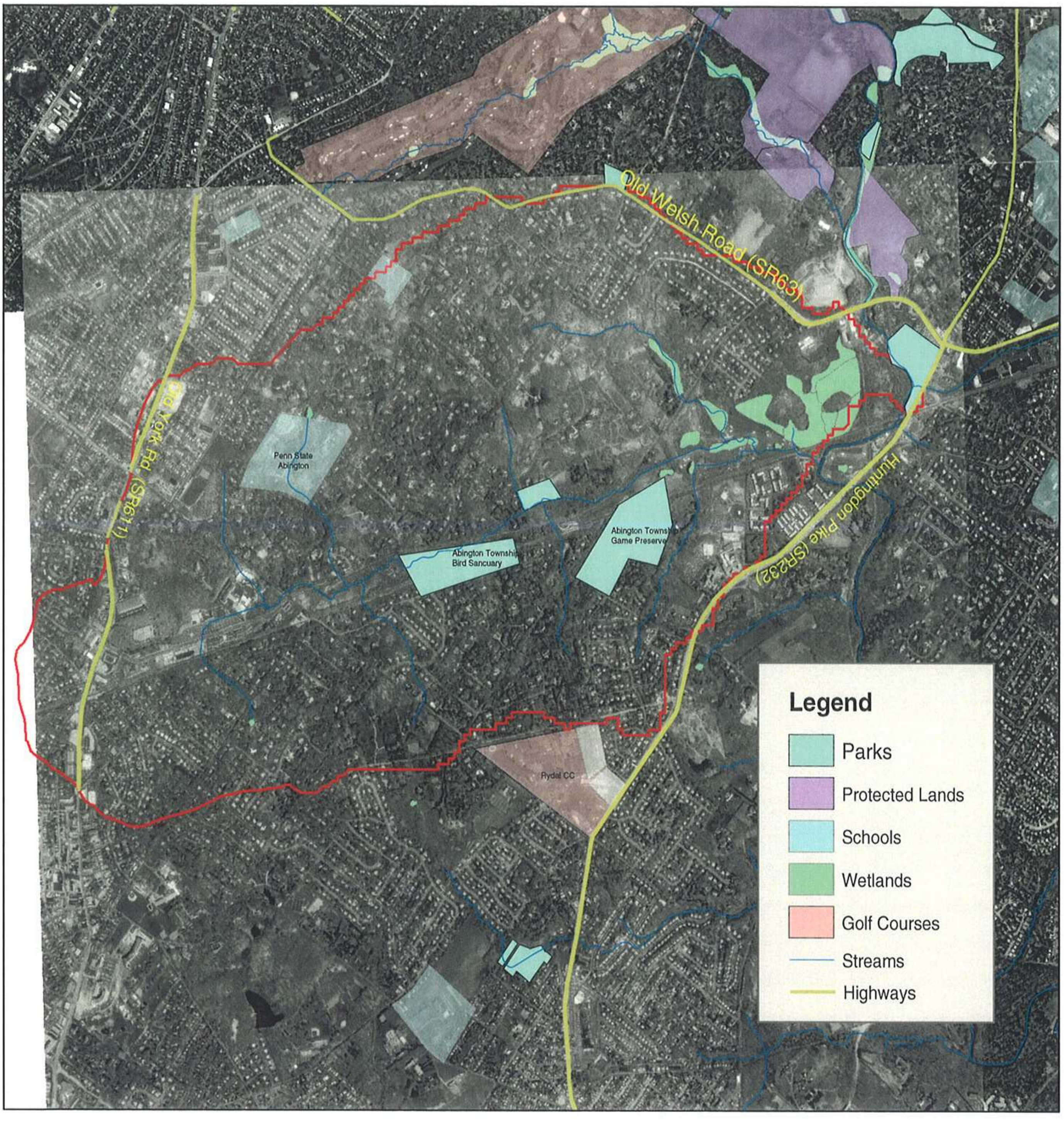


Subwatershed 6 *Meadow Brook*

<u>*Drainage area*</u> 3.86 sq. miles <u>*Stream miles*</u> 7.79

<u>*Location*</u> — Abington Township (91%), Lower Moreland Township (8%)
<u>*Physiography*</u> — Piedmont Upland Section (100%)
<u>*Ecoregions*</u> — Level III: Northern Piedmont (100%), Level IV: Piedmont Uplands (100%)
<u>*Geology*</u> — Felsic Gneiss (51%), Wissahickon Formation (43%)
<u>*Soils*</u> — Moderately poorly drained (57%), Moderately well drained (34%)
<u>*1995 Land use*</u> — Residential (63%), Wooded (20%), Parking (5%)



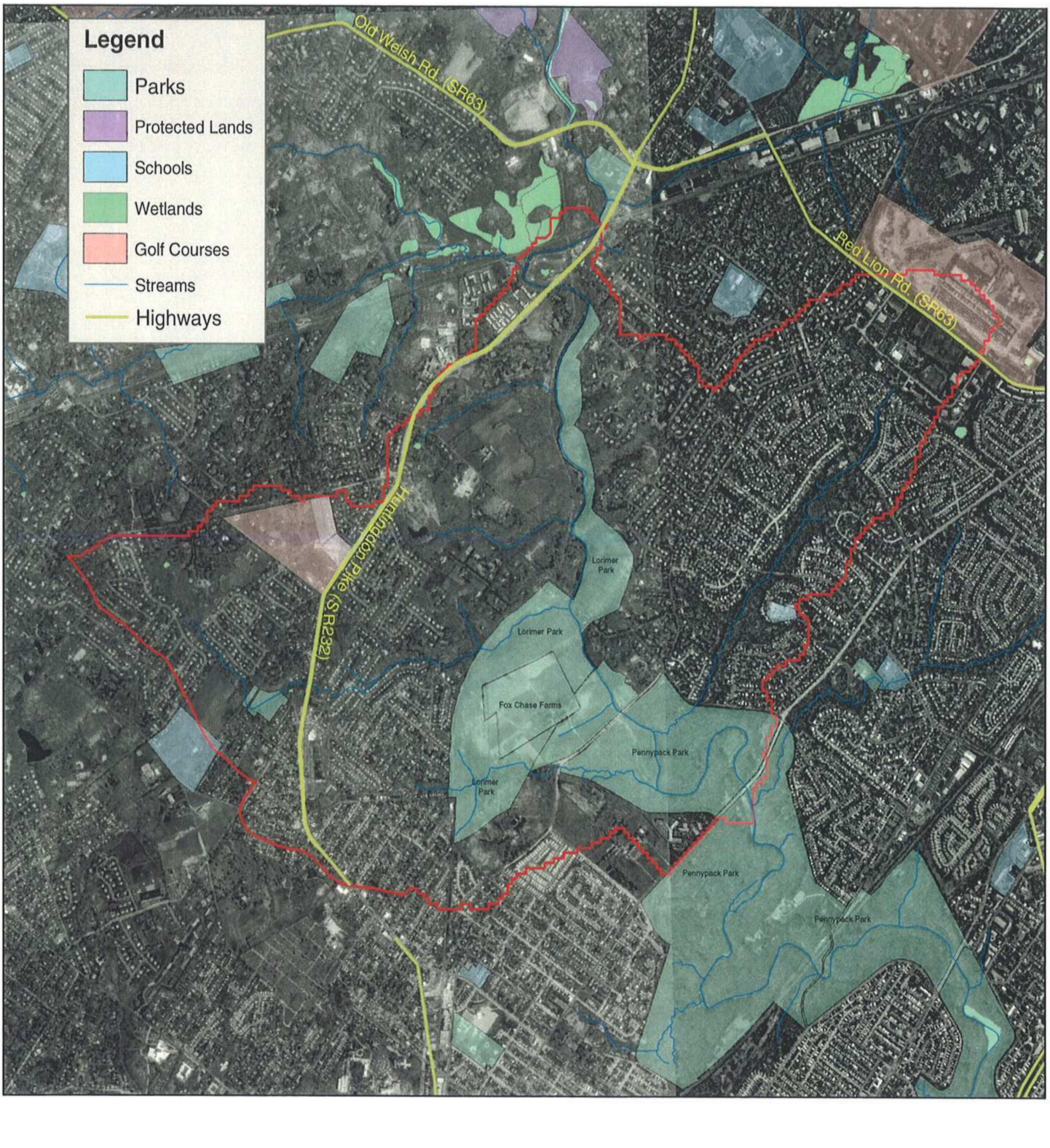


Subwatershed 7 *Rockledge Branch*

<u>*Drainage area*</u> 4.88 sq. miles   <u>*Stream miles*</u> 11.07

<u>*Location*</u> — Abington Township (59%), City of Philadelphia (34%), Rockledge Borough (4%)
<u>*Physiography*</u> — Piedmont Upland Section (100%)
<u>*Ecoregions*</u> — Level III: Northern Piedmont (100%), Level IV: Piedmont Uplands (100%)
<u>*Geology*</u> — Wissahickon Formation (98%)
<u>*Soils*</u> — Moderately well drained (54%), Moderately poorly drained (37%)
<u>*1995 Land use*</u> — Residential (51%), Wooded (28%), Agriculture (8%)

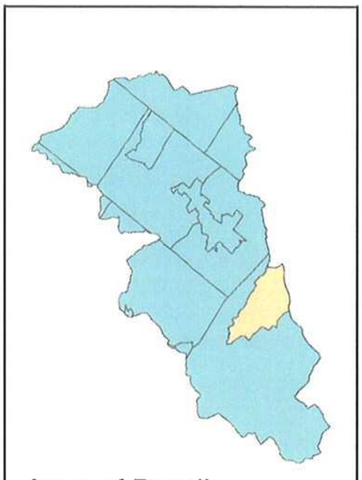
Area of Detail

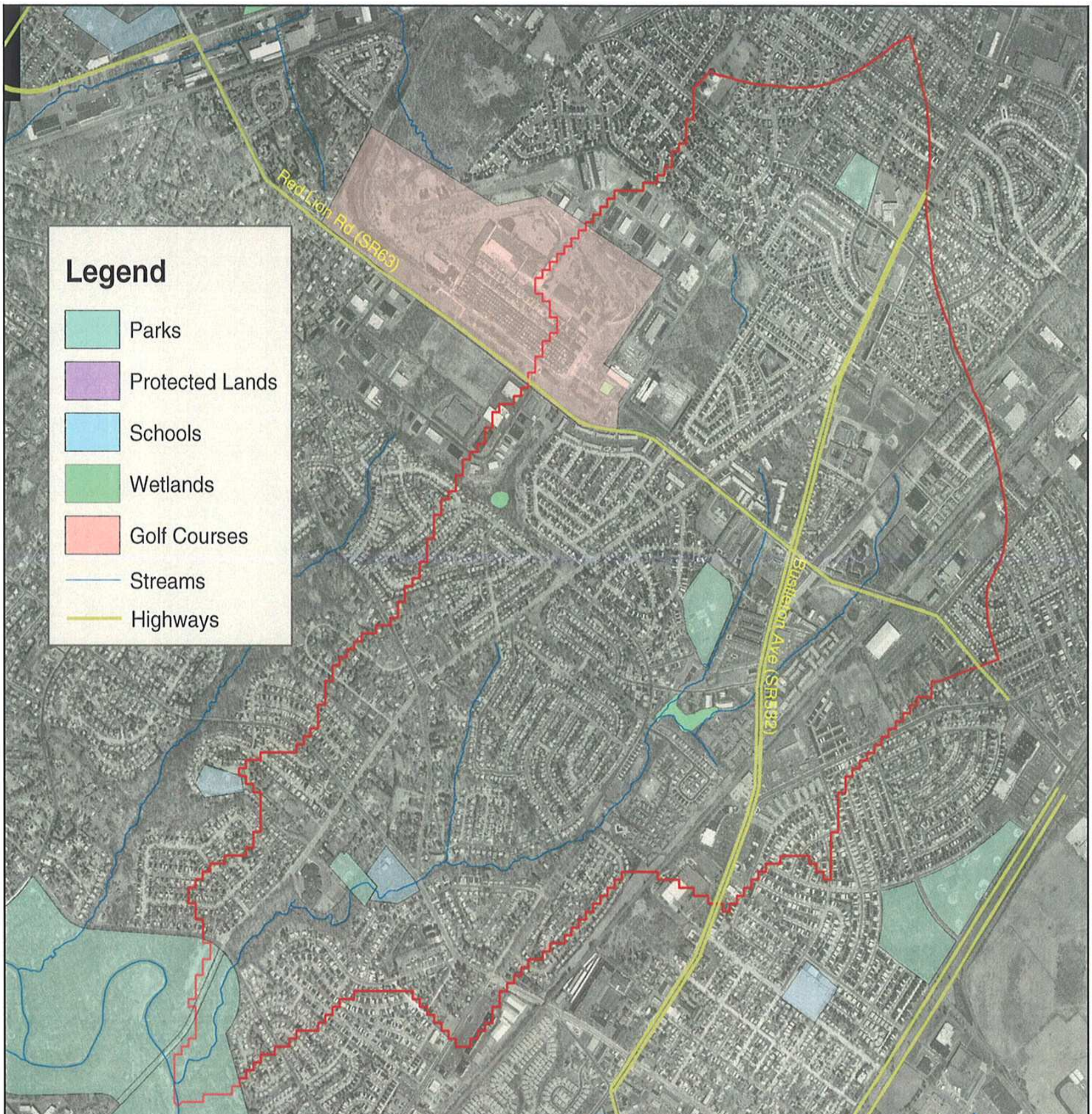


Subwatershed 8 *Lower Pennypack*

Drainage area 2.69 sq. miles   Stream miles 4.57

Location — City of Philadelphia (100%)
Physiography —Piedmont Upland Section (100%)
Ecoregions — Level III: Northern Piedmont (100%), Level IV: Piedmont Uplands (100%)
Geology — Wissahickon Formation (84%), Mafic Gneiss (15%)
Soils — Moderately well drained (94%)
1995 Land use — Residential (66%), Wooded (7%), Light manufacturing (7%), Parking (6%), Commercial/services (6%)

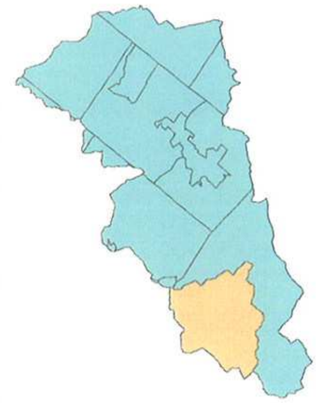




Subwatershed 9 *Sandy Run*

Drainage area 7.26 sq. miles *Stream miles* 10.29

Location — City of Philadelphia (100%)
Physiography — Atlantic Coastal Plain Province – Lowland and Intermediate Upland Section (65%), Piedmont Upland Section (35%)
Ecoregions — Level III: Northern Piedmont (98%), Level IV: Piedmont Uplands (98%)
Geology — Wissahickon Formation (73%), Pensauken and Bridgeton Formations (23%)
Soils — Moderately well drained (85%), Poorly drained (8%)
1995 Land use — Residential (56%), Wooded (16%), Commercial/services (6%), Agriculture (6%), Parking (5%)



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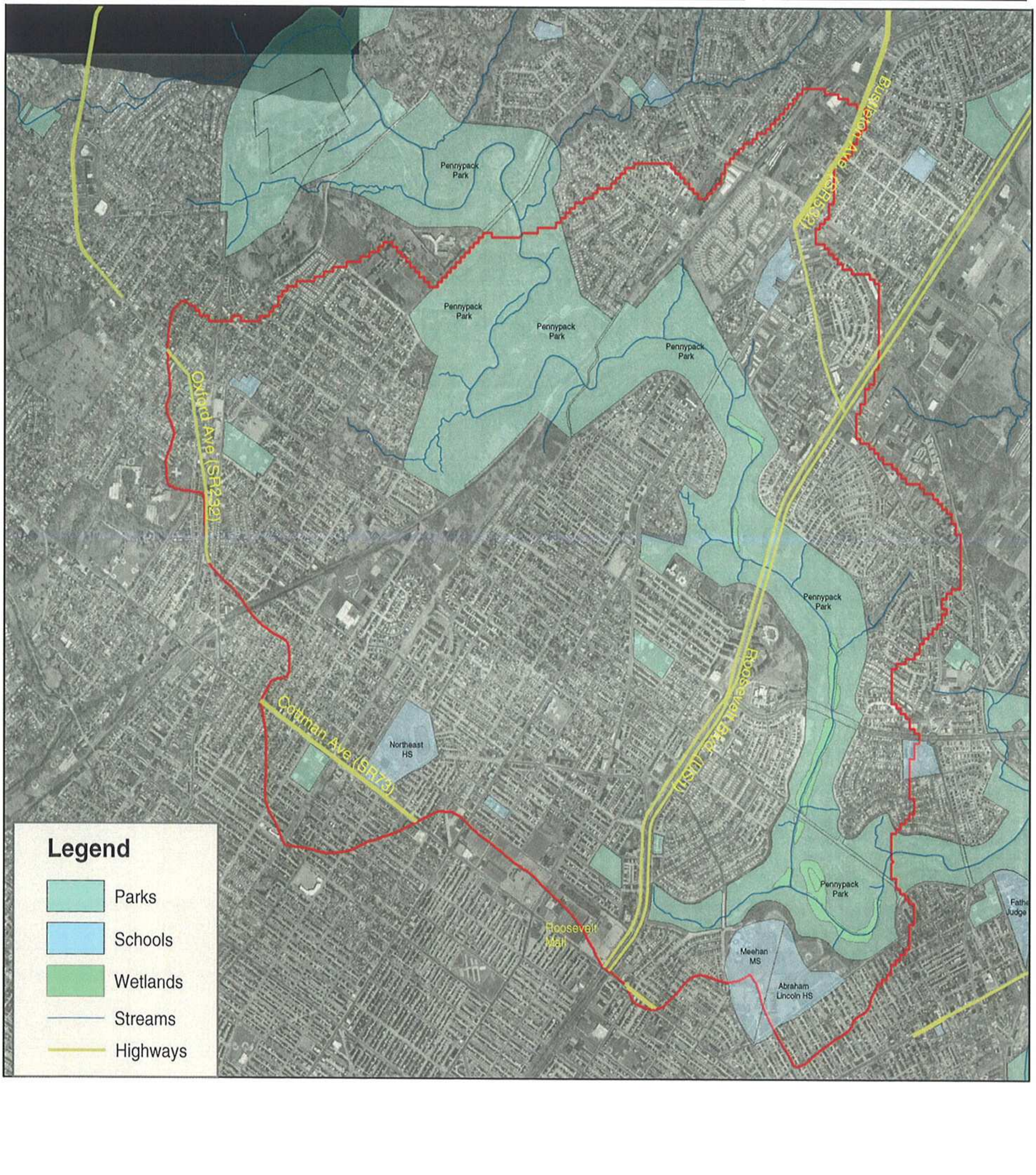
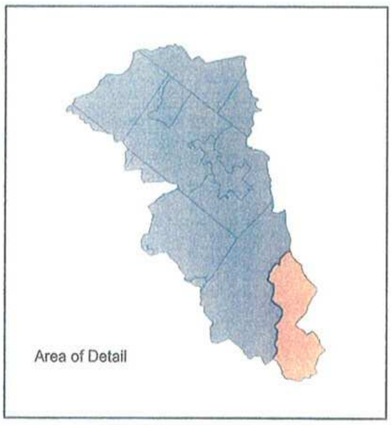
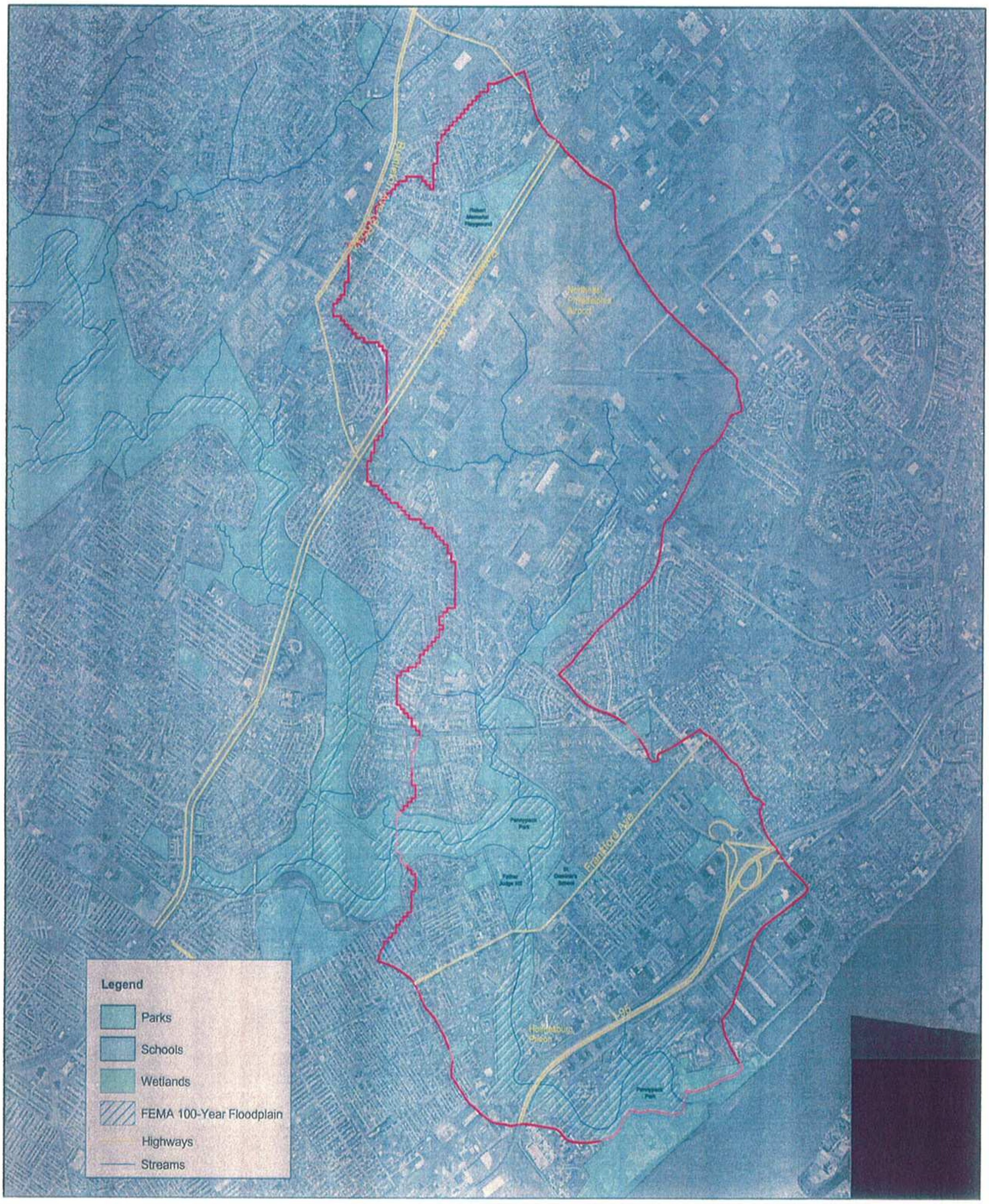


Subwatershed 10 *Mouth of Pennypack*

<u>*Drainage area*</u> 6.01 sq. miles <u>*Stream miles*</u> 9.17

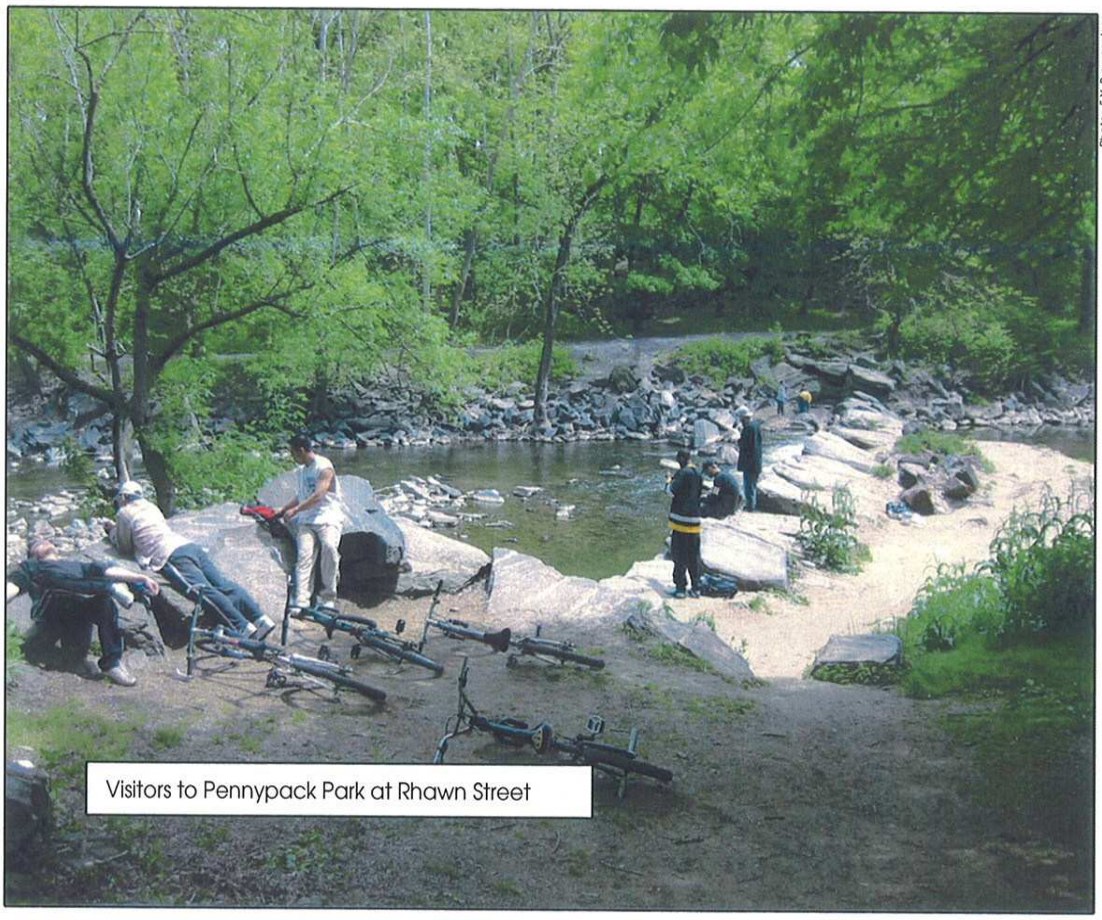
<u>*Location*</u> — City of Philadelphia (100%)
<u>*Physiography*</u> — Atlantic Coastal Plain Province – Lowland and Intermediate Upland Section (92%), Piedmont Upland Section (8%)
<u>*Ecoregions*</u> — Level III: Northern Piedmont (57%), Middle Atlantic Coastal Plain (43%), Level IV: Piedmont Uplands (57%), Delaware River and Terraces and Uplands (43%)
<u>*Geology*</u> — Wissahickon Formation (44%), Pensauken and Bridgeton Formations (37%), Trenton Gravel (15%)
<u>*Soils*</u> — Moderately well drained (51%), Poorly drained (37%)
<u>*1995 Land use*</u> — Residential (32%), Commercial/services (16%), Transportation (15%), Wooded (13%)





Stream Characteristics

The Pennypack Creek drainage system includes more than 80 miles of stream channels (Figure 5.11). The main stem of the Pennypack Creek originates in Horsham Township at an area historically known as Maple Glen. From Maple Glen, the Creek flows east through a series of agricultural lands and commercial and residential developments before entering Hatboro Borough. Within the Borough, the Creek flows southeast and passes under I-276. The main stem of Pennypack Creek then turns east, flowing through protected lands of the Pennypack Preserve owned by the Pennypack Ecological Restoration Trust, within Upper Moreland Township. Still largely within the boundaries of the Pennypack Preserve, the Creek then flows south through the Borough of Bryn Athyn and into Lower Moreland Township. Within Bryn Athyn Borough, the Southampton Creek, which drains portions of Warminster and Upper Southampton Townships, enters the Pennypack Creek from the northeast. The Pennypack Creek then exits the Pennypack Preserve, crossing SR63 and entering Abington Township where the creek flows through Lorimer County Park. Just before entering Lorimer Park, Pennypack Creek receives flow from two more tributaries, Meadow Brook, which drains east through Abington Township, and Huntington Valley Creek, which drains west through sections of Lower Moreland Township. After exiting Lorimer Park, Pennypack Creek flows into the City of Philadelphia for approximately eight miles before emptying into the Delaware River. The Pennypack Creek is surrounded by Pennypack Creek Park throughout its journey through the City of Philadelphia. Within the City, several tributaries including Rockledge Branch, Paul's Run, Sandy Run, Redd Rambler Run, and Wooden Bridge Run flow into the Creek.



Visitors to Pennypack Park at Rhawn Street

Photo: F.X. Browne, Inc.

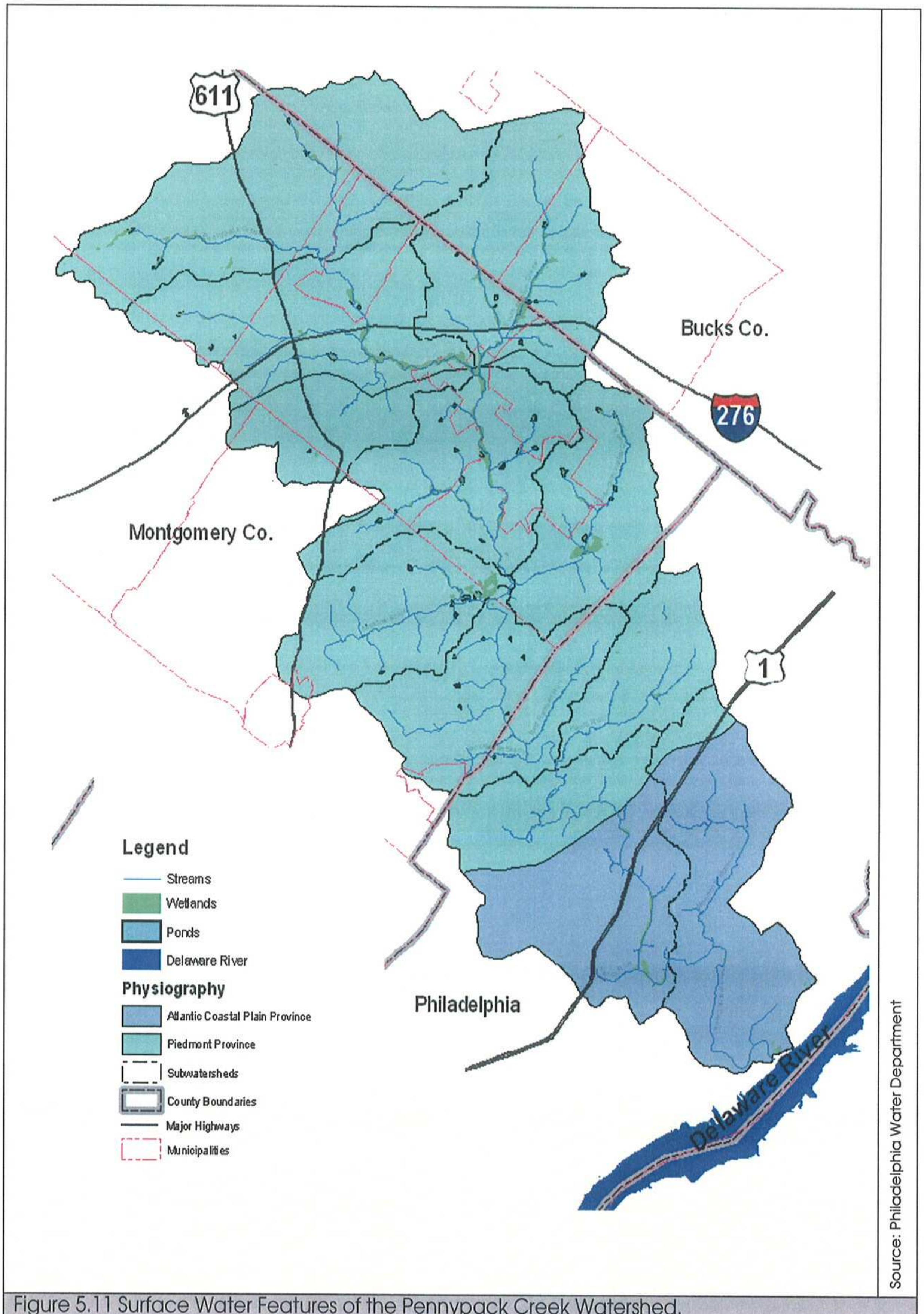
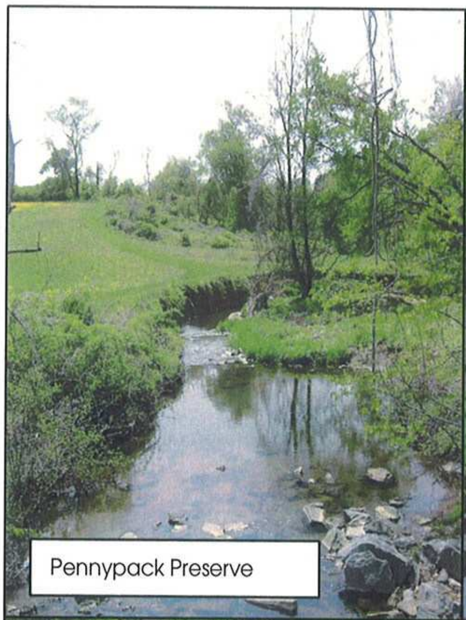
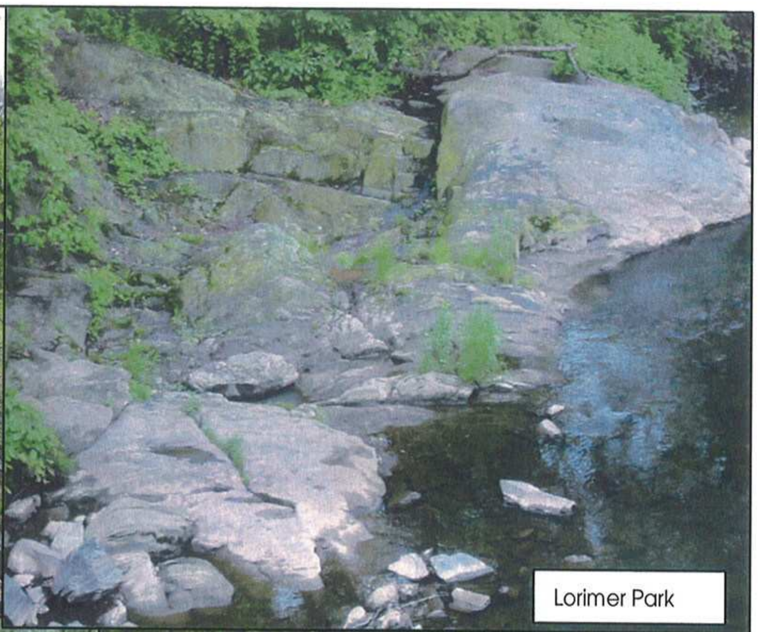


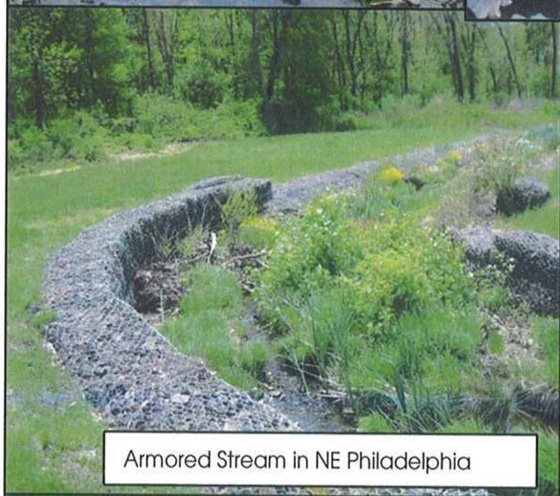
Figure 5.11 Surface Water Features of the Pennypack Creek Watershed.

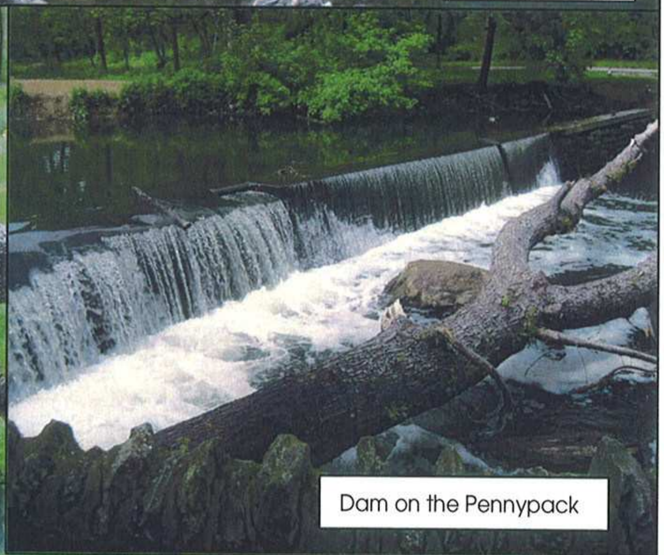
VIEWS OF THE PENNYPACK CREEK


Pennypack Preserve

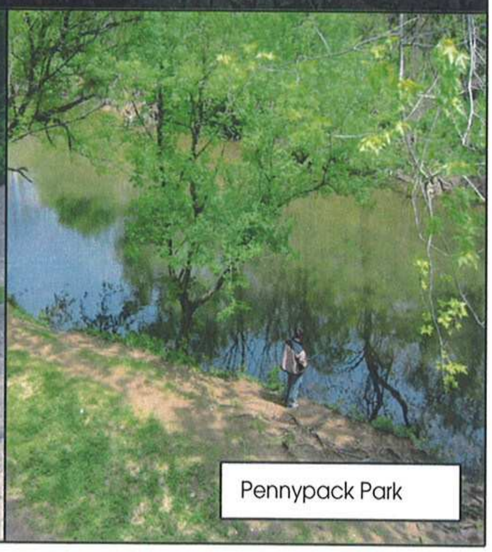

Lorimer Park

Photos: F.X. Browne, Inc.


Armored Stream in NE Philadelphia


Dam on the Pennypack

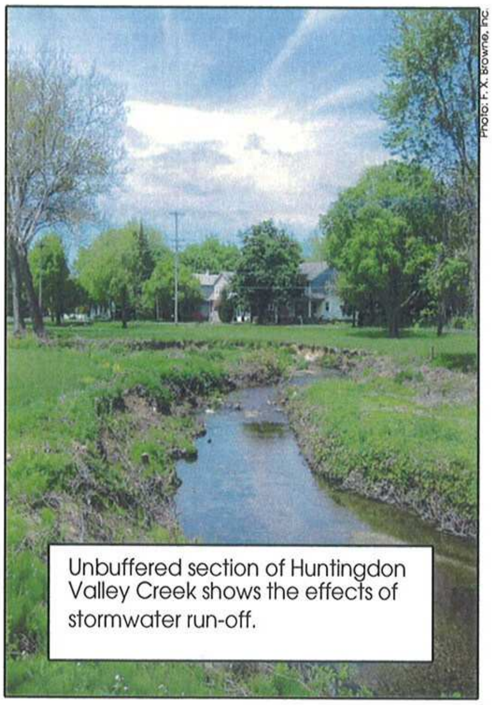

Anglers in Pennypack Park


Pennypack Park

STREAM ORDER

The stream network that drains the Pennypack Creek Watershed consists of a complex web of tributaries and branches that feed main stem of the Creek. Expressing where a segment is within this drainage network can tell us a great deal about that section of stream. Stream order is a way of expressing the position of a particular stream segment within the drainage network. First order streams have no tributaries and are the upstream-most stream segments in a watershed – they are the beginning of the stream system. When two first order streams join they form a second order stream. Two second order streams join to form a third order stream and so on. Most of the stream miles in a watershed are usually first and second order (low order) streams. These low order streams are quite sensitive to changes in surrounding landuse. For instance, as headwater areas are developed, impervious surfaces prevent groundwater recharge, which reduces base flow and may result in disappearance of low order stream segments.

The complexity of the branching pattern of a stream's headwaters and low order stream network provide clues to the extent of physical alteration the watershed has undergone. Not only are low order streams the most sensitive to land use change, they are also typically, the first water features to be filled, channelized or contained in pipes as a watershed is developed. A pronounced lack of first and second order streams is characteristic of watersheds that have been highly developed. Figure 5.12 presents steam ordering for the Pennypack Creek Watershed. This map clearly shows the absence of 1st order tributaries in many areas of the watershed.



Unbuffered section of Huntingdon Valley Creek shows the effects of stormwater run-off.

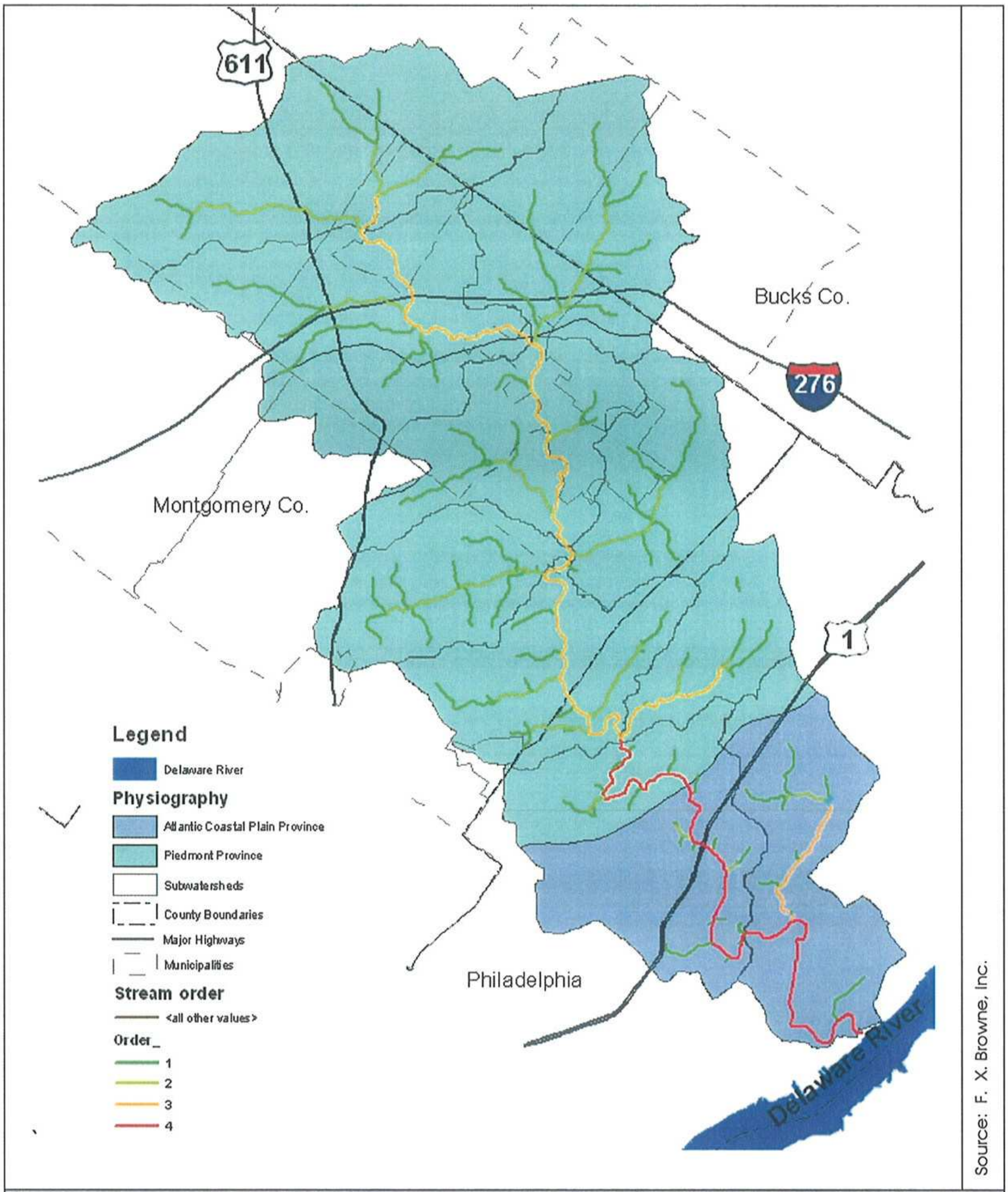


Figure 5.12 Stream Order of Pennypack Creek Watershed Streams.
Note the relative absence of first order streams in the city and urbanized portions of the watershed.

Slope

The steepness of a stream's valley strongly influences how that stream behaves. Valley slope (and therefore stream slope) influences the way the stream transports sediment and the amount of energy contained in a stream's flow. Streams that flow through steeply sloping topography tend to be high energy systems that have the ability to erode and transport large quantities of sediment. High gradient streams are often confined by steeply sloping valley walls and therefore tend to run relatively straight. These streams can be contrasted with the slow moving, meandering streams found in the relatively flat areas of the Coastal Plain. Low energy streams lack the ability to move large quantities of sediment. The streams are typically unconfined by valley walls and often cut meanders through previously deposited floodplain sediments.

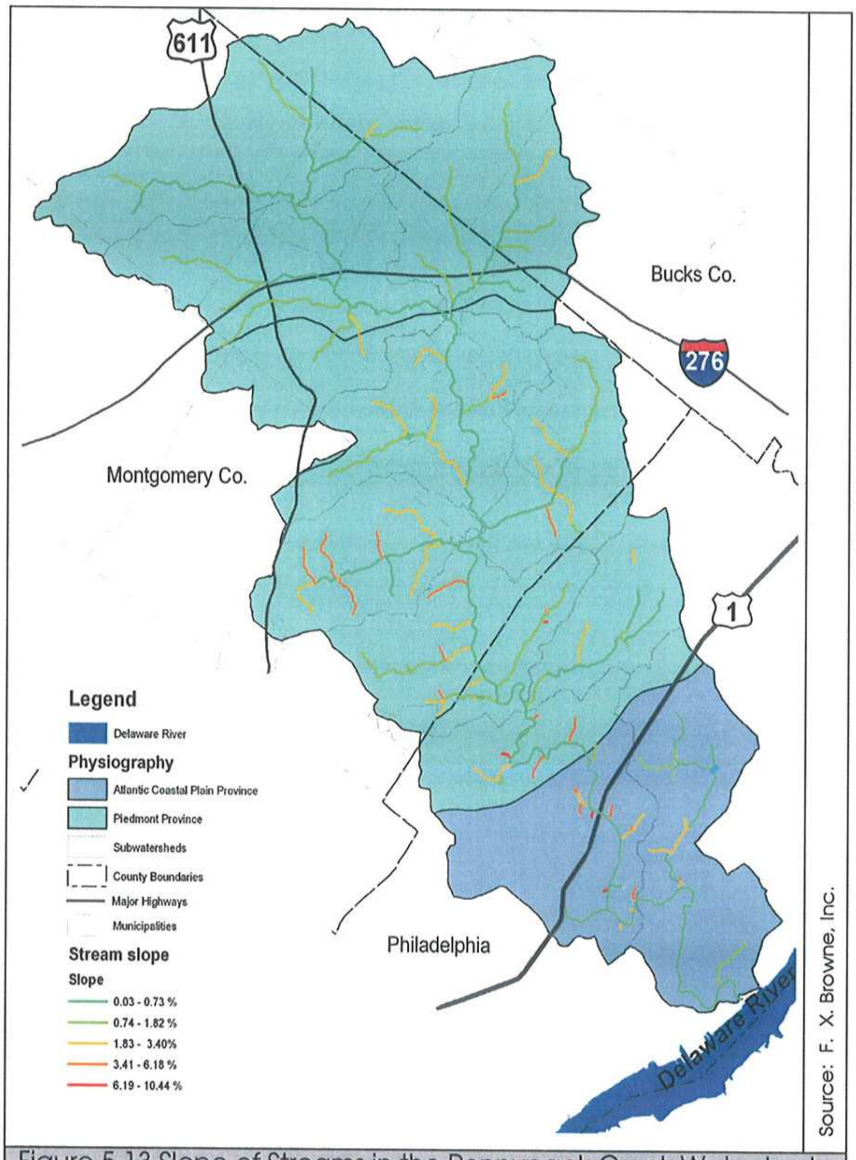


Figure 5.13 Slope of Streams in the Pennypack Creek Watershed.
The slope map of the watershed identifies sections of the watershed containing potential high energy streams with potential to export large amounts of sediment.

Figure 5.13 illustrates how stream slope varies throughout the watershed. Orange and red stream segments on the map indicate where the stream is flowing through steeper sloped areas of the watershed. This analysis provides an insight to areas that contain high energy streams that may be experiencing erosion problems and exporting sediment downstream. Not surprisingly many of the tributaries in the central portion of the watershed, which lies in the Piedmont Uplands physiographic province, are among the most steeply sloping streams in the watershed.

SINUOSITY

Sinuosity is the ratio of a stream's length to the valley length, or more simply—how straight a stream is or how much it meanders. Natural streams exhibit certain meander characteristics as the stream reacts to erosion, sediment loading and geologic features of the watershed. Stream meandering reduces the amount of energy carried by a stream and typically results in sediment deposition on the inside bends of a stream and erosion of the banks on an outside bend where shear stresses are greater. Because sinuosity tends to be correlated with slope (i.e., steeply sloping streams tend meander less than low gradient streams), the prevalence of low sinuosity, low sloping streams may indicate the presence of stream segments that have been artificially straightened or channelized.

Figure 5.14 shows the ranges of channel sinuosity found within Pennypack Creek Watershed.

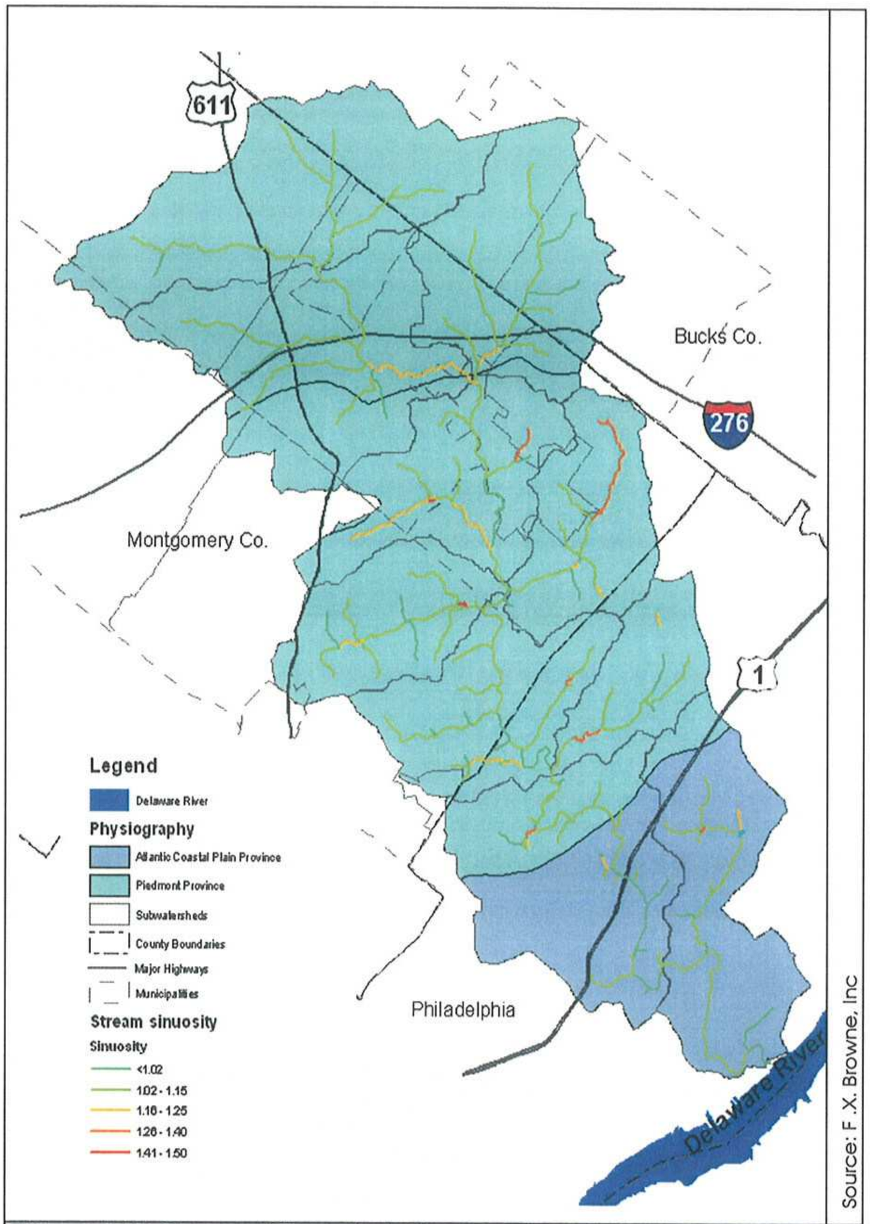
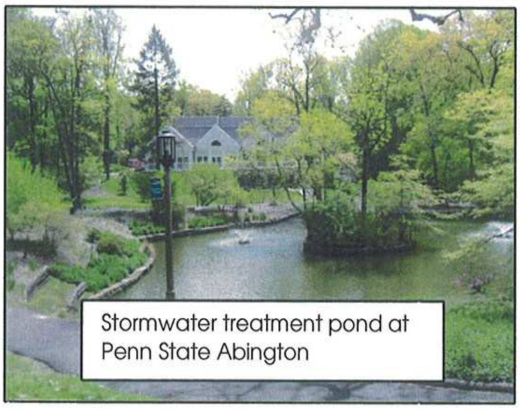


Figure 5.14 Channel Sinuosity in the Pennypack Creek Watershed.
The low sinuosity values of the streams in the Pennypack Creek Watershed suggests that many stream segments have been artificially straightened.

Ponds

Generally ponds are small areas of standing water that are formed by diverting water into a depression in the earth or excavating earth down to the groundwater table. Naturally formed ponds are more uncommon and are usually fed by groundwater or created by beaver damming a creek or stream. All of the ponds in the watershed today were artificially created. Sixty one major ponds within the Pennypack Creek Watershed cover almost 38 acres of land.



Stormwater treatment pond at Penn State Abington

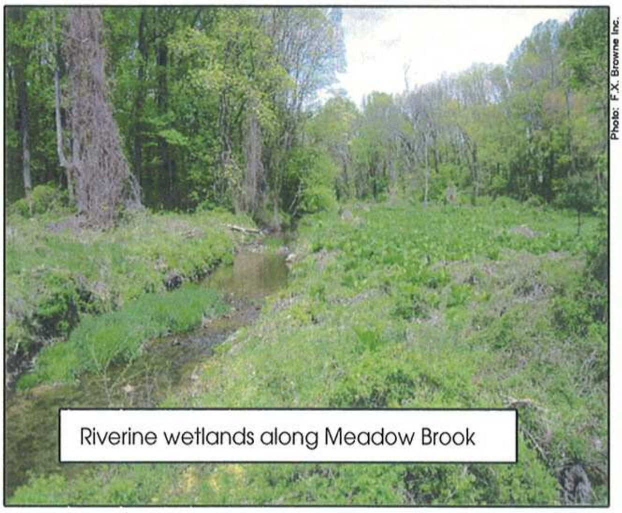
Photo: F.X. Browne, Inc

Ponds' still water column allow for the settling of sediments. This attribute has resulted in the use of ponds as a stormwater management practice. Unless maintained, however, ponds fill with sediment and concentrate organic matter and pollutants from stormwater run-off. As organic materials accumulate in pond sediments and decay, pond water quality declines and may become anoxic. These low oxygen waters combined with elevated nutrient levels often found in pond water can exert a negative impact on the water quality of receiving streams. Because of shallow water depth and a lack of tree cover, ponds are also often a source of thermal pollution to downstream waters.

A recently completed study on ponds in the Pennypack Creek Watershed conducted by Temple University and the Philadelphia Water Department indicates that nearly 90% of first order streams in the Pennypack Creek Watershed in Montgomery County have ponds. This statistic indicates that dammed first order streams are prevalent in the watershed, negatively affecting natural hydrologic cycles.

Ponds identified in the study are shown in Figure 5.11.

Wetlands



Riverine wetlands along Meadow Brook

"Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promote the development of characteristic wetlands soils."
-- EPA, America's Wetlands: Our Vital Link Between Land and Water

Wetlands typically fall within three classifications based on their relationship to surface waters. They are lacustrine, riverine and palustrine. Lacustrine and riverine wetlands are found along the shores of lakes (lacustrine), rivers and streams (riverine). Palustrine wetlands are not associated with these surface water bodies and can evolve in areas with poorly drained soils or a high groundwater table.

According to the National Wetlands Inventory, the Pennypack Creek Watershed contains approximately 502 acres of wetlands (see Figure 5.11). The National Wetlands Inventory is a service of the U. S. Fish and Wildlife Service that identifies wetlands from aerial photographs. These wetlands are not field verified and may contain data errors or inaccuracies. Field verifications are necessary for determination of jurisdictional wetlands.

The majority of the wetlands in the watershed are riparian, or riverine, wetlands located adjacent to stream channels. Concentrations of riparian wetlands are found within protected corridors adjacent to the main stem of Pennypack Creek including the sections of the main stem of the Pennypack Creek downstream of Hatboro Borough and upstream of SR63 that flow through the protected lands of the Pennypack Preserve. The largest single wetland complex is located in Lower Moreland and Abington Townships at the confluence of Meadow Brook and Huntingdon Valley Creeks with the Pennypack Creek.

Most of the wetlands within Pennypack Creek Park are palustrine wetlands and many have been altered significantly by human activity. Many former wetland areas within the park have been drained or filled. The most common types of wetlands found during the Fairmount Park Commission (FPC) survey were phragmites marshes, cattail marshes, and skunk cabbage seeps (FPC, 2001). The FPC report also notes several areas in the Park that may possess wetland hydrology but are prevented from developing wetland vegetation because they are maintained as open fields through frequent mowing (FPC, 2001).

There is a significant tidal wetland found in Pennypack Park at the mouth of the Pennypack Creek. This wetland is inundated daily as the tide rises on the Delaware River. The FPC has restored these wetlands in an effort to create a habitat that was prevalent along the Delaware River before European settlement.

The Philadelphia Water Department is performing a comprehensive wetland assessment of the watershed. The purpose of this assessment is to identify the size, quality and location of wetlands in city watersheds, including portions of those watersheds outside of the city. The assessment will ultimately identify potential wetland restoration sites that can be utilized to provide water quality improvements for stormwater or combined sewer overflow effluents.

Field studies on the Pennypack Creek Watershed were completed in late 2004. Wetlands were identified using the U.S. Army Corps of Engineers *Wetland Delineation Manual*. Wetlands were identified as jurisdictional wetlands but boundaries were not delineated. Currently, Philadelphia Water Department is compiling field data and identifying and prioritizing wetland restorations that can be implemented.

Results of the wetlands assessment for the Pennypack Creek Watershed are expected in late 2005 but were not available in time for inclusion in this report.

5.2 USES AND VALUES

Introduction

Rivers can be viewed in terms of their utility, functionality and the work or goods they provide (the resource's "Uses"). Rivers and streams can also be evaluated by how they are perceived, cherished or disparaged (the "Values" of the river). The Pennypack Creek and its tributaries have provided a variety of uses and values to human inhabitants of the watershed for thousands of years. Early Native Americans used the streams for sources of drinking water and food as well as for transportation and a guide for trails. Native Americans valued the stream for its life giving qualities and the benefits the stream bestowed on their people.

Early American settlers also utilized and valued the Creek for these reasons but the advent of the industrial revolution brought new uses and values for the Creek. The Creek powered mills and transported goods from agricultural lands to market towns and the Delaware River. The creek also carried industrial and wastewater off to the Delaware River. Settlers valued the creek for its benefit to commerce and trade but as it became more polluted from human and industrial wastes the Creek's value as a place of solitude and beauty diminished.

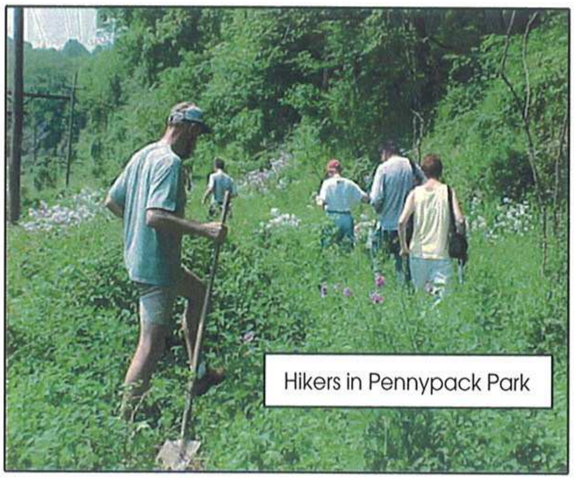

Hikers in Pennypack Park

Photo: Philadelphia Water Department

Today, watershed residents fish in the Pennypack Creek, visit the stream side parks and enjoy the diversity of nature present in the watershed. The Pennypack Creek contributes to sources of drinking water and conveys waste water and stormwater away from suburban development to the Delaware River. Watershed's residents have conflicting feelings about the stream's values today. Many see it as great recreational amenity, a destination for picnics, peace and wildlife watching. To many others the creek brings destruction from flood waters, poor water quality and eroding streambanks as a result of inadequate stormwater management. Changing the way the Pennypack Creek is perceived and valued will ultimately influence the manner in which the stream is used.

Non-consumptive Uses

Passive Recreation and Aesthetics

Most participants in the public outreach and education events conducted by the River Conservation Plan team expressed how they enjoyed visiting the parks along the Pennypack Creek for hiking, bike riding, wildlife watching or other passive recreation usage. Many respondents reported that natural areas along the creek were important places for them to just "get away" from urban and suburban life. Notable passive recreation activities important to watershed residents include hiking, wildlife and bird watching and learning about nature.

Trails along the large passive recreation lands in the watershed are regional destinations for people to enjoy the diverse biological communities and habitats that the Pennypack Creek makes possible. The Pennypack Preserve offers 2.5 miles of multi-use trails available for biking, horseback riding, hiking and walking leashed pets. The preserve maintains 6.5 miles of hiking trails. Pennypack Park has over 45 miles of multi-use trails.

Wildlife and bird watchers come to these preserves to view some of the hundreds of plant species and over 160 species of birds that visit the preserve and parks each year. Rare avian visitors to the watershed, including bald eagles, make outings along the Pennypack Creek an adventure.

Both Pennypack Park and the Pennypack Preserve have environmental education centers that make use of the Pennypack Creek and surrounding environment for educational purposes. The Pennypack Environmental Center, in Pennypack Park, and Pennypack Ecological Restoration Trust, operating the Pennypack Preserve, use the natural areas in their care to educate students and concerned citizens about ways in which they can be better stewards of their watershed.

Conversely, the overwhelming popularity of these parks and preserve can contribute to the loss of enjoyment by users. Crowding and conflicting uses can ultimately result in declining stewardship if proper management measures are not implemented. Park users become sources of litter and uncollected pet waste that reduce the aesthetic appeal of park lands and open space. Even non-consumptive uses have the potential to exert negative impacts on the stream environment if users are not cognizant of the cumulative effects of their actions. These factors make public education and management planning critical to long term sustainability of passive recreational uses of the watershed's natural areas.

Consumptive Uses

Drinking Water

The Pennypack Creek Watershed contributes to the sources of drinking water for residents both within and outside of the watershed basin. The suburban communities in the upper watershed historically relied on groundwater sources for their drinking water, while residents in municipalities in the lower watershed relied on a mixture or groundwater from within their borders and surface water from the Baxter Water Treatment Plant on the Delaware River, in the City of Philadelphia.


Photo: Philadelphia Water Department

There are no surface water intakes on the Pennypack Creek itself but the creek joins the Delaware River just downstream of the intakes for the Baxter Water Treatment Plant. The Aqua-Pennsylvania Water Company does have a permit to withdraw water from the Pennypack Creek at Bethayres, for potable water uses but has not utilized this source.

The Baxter Water Treatment Plant treats 180 million gallons of drinking water each day and provides that water to 60 percent of Philadelphia City residents as well as residents of lower Bucks County, including Upper Southampton Township.

The 2004 PWD Annual Drinking Water Quality Report states that water quality from the Pennypack Creek influences the water quality entering the Baxter Water Treatment Plant intakes when the tide was rising on the Delaware River. Rising tides effectively force water being discharged from the Pennypack Creek towards the water treatment plant, carrying with it any sediment or pollutants that may have been in the Pennypack Creek.

Maintaining water quality in the Pennypack Creek to protect the Creek's critical use as a contributor to drinking water supply is a major concern of the Philadelphia Water Department.

Fishing

Fishing is another important use of the Pennypack Creek for watershed stakeholders. The Pennypack Creek is the home stream for the active Southeastern Montgomery County Chapter of Trout Unlimited and is a destination for many watershed residents and visitors. Sport fish supported by the Pennypack Creek include species of bass, catfish and stocked trout. Fishing attracts numerous visitors to the stream where they also engage in passive recreation and enjoyment of the aesthetic beauty of the creek and its surroundings.


Photo: F. X. Browne, Inc.

Anglers take home their catch

The PA Fish and Boat Commission stock rainbow and brown trout in the Pennypack Creek downstream from Moredon Road in Lorimer and Pennypack Parks. Without trout stocking, Pennypack Creek would not be the destination for fisherman that it is today. The Commission also stocked 667,000 hickory shad fry in 2004. The hickory shad is smaller than the better known american shad and is a good sport fish to catch due to its fighting ability. The Commission released the fry in hopes that the shad would imprint themselves on the creek and return to the Pennypack to breed after spending a portion of their lives in the ocean.

The PA Fish and Boat Commission, Southeast Montgomery County Chapter of Trout Unlimited, FPC and Philadelphia Water Department are all involved in cooperative projects aimed at improving the in-stream habitats of the Pennypack Creek to support its use as a destination fishery.

Ecological Values

Biodiversity

A healthy stream system can add great value to the quality of life for that watershed's residents. Diverse biological communities can add to the aesthetic enjoyment and economic value of a watershed's resources. Diverse biological communities can add to the breadth of sensory experiences, attract ecotourism or support industries that rely on renewable natural resources, such as forestry or hunting or fishing.

Biodiversity in the Pennypack Creek Watershed shows signs of succumbing to the pressures of the urban and suburban land uses encroaching on the watershed's natural areas. Large populations of deer, increasing infestations of nonnative invasive plant species and degraded in-stream habitat all reduce biodiversity in the watershed and promote the proliferation of those groups of flora and fauna that have evolved to cope with persistent environmental disturbance.

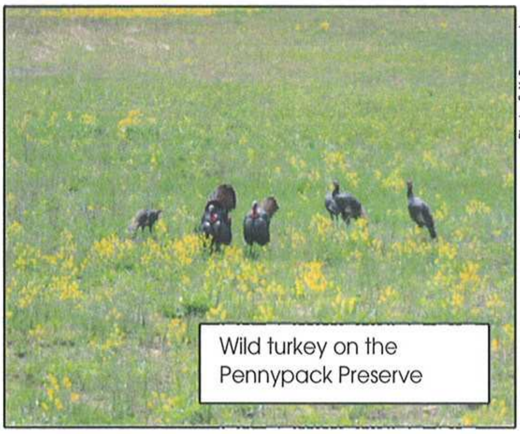


Photo: F. X. Browne, Inc.

Wild turkey on the Pennypack Preserve

As species of plants and animals disappear from the watershed, the watershed's value as a refuge for wildlife, destination for visitors and motivator for environmental stewardship decreases. The Pennypack Creek's biodiversity not only provides economic value to the region but also provides incentives for public stewardship of the resource.

Habitat degradation of the Pennypack Creek has severely limited aquatic biodiversity. According to studies conducted by the Philadelphia Water Department, fish communities are heavily weighted towards generalist feeders that are pollution tolerant. Sport fish such as bass are present but the Creek does not support the numbers of those fish that a healthier stream ecosystem would. Pollution intolerant species of non-indigenous trout are present in the stream because they are stocked by the PA Fish and Boat Commission.

Aquatic benthic macroinvertebrates form the base of the stream system food chain. These organisms inhabit the interstitial spaces between rocks and gravel in the stream bed and perform the important function of breaking down decaying vegetative matter and grazing on algae. Populations of these organisms in the Pennypack Creek are also dominated by pollution tolerant generalist feeders, almost to the exclusion of any pollution intolerant species.

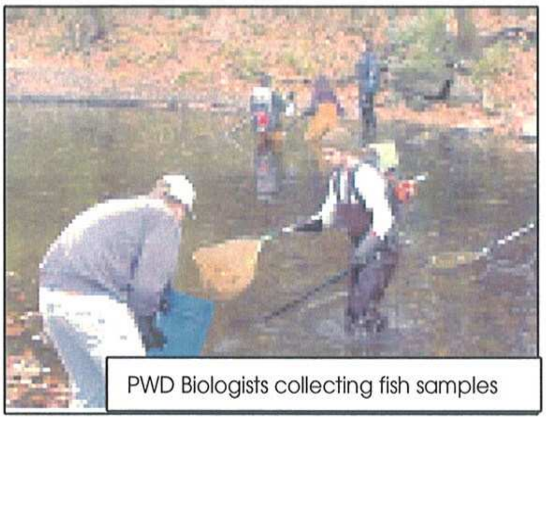


Photo: Philadelphia Water Department

PWD Biologists collecting fish samples

Philadelphia Water Department studies indicate that aquatic community biodiversity decreases as one travels upstream. This observation correlates to the absence of large areas of protected riparian forests or natural areas in the watershed north of the Pennsylvania Turnpike. These headwaters areas are experiencing residential development that has already occurred in the lower watershed area. New stormwater management ordinances make it possible for new development to exert less of an impact on the stream ecosystem than historical development did if these ordinances are faithfully enforced and communities are planned with resource protection in mind.

It is interesting to note that one key person interview performed for this study indicated that residents of the upper watershed lacked the connection to the Pennypack Creek that residents of the lower watershed enjoyed. This lack of connection is certainly due in part to limited access to the creek and a dearth of large public open spaces along the creek. A lack of biodiversity, in the form of a valued sport fishery or highly visible, forested creek corridor may also be a factor in this disconnection.

NUTRIENT CYCLING

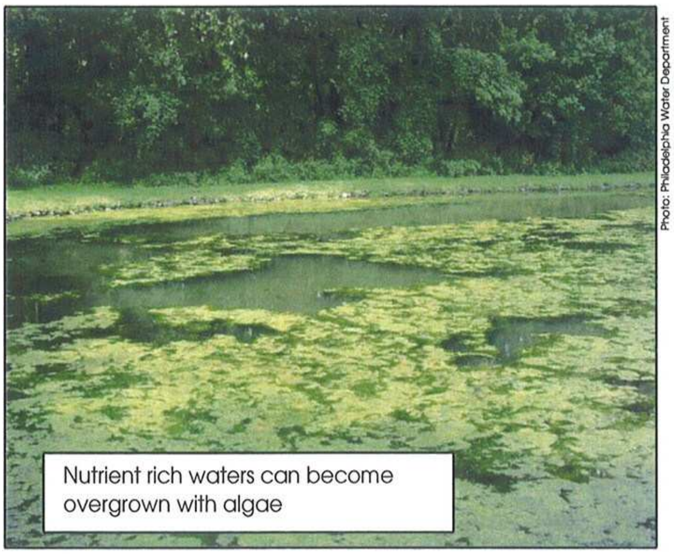
The Pennypack Creek has long been the recipient of wastewater and industrial discharges. Healthy stream ecosystems have the assimilative capabilities to process nutrients such as nitrogen and phosphorous in wastewater discharges and reduce their negative impacts on the stream water quality. The process of uptake and conversion of nutrients by microorganisms and plants is chemically complex but the result is that decaying plant, animal matter or sewage is converted by microorganisms and plants into biomass, vegetative matter or processed into inert gases that dissipate into the atmosphere. Microbial biomass and vegetative matter forms the basis of the food chain that, if not overwhelmed, can result in a healthy and balanced stream community. A stream's assimilative capacity to process and absorb these nutrients provides a service that would cost industry billions of dollars to accomplish with treatment or technical solutions.

Excess nutrients can cause algal blooms

Photo: Philadelphia Water Department

A stream's assimilative capacity can, however, be overwhelmed. Too many discharges or too much of a certain nutrient can disrupt the biological communities in the stream and result in a cascade of negative impacts.

Before the Clean Water Act in 1972, wastewater collection systems discharged untreated or partially treated wastewater into streams and rivers. As more of these dischargers appeared on the Pennypack Creek, the nutrients in the discharges quickly overwhelmed the stream's assimilative capacity to process them. Elevated levels of nitrogen and phosphorous encourage algal growth and while algae are photosynthetic and can produce oxygen, large masses of dead and decaying algae actually consume oxygen. Throughout the night, algae also consume oxygen in water to build biomass until photosynthesis resumes with daylight. Partially treated wastewater also consumes oxygen as microorganisms in the stream break down organic matter in the wastewater. These conditions create low in-stream oxygen levels that result in the decrease of aquatic life that is dependent on oxygen for survival, namely species of fish and benthic macroinvertebrates. Historically, this situation repeated itself in the streams across the Delaware Valley and the nation.



Nutrient rich waters can become overgrown with algae

The passing of the Clean Water Act and subsequent federal funding to upgrade wastewater treatment plants promoted the recovery of water quality in the streams and creeks of the nation. Today, while nutrient inputs from wastewater treatment plants have been greatly reduced, they are still a major source of nutrients to the Pennypack Creek.

Non-point source pollution or polluted stormwater run-off is another major source of nutrients entering the Pennypack Creek. Water quality testing by the Philadelphia Water Department shows that elevated nutrient levels occur in the creek after storm events. Sources of these nutrients include lawn and garden fertilizers, atmospheric deposition from poor air quality, and eroding soil from streambanks and even pet wastes.

Reductions in stream base flow aggravate the nutrient overloading of stream systems. In a natural watershed, streams like the Pennypack Creek are consistently supplied with water from groundwater sources. In urbanized streams, conventional stormwater conveyance systems can prevent water from infiltrating into the ground and providing base flow for streams. Reduced base flow increases the concentration of nutrients in wastewater discharges and reduces the capacity of a stream system to assimilate nutrients.

As with many issues facing the Pennypack Creek, better stormwater management and reductions of non-point source pollution will improve nutrient assimilation and allow the aquatic ecosystem to act as a natural nutrient buffer to downstream waters. The value of this service cannot be underestimated when considering the costs of water quality BMPs or upgrading treatment facilities to remove nutrients from stormwater and wastewater.

5.3 Condition and Functioning

Introduction

The conditions and functioning of a stream system have a direct impact on a water body's uses and values. Poor water quality limits ecological communities as well as recreational and industrial uses of a river or stream. Historic water quality degradation has led many cities and towns to ignore and neglect their surface water resources. This section of the plan will assess the condition and functioning of the Pennypack Creek and analyze how "state of the stream" affects the way residents utilize and value the creek.

Water Quality and Habitat Monitoring

Physical, biological and chemical monitoring is used to evaluate the overall health and condition of a stream system. Water quality and the physical habitats available to biologic communities in a stream system are intricately intertwined. Causes of degraded water quality also affect physical habitats. For example, stream bank erosion not only adds total suspended solids to a stream (a chemical parameter) but also interferes with gill function of aquatic organisms and smothers benthic habitats where many aquatic organisms live (biological parameters). This interaction of water quality, biological communities and habitat quality makes comprehensive watershed management and improvements critical to preserving and improving stream resources.

Water chemistry is an important component of water quality that in part determines the range of biological activities and the diversity and stability biological communities present within a particular stream system. Chemical parameters, from levels of toxic materials to nutrients and dissolved oxygen, all play a role in how a stream functions and how it is valued. Chemical parameters are measured against established water quality standards to assess the potential limitations of a creek or river. For example, water bodies with low dissolved oxygen levels cannot support trout populations and water bodies with high levels of certain chemicals may be unsuitable for drinking water treatment.

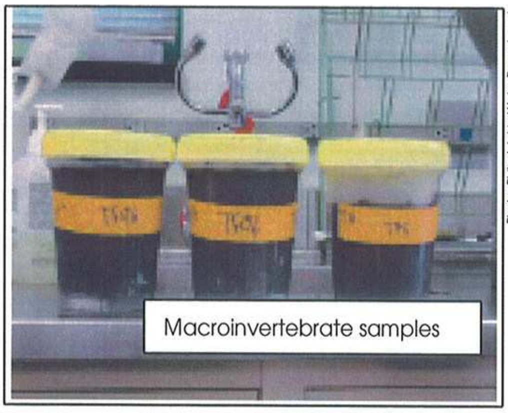


Photo: Philadelphia Water Department

Macroinvertebrate samples

Biological communities, aquatic macroinvertebrates and fish can offer a more holistic insight into stream water and physical habitat conditions. Water chemistry sampling presents a picture of water quality during a brief moment in time. Since biological communities are "full time" residents of a stream or river, the composition of aquatic communities gives insight to the range of water quality and habitat conditions. Species' compositions and the presence or absence of pollution tolerant organisms can even assist in identifying the kinds of pollution affecting a stream.

Significant studies and monitoring efforts have been conducted in the Pennypack Creek Watershed by the PA DEP, PA Department of Health, Philadelphia Water Department and the Academy of Natural Sciences. While chemical water quality has shown some improvement, pollutants in stormwater flows still affect the water quality of the creek and its tributaries, and certain habitat quality and aquatic life indicators have not improved since historical monitoring began in the 1960s.

CURRENT STATUS AND TEMPORAL TRENDS

303d List

Section 303d of the Clean Water Act requires that states assess the water quality in streams biennially. Streams not meeting water quality criteria are placed on a 303d list of impaired waters and the state then must develop a remediation plan. In 1999, PA-DEP assessed the Pennypack Creek Watershed using EPA approved Rapid Bioassessment Protocols. These protocols integrate habitat and biological community assessments to gauge whether a wadeable stream is meeting its designated use. Subsequent PA-DEP assessments indicated that 82% (66 of 79 stream miles) of the stream miles in the watershed were impaired and unable to support healthy aquatic life communities protected by the Clean Water Act. According to the PA-DEP *Watershed Restoration Action Strategy for the Poquessing and Pennypack Creek Watersheds,* all but six of the assessed stream miles in the watershed are impaired by urban run-off, water flow variability and flow and habitat alterations. According to the 303d list, only a small portion (0.34 miles of stream) of the main stem of the Pennypack Creek violates chemical water quality criteria due to elevated levels of pathogens from a municipal point source. Other studies, however, suggest that significant portions of the Pennypack stream system, particularly within the City of Philadelphia, are impacted by pathogens from point source discharges (see below).

The stream miles in the tidal portion of the Pennypack Creek were not assessed under this monitoring program because the monitoring protocol is only applicable to wadeable streams.

Philadelphia Water Department Baseline Assessment

In 2002-2003, the Philadelphia Water Department conducted chemical water quality monitoring at thirteen different locations and biological and habitat assessments at twenty locations throughout the Pennypack Creek Watershed. The Water Department collected weekly chemical samples during the months of January, February, April, May, August, and September for thirty-three physical and water quality parameters. According to the *Baseline Assessment of the Pennypack Creek Watershed*, chemical analysis of the Pennypack Creek Watershed shows evidence of impact from human activities. While most of the parameters monitored met water quality standards, the report noted elevated levels of fecal coliform and nutrients and expressed a potential for improvement for dissolved oxygen parameters.

The report noted that fecal coliform levels violated water quality standards during base flow conditions at some monitoring sites. The most likely sources of these bacterial contaminants included failing or inadequate septic systems, leaking sewer infrastructure, illegally cross-connected sanitary sewers, and domestic or wildlife sources.

The report further identified nutrient concentrations as consistent with point source pollution. The presence of elevated levels of phosphorous in the main stem of the Pennypack Creek downstream from wastewater treatment facilities suggest that nitrogen may the limiting nutrient affecting algal growth or that the system may be co-limited. Thus, significant reductions in both nitrogen and phosphorus may be required in order to reduce algal growth in the Creek,

The *Assessment's* sampling schedule did not allow the Department to develop a comprehensive dissolved oxygen profile of the Creek's water. Grab sampling did not capture minimum dissolved oxygen values nor could the data be used to develop a daily mean value but the creek does appear to be meeting state dissolved oxygen standards. The presence of brown trout of different age classes in the creek suggests that these stocked fish are surviving periods of dissolved oxygen fluctuation.

It is important to note that the chemical sampling included in the *Baseline Assessment* presents a snapshot of water quality conditions in the Pennypack Creek Watershed. Many of these chemical parameters show great temporal and spatial variability and further analysis and assessment are needed to more accurately characterize chemical water quality in the Pennypack Creek Watershed.

Sample collection

Photo: Philadelphia Water Department

Biological and habitat monitoring was conducted during April of 2002 at twenty locations, 14 on the mainstem of the Pennypack Creek and six on tributaries. The Philadelphia Water Department also performed an assessment of the tidal Pennypack Creek using protocols appropriate for that habitat. Results of the assessment indicated that the watershed is characterized as "severely impaired." Impairment appears to be a result of physical habitat degradation as opposed to impairments to water quality. The report indicates that the effects increased stream temperatures, reduced dissolved oxygen, sediment scouring and deposition, and abundance of algal periphyton and fine sediments resulting from large areas of impervious surfaces and stream system modifications skew biological communities to generalist species that are tolerant of degraded conditions. These results confirm the PA-DEP assessment and support listing of the Pennypack Creek and its tributaries on the 303d list of impaired waters.

Pennypack Park Master Plan

As part of the Pennypack Park Master Plan, the Fairmount Park Commission contracted with the Academy of Natural Sciences to conduct a Stream Quality Index (SQI) Assessment of the Pennypack Creek in Pennypack Park. The SQI is based on stream geomorphology, aquatic habitat and riparian condition. This assessment once again reinforces the interconnection between habitat quality and stream function. Results of the assessment indicate that all but one of 77 stream reaches assessed in the Park in 1999 were identified as impaired or moderately impaired with regard to aquatic habitat. The remaining reach was classified as severely impaired.

The study also performed EPA Rapid Bioassessment Protocols on the Pennypack Creek and obtained findings consistent with the PA-DEP and aforementioned Philadelphia Water Department studies. The biological communities of fish and aquatic macroinvertebrates in the Pennypack Creek are typical of impaired aquatic systems.

Historic Water Quality Data

The PA-DEP and PA Department of Health conducted chemical and biological water quality monitoring from 1969 to 1980 (Health Department monitoring ceased in 1974). These studies indicate that the water quality Pennypack Creek Watershed was impaired in 1969. Sources of impairment were noted to be point source discharges from overburdened wastewater treatment plants and failing or malfunctioning septic systems and sewer infrastructure. Later reports (PA-DEP 1980) indicated that sediment from stormwater flows were contributing to impaired water quality and degradation of in-stream habitats of the Pennypack Creek even as inputs from point sources and failing sewer infrastructure continued.

MAJOR STRESSORS

Stormwater Effects

Current and historical water quality monitoring indicate that stormwater flows have had a significant impact on the quality of the Pennypack Creek and its tributaries since at least the 1970s. Flow variations resulting from lack of base flow, large areas of impervious cover and inadequate stormwater management have contributed to streambank erosion, sedimentation of benthic habitats and unstable stream morphology.

These forms of water quality impairment are in some ways more difficult to address than chemical water quality parameters as stormwater has multiple sources and improvements in stormwater management entail considerable capital infrastructure improvements.

Wastewater Effluent

Wastewater effluent has been a historic source of biological and chemical impairment in the Pennypack Creek Watershed. Early water quality studies by the PA Department of Health and the PA-DEP indicate that the Hatboro-Upper Moreland Wastewater Treatment Plant was operating at above capacity and releasing poor quality effluent for a number of years in the early 1970s. Other smaller wastewater "package plants" were also discharging elevated levels of nutrients and pathogens into the Pennypack Creek and its tributaries. Improvements in wastewater treatment, collection system infrastructure and consolidation of systems have helped to reduce wastewater inputs into the Pennypack Creek.

Combined Sewer Overflows in the lower watershed basin continue to pose a challenge for water quality in the Pennypack Creek. These overflows deliver untreated sewage directly into the creek during times of heavy precipitation. Combined Sewer Overflows are occurring less frequently due to measures being taken to control them, which are discussed in more detail later in this chapter.

Current water quality studies indicate that leaking sewer infrastructure and failing septic systems still contribute to nutrient and bacterial levels in the watershed. High levels of fecal coliform in base flow conditions and elevated phosphorous levels indicate that gains still need to be made to reduce these inputs.

According to the EPA there are four wastewater treatment facilities discharging into the Pennypack Creek or one of its tributaries. The largest is the Upper Moreland-Hatboro Joint Municipal Authority Wastewater Treatment Plant which is permitted to discharge over seven million gallons of treated wastewater each day. Table 5.1 is a list of the wastewater treatment facilities in the watershed and their permitted discharge amounts. Figure 5.15 is a map of the permitted wastewater treatment plants that discharge into the Pennypack Creek Watershed.

Table 5.1 Wastewater Dischargers in the Pennypack Creek Watershed

Facility	Receiving Stream	Permitted Discharge (million gallons per day)
Bryn Athyn Borough / Academy of the New Church	Huntingdon Valley Creek	0.065
Chapel Hill (Lower Moreland Authority)	Southampton Creek	0.279
Meadowbrook Apartments	Pennypack Creek	0.106
Upper Moreland - Hatboro Joint Sewer Authority	Pennypack Creek	7.173

Source: U. S. EPA Envirofacts Warehouse

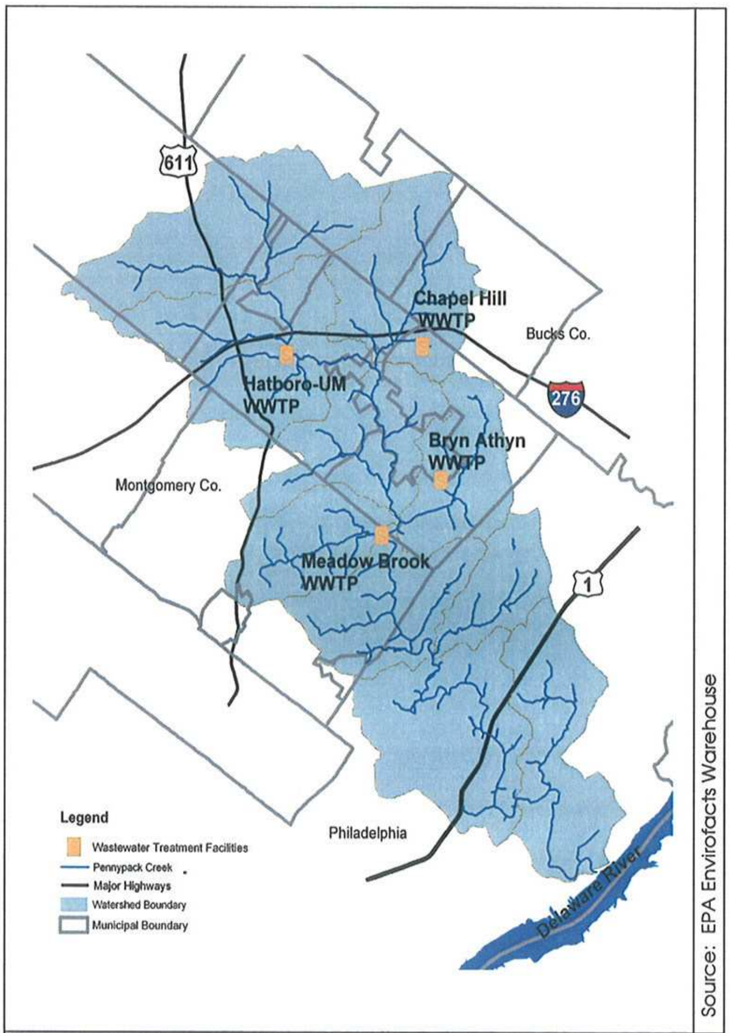


Figure 5.15 Wastewater Treatment Plants Discharging into the Pennypack Creek Watershed

Cross Laterals

Illegally connected cross laterals are an additional, uncontrolled source of raw sewage input into the Pennypack Creek Watershed. Cross-laterals occur when a sanitary sewer line is connected to the stormwater collection system. These cross laterals allow untreated sewage to be discharged directly into a stream or other waterbody. Dry weather storm sewer discharge is one indication of potential illegal sewer lateral connections.

As a condition of the NPDES Phase II Stormwater regulations, municipalities are required to identify dry weather storm sewer discharges and inventory their stormwater infrastructure. Elimination of illegal cross lateral connections will greatly improve water quality, especially in the lower end of the watershed.

Other Point Sources

There are 20 NPDES permitted point source discharges in the Pennypack Creek Watershed, four of which discharge wastewater effluent into the watershed's streams. Information regarding discharge flows and composition was not available in the EPA NPDES database, however industrial point sources are not indicated as a source of impairment in this watershed. Table 5.2 identifies the permitted NPDES discharges in the watershed, their permit numbers and industry type.

Table 5.2 Permitted NPDES Discharges into the Pennypack Creek Watershed

NPDES ID Number	Facility Name	Facility Type
PA0030023	Bryn Athyn Borough Sewage Treatment Plant	Sewerage Sytems
PA0012238	ABB Automation Inc	Industrial Instruments
PAR130001	American Bank Note Company	Commercial Printing
PAR500003	Bethayres Reclamation Corp	Refuse Systems
PAR230003	Bostik Incorporated	Adhesives And Sealants
PAG050064	BP Products Na Inc	Gasoline Service Stations
PA0046868	Chapel Hill WWTP	Sewerage Systems
PA0052922	Conte Luna Foods Inc	Pasta
PAR210004	Delaware Valley Concrete	Ready-Mixed Concrete
PA0052256	Fredericks Company	Glass Products
PA0050831	HPC Associates	Sewerage Systems
PA0057533	Jacks Auto Repair Inc	Gasoline Service Stations
PAG050030	Kayo Oil 2705824	Gasoline Service Stations
PAG050054	Motiva Ent Llc	Gasoline Service Stations
PA0022411	Naval Air Station Joint Reserve Base Willow Grove	National Security
PAR230030	Procter & Gamble Company	Pharmaceutical Preparations
PAR110044	Refreshment Machinery Incorporated	Automatic Vending Machines
PA0038296	Sun Company Incorporated Willow Grove Terminal	Petroleum Bulk Stations And Terminals
PAR800068	United Parcel Service Inc	Courier Services
PA0025976	Upper Moreland Hatboro Joint Sewer Authority	Sewerage Systems

Source: EPA Envirofacts Warehouse

Riparian Corridor Removal

Riparian vegetation shades stream channels, holds streambank soils in place and provides leaf litter and structure for aquatic organisms to utilize. Widespread removal of riparian vegetation affects chemical water quality, impacts biological communities, and impairs physical stream habitat.

As noted in previous chapters, large areas of the lower Pennypack Creek Watershed are protected in preserved land that contain significant riparian corridors (noting issues associated with increasing infestations of invasive plant species and negative impacts of deer browse). The stream segments in the upper reaches of the watershed, particularly above the Pennsylvania Turnpike (I-276), are generally more poorly buffered. Removal of riparian buffers in the headwaters and the upper reaches of the watershed have had a negative impact on the water quality and in-stream habitat of the entire Pennypack Creek Watershed as pollutants contained in stormwater run-off and increased stormwater velocities are introduced to stream channels and exported downstream.

Photo: F.X. Browne, Inc

Abandoned bridge at Huntingdon Pike is an example of a constriction on the stream

Hydrologic Modifications

Dams, channelization and confinement and other hydrologic modifications of the Pennypack Creek have altered the water quality chemistry, biologic communities and physical stream habitat in the watershed.

Historic dams and other flow restrictions such as bridge crossing and culverts have interfered with natural sediment transport in the watershed. Dams and other restrictions slow the flow of water and result in sediment deposition upstream of the structure. These pools contribute to elevated stream temperatures, reductions in aquatic habitat and decreases in dissolved oxygen in the water. Dams also have an obvious effect on preventing upstream passage of fish, including anadromous species that live in estuaries and the ocean and spawn in fresh water. Channel restrictions often result in inundation and increased flooding of upstream areas during times of heavy flow. These structures often result in downstream bank erosion and channel degradation as flows are concentrated through bridge and culvert openings (see discussion of geomorphic impacts, below).

Stream channelization and confinement also alter sediment transport regimes and effect downstream habitat and water quality. Channelized streams carry increased velocities that erode stream banks and channels. Once a channelized stream enters a natural stream channel, velocities are reduced and sediments settle out of the water, smothering aquatic habitat and ultimately exacerbating flooding. Channelization also interferes with the interaction between a stream system and its riparian corridor.

IMPACTS ON USES AND VALUES

Stormwater and wastewater discharges have exerted considerable negative impacts on the health and enjoyment of the Pennypack Creek and its tributaries. Habitat degradation associated with stormwater flows has impacted aquatic communities and recreational opportunities afforded by the creek. Continued success of fish stocking efforts and restoration of the hickory shad run on the Pennypack Creek are dependent on maintaining and even improving water and habitat quality in the watershed.

Elevated bacteria levels make the Pennypack Creek unsafe for swimming

Photo: F.X. Browne, Inc.

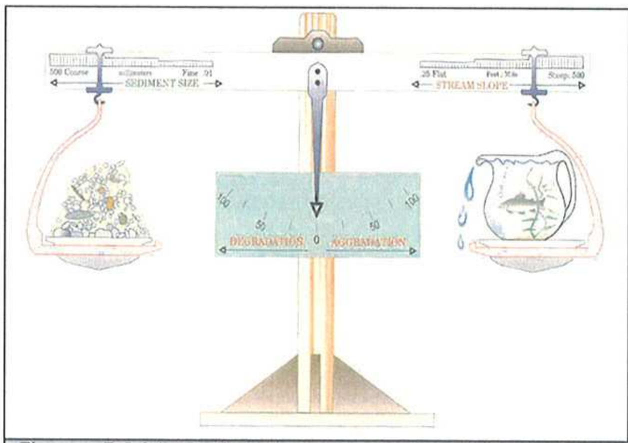
Wastewater discharges and failing sewer and septic systems contribute bacteria, pathogens and nutrients to the watershed's streams and make swimming in the creek unadvisable, especially after storm events. Excess nutrients and associated algal blooms can cause offensive odors and affect enjoyment of the stream.

These negative impacts are especially apparent in areas of the watershed that lack natural stream buffers and opportunities for stream water quality to recover from upstream discharges.

Dams and other infrastructure that impede natural stream flows have contributed to reduced habitat and water quality throughout the watershed. Alteration in sediment transport and the flow regime of the streams in the watershed has created a stream system that is out of balance. Flooding, erosion and sedimentation issues that affect property values, reduce recreational opportunities and native aquatic habitats are all a result of the stream's response to these anthropogenic stressors.

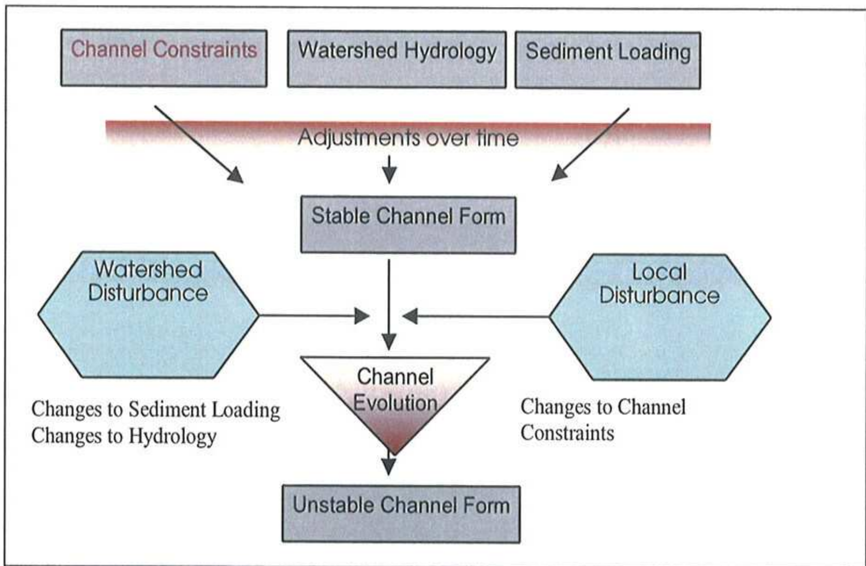
Geomorphic Stability

Stable stream channels exist in a state of dynamic equilibrium in which the pattern, profile, and dimension of the stream channel allow the transport of sediment with the available flow to the stream, within the context of stream valley constraints. Changes to watershed hydrology, sediment loading, or stream channel boundary conditions (e.g., channel confinement or removal of riparian vegetation) can disrupt the channel's dynamic equilibrium, stimulating adjustment processes within the channel (e.g., widening, lateral migration of meanders, downcutting, aggradation). Through these adjustment processes, the stream channel attains a new equilibrium in which the new channel form reflects the changes in external watershed and stream corridor conditions. Figure 5.16 is a conceptual picture of the equilibrium between stream hydrology and sediment transport capacity. An increase in either input disrupts stream equilibrium. Figure 5.17 outlines the process of stream channel evolution.



Source: Federal Interstate Stream restoration Working Group

Figure 5.16 Lane's Balance Lane's balance describes the equilibrium between stream hydrology and sediment transport.



Source: F.X. Browne, Inc.

Figure 5.17 Stream Channel Evolution.
Local and watershed disturbances can disrupt stream equilibrium and result in unstable stream channels.

In particular, urbanization can change the amount, timing, and volume of water delivered to streams, as well as the amount and type of sediment supplied to streams. These changes can stimulate geomorphic instability within stream channels that drain urban watersheds. These changes are conceptualized in channel evolution models (CEMs), which describe predicable responses in channel form following landscape urbanization. Major adjustment processes in stream channels include stream incision and aggradation, which are discussed in more detail below.

Severely incised stream channel in a suburban neighborhood outside of Philadelphia

Stream Incision

As the frequency and intensity of storm runoff from urban landscapes increases, headwater stream channels typically downcut (e.g., lower their bed elevation) in response to increased stream energy. Stream incision can also be stimulated by straightening of stream channels, which increases stream slope.

Severely Incised stream disconnected from its floodplain

The process of incision creates conditions that lead to stream widening through bank erosion and failure. This occurs for several reasons. Incised stream channels in urban settings tend to have high, steep banks that are prone to erosion. As the incision process proceeds, root systems of existing vegetation on the top of the streambank no longer reach to the base of the stream channel. The absence of root structures at the base of the stream channel increases the vulnerability of the lower bank areas to erosion processes. Further, because of high bank height, incised streams flood less frequently. Consequently, the energy dissipation that occurs as stream flows overtop the stream bank and flow on the floodplain cannot occur. The containment of flood flows within the active channel increases erosive forces within the channel, which further contributes to bank erosion and failure and stream widening. Figure 5.18 illustrates how these changing forces affect stream channel morphology.

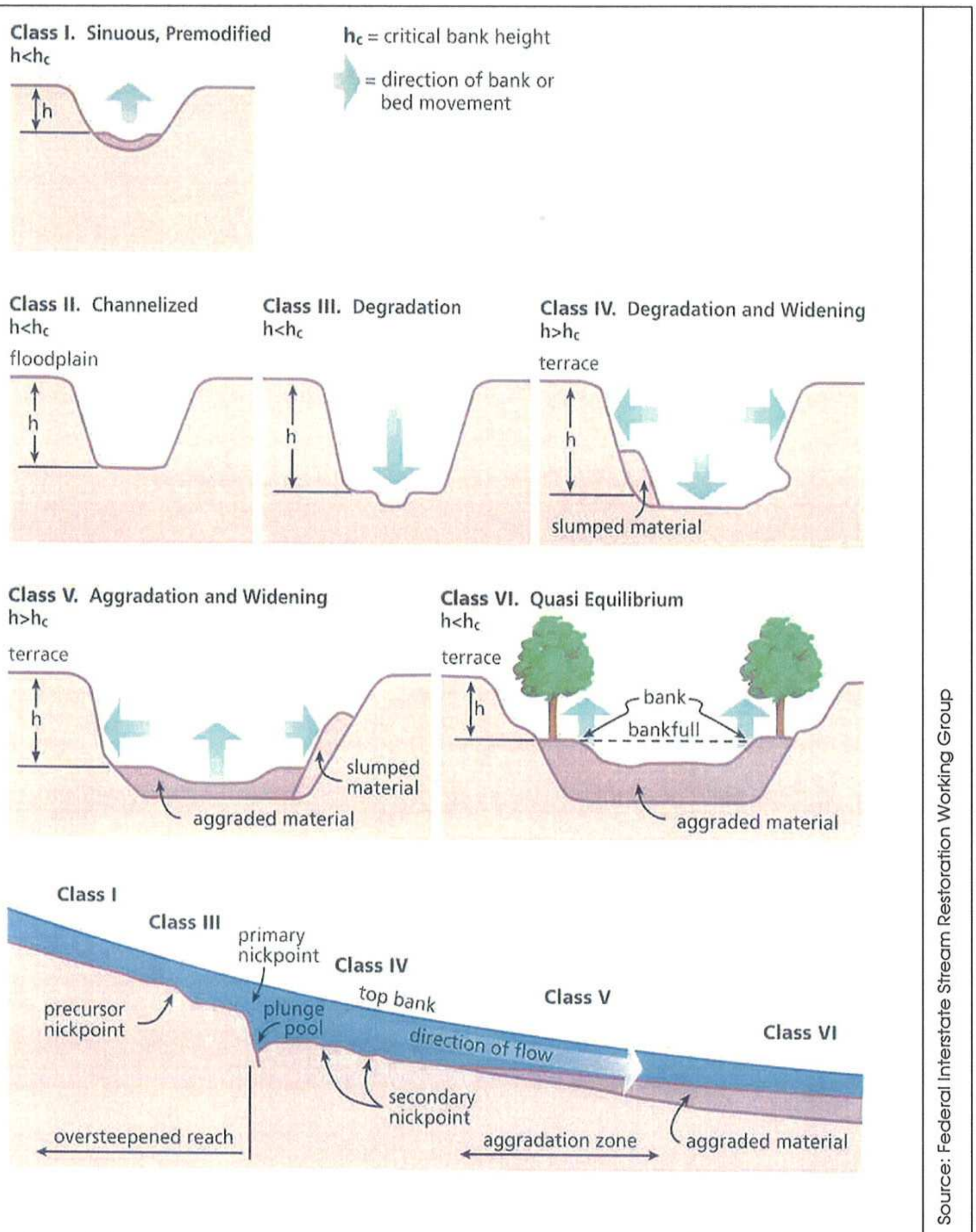


Figure 5.18 Channel Evolution Model.
Stream systems exhibit typical adjustments as surrounding landscapes urbanize.

Incised and widening streams create problems for infrastructure in and around the stream corridor. Utility lines, once buried beneath the stream, are exposed as the streambed elevation lowers or as streambanks retreat. Bridge abutments and foundations can be compromised as the stream channel downcuts. Retreating streambanks endanger roadways, buildings and other infrastructure.

Although incised streams will eventually attain equilibrium and develop a new floodplain, active intervention through bank and channel stabilization often prevents this eventual equilibrium point from establishing. Historically, threats and damage to infrastructure as a result of incised streams have prompted attempts to stabilize the incising stream channels using structural means including bank stabilization using rock revetments or concrete walls, the lining of stream channels with concrete or rock, the straightening of stream channels, and confinement of open channels within pipes and culverts. These and other management approaches can further destabilize stream systems, reduce the aesthetic quality and accessibility of stream systems, compromise physical stream habitat, and restrict the movement of stream organisms within the stream channel.

In addition to causing infrastructure damage, the incision of stream channels has other consequences. First, stream incision tends to simplify the range of physical habitats found in the stream. Incised stream channels typically lack the full range of flow velocities, water depths, and hydraulic conditions that characterize undisturbed channels. Attempts to stabilize incised stream using structural means further degrade in-stream habitat through the disruption of natural bank vegetation, the elimination of stream shading, and the removal of debris piles and large woody debris inputs to the stream.


Stream incision frequently results in exposed infrastructure including utility lines and sewer pipes.

Photo: F. X. Browne, Inc.

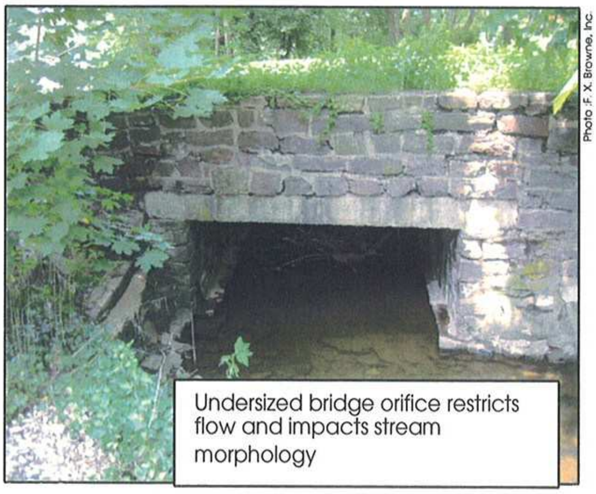
Incised and widening headwater streams represent a tremendous source of sediment supply to downstream reaches. Increases in sediment supply as a result of incised and widening streams are seldom quantified. Increases in sediment loading can have consequences for the geomorphic stability, habitat quality, and water quality of downstream reaches. First, increases in sediment supply to downstream reaches can cause these reaches to aggrade (i.e. increase bed elevation). The aggradation process represents an opposite, but no less destructive stream adjustment process to the incision process. Siltation within aggrading stream reaches often results in the filling of pool habitats and the clogging of riffle habitats. Both of these processes have important consequences for physical habitat quality.

Stream Aggradation

Downstream channel aggradation has the opposite effect on flood frequency as stream incision. Because of increasing bed elevation and lower bank height, flood frequency increases in aggrading stream reaches. Together with increased runoff volume and peak flows, aggradation within urban streams can produce overbank flooding 10-15 times per year or more. Increases in flood frequency and magnitude often result in an increase in the frequency and magnitude of flood damage. The presence of undersized bridges and culverts that retard the passage of flood waters can further increase the severity and frequency of flooding events.

Increases in flooding as a result of channel aggradation, changes to watershed hydrology, and channel constrictions create the need to reduce flooding. Historically, typical approaches to reducing flooding have included the construction of levees and floodwalls. Such responses sever the connection between the active stream channel and the floodplain, and have important consequences for stream processes including nutrient and organic matter cycling, and the movement of aquatic organisms including fish.

INFLUENCE OF CHANNEL MODIFICATIONS



Undersized bridge orifice restricts flow and impacts stream morphology

In addition to changes to watershed hydrology and sediment loading, urbanization often results in direct changes to stream corridors. These changes include the removal of riparian vegetation and wetlands, regrading and filling of floodplains, removal of large wood and debris piles from the active stream channel, piping and/or burial of stream channels, structural bank stabilization, channel straightening, lining, and dredging, and bridge and dam construction. Some of these processes occur in direct response to channel widening or incision (e.g., bank stabilization), while some are simply related to the expansion of the urban landscape (e.g., bridge construction).

Direct channel modifications are also an important trigger for stream adjustments. For example, bridge construction often results in the confinement of the stream channel, which accelerates flow through the bridge opening. This accelerated flow, in turn, creates bed scour within and immediately downstream of the bridge opening. The resulting material is then transported downstream where it often accumulates within a mid-channel bar. This sediment accumulation often results in the redirection of stream flow into adjacent streambank areas, causing streambank erosion. In many urban streams, these and other local stream adjustments are taking place within the context of larger-scale adjustment channel processes instigated by land use changes.

CURRENT STATUS AND TEMPORAL TRENDS

Geomorphic stability is difficult to directly measure over short time spans. Visual evidence including high banks and exposed infrastructure can be helpful in identifying incised or actively widening stream reaches, while observation of filled pools, low bank height, and buried outfall can assist in identifying aggrading reaches. Review of historical photographs and discussions with creekside residents can assist with corroborating these conclusions. That said, the only definitive method for diagnosing geomorphic stability is through repeated measurements of channel profile, pattern, and dimension over time, or through direct measurement of sediment transport over time. Historical analysis of flow data from gauging stations (e.g., flood frequency analysis) can help to identify changing hydrologic conditions which may stimulate channel adjustments.

In the Pennypack Creek Watershed, as in many other urban streams, a comprehensive assessment of geomorphic stability, either through visual inference or direct measurements, has not been performed. Currently, the Philadelphia Water Department is conducting a comprehensive geomorphic assessment of the Pennypack Creek Watershed. Unfortunately, the results of this study will not be prepared in time for inclusion into the River Conservation Plan. This study should help to further assess the geomorphic condition of streams throughout the Pennypack Creek Watershed.

Based on the extent of urban development in the Pennypack Creek Watershed, we can assume that many of the channel adjustment processes typically found in urbanizing watersheds have or are taking place within Pennypack Creek and its tributaries. Much of the urban and inner suburban development within the Pennypack Creek Watershed predates stormwater management regulations. Thus changes to stormflow rates and volumes within the areas were most likely sufficient to produce significant channel adjustment processes. The magnitude of channel adjustment processes may be somewhat lessened by the fact that much of the watershed historically supported poorly drained soils. Thus, the magnitude of hydrologic change in the watershed may be somewhat less than in watersheds supporting well drained soils.

Like many streams in the region, the Pennypack Creek supported dozens of milling operations during the 1700 and 1800s. Most of these operations required the construction of on-line mill ponds, which were created by damming the stream channel. This process resulted in the build up of, in some cases, many feet of sediment behind the mill dams within the active stream channel. The largely agricultural nature of the watershed during the 1700 and 1800s meant that large volumes of fine grained sediments from field erosion were delivered to the stream on a regular basis. This source of sediment in conjunction with the presence of mill dams throughout the watershed produced conditions that resulted in channel aggradation. As streamflows increased from increasing urban landscapes, it is likely that streams in the watershed rapidly downcut through these unconsolidated deposits.

The presence of a largely intact stream corridor along much of the main stem of Pennypack Creek has undoubtedly reduced the severity and intensity of channel modifications within this area. Thus, local channel instability created by such activities as bridge constrictions, riparian vegetation removal, channelization, and bank revetments may be less severe than in many other urban watersheds. Many of the large bridges that traverse the Pennypack Creek Park (e.g., Rhawn St. Holme Avenue, Roosevelt Blvd.) span the entire floodplain and do not present significant geomorphic obstructions. There are many small bridges and culverts that carry park trails across tributary streams. Many of these bridges and culverts are causing local scour and erosion problems (FPC, 2001).

Perhaps the best indication of the geomorphic alteration in the Pennypack Creek Watershed comes from research performed by the Patrick Center for Environmental Research on the geomorphic condition of Fairmount Park streams (Cianfrani et. al, 2000). Researchers compared channel morphology for 19 channels in Fairmount Park with 167 channels in undeveloped, rural areas elsewhere in the state. Results showed that Fairmount Park stream channels were 110% wider and 80% deeper than rural channels. Bank angles of streams in Fairmount Park were steeper than rural streambank. Also, 20% of stream channels in the Fairmount Park system were found to possess active floodplains, compared with 60% for rural stream segments. Pool/riffle sequences were less common in Fairmount Park streams and pools were shallower in Fairmount Park streams than in rural streams.

While stream corridor modifications along the central and lower main stem of Pennypack Creek have been restricted by the presence of protected lands, several areas within Pennypack Park, particularly in the lower sections of the park, appear, from informal observation, to be actively aggrading. In these areas, we observed the presence of extensive mid-channel bar deposits, low bank height, and an absence of deep pools. Our observations of the main stem of Pennypack Creek within the Pennypack Preserve as well as Lorimer Park revealed only moderate evidence of geomorphic instability. In general, stream channels in these areas do not exhibit symptoms of incision or aggradation, although areas of bank erosion are certainly present throughout.

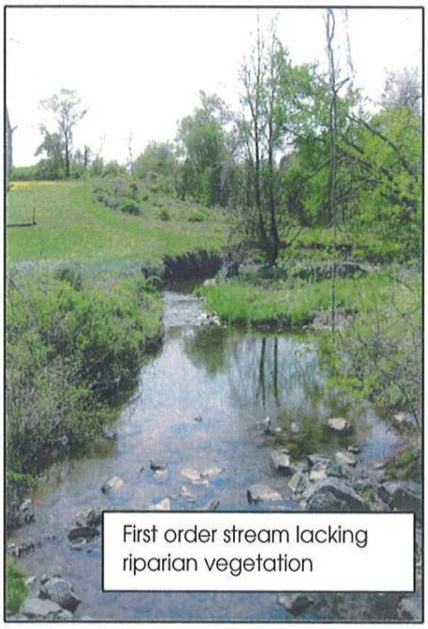
Many of the tributaries that flow into the Pennypack Park, Lorimer Park, and the Pennypack Preserve, originate outside of protected lands. Based on informal observations, many of these tributaries appear to be deeply incised and/or widened. For instance, Wooden Bridge Run, which runs from the Northeast Philadelphia Airport to Pennypack Creek Park, appears to be severely incised throughout much of its length. For example, we found clear evidence of channel widening in a tributary within Lorimer Park.

Upstream of the Pennypack Preserve and in tributary systems such as Southampton Creek, Huntingdon Valley Creek, and Meadow Brook, the majority of streams in the Pennypack Creek Watershed flow through marginally wooded riparian areas in close proximity to active urban landuses. In many of these areas, the stream channels are traversed by dozens of bridges, many of which appear to be significantly constraining the stream channel. These bridge constrictions may be having isolated and cumulative impacts on geomorphic stability. From a review of aerial photographs, many stream segments within the upper portion of the watershed appear to have been artificially straightened. Straightened stream reaches are particularly prevalent along major rail corridors near industrial areas and along the Pennsylvania Turnpike corridor.

Major Stressors

Stormwater Effects

The unregulated flow of stormwater into streams within the Pennypack Creek Watershed is undoubtedly the leading source of geomorphic instability within the channel. Because most of the watershed is significantly built-out and lacks stormwater controls, the changes in hydrology as a result of urban development in the Pennypack Creek Watershed have most likely been severe.



First order stream lacking riparian vegetation

Photo: F.X. Browne, Inc.

What is not known is the exact extent of the geomorphic instability that these land use changes have produced, and whether active channel adjustment processes are still occurring in large measure.

Stormwater impacts of geomorphic channel stability are most severe in Subwatersheds 1, 2, 3, 5, 7, 8, 9, 10 where impervious surfaces associated with commercial, residential, and industrial development cover the majority of land surface and significant stormwater infiltration, detention, or retention devices are generally absent. The many steeply sloping tributaries that flow into Pennypack Creek Park and drain highly urbanized sections of northeast Philadelphia may be particularly affected by stream incision processes. Land uses in the Subwatershed 6 and particularly Subwatershed 4 are less intensely urban. As a result, stormwater-related geomorphic impacts may be less severe in these subwatersheds.

Riparian Corridor Removal

The removal of riparian vegetation has occurred to varying degrees throughout the Pennypack Creek Watershed and may be contributing to increased bank erosion rates and localized geomorphic instability in various locations. The removal of riparian vegetation can also increase the vulnerability of stream channels to changes in hydrology and may accelerate channel adjustment processes. According to GIS mapping of riparian corridor completed by the Heritage Conservancy, approximately 72% of the stream miles within the watershed are buffered by forest vegetation on both sides of the stream, while 22% lacked a buffer on one side of the stream, and 14% of stream miles lacked a buffer on both sides of the stream. These statistics, however only tell part of the story. If the sections of the main stem Pennypack Creek that are protected by Pennypack Park and other protected lands are subtracted, the percentage of unbuffered stream miles increase somewhat. Also, the fully-buffered segments identified in the Heritage Conservancy Study include segments with thinly forested or highly degraded buffers. The study does not differentiate buffers on the basis of width or vegetation quality. Thus, the percentage of stream miles that are well buffered by mature forest is likely far lower than 72%.

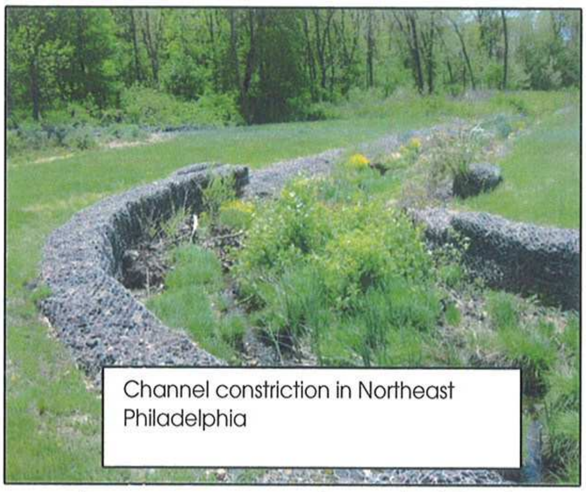
In general, extended stretches of stream where the riparian corridor has been completely removed are fairly rare. We did observe several locations where streams flowing through and adjacent to industrial parks were poorly buffered for distances of several hundred feet. These areas include Huntington Valley Creek along Philmont Avenue upstream and downstream of Red Lion Road, as well as along the western side of Park Avenue in Warminster Township. Riparian buffer removal is also pronounced within several of the golf courses in the watershed including Huntington Valley Country Club and Philmont Country Club.

Hydrologic Modifications

Hydrologic modifications include bridge and culvert constructions, buried and piped stream segments, channelized stream reaches, dams, areas of floodplain filling or regrading, bank revetments, and channel lining. Paradoxically, many of these features represent an attempt to control geomorphic stream instability, but act instead to further destabilize stream systems.

Bridge Constrictions

Although bridge constrictions in the Pennypack Creek watershed have not been extensively inventoried, we estimate that there are upwards of 200 bridges within the Pennypack Creek. Informal observation indicates that many of these bridges are undersized and present significant local impacts to geomorphic stability. Further, the cumulative impact of bridge constrictions on the overall stability of the stream system is not known.



Channel constriction in Northeast Philadelphia

Photo: F. X. Browne, Inc.

Channelization

Stream channelization severely disrupts channel form and can encourage stream incision by increasing slope. Most of the stream miles within the Pennypack Creek Watershed do not appear to have been straightened or channelized. However, many stream segments within the Pennypack Creek Watershed have been artificially straightened. Informal observation and review of aerial photographs indicate that the majority of straightened stream reaches are associated with the Pennsylvania Turnpike (I-276) as well as industrial complexes that occur along major rail corridors. Several other channelized stream segments are associated with commercial and industrial complexes where streams have been rerouted along the property margins.

Burying and Piping

Buried and piped streams represent a nearly complete destruction of natural channel processes including overbank flooding and groundwater interaction and a complete loss of natural channel features including riffles, pools, meander bends, and stream banks. Several miles of stream within the watershed have been buried or piped. Headwater streams and associated wetland complexes in agricultural areas were often drained to increase the area of productive land. In the City of Philadelphia and, to a lesser extent, in the suburbs, streams were filled or piped to maximize the land area available for development. Stream valleys were often filled with coal ash and other waste materials.

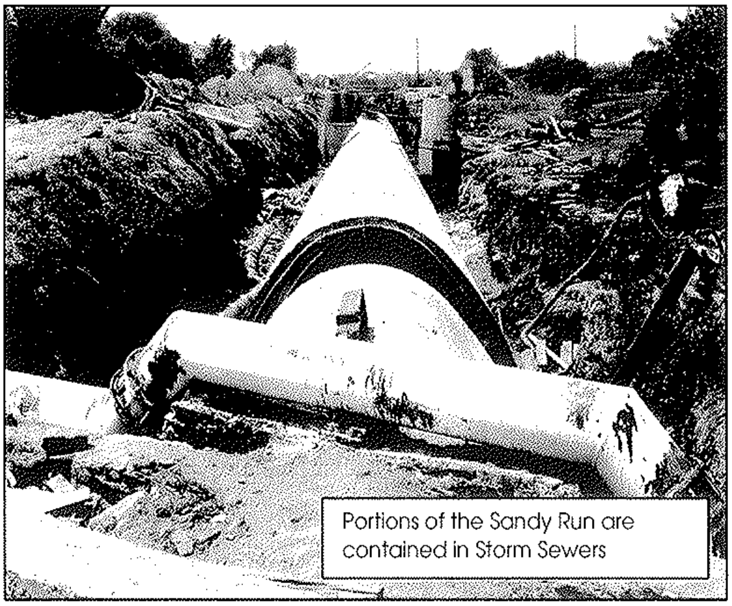

Portions of the Sandy Run are contained in Storm Sewers

Photo: Philadelphia Water Department

Incidences of buried and piped stream segments are found throughout the Pennypack Creek Watershed, especially in the Sandy Run Watershed (Subwatershed No. 9). In the Sandy Run Watershed vast sections of the stream network were filled and enclosed in underground sewer lines that now run underneath the Rhawnhurst section of Northeast Philadelphia. The USGS report analyzing topographic change within the City of Philadelphia (USGS, 2000) clearly shows the locations of buried stream valley network that once drained the Sandy Run Subwatershed.

While Sandy Run is the most extensive incidence of stream enclosure within the watershed, it is certainly not the only example. Aerial photographs reveal many other instances where a visible stream channel disappears only to reappear several hundred yards later. In other cases, GIS stream line coverages pass directly through existing buildings, or existing headwater streams dead end thousands of feet downstream of where drainage patterns suggest source areas of the stream should be located. In addition to the Sandy Run subwatershed, numerous buried and piped stream segments occur in Subwatershed 8 – Lower Pennypack, (drained by Paul's Run), Subwatershed 10 – Mouth of Pennypack, (drained by Wooden Bridge Run). We also identified a significant section of an unnamed tributary located west of Park Avenue in Warminster Township that may have been buried or piped.

Dams and Impoundments

Dams and impoundments also have significant impacts on stream geomorphology. Dams alter the energy of water flow in both upstream and downstream reaches and represent a physical barrier for the transport of large particles along the stream bottom (bedload). Upstream of a dam, flow is typically retarded, leading to the localize deposition of suspended sediments within the active stream channel. Downstream of dams, sediment-starved water often creates highly erosive conditions that result in channel downcutting and armoring. Historically, more than 30 dams were located on streams with the Pennypack Creek Watershed. Most of these dams were created to support milling operations. By 1900, most active milling operations within the watershed had ceased and many of the dams were presumably either removed or breached during storm events.

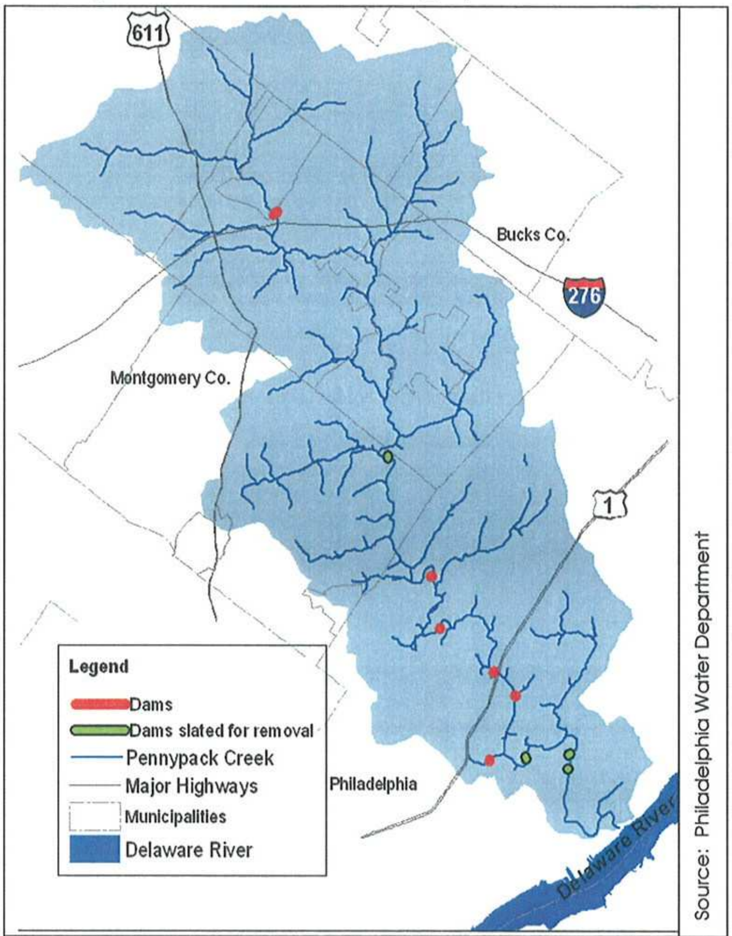


Figure 5.19 Existing Dams on the Pennypack Creek

Today, there are eight remaining dams in the Pennypack Creek Watershed. All of these structures are so-called run-of-the-river dams whose impoundments are generally contained within the active stream channel. Several of the dams have been partially breached. Given the size, condition and age of the dams, it is unlikely that these structures represent significant impacts to geomorphic stability. Significant efforts are underway in the watershed to remove four of these structures (Frankford Avenue Dam, Rhawn St. Dam, Lorimer Park Dam, and Spring Dam). Because many of the dams have been in place for over 150 years, the removal of the dams could create a source of geomorphic stability. Stream channels often undergo active adjustment and downcutting following dam removal. Figure 5.19 shows the locations of the existing dams on the Pennypack Creek.

Impacts on Uses and Values

The impact of alterations to stream geomorphology is hard to quantify in the Pennypack Creek Watershed. First, the extent of geomorphic alteration and stream adjustment has not been well studied in this watershed to date. The on-going PWD Geomorphic Assessment should go a long way to better understanding the extent of geomorphic impacts within the watershed. Second, geomorphic form and stability affect many other aspects of stream condition and function including stream aesthetics, downstream water quality, stream accessibility, habitat quality, lateral and longitudinal connections, and in-stream flows. However, the exact connection between stream geomorphology and these other functions is difficult to document and measure.

Certainly geomorphic alternations have had profound impacts on the physical habitat diversity and quality within the Pennypack Creek. Both stream incision and aggradation can significantly reduce the variety and quality of in-stream physical habitats. Among other impacts, incised streams are generally less integrated with adjacent riparian and floodplain habitats. The diversity of channel velocity, particle sizes, and depths is often reduced by the incision process resulting in simplified channel structures that offer limited sources of stable substrate for aquatic communities and refugia for macroinvertebrate and other aquatic organisms from disturbance, debris jams and sources of large wood. Similarly, aggraded channels often lack stable substrate and lack of pool and riffle habitat sequences.

Stream aggradation within lower gradient stream reaches may be partially responsible for increasing flooding frequency and magnitude. Flooding continues to be a major concern in the Pennypack Creek Watershed and the role of channel morphology in the flooding process needs to be better understood. While natural streams should regularly flood, sediment accumulations within aggrading channels may decrease channel capacity to the point where even small rain events produce significant floods.

There is evidence that geomorphic instability may reduce the perceived quality and value of stream channels for recreational purposes. Incising or aggrading channels impair the visual qualities of stream channels, creating the perception that the stream is either clogging with sediment or has become nothing more than a "gully".

Still, the exact correlation between geomorphic condition and habitat quality in the Pennypack Creek Watershed is poorly described. At best, data collected by the Patrick Center for Environmental Research, for the Fairmount Park Master Plans suggests that the link between geomorphic condition and habitat quality is complex. As part of the development of Natural Lands Restoration Plans for the various Fairmount Park components, Patrick Center researchers assessed riparian corridor quality, in-stream habitat quality, and geomorphic condition for more than 400 stream reaches covering over 60 km of stream channels within Fairmount Park. The approach used various visual observations and stream measurements to construct an index value for each parameter. Surprisingly, this research showed no relationship between geomorphic condition and habitat quality. Riparian condition was not significantly correlated with geomorphic condition or habitat quality. This research demonstrates that linkages between stream geomorphology and commonly ascribed habitat values are, at best, complex. Nevertheless, given our current understanding of stream systems, geomorphic change is most likely a major source of physical habitat degradation on a watershed-wide scale.

In-stream Flows

In-stream flows in rivers and streams are the result of complex interactions between precipitation, stormwater run-off and base flow provided by groundwater. In Chapter 2 we reviewed the natural and urban water cycles. In a watershed that is in a natural state, as much as 50% of precipitation infiltrates into the ground. This infiltrated water recharges aquifers and provides base flow for streams. In a heavily developed watershed such as the Pennypack Creek Watershed, much of the precipitation is carried off impervious surfaces as stormwater run-off. In addition to increasing stormwater flows to rivers and streams, impervious surfaces prevent groundwater recharge and reduce the amount of water available for stream base flow. Excessive groundwater withdrawals for drinking water and industrial processes exacerbate this problem by further reducing amounts of groundwater available for base flow.

Figure 5.20 details the interaction between ground and surface waters.

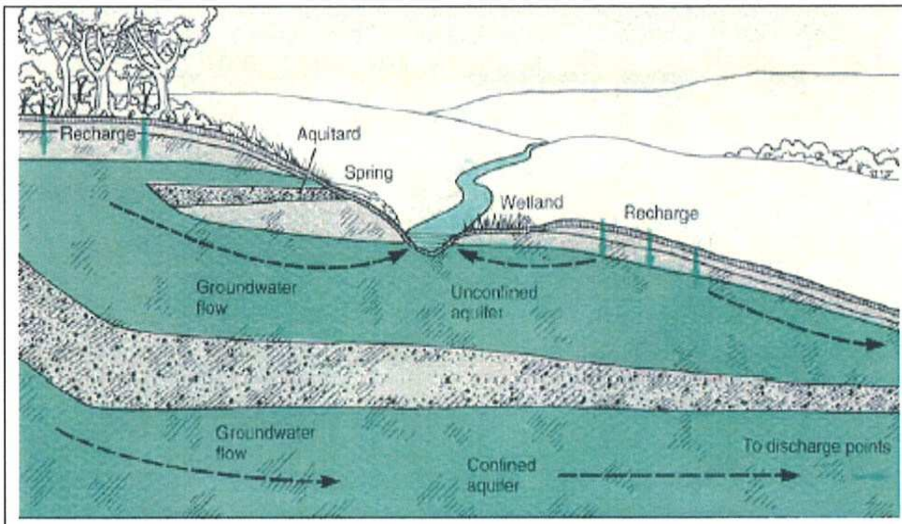


Figure 5.20 Groundwater Recharge. Precipitation that infiltrates into the ground is stored in aquifers until the aquifer flow intersects with a water body such as a stream or the ocean. The groundwater is then discharged into the waterbody providing base flow.

Source: PA DEP *Groundwater: A Primer for Pennsylvanians*

The results of these conditions are a stream that is "flashy" in nature; that is, it has little or no water in it to support aquatic life during the summer or dry periods and is prone to flooding and excessive stormwater flows when it rains. In streams with minimal base flow, wastewater treatment plant effluent may constitute the majority of water in the stream during periods of low flow.

CURRENT STATUS AND TEMPORAL TRENDS

Developed areas of the watershed with significant impervious surfaces are discussed in Chapter 4. A review of the land use map of the watershed reveals that much of the headwaters areas of the watershed and areas where first order streams arise are surrounded by residential and commercial urban land uses. The presence of large natural areas and riparian buffers largely begins in the middle of the watershed at the Pennypack Preserve.

The Delaware River Basin Commission (DRBC) has designated a groundwater protection zone for southeastern Pennsylvania which includes the entire Pennypack Creek Watershed. Under the DRBC provisions, any new wells that will withdrawal more than 10,000 gallons per day need to obtain DRBC permits. Figure 5.21 includes locations of DRBC permitted wells including public water supply wells. This map does not capture the entire universe of groundwater withdrawals in the Pennypack Creek Watershed— a large number of smaller unpermitted domestic wells are in operation throughout the watershed. DRBC data, used to create the map, indicates that large permitted groundwater withdrawals accounted for 1,207 million gallons of water pumped from aquifers in the Pennypack Watershed in 1998. These withdrawals exert a serious impact on the in-stream base flows of the Pennypack Creek.

The identification and protection of important groundwater recharge areas in the Pennypack Creek Watershed as critical open space is badly needed. Water conservation can play a role in protecting aquifers in the region by reducing the amounts of water that is pumped from local aquifers to meet the demands of increasing populations, especially in the headwaters of the watershed where stream flows are particularly dependent on base flow.

Figure 5.21 shows that the large majority of permitted wells are in the headwaters of the watershed, located in the Stockton geologic formations. The implications of these well locations include reduction of base flow in headwaters streams as well as increasing stress on these aquifers as the headwaters region is developed and groundwater recharge decreases with increased impervious surfaces.

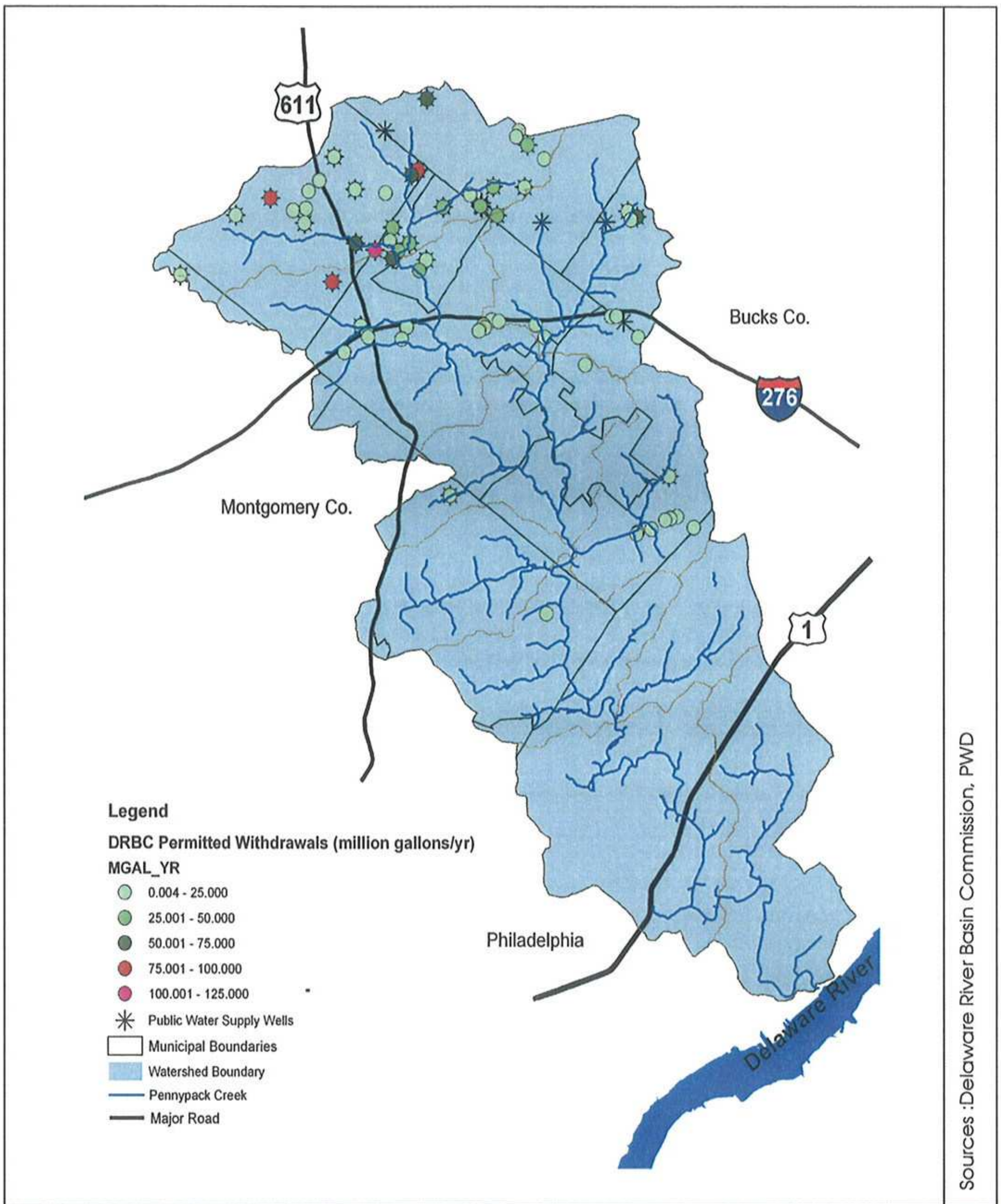


Figure 5.21 DRBC Permitted Groundwater Withdrawals in the Pennypack Creek Watershed. This map uses the most recent data available from the DRBC. Permitted withdrawal amounts are from 1998 reports. Note that most groundwater withdrawals are located in headwaters regions of the watershed where maintaining base flow in first order streams is critical to water quality and stream habitat

MAJOR STRESSORS

The state's 303d list of impaired waters identifies fluctuations in stream flows and impacts of stormwater run-off as the causes of impairment for 82% of the stream miles in the Pennypack Creek Watershed. These fluctuations include low or no flow in small streams during the summer or dry periods or result in-streams whose flows are dominated by wastewater treatment plant effluent. Low base flow in warm seasons contributes to reduced dissolved oxygen in streams and rivers which further skews biological communities to species that can tolerate those conditions.

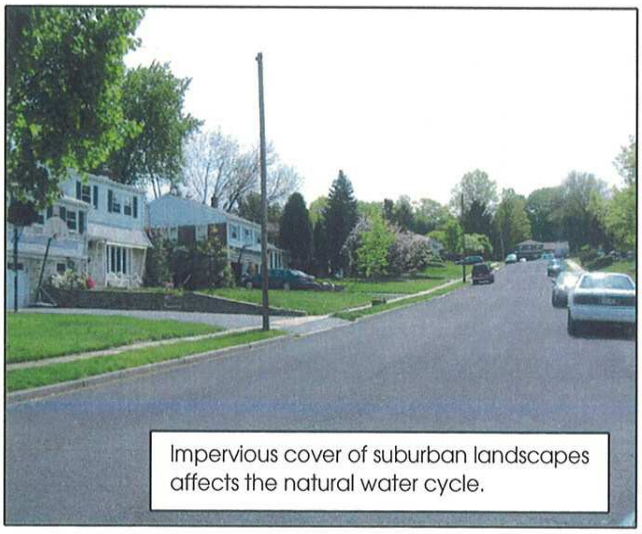
A high percentage of wastewater effluent in stream flows can result in nutrient enrichment in streams. Nutrient enrichment exacerbates low dissolved oxygen levels by encouraging algal growth. Large percentages of wastewater effluent reduce a stream's natural ability to assimilate and process pollutants.

Reduced base flow is just one side of the in-stream flow challenge facing the Pennypack Creek Watershed. After periods of low or wastewater dominated flows, large stormwater inputs overwhelm stream systems with high velocity flows that only remain in the stream channels for a few hours or at most, days. Increased storm velocities disrupt habitat by alternately eroding stream bank and channel materials and then depositing those materials in lower-energy downstream stream channels. The result of these two extremes in habitat conditions is readily seen in the biological monitoring results presented earlier in this chapter.

IMPACTS ON USES AND VALUES

Fluctuations in in-stream flows, reduced base flow and dominance of wastewater effluent in-stream flows exert a number of impacts on the uses and values of the Pennypack Creek Watershed.

Impacts on habitat and biological communities have been extensively explored throughout this chapter and flow fluctuations in the watershed's streams contribute to loss of biodiversity and habitat loss.



Impervious cover of suburban landscapes affects the natural water cycle.

Photo: F.X. Browne, Inc

Stream flow fluctuations also impact the water and wastewater utilities' uses of the Pennypack Creek Watershed. Reductions in natural flows and a stream's ability to assimilate pollutants in wastewater effluent present challenges to wastewater utilities to improve effluent quality through technology. A job that would have been performed by natural biota in flowing stream requires significant capital investment to accomplish in a wastewater treatment plant. Impacts of this fact are being realized in other watersheds in the region as TMDL plans are being developed and wastewater treatment plants are being required to drastically reduce phosphorous discharges to improve stream water quality. At least a portion of this problem is due to the fact that in those watersheds, wastewater effluent accounts for 90% of base flow in the summer months. Those streams cannot process effluent nutrients without natural base flow to facilitate the process.

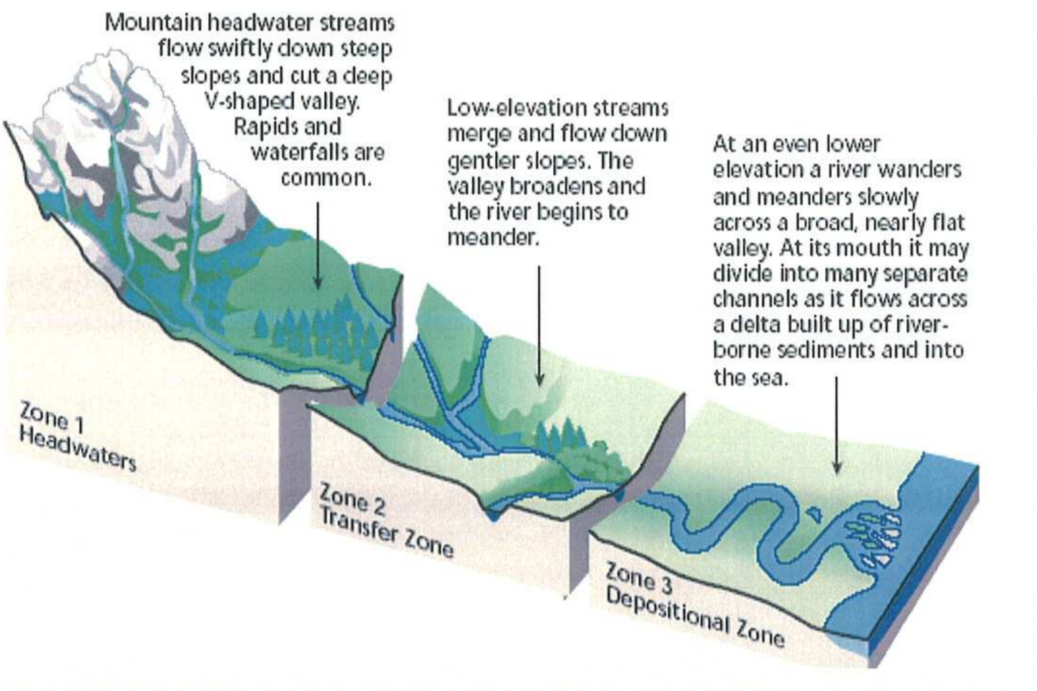
The increased volume of stormwater that results from large impervious surfaces also affects wastewater treatment process, especially in Philadelphia where there are areas with combined stormwater and sanitary sewers. This increased flow can result in combined sewer overflows or flows that overwhelm treatment plant capacity. Even in places where the sewers are separated, leaking sewer infrastructure can allow stormwater to infiltrate pipes and be carried to wastewater treatment plants. If infiltration and inflow into sewer pies are large enough, these flows can overwhelm a plant's capacity during storm events. Treatment plants in the Pennypack Creek Watershed experienced significant inflow and infiltration problems in the 1970s (PA Health Department 1971).

Drinking water utilities are also affected by water quality challenges created by wastewater effluent dominated streams. Elevated nutrient levels in these streams promote algal growth that not only reduces dissolved oxygen in the stream, but some species can produce toxins that are harmful to humans and wildlife. Other algal species impart taste and odor compounds into sources of drinking water that can be noticed by consumers in amounts as low as parts per trillion. These compounds are especially expensive to remove from drinking water sources and preventing their growth in source waters in the first place is a priority of source water protection efforts.

Pathogens in untreated sanitary sewage that enters the creek during stormflows pose an additional challenge for drinking water utilities. Removal of pathogens such as *Giardia* and *Cryptosporidium* from drinking water sources is especially difficult during storm events when levels of sediment are high. Large amounts of sediment in water sources pose challenges to the filtration process and high concentrations of organic matter interfere with the disinfection process.

Lateral and Longitudinal Connectivity

Natural stream systems are connected both longitudinally from headwaters to mouth, and laterally from the active stream channel to adjacent flood plain areas and with adjacent groundwater flows beneath the stream bed. Although interruptions to these connections occur in nature (e.g, waterfalls, beaver dams, etc.), connectivity in river systems is a critical aspect of ecosystem function.



Source: Federal Interstate Stream Restoration Working Group (FISRWG)

Figure 5.22 Longitudinal Connectivity. Natural stream systems are connected longitudinally from headwater to mouth. Upstream stream segments are most intimately linked with landscape processes, while downstream segments are strongly influenced by the delivery of water and materials from upstream channels.

Longitudinal connections (see Figure 5.22) permit the flow of water and materials (e.g., sediment, nutrients) from headwaters to mouth, as well as the movement of stream organisms upstream and downstream along the stream channel and in adjacent floodplain areas. Upstream-downstream connectivity is essential for the transmission of flood waters and sediment without causing unstable channels. Connections between upstream and downstream channels are also critical for the migration of fish populations. Upstream areas provide critical population sources for the recolonization of downstream habitats following floods.

Lateral connections between the active stream channel, stream bank, floodplain, and the hyporeic zone (the zone below the stream bed where active mixing of stream and groundwater occurs) surrounding the stream channel are equally critical aspects of stream systems. For instance, seasonally flooded floodplain terraces and backwater areas are critical areas for fish production and organic matter cycling in many river systems. As discussed in the previous section, regular flood cycles are critical to geomorphic stability of river channels. The connection between riparian forests and stream channels is a critical aspect of stream ecosystem function. In woodland streams, inputs of leaves, sticks, seeds, and other organic materials from the riparian areas form the primary food source that sustains stream macroinvertebrates and, indirectly, fish. The continuous shading of streams by riparian forests maintains cool stream temperatures that increase dissolved oxygen levels and prevent thermal stress to aquatic organisms. The input of large woody debris (fallen trees and branches) provides essential food resources and habitats in woodland streams. In many streams, stream organisms escape from turbulent flood waters by accessing floodplains or by retreating into the deep gravels of the hyporeic zone.

Laterally and longitudinally connected stream corridors are also important for human uses and values. The concept of a greenway requires a longitudinally connected river corridor through which people can move along the river via trail networks. Lateral connectivity is also important to provide access to river areas and to provide a sense of insulation, tranquility, and isolation from surrounding areas. The overall sense of beauty and the overall natural experience of visitors are enhanced by laterally and longitudinally connected stream corridors. The quantity and quality of terrestrial and aquatic habitats and the diversity of animal and plant life is enhanced within connected river corridors, thus increasing the value of such corridors for birding, hiking, nature interpretation, and general enjoyment.

Land use changes and stream corridor modification have radically altered both lateral and longitudinal connections within stream systems in southeastern Pennsylvania. Historically, Peidmont and Coastal Plan streams flowed through a nearly continuous corridor of riparian forests surrounded by floodplain forests and forested wetlands. The removal of riparian forests has radically altered the ecology of these environments. The disruption of riparian forest cover increases stream temperature; increases the growth of algae, bryophytes, and macrophytes within the stream channel; increases bank erosion rates; and reduces the input of important food sources in the form of leaves and large wood.

As mentioned previously, stream incision leads to the disconnection of stream channels with adjacent floodplains. Particularly in larger, lower gradient rivers, where the periodic pulse of flood waters on to the floodplain is a central and organizing process around which biological communities develop and respond, stream incision represents a radical disruption of the stream system. Figure 5.23 is a diagram of a typical floodplain. Note how a floodplain provides water storage area when streams overflow their banks.

Dams and impoundments represent an obvious impact to upstream/downstream connections. Most dams partially or completely limit the migration of fish populations from larger streams to headwater streams. For migratory fish populations, the ability to move upstream and downstream from headwater areas to large rivers, estuaries, and marine habitats is a prerequisite for survival. For these populations the presence of dams and impoundments dramatically reduces the overall quantity of stream habitats available for various life cycle stages.

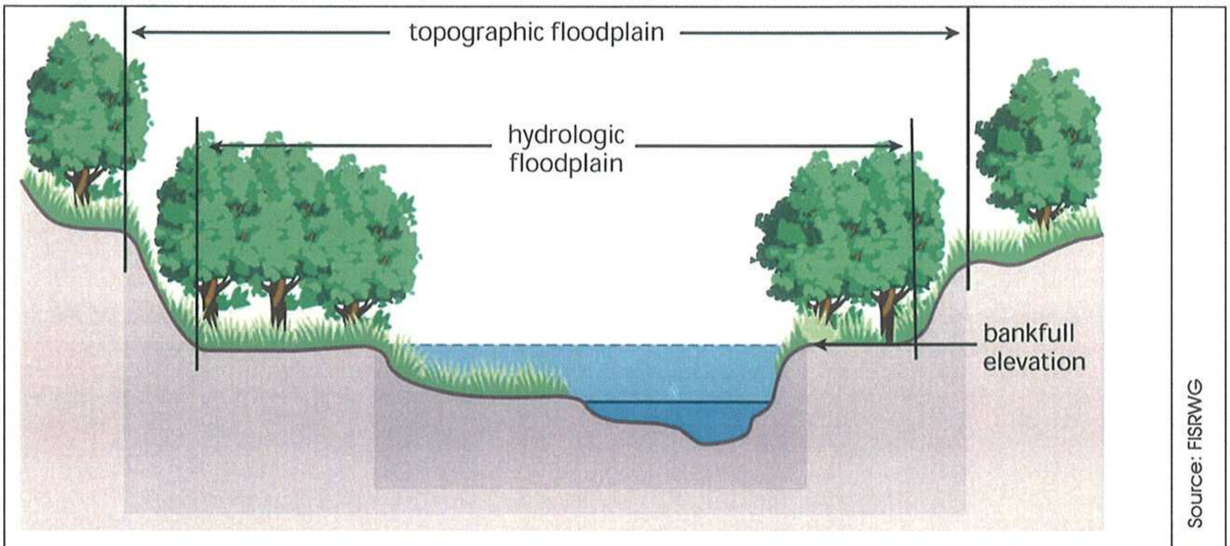


Figure 5.23 Floodplain Diagram. A functioning floodplain provides storage for high stream flows and dissipates stream flow energy

Road and rail corridors often represent significant disruptions in natural system systems. In many instances, bridges do not span the entire floodplain and thus impede the flow of water within floodplain areas. Also, in many cases, floodplain areas are regraded and filled to accommodate transportation corridors.

The burying and piping of stream channels also represents a significant interruption in lateral and longitudinal connections. The piping of stream channels completely eliminates lateral connections with floodplain, riparian forests, and groundwater mixing zones. Piped streams also in many cases present significant migration barriers for fish and other aquatic organisms, particularly during low flow.

CURRENT STATUS AND TEMPORAL TRENDS

Longitudinal and lateral connectivity is disrupted in the Pennypack Creek by the removal of riparian forest cover, the regrading and filling of floodplains, the incision of stream channels due to increases stormwater runoff, the presence of several dams and impoundments, and the burying and piping of many stream segments.

Because the central and lower portions of Pennypack Creek are largely surrounded by protected lands, lateral and longitudinal connectivity within this corridor is generally high. The main stem of the Pennypack Creek from the Pennypack Preserve to the mouth is contained within a nearly continuous riparian corridor. The only significant interruption in the riparian corridor occurs between the upstream end of Lorimer Park to the downstream end of the Pennypack Preserve. Major rail and road corridors represent significant interruptions to the stream corridor, particularly the Pennsylvania Turnpike and SEPTA's R3 rail corridor that parallels Meadow Brook and Huntingdon Valley Creek.

However, even within protected corridor, lateral and longitudinal connections have been interrupted in places. For instance, the riparian canopy has been partially or fully removed within many park areas to make way for ball fields, picnic areas, and parking areas. Within Lorimer Park, the riparian canopy has been almost completely removed along the western bank of Pennypack Creek for a distance of over 1,000 feet. Also, within Lorimer Park a flood levee extends along the western bank of the creek for a distance of several hundred feet. Similar situations occur within Pennypack Park. Although the park contains a well forested stream corridor in most places, occasional areas have been cleared to make room for ball fields, parking areas and other park infrastructure. Several extant and relic dams occur within the park creating barriers to fish passage. Two elevated sanitary sewer lines cross the creek within the Park and present significant barriers to fish passage.

Figure 5.24 Development within 100 Year Floodplain.
This year 2000 aerial photo shows significant development within the 100 Year Floodplain (shaded area). This is not an uncommon situation in the Pennypack Creek Watershed.

Historically, many of the riparian wetlands that surrounded the creek have been drained or filled. Even within the Pennypack Park, many of the historical floodplain wetlands have been eliminated (FPC, 2001). In many areas within the watershed, buildings, roads, and other infrastructure extend well into the 100-year floodplain. Even where riparian corridors surround the stream, they often lack the width and ecological quality of native floodplain forests. In many cases, floodplain areas have been filled or regraded in connection with flood plain development.

Figures 5.24 and 5.25 illustrate typical alterations that occur within stream corridors in the Pennypack Creek Watershed. Figure 5.24 is an aerial photograph showing significant development in the Creek's 100 year floodplain. Development in the floodplain is responsible for millions of dollars in property damage when the stream overtops its banks. This is not an uncommon condition in the Pennypack Creek Watershed. Figure 5.25 is an aerial photograph that shows the limitation imposed on riparian buffers by infrastructure and development in the watershed. Again, this is not an uncommon situation in the Pennypack Creek Watershed.

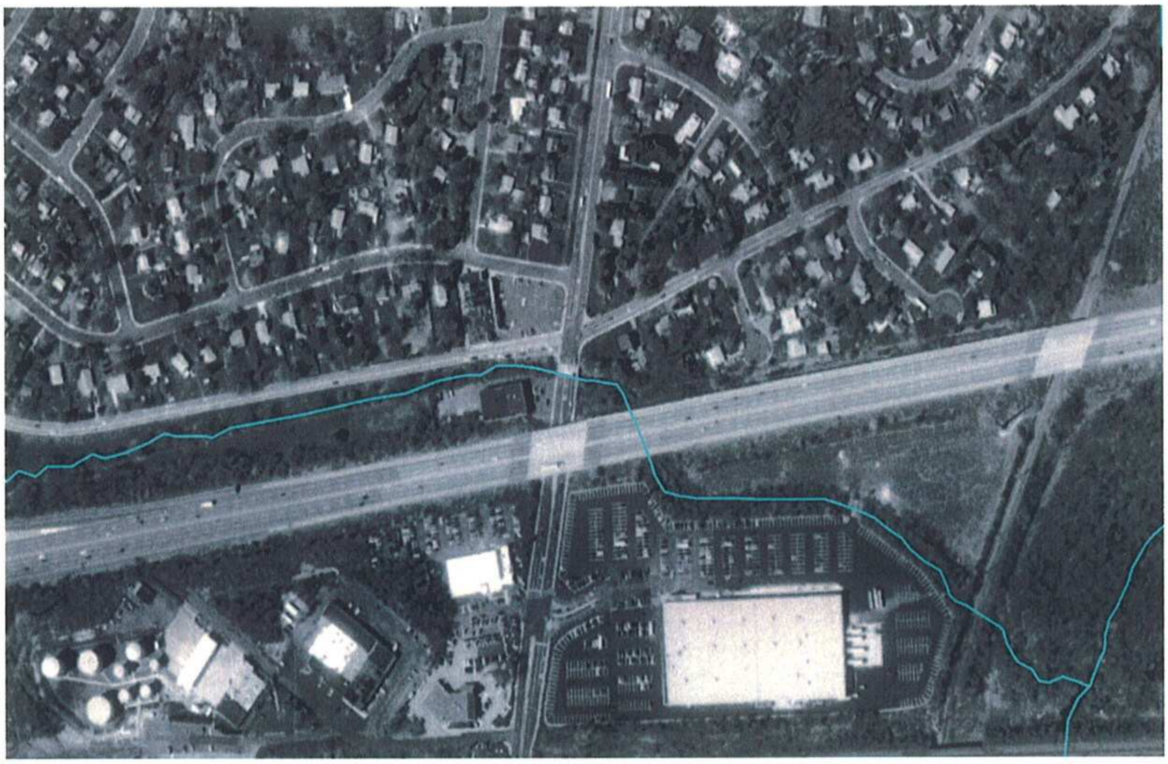


Figure 5.25 Forested Riparian Corridor. Most of the forested riparian corridor throughout the watershed is relatively thin due to the impacts of infrastructure and development in the watershed

The burying and piping of stream channels, particularly within the Sandy Run drainage but also within Paul's Run and in suburban areas of the drainage, represent severe disruptions of upstream/downstream and lateral stream connectivity. Streambank revetments including walls and rip-rapped banks represent interruptions in the connectivity of streambank environments.

Major Stressors

Existing dams and interruptions in riparian vegetation appear to be the most significant stressors to longitudinal conductivity within the Pennypack Creek Watershed. Additionally, the burying and piping of extensive portions of the Sandy Run and Paul's Run drainage network as well as certain headwater stream segments within the upper portions of the watershed severely impacted stream corridor connections.

Stream incision and filling and grading of floodplains are most likely represent the most drastic impacts to lateral connections within the watershed.

Impacts on Uses and values

Loss of stream corridor connections affects the ways that the Pennypack Creek is used and valued. The existence of a relatively laterally and longitudinally connected, natural river corridor is a central aspect of the Pennypack Creek's importance as a recreational resource. Where the stream is less connected to its floodplain and to adjacent and upstream riparian areas such as in the suburban reaches, the recreational value and use of the Pennypack Creek diminishes dramatically. This conclusion is supported by the RCP survey that showed that Philadelphia residents were more likely to value and use the Pennypack Creek as recreation resources than were suburban residents.

Flood Conveyance

A significant function of urban and suburban streams is the ability to effectively transport storm and surface water flows from developed areas downstream. The value of storm and flood water conveyance is not often considered when the system functions well. When the stream's ability to transport heavier flows is diminished and widespread property losses increase due to flooding, streams often attract more attention.

One hundred year floodplains are commonly used to delineate land that has a significant risk of being inundated during any given year. The 100-year floodplain is often used as the basis for regulations restricting development and construction activities in the floodplain. In order to qualify for the FEMA National Flood Insurance Program, communities must have floodplain regulations in effect. The FEMA 100-year Floodplain is shown on each of the sub-watershed overview maps.

Current status and temporal trends

The ability of the Pennypack Creek and its tributaries to convey floodwaters has been seriously impacted by the construction of stream constrictions, culverts and bridges. Areas of channel aggradation and sedimentation resulting from upstream erosion also reduce the stream's capacity to convey flood waters downstream safely and effectively. Finally incursion into the floodplain by buildings and structures throughout the watershed has greatly interfered with the stream system's ability to convey heavy storm flows without causing loss of property and even lives.

Floodplain encroachment not only poses a risk to property owners but oftentimes measures taken to protect one property export the water and flooding down stream. Channelized stream segments and armored stream banks are two examples of structures that protect one property and exacerbate downstream problems.

The Center for Sustainable Communities at Temple University is currently evaluating conditions affecting flooding in the Pennypack Creek Watershed. Flood damage from Hurricane Floyd (1999) and Tropical Strom Allison (2001) encouraged the municipalities in the watershed to band together with Temple University to take a comprehensive look at the flooding problem in the watershed.

The study, when completed, will result in a model stormwater ordinance for watershed municipalities, updated floodplain maps and identification of constrictions of the stream channel that interfere with flood conveyance.

Impacts on Uses and values

Property damage and loss of life in the watershed are well documented throughout this plan but historic flood damage has helped to change the way land will be developed in the watershed in the future. The findings and recommendations contained in the Temple University Floodplain Study will result in better stormwater and floodplain management that will not only reduce economic losses but will have a positive impact on the watershed environment.

Updated floodplain maps will help to identify properties at risk and may be used to plan future buy-outs and open space acquisitions. Tragic and persistent flooding events along the Pennypack Creek and its tributaries have promoted a shift in flood management from constructing flood control structures that export problems downstream to more natural solutions that require groundwater infiltration and restore natural floodplain function.

5.4 Current and Historical management and regulation

Jurisdiction over Pennsylvania's watershed resources is distributed across state, federal and municipal authorities, and in the Delaware River Watershed, an interstate compact agency. Water resources and watershed management is also the domain of non-profit and advocacy organizations who share the purpose of protecting watershed resources. The following sections provide an overview of the regulatory and organizational framework that affects watershed management in the Pennypack Creek Watershed

State and Federal Regulations

Both Pennsylvania State Law and United States Federal Law have provisions to protect water resources from degradation and pollution. Federal water quality laws fall under the jurisdiction of primarily two agencies: the Environmental Protection Agency and the United States Army Corps of Engineers. State agency jurisdiction over water quality regulations is the domain of the Pennsylvania Department of Environmental Protection.

The federal government grants Pennsylvania administrative powers over water quality regulations and wetland and water disturbances below certain sizes as long as Pennsylvania State regulations remain at least as stringent as the federal legislation protecting water resources. Major state and federal regulations affecting water quality will be reviewed in the following sections.

Major Federal regulations

Clean Water Act

The Federal Water Pollution Control Act, also known as the Clean Water Act, was passed in 1972 with the purpose restoring and maintaining the integrity and quality of the nation's waters. The Clean Water Act sets water quality standards for discharging waste into water bodies and established a permitting system (National Pollutant Discharge Elimination System) to track discharge effluent quality. The Clean Water Act deals exclusively with surface water resources. The Act does not contain legislation regarding water quantity or water withdrawal issues or groundwater quality and pollution.

The passage of the Clean Water Act was accompanied by federal funding, particularly the Construction Grants Program, to construct and upgrade wastewater treatment plants to assist communities to meet Clean Water Act standards for effluent water quality. The passage of the Act combined with this funding source resulted in significant improvements to stream water quality all across the United States.

Section 208

Section 208 of the Clean Water Act requires statewide and regionwide water pollution control planning. The objective of this legislation is to reduce non-point source pollution as well as pollution from surface mining and construction. Section 208 does not provide the EPA with a mechanism to ensure that these pollution control plans are implemented.

Section 303d and 305b Impairment

The Clean Water Act requires that states develop biennial inventories of their waterways and assess whether those waterbodies are meeting proscribed water quality or aquatic life usage standards. States are required to compile the information from these inventories in a report referred to as the 305b report. The 305b report contains information on all of the waterbodies of the state and whether those waterbodies are meeting Clean Water Act standards. The reports are required to identify environmental stressors affecting these waterbodies and potential sources of those stressors.

The 303d list is the list of a state's waterbodies that do not meet water quality criteria or exhibit evidence of aquatic life use impairment. This list serves to identify impaired waterbodies and identifies the causes of impairment. The Clean Water Act requires that waterbodies that appear on the 303d list must have a Total Maximum Daily Load plan (TMDL) developed for that water body. The TMDL determines how much of the identified pollutants the waterbody can safely assimilate and sets limits on pollutant loads entering those waterbodies. The limits are generally placed on NPDES permitted discharges to measure and control reductions in pollutant loading. Since small municipal storm sewer systems are now required to obtain NPDES permits for their stormwater discharges, a mechanism now exists for placing limits on stromwater effluent loading on waterbodies.

Section 402 NPDES

Section 402 of the Clean Water Act established the NPDES permitting system to track and control point source discharges into waters of the United States. The program was to be implemented in two phases. Phase I requires NPDES permits for municipal separate storm sewer systems (MS4s) for municipalities serving populations of 100,000 people or more. Phase I also regulated discharges from industrial point sources and construction sites of 5 acres or more. NPDES Phase II regulations took effect in 2003. As of 2003, designated MS4s with populations less than 100,000 within an urbanized area and meeting population density criteria (>1,000 people / mi.^{2}) are required to apply for NPDES permits. Each municipality in this study area is a designated MS4, and they are required to submit plans to address six minimum control measures set forth by the state DEP.

Minimum measures include:

- Public education and outreach.
- Public participation and involvement.
- Elicit discharge detection and elimination.
- Construction site runoff control.
- Pollution prevention.
- Good housekeeping for municipal operations.

NPDES Phase II regulations require that increases in run-off from the typical two year storm either be infiltrated into the ground or treated with water quality BMPs. This requirement is directed at improving the quality of stormwater run-off from smaller storms by capturing the "first flush" of pollutants from a rainfall event.

NPDES permits set limits for the amounts of pollutants that can be discharged into a water body in a given time period. These limits are generally tied to achievable results based on the best available treatment technology and are a mechanism for the EPA to ensure water quality improvement from point source dischargers as improvements in technology are made.

Section 404 Wetlands and Waters

Section 404 of the Clean Water Act is most commonly associated with wetland protection but the regulation actually protects all "waters of the United States" from being filled or having dredge materials deposited into them. Section 404 follows a sequence of events to protect waterbodies. The first step is avoidance; projects should avoid disturbing wetlands or waters of the U.S. The second step is minimization; proposed disturbances should be designed to minimize impact on waterways. Lastly, if wetland or waterbody disturbance is unavoidable, the act calls for mitigation or replacement of disturbed wetlands or waterways.

MAJOR STATE LEGISLATION

Act 167 Stormwater Management

The Stormwater Management Act of 1978 required that counties and municipalities develop watershed based stormwater management plans. These plans are referred to as Act 167 Plans in reference to the Act of State Assembly that authorized the plans. The purpose of Act 167 Plans is to provide for scientifically based watershed wide stormwater management planning to reduce flooding and improve stormwater management across political boundaries throughout sub-watersheds and entire watershed basins.

Upon completion of an Act 167 Plan, each municipality in the watershed is required to adopt a model stormwater ordinance. Adoption of this common ordinance is meant to address the deficiency of each municipality having different requirements for stormwater management. The Act 167 Plan ensures that upstream communities consider the impacts of land use and development decisions on downstream communities.

Act 537 Sewage Facilities Act

The Pennsylvania Sewage Facilities Act was enacted in 1966 to require municipalities develop sewage facilities plans to ensure adequate sewer service for existing residents and future growth. The plan established provisions for permitting on-lot sewage facilities and set standards for sewage disposal systems. Oversight of the wastewater treatment process is the responsibility of a number of levels of government and regulatory agencies. Wastewater utilities or on-lot sewage system operators are responsible for the daily operations and treatment of wastewater. Municipal government develops and implements Act 537 Plans. The PA DEP approves Act 537 plans, provides oversight of effluent water quality and manages the NPDES permitting system in Pennsylvania for the EPA. The Delaware River Basin Commission is also involved in setting water quality objectives as related to sewage facility effluents. The Montgomery County Health Department largely manages approval of on-lot sewage systems and approving Act 537 Planning modules that include on-lot systems.

Clean Stream Law

The Clean Stream Law is Pennsylvania's comprehensive water pollution control law. The law was originally enacted in 1937 to establish Pennsylvania's right to "preserve and improve" the purity of the state's surface and ground waters. Subsequent amendments to the law establish erosion and sedimentation control requirements, sewage facilities regulations, nutrient management standards from livestock operations and underground storage tank regulations. The Clean Stream Law established state jurisdiction for water regulations that are generally protected under the Federal Clean Water Act.

Regional Watershed Management Efforts

In addition to statutory mechanisms, federal, state and municipal government provide programmatic support to assist local watershed residents manage their watershed resources. The programs typically take the form of capacity building, grant programs or comprehensive planning efforts that may beyond the resources of local grass roots organizations.

PA DEP Watershed Management Programs

The PA-DEP's Office of Water Management is responsible for regulating all of the water resources in the Commonwealth of Pennsylvania. The Office of Water Management regulates water resources ranging from regulation of drinking water quality to administering permits for encroachments upon waterways and wetlands. The Office of Water Management coordinates policy and procedures which influence sewage facilities planning, dam safety, erosion and sediment control and non-point source pollution as well as overseeing the planning and design of flood protection and stream improvement projects. Three Office of Water Management programs that particularly effect watershed management in the Pennypack Creek Watershed are the Coastal Zone Management Program, the Water Quality Assessment and Standards Program and the Regional Watershed Management Program.

PA-DEP established the PA Coastal Zone Management Program in 1980 under the Authority of the Federal Coastal Zone Management Act. Pennsylvania's Coastal Zone in southeastern Pennsylvania is the Delaware Estuary (See Figure 5.26). The Coastal Zone Management Program administers a grant program from the National Oceanic and Atmospheric Administration to fund projects that improve or advance wetlands, public access to water resources, public involvement, fisheries management and other issues related to protecting estuary resources. The Coastal Zone Management Program has provided important federal dollars to implement environmental projects in the Delaware Estuary.

PA-DEP's Water Quality Assessment and Standards Program conducts biennial water quality and aquatic habitat monitoring to develop the 305b report and 303d listing. These reports ultimately determine which watersheds are determined to be impaired and will require a TMDL plan. Currently there is a Watershed Restoration Action Strategy, developed by the PA-DEP, to restore the clean water, public health and natural resource goals for the Pennypack Creek Watershed. The Watershed Restoration Action Strategy identifies the Pennypack Creek Watershed as a priority for restoration in Pennsylvania.

Each watershed identified in the State Water Plan has a PA-DEP Watershed Manager that coordinates watershed restoration and protection activities among the various organizations, groups and agencies that are active in the watershed. Watershed managers offer technical assistance to watershed organizations and administer grants awarded through the Growing Greener Program and most importantly act as a liaison between active watershed organizations and the state regulatory and funding body.

City of Philadelphia Watershed Partnerships

The City of Philadelphia facilitates watershed partnerships in all of the city's watershed basins in order to create a mechanism for watershed stakeholders to come together to improve the water quality and environment of the city's rivers and streams. Watershed Partnerships reach beyond the city boundaries to suburban communities upstream of the city in order to affect positive changes throughout watershed basins. The Partnerships act as forums for participating members to work together to develop strategies that achieve higher levels of environmental improvement through the sharing of information and resources.

A very tangible result of the city's Watershed Partnership program has been the completion of a watershed management plan and a River Conservation Plan for two city watersheds (Darby Creek and Tacony-Frankford Creek). Two more River Conservation Plans are currently underway (Pennypack Creek and Poquessing Creek). These plans have served as focal points for the organization of Watershed Partnerships. The Watershed Partnerships increase the likelihood of plan implementation and ensure that diverse watershed stakeholders are included in critical decision making processes.

Delaware Estuary Program

The EPA established the National Estuaries Program in 1987 to improve the water quality of Estuaries of National Importance. The Delaware Estuary was accepted into this program in 1988. The Delaware Estuary is essentially the tidal portion of the Delaware River and the entire lengths of the tributaries to the Delaware that enter the river south of Trenton, New Jersey. Figure 5.26 is a regional map of the Delaware Estuary. The Pennypack Creek Watershed lies within the Delaware Estuary.

The Delaware Estuary Program completed a Comprehensive Conservation and Management Plan in 1996 that laid out management objectives for the 13,262 square mile estuary through the year 2020. The estuary program administers a grant program that supports habitat and water quality projects in estuary watersheds that support the objectives of this comprehensive management plan.

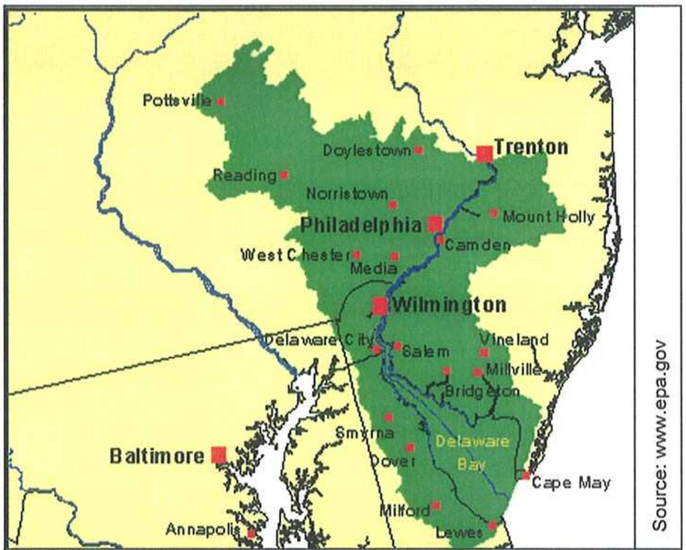


Figure 5.26 Map of the Delaware Estuary Program Study Area. This study includes the Pennypack Creek Watershed. The Delaware Estuary in Pennsylvania corresponds to the PA Coastal Zone Management Area.

Delaware River Basin Commission Comprehensive Plan

The Delaware River Basin Commission (DRBC) was created as a result of a Compact between New York, New Jersey, Pennsylvania, Delaware and the Federal Government in 1961. The commission is given jurisdiction water quality protection, water supply allocation, regulatory review (permitting), water conservation initiatives, watershed planning, drought management and flood control activities within the Delaware Watershed in these four states.

The DRBC Comprehensive Plan is intended to describe implementation of water resource projects and construction of facilities which Commission finds to be in the public interest. It does not mandate construction of any project or the acquisition of any land. The Comprehensive Plan provides a framework for the orderly development of water resources of the basin.

Currently the DRBC Comprehensive Plan has not identified any water resource projects in the Pennypack Creek Watershed but the Pennypack Creek Watershed does lie within the DRBC

Groundwater Protection Zone of Southeastern PA. The purpose of this permitting system is to ensure that groundwater withdrawals in the zone do not exceed safe groundwater yields, deplete aquifers and endanger stream base flows.

Infrastructure Management

Wastewater Systems

Combined Sewer Systems are sewage systems that convey both sanitary sewer and stormwater in a common pipe. An intercepting sewer then carries these combined flows to the wastewater treatment plant. In times of heavy precipitation, stormwater runoff can overwhelm the capacity of the intercepting sewer and cause a Combined Sewer Overflow or a discharge of a combination of untreated sanitary sewage and stormwater from the pipe into a waterbody. Combined sewers were generally constructed before water quality regulations prohibited the discharge of raw sewer into water bodies. Retrofitting and replacing combined sewers present an enormous capital expense for municipalities and cities to undertake.

In order to meet Clean Water Act Regulations, the Philadelphia Water Department developed a Combined Sewer Overflow Long Term Control Plan. The plan was submitted to DEP in 1997 and is being implemented in three phases. The phases include immediate implementation of a program to implement nine minimum control measures, design and construction of capital improvements to improve the performance of the Combined Sewer System and comprehensive watershed based planning, water analysis and monitoring.

The nine minimum control measures include practical cost-effective practices that can be implemented in a short time frame, such as measures to maximize the use of the sewer collection system for storage of combined sewage during rain events and a comprehensive monitoring program to identify leaks and infiltration into the system. Examples of capital improvements include targeted inflow / infiltration reduction programs and a Water Pollution Control Plant Wet Weather Treatment Maximization Plan. The water quality monitoring program mentioned throughout this document and the formation of the Pennypack Partnership are examples of comprehensive watershed monitoring and management efforts being implemented by the Philadelphia Water Department.

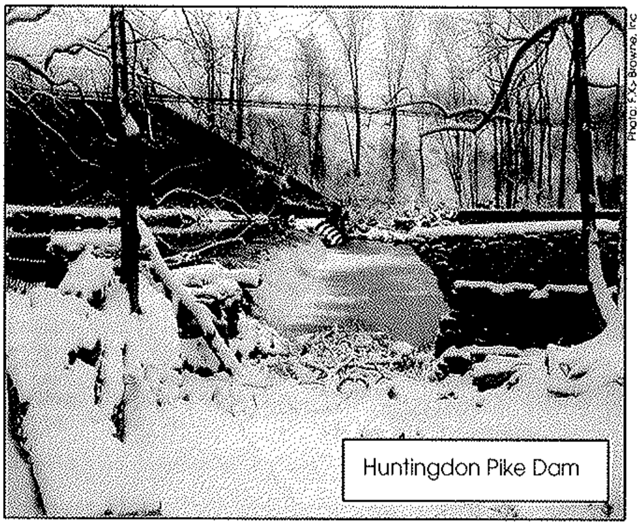
The Long Term Control Plan has provided great benefits on water quality in the city's streams. Since implementation of the program began in 1995, combined sewer overflow discharges have been reduced by over 2 billion gallons of combined sewage per year (PWD).

Restoration Efforts

The Philadelphia Water Department, Fairmount Park Commission, Pennypack Ecological Restoration Trust, Southeastern Montgomery County Chapter of Trout Unlimited and the PA Fish and Boat Commission have been actively restoring in-stream and riparian habitats throughout the watershed. Many of these projects have utilized volunteer labor to plant riparian vegetation, remove invasive species or install in-stream habitat structures.

An exciting collaborative restoration effort being coordinated by the PA Fish and Boat Commission is an effort to remove or mitigate fish passage obstructions of the Pennypack Creek. The Water Department and Fairmount Park Commission have obtained funding and designed the removal of the Frankford Avenue and Rhawn Street Dams on the lower Pennypack Creek and are implementing the installation of a fish passage device around an exposed sewer lateral located between these two dams. When completed, these projects will open 4.5 miles of stream to fish passage and restore the lower Pennypack Creek to a free flowing state.

These projects are part of a watershed wide effort to open the creek to fish passage and restore a more natural flow regime. In Montgomery County, project partners have acquired approval for dam removal for two other dams on the Pennypack Creek; the Bethayres Dam owned by the Aqua America Corporation and the Huntingdon Pike Dam owned by the Korman Corporation. Project partners have obtained partial funding commitments for these projects and are seeking additional funding that could possibly restore the entire Pennypack Creek to a free flowing condition and open it to migratory fish passage that has not been present since early colonial times.



Huntingdon Pike Dam

CHAPTER 6
BIOLOGICAL RESOURCES

6.1 Vegetation

The native biodiversity of a region is greatly influenced by the region's topography, climate and geology. Topography of the Pennypack Creek Watershed changes from gently rolling hills in the Piedmont to the level Coastal Plain with a transition area along the Fall Line. The watershed receives an average of 41 inches of rainfall each year and is rich in water resources. These conditions, combined with fertile soils derived from diverse geologic formations, historically supported forest cover over the entire Pennypack Creek Watershed. These forests were mostly clear-cut for agriculture and fueled early industry in the region. Remnants of second growth, or forests that have regrown since clear cutting, still exist along stream valleys and in the region's parks and open spaces.

Floodplain vegetation in Pennypack Park

Forest cover and vegetation in the Piedmont region (roughly the area north of Frankford Avenue) is characteristic of the Oak–Chestnut forest community-type, typical of forest communities throughout Pennsylvania. Since widespread chestnut blight nearly eradicated the American chestnut in the 1900s, the forest is more accurately known as a Mixed Oak hardwood community. Tree species representative of this community include northern red oak hickories (*Carya* spp.), beech (*Fagus grandifolia*) and tulip tree (*Liriodendron tulipifera*). The shrub layer of these forests contain various species of viburnum (*Viburnum dentatum, V. recognitum and V. acerifolium*) and spicebush (*Lindera benzoin*). Floodplain and riparian forests in this region are typified by river birch (*Betula nigra*), sycamore (*Platanus occidentalis*) and box elder (*Acer negundo*). Dogwood species (*Cornus* spp.) and spicebush (*Lindera benzoin)* are the dominant shrubs found in the floodplains of the Piedmont.

There are numerous small wetland communities found in the watershed, including skunk cabbage and sedge-rush-grass wetlands. Vegetation found in these communities includes skunk cabbage (*Symplocarpus foetidus*), sensitive fern (*Onoclea sensibilis*), jewelweed (*Impatiens capensis*) and species of alder (*Alnus* spp.), dogwood (*Cornus* spp.) and viburnum (*Viburnum* spp.). Forested wetlands in the watershed are usually associated with riparian or floodplain environments and are discussed above.

In the Coastal Plain, the vegetation along the creek is characterized by tidal freshwater marsh. Flora includes spatterdock (*Nuphar lutea*) and, to a lesser extent, rice cutgrass (*Leersia oryzoides*), rose mallow (*Hibiscus moscheutos*) and multiflowered mud plantain (*Heteranthera multiflora*). The Coastal Plain supports species more typical of habitats south and east of Pennsylvania. Many of these species have been extirpated (no longer present in the state) due to loss of habitat elsewhere in the state. Since little natural Coastal Plain vegetation is still present in Pennsylvania, remaining communities, such as the tidal marsh at the mouth of Pennypack Creek, are important to preserve and restore.

In 1998, Fairmount Park Commission's Environment, Stewardship and Education Division (ESED), formerly the Natural Land Restoration and Environmental Education Program, constructed a large, restored intertidal marsh wetland at the mouth of the Pennypack Creek. The Pennypack Park Master Plan recommends monitoring of this wetland to control non-native invasive plant species and to install additional plantings to assist native vegetation establishment. There is also a small old field wetland and tidal mud flat present in the southwest corner of Pennypack Park, which represents a remnant of native tidal wetland communities that were historically present along the Delaware River. These small wetlands are important refugia for plant and animal species found nowhere else in the state except within tidal wetlands along the Delaware River.

Native vegetation in the Pennypack Creek Watershed has been severely impacted by a large population of white-tailed deer (*Odocoileus virginianus*), habitat destruction, disturbance, and competition from non-native invasive plant species. Deer browse and the presence of invasive plant species combine to cause the greatest threats to native floral biodiversity. Large populations of deer in the natural areas of the Pennypack Creek Watershed preferentially browse on native vegetation. This results in forests devoid of understory vegetation where the deer can reach and eat the herbaceous plants, shrubs, and tree saplings. Deer over-browsing saplings interrupts the process of forest succession. Thus, aging and dying trees are not being replaced. An absence of a shrub layer presents serious implications for birds and small animals that breed and forage in the forest understory.


Japanese Knotweed, an aggressive invader of riparian lands

Photo: Britt Slattery, USFWS Invasive Plants of the Eastern United States CD-ROM

Removal of the forest understory creates opportunities for colonization by invasive non-native plants. Non-native plants threatening biodiversity in the Pennypack Creek Watershed include Japanese knotweed (*Polygonum cuspidatum*), multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), mile-a-minute vine (*Polygonum perfoliatum*), porcelainberry (*Ampelopsis brevipedunculata*) Japanese stiltgrass (*Microstegium vimineum*), garlic mustard (*Alliaria petiolata*) and Norway maple (*Acer platanoides*) among many others.

The Fairmount Parks ESED, Friends of Pennypack Park and the Pennypack Ecological Restoration Trust all utilize volunteers and land management techniques to control invasive plant species on their properties. These efforts are critical to preserving native plant biodiversity in the Pennypack Creek Watershed.

6.2 Wildlife

Terrestrial

A long history of intensive land uses and disturbances has severely reduced the native terrestrial faunal biodiversity in the watershed since pre-colonial times. Habitat loss and fragmentation present the greatest difficulty in protecting existing populations and restoring historical wildlife species. Human population density in the watershed has created an environment that will require dedicated management to sustain healthy natural ecosystems. There are still large natural areas found in the watershed and these lands offer an opportunity to preserve and protect sustainable native wildlife populations. The large contiguous natural areas, found in Pennypack Park, Lorimer Park, and the Pennypack Preserve, provide a glimpse of the biological communities that once existed in the watershed.

The Great Blue Heron is a common visitor to the Pennypack Creek and watershed wetlands

Photo: F. X. Browne, Inc.

Faunal lists of birds, mammals and reptiles found in the watershed are included in Appendix B of this report. Faunal lists were compiled from information from the Fairmount Park Master Plan and Pennypack Ecological Restoration Trust. Pennypack Park and the Pennypack Preserve contain a diversity of habitats from wetlands to forests to managed meadows. Faunal observations from these locations probably capture the breadth of biodiversity in the watershed.

Deer

Populations of white-tailed deer (*Odocoileus virginianus*) have grown dramatically in the Pennypack Creek Watershed over the last thirty years. Absences of natural predators and increases in edge habitat have allowed deer populations to grow beyond the capacity of the few remaining natural areas to sustain them. Deer browse on herbaceous ground cover, shrubs, and sapling trees, as well as acorns and other seeds. The result of browsing by a high density deer population has been the interruption of the natural life cycle of forest regeneration.

Deer preferentially feed on native vegetation and open forest habitat to invasive plants. As the forest understory disappears, small birds and animals that rely on this vegetation for cover and food can no longer live or reproduce in these forests.

Controlling the deer population in the Pennypack Creek Watershed is critical to ensuring the sustainability of the watershed's few remaining forests and intact ecosystems. Various efforts to control deer have been attempted throughout the region, ranging from managed hunts to using exclusionary fencing around large plots of land on order to promote forest regeneration.

Controlled hunts of deer in Pennypack and Lorimer Parks in 2001, 2002 and 2003 reduced deer herds in those parks and, according to Montgomery County Office of Communications, have had a beneficial impact on regeneration of vegetation in Lorimer Park. These hunts, carried out by sharpshooters in Pennypack Park and archers in Lorimer Park with special permits, were controversial and elicited protests from animal rights groups and community activists.

Other attempts to promote vegetative growth in the parks include building deer exclusion fences around restoration plantings, using tree shelters for smaller plantings, and planting trees that are taller than the deer browse line. All of these options add cost to restoration projects, reducing the amount of vegetation that can be planted. With the exception of exclusionary fencing, these other methods do little to protect the forest understory and herbaceous layer from deer browse. The Pennypack Park Master Plan indicated that controlling deer browse is critical to successful restoration of natural lands in Pennypack Park and the whole Pennypack Creek Watershed.

Aquatic

Aquatic fauna in the Pennypack Creek Watershed has been extensively studied by the Philadelphia Water Department and PA DEP as part of their habitat and water quality studies. Fish and aquatic macroinvertebrate studies indicate the aquatic communities in the Pennypack Creek are typical of disturbed habitats and are dominated by pollution tolerant, generalist feeders.

FISH

Fish assessments, conducted by the Philadelphia Water Department throughout the Pennypack Creek Watershed in 2002-2003, collected a total of 16,869 individual fish of 39 different species. Of these 39 species, seven species accounted for over 80% of the total number of individuals collected. This skewed community composition is typical of impaired water bodies. Studies did, however, document a number of sport fish (small and large mouth bass (*Micropterus dolomieiu* and *salmoides)*, striped bass (*Morone saxaltilis*), rainbow and brown trout (*Oncorhyncus mykiss* and *Salmo trutta*), and an American shad (*Alosa sapidissima*) which are often sought by recreational anglers. The small number of these sport fish collected suggests that stream habitat and/or water quality must be improved in order to enhance the fishery.

Studies showed that aquatic biodiversity decreases in an upstream direction and seems to indicate a high level of disturbance which increases as one travels up the stream. Trout stocked by PA Fish and Boat Commission in the Pennypack Creek accounted for half of the pollution intolerant species collected. Collection of stocked trout in August and September of 2002, as well as anecdotal reports from Southeastern Montgomery County Chapter of Trout Unlimited, seem to indicate that some stocked trout individuals survive the summer months.

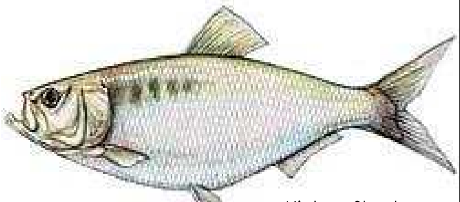

Hickory Shad

Illustration: PA Fish & Boat Commission

The PA Fish and Boat Commission is currently working with Southeastern Montgomery County Chapter of Trout Unlimited, Philadelphia Water Department and Fairmount Park Commission to improve fish habitat in the Pennypack Creek. These organizations and other partners are working to remove obstructions to fish passage on the stream in order to allow migratory fish access to the Pennypack

Creek Watershed. The PA Fish and Boat Commission released Hickory Shad (*Alosa mediocris*) fry to restore breeding populations of this endangered anadromous fish to the Pennypack Creek. Over 665,000 fry were stocked in 2004 and an additional eight million fry were stocked in 2005. This effort is an extension of the Fish and Boat Commission's efforts to bring breeding populations of American Shad (*Alosa sapidissima)* back to its historic range in Pennsylvania's rivers.

A complete list of fish species collected by the Philadelphia Water Department during the 2002-2003 monitoring season is included in Appendix C of this report.

AQUATIC MACROINVERTEBRATES

Aquatic macroinvertebrates, literally aquatic organisms that are large enough to see with the unaided eye and lack a backbone, are used by scientists as an indicator of water and habitat quality. Macroinvertebrate diversity and the presence of a variety of pollution sensitive species, particularly *Plecoptera* , *Ephemeroptera,* and certain *Trichoptera* taxa, indicate the biologic health of a stream system and can offer clues to both water quality and stream habitat values. Many of these organisms are insects whose larvae spend a portion of their life cycle in the water. Other important groups include taxa of aquatic insects, worms, and crustaceans.

Macroinvertebrates are generally less mobile than fish and therefore tend to be good indicators of localized water and habitat quality conditions. Macroinvertebrates are used extensively as indicators of stream quality in urban watersheds.

Macroinvertebrate surveys conducted by the Philadelphia Water Department and historical surveys conducted by the Pennsylvania Department of Health indicate that the Pennypack Creek has experienced impaired stream conditions since at least the late 1960s (dates of earliest survey records). Historic records indicate, and recent studies reaffirm, that the Pennypack Creek supports a macroinvertebrate community that is typical of impaired streams. This community consists of relatively small number of taxa of generalist feeders that are moderately pollution tolerant. Recent records reveal very few pollution sensitive taxa overall. When present, pollution sensitive *Ephemeroptera, Plecoptera*, and *Trichoptera* taxa occurred in very low densities.

Appendix D of this report includes the list of macroinvertebrate taxa collected by the Philadelphia Water Department in 2002-2003.

6.3 PNHP Species

Pennsylvania Natural Heritage Program (formally Natural Diversity Inventory)

The Pennsylvania Natural Heritage Program (PNHP) is a cooperative project between the PADCNR Bureau of Forestry, the Western Pennsylvania Conservancy, and The Nature Conservancy. The purpose of the PNHP is to "identify and describe the Commonwealth's rarest and most significant ecological features. These features include plant and animal species of special concern, rare and exemplary natural communities, and outstanding geologic features" (PA DCNR). Table 6.1 lists the PNHP species and communities found within the Pennypack Creek Watershed.

In Pennsylvania, protection of plant and animal life falls under the jurisdiction of three agencies. PADCNR Bureau of Forestry is responsible for protecting plant life. The PA Fish and Boat Commission has jurisdiction over fish, reptiles and amphibians and the PA Game Commission has jurisdiction over bird and mammal species.

Table 6.1 PNHP Species in the Pennypack Creek Watershed

Species Name	Common Name	State Rank	Status	Proposed Status
Plants				
Alasmidonta varicosa	brook floater	S2		PE
Amelanchier canadensis	serviceberry	S?	N	
Andropogon gyrans	elliott's beardgrass	S3	N	PR
Baccharis halimifolia	eastern baccharis	S3	PR	PR
Bartonia paniculata	screw-stem	S3	N	TU
Cuscuta pentagonia	dodder	S2	N	TU
Eupatorium rotundifolium	eupatorium	S3	TU	
Glyceria obtusa	blunt manna-grass	S1	PE	PE
Juncus filiformis	thread rush	S3	PR	PR
Magnolia virginiana	sweet bay magnolia	S2	PT	PT
Panicum lucidum	shining panic-grass	S1	TU	PE
Polygala cruciata	cross-leaved milkwort	S1	PE	PE
Woodwardia areolata	netted chainfern	S2	N	PT
Fish				
Gasterosteus aculeatus	threespine stickleback	SA?	PE	PE

Source: PA DCNR

Table 6.2 serves as the key to the state status ranking system. This ranking system describes the status of threatened and endangered species found in the Pennypack Creek Watershed. There are two Pennsylvania Endangered plants and one Pennsylvania Endangered fish historically found in the Pennypack Creek Watershed. It is important to note that of the fourteen species on the PNHP list, only Dodder (*Cuscuta pentagonia*) and Eupatorium *(Eupatorium rotundifolium*) were identified in recent species lists from the ESED Pennypack Park Master Plan and Philadelphia Water Department fish surveys of the creek. Species lists from the Pennypack Preserve indicate occurrences of sweet bay magnolia (*Magnolia virginiana*) and serviceberry (*Amelanchier canadensis*). This does not mean that these species are not present in other natural areas of the watershed or that other fish species do not inhabit the Pennypack Creek.

The ESED Pennypack Park Master Plan mentions the potential to restore populations of the Threespine Stickleback (*Gasterosteus aculeatus*), a Pennsylvania endangered fish, to tidal ponds in the lower portion of the watershed.

Table 6.2 Key to Global and State Ranking System

State Element Ranking	Implication	State Status	Implication
S1	Critically Imperiled in the State (<5 Occurrences)	PE	PA Endangered
S2	Imperiled In The State (6-20 Occurrences)	PR	PA Rare
S3	Rare Or Uncommon in the State (21-100 Occurrences)	PT	PA Threatened
S4	Apparently Secure in the State	PX	PA Extirpated
S5	Demonstrably Secure in the State	CA	Candidate at Risk
A	Accidental in the State	N	No Current Legal Status
B	Breeding Population in the State	TU	Tentatively Undetermined
N	Non-Breeding Population		
X	Believed to be Extirpated from State		
?	Uncertain Status		

Source :PA DCNR

6.4 Important Habitats

Pennypack Park, Lorimer Park, and the Pennypack Preserve contain the largest contiguous tracts of land and diversity of habitats in the watershed. These parks and natural lands contain important tracts of forests, wetlands and meadows that provide habitat for various animal and plant species.

There are other smaller natural areas in the watershed that potentially harbor important populations of native plants and animal species. Linking these natural areas with major green corridors will increase the value of these smaller natural areas in terms of their ability to sustain diverse plant and wildlife populations.

Forests

Pennypack and Lorimer Parks and the Pennypack Preserve all contain significant acres of second growth forest. Since the watershed was largely clearcut for agriculture since early European settlement, existing forests are considered "second growth" because they have regrown since clearcutting. However, there are several small areas of old forest, primarily found on the steep slopes and riparian zones along the Pennypack Creek.

Remaining forest communities are experiencing significant threats from deer browsing and the presence of non-native invasive plant species that have severely restricted the understory habitats in the watershed's forests. These understory habitats are critical for small birds and animals that nest, forage, and hunt in this level of the forest vegetation. Pressure on the understory level of these forests is also interrupting the replacement and recruitment of canopy trees in the forests. Since sapling trees are being eaten or displaced from their natural habitat by invasive species, the trees in the existing forests are aging, dying and not being replaced.

The remaining forests in the watershed will require extensive management in order to ensure their long term viability and survival. Important management considerations include managing the deer population throughout the watershed, excluding deer and invasive plant species from restoration sites and existing critical natural areas and creating sustainable habitat structure in the watershed's forests so that they can host the diversity of wildlife historically found in the region's forests. Some of these management options are controversial and all will require great cooperation and effort from all of the watershed stakeholders in order to be successful.

Wetlands

There are many small wetlands still found in the Pennypack Creek Watershed. Most of these wetlands are associated with the stream system and its floodplains. These small wetlands are a result of a high water table or water from the creek overtopping its banks and pooling in depressions. These riparian wetlands are threatened by the severe hydrologic fluctuations caused by the urban and suburban development of the watershed and its attendant increases in stormwater flows. In many places, streambed erosion and downcutting has resulted in a stream that is disconnected from its floodplain, and as a result, many riparian wetlands no longer receive the flow required to sustain wetland hydrology. Wetlands in the watershed are also under pressure from non-native invasive species, especially in riparian zones, where disturbance from high velocity stormflows opens habitat to colonization from invasive species.

Emergent wetland vegetation

Pennypack Park contains some regionally significant wetlands because of its location and tidal characteristics. The park contains the portion of the watershed that is located in the Atlantic Coastal Plain Ecoregion and also the tidal portion of the Pennypack Creek. These two factors make the lower Pennypack Creek Watershed home to biological communities that have been disappearing from Pennsylvania since the time of the earliest settlements.

Historically, wetlands in the Coastal Plain have been filled and paved over to facilitate development of the city of Philadelphia and the Delaware riverfront. As previously discussed, the Coastal Plain regions of the Pennypack Creek Watershed support biological communities that are typically found to the south and east of Pennsylvania. Species found in these communities are at the edges of their geographical distribution and typically found nowhere else in the state. The tidal freshwater marshes and Coastal Plain wetlands in Pennypack Park are important reserves of these disappearing habitats.

Currently there are two large restored tidal wetlands at the mouth of the Pennypack Creek located within the park and one small wetland along the Delaware River downstream of the mouth of the Pennypack, also located in the park. These restorations have improved rare coastal habitats in Pennsylvania and provide an opportunity to reintroduce native flora and fauna that have been extirpated from the watershed.

The Philadelphia Water Department is performing a comprehensive wetland assessment of the Philadelphia watersheds including the Pennypack Creek. The purpose of this assessment is to identify the size, quality and location of wetlands in the city's watersheds, including portions of those watersheds outside of the city. The assessment will ultimately identify potential wetland restoration sites that can be utilized to provide water quality improvements for stormwater or combined sewer overflow effluents.

Field studies on the Pennypack Creek Watershed were completed in late 2004. Wetlands were identified using U.S. Army Corps of Engineers *Wetland Delineation Manual*. Wetlands were identified as jurisdictional wetlands but boundaries were not delineated. Currently the project consultants are compiling field data and identifying and prioritizing potential wetland restoration projects.

Results of the wetlands assessment for the Pennypack Creek Watershed are expected in 2005. Results of this report will be included in this plan if they are available before the Draft of this plan is completed.

Meadows

Meadow Trail at Lorimer Park

Photo: Joanne Dahme

Meadow, grassland and succesional habitats are fairly uncommon in the Pennypack Creek Watershed. Upland meadows are particularly susceptible to invasive species that can tolerate a wide range of habitat conditions and sunlight. In Pennypack Park, meadows are often preferred spots for illegal dumping and vandalism. Meadows left in their natural state succeed to woodlands over time unless they are managed to remain meadows through burning or periodic mowing.

Meadows provide habitat for a number of species that have been in decline in Pennsylvania since agricultural fields and hedgerows have been converted to urban and suburban land uses. Many species of invertebrates, grassland nesting birds and plant species are found only in large tracts of native grasslands.

There are a number of meadows found in Pennypack and Lorimer Parks but the highest quality native grassland meadows can be found on the Pennypack Preserve. The Pennypack Ecological Restoration Trust has been restoring native warm season grass meadows on their property for over five years and has created over 100 acres of native warm season grass meadows that are managed to provide habitat for grassland species, especially nesting birds.

The ESED Pennypack Park Master Plan also identifies the need to restore and manage grasslands in the park to improve habitat diversity.

In addition, there are many opportunities in the watershed, outside of the parks, to support the creation of grassland habitats and to encourage their use by grassland nesting birds. Large open areas, such as corporate office park fields, can be managed as meadows by reducing mowing to one time per year. Mowing can be scheduled for late summer to avoid grassland nesting bird breeding season. These management measures would save property owners mowing and management costs while improving habitat. Tall grass meadows also reduce stormwater run-off from a site and the taller vegetation can improve stormwater quality.

6.5 NATURAL AREAS INVENTORY

County Natural Areas Inventories are surveys of rare, threatened and endangered species and locations of high quality natural areas found within Pennsylvania's counties. Natural Areas Inventories identify important resources and offer management recommendations to protect these sites and biological communities. The inventories can serve as guides to identify sites that are important to preserve and protect in their natural state. Bucks and Montgomery Counties have conducted Natural Areas Inventories in 1999 and 1997 respectively. Philadelphia does not have a Natural Areas Inventory, however the ESED Parks Master Plans (1999) have identified important natural areas, as well as rare, threatened, and endangered species found within the Fairmount Park System and can serve as an inventory of natural areas for Philadelphia.

Rare species found in the park and identified in the Pennypack Creek Park Master Plan include Dodder (*Cuscuta campestris*) and Eupatorium (*Eupatorium rotundifolium*). The tidal wetlands at the mouth of the Pennypack Creek and the old field meadow on the west bank of the creek between Verree and Krewstown roads are examples of important habitats in the park. The ESED Pennypack Park Master Plan provides detailed species and habitat descriptions in their report.

The Natural Areas Inventory of Montgomery County indicates that there are three sites of statewide significance and two locally significant natural area sites found within the Pennypack Creek Watershed in the county. There are no Natural Area Inventory sites in the Pennypack Creek Watershed located in Bucks County. The Montgomery County sites are listed below in order of their significance:

Sites of statewide significance

HIGH PRIORITY PROTECTION FOR MONTGOMERY COUNTY

Frazier's Bog, Upper Moreland Township

A small remnant of this wetland community persists. The site is significant due to the presence of three plants of special concern including a PA threatened shrub. Much of the bog was lost to the development of an adjacent golf course. The remaining habitat would benefit from preservation and invasive species control.

GENERAL PRIORITY PROTECTION FOR MONTGOMERY COUNTY

Willow Grove Station, Horsham Township

This site consists of a grass species of special concern on the grounds of the Willow Grove Naval Air Station. The Natural Area Inventory recommends management of the habitat to preserve this species of grass.

Willow Grove Roadside

This site contains a small population of a rare plant near the Willow Grove Turnpike exchange. The Natural Area Inventory did not recommend protection of this site.

Sites of local significance:

HIGH PRIORITY FOR LOCAL PROTECTION FOLLOWING PRESERVATION OF SITES OF STATEWIDE SIGNIFICANCE

Bethayres Swamp, Lower Moreland Township

This wetland consists of a grass, rush and sedge marsh, shrub swamp community and a small area of forested lowlands. The Natural Area Inventory identifies this site as good bird habitat in the developed region of Montgomery County.

LOW PRIORITY FOR LOCAL PROTECTION FOLLOWING PRESERVATION OF SITES OF STATEWIDE SIGNIFICANCE

Big Oak Woods, Abington Township

This location is currently protected within Lorimer Park but would benefit from management to prevent the encroachment of invasive plant species. The site exhibits good oak forest community structure including understory shrub vegetation.

Native biological communities are under great pressure in the Pennypack Creek Watershed. Preservation and management of prioritized natural areas and habitats are obvious starting points to maintain watershed biodiversity.

CHAPTER 7
CULTURAL RESOURCES

7.1 Recreation

Demand

Recreational uses and needs are generally determined by political boundaries such as municipal or county government divisions. This is typically the case because recreational activities are often financed through tax dollars, special recreational fees or funds set aside for recreation from fees paid by developers for that purpose.

On a watershed basis, river and stream related recreational demands are generally related to passive recreation, hiking and fishing. The River Conservation Plan Citizen's Survey identified hiking and enjoyment of nature as the two most important activities that respondents enjoyed with regards to the Pennypack Creek. In addition, the PA Fish and Boat Commission's efforts to stock the Pennypack Creek with trout and reinstate native hickory shad runs to the Pennypack underscore the importance of fishing to the residents of this watershed.

There are certainly other recreational demands and needs for the residents of the Pennypack Creek Watershed. There are demands for ball fields, playgrounds and other recreational activities that are met through neighborhood, county and regional parks. As the watershed's population ages (eight of ten of the study municipalities, including Philadelphia, have >15% of their populations in the "Over 65" age category), recreational needs and programming will change. Aging populations require more passive recreational opportunities, walking trails and senior programming at recreation centers.

Geographic Information Systems analysis of available data regarding municipal parks in the watershed indicate that, with the exception of a small section of Lower Moreland Township near Huntington Valley Country Club, no resident lives more than one mile from a community or municipal park or playground within the watershed.

Recreational and open space standards are often expressed as acres of recreational space per 1,000 people. The Delaware Valley Regional Planning Commission (DVRPC) has developed a population density standard to determine the open space needs for the region. DVRPC standards are reproduced in Figure 7.1. According to these standards and the population density of the watershed (4,642 persons/ sq. mi.), recreational need for the watershed should be at least 8 acres of sub-regional (county and Fairmount Park) parks per 1,000 residents if the watershed is viewed as a sub-region of the Delaware Valley. As seen in Figure 7.1, Lorimer Park and Pennypack Park provide 7 acres of sub-regional parks per 1,000 residents. This figure is just short of the recommended standard and is probably adequate for those portions of the lower watershed that are built out and will not see significant increases in population.


Photo: Pennypack Ecological Restoration Trust

Trail on Pennypack Preserve

Table 7.1 Pennypack Creek Sub-Regional Park and Delaware Valley Regional Planning Commission Sub-Regional Park Standards

DVRPC Standards		Pennypack Creek Watershed			Sources: DVRPC, U.S. Census 2000
Density (people/sq. mi)	Standard (acres / 1000 people)	Density	Sub-regional Parks (Acres in Pennypack and Lorimer)	Acres / 1000 people	
500-4,999	8	4,642	1,850	7	
5,000-9,999	6				
>10,000	4				

Currently the distribution of the sub-regional parks is located in the lower watershed where population densities are the greatest. Growing population in the upper watershed may require additional county parklands and open space in those portions of the watershed. The presence of the Pennypack Preserve in the center of the watershed will help to meet this sub-regional demand for passive open space and recreation.

It is important to note that recreational planning operates within political boundaries and that there are recreation centers and parks located outside of the watershed but is still available to meet the needs for watershed residents.

Facilities (Supply)

There are many recreational opportunities for the residents of the Pennypack Creek Watershed. From horseback riding and passive recreation to volleyball and after school programs, opportunities abound for residents to participate in recreation activities.

According to DVRPC 2000 land use data, 1,605 acres of land (4.5% of the watershed) is in the recreational category. This land use category includes both public and private recreational facilities such as playgrounds and golf courses. Much of the public parkland in the watershed is categorized as wooded. Wooded land occupies 5,190 acres or 14% of the watershed land area. There are approximately 65 community parks and schools that sponsor, host or allow recreational activities at their sites in addition to Pennypack and Lorimer Parks. Many of the municipalities in the watershed, as well as the City of Philadelphia Department of Recreation, offer additional recreational programming such as organized youth sports as well as courses, clubs and arts and crafts.

There are approximately 2,638 acres of municipal, city and county parklands in the Pennypack Creek Watershed. Approximately 65% of those park lands (1,733 acres) are in the city of Philadelphia. Pennypack Park accounts for almost 60% of the total park acreage in the watershed.

Baseball, softball and basketball facilities are present at 28 of the 65 park and recreation facilities analyzed. Soccer fields were available at 17 facilities while only seven have football fields. Thirty facilities identified have playgrounds and tot-lots, although this is probably an underestimation of the number of playground facilities in the watershed as many homeowner associations and apartment complexes also provide playground facilities. Only six recreation centers indicated that they had Senior

Citizen facilities and all but one of these recreation centers are located in the city of Philadelphia.

Spatially, these programmatic opportunities seem more accessible in city recreation facilities. When they are available in the suburbs, the programs are centralized in municipal recreation centers or township buildings. This spatial distribution can make access to recreational programs difficult for segments of the population that are transit dependent or dependent on other people to drive them to activities, namely senior citizens and those that are too young to drive. These age groups are usually the target populations for municipal recreation programs.

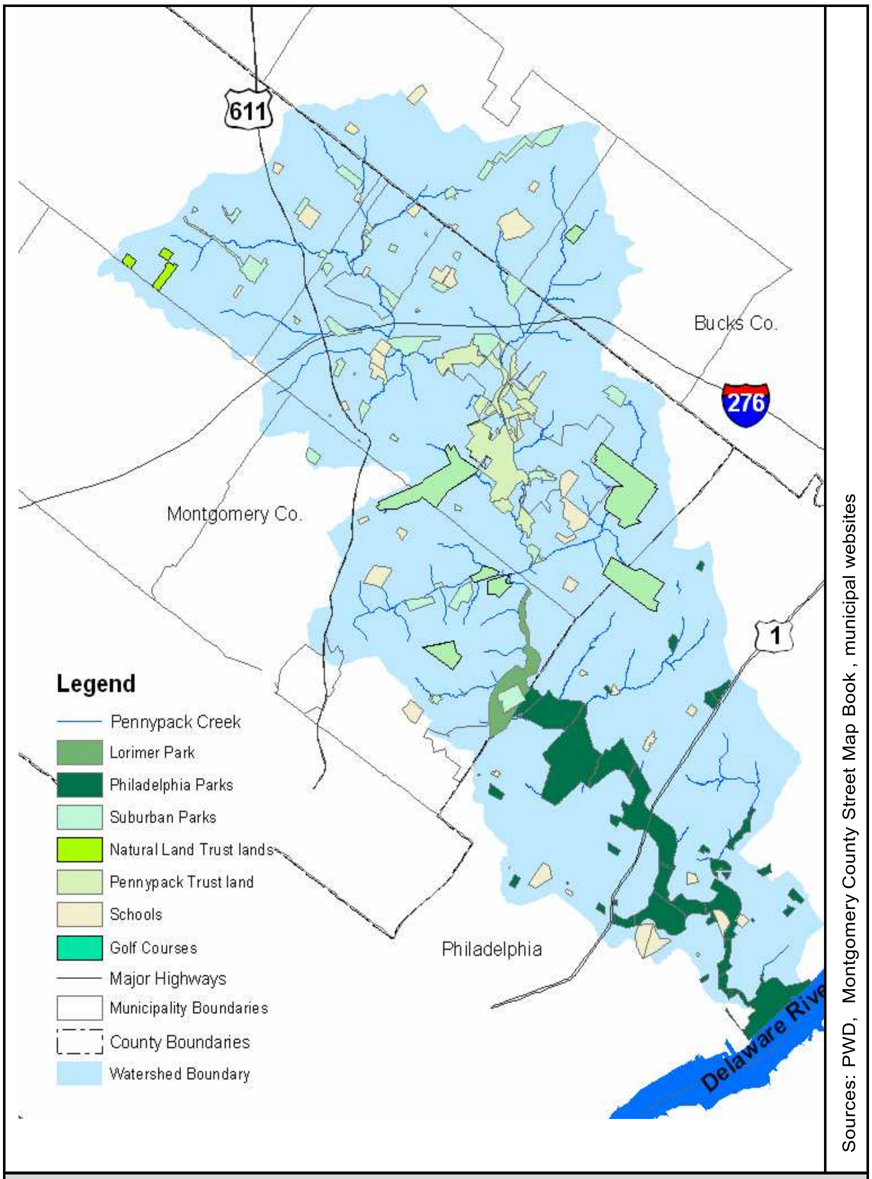


Figure 7.1 Open Space and Recreational Facilities in the Pennypack Creek Watershed.

Figure 7.1 is a map of the green spaces and recreational facilities in the Pennypack Creek Watershed. Park and recreational land uses are discussed in more depth in

Chapter 4 of this report. A matrix of the municipal recreational opportunities and facilities in the watershed can be found in Appendix E of this report.

A review of the matrix indicates that, in general, suburban communities would benefit from more diverse recreational programming, especially with regards to senior citizen activities.

Trails

Pennypack Park, Lorimer Park and the Pennypack Preserve host extensive trail networks that are open to the public. These trail systems offer excellent access to the natural areas of the watershed for passive recreation users and contribute significantly to the usage of these recreational and open space lands.

In addition to these three trail systems, there are three regional trails recommended by the Montgomery County Planning Commission that will greatly benefit the residents of the Pennypack Creek Watershed. They are the Cross County Trail, The Pennypack Trail and the Power Line Trail. These proposed trails will link other regional trails to the Pennypack Creek Watershed and the existing trail network of Pennypack Park. The regional trails will provide pedestrian and bike transportation corridors between natural areas and cultural and economic centers of the watershed and region.

The Montgomery County Planning Commission has commissioned a design and engineering study of the Cross County Trail. The Power Line Trail is in the planning stages and one section (2.5 miles in length) in Horsham Township has already been built. The Pennypack Trail is in the proposal stage. Figure 7.2 is a map of the proposed regional trail network taken from the Fairmount Park Commission Environment, Stewardship and Education Division's (ESED) *Pennypack Park Trail Master Plan*.

LORIMER PARK TRAILS

Lorimer Park has approximately six miles of hiking trails and bridle paths through the park's woodlands and meadows. The Lorimer Park Trails are an important component of the proposed Pennypack Trail, linking the Pennypack Preserve to Fairmount Park and the Delaware River.

PENNYPACK PARK TRAILS

Pennypack Park has an extensive existing trail network with approximately 44 miles of designated trails. The park's trail system runs the length of the park and has numerous ancillary trails that provide access into natural areas of the park and into the surrounding residential neighborhoods. The main trail, running along Pennypack Creek, runs from the Montgomery County line to the Delaware River, although the path of the trail diverges from the creek in the vicinity of State Road due to challenges posed by state and county detention facilities and Interstate 95.

There are also a number of unofficial or rogue trails through Pennypack Park. These trails present a challenge to park managers as they oftentimes promote erosion and the trampling of natural areas and vegetation. Rogue trails generally are created by continued use to attain access to the creek or to connect other access points to the designated trails. Illegal ATV and dirt bike trails were noted sources of rogue trails in Pennypack Park.

ESED completed a Trail Master Plan for Pennypack Park in 2001. The Master Plan was the result of extensive research and public outreach by ESED and proposed procedures for the long term maintenance, sustainability and enhancement of the trails in Pennypack Park. Major recommendations from the trail master plan include the use of volunteer groups for trail maintenance and repair, expanding the program that requires bike riders, equestrians and skaters to obtain a permit to utilize park trails, and expanding the voluntary donation program throughout Fairmount Park. The trail master plan also recommends increased efforts to control ATV and other illegal activities in the park system. The *Pennypack Park Trail Master Plan* prioritized restoration needs for the natural areas of the park as they related to rogue trails, poorly designed stream crossings and eroding trails edges. This document will serve as a good model for trail maintenance throughout natural areas for the other proposed trails in the watershed. Table 7.2 is reproduced from the *Pennypack Park Trail Master Plan*. The table details the miles of trails and their use in Pennypack Park.

Table 7.2 Existing Trail System Statistics for Pennypack Park

Trail Description / Use	Existing length (miles)
Multi-use (paved)	10.98
Multi-use (unpaved)	29.78
Hiking only (unpaved)	2.86
Abandoned	4.75
Rogue / Degraded / Redundant	11.20
Total Sanctioned Trails	43.62

Source: Fairmount Park Commission

PENNYPACK PRESERVE

The Trust maintains approximately nine miles of trails on two trail systems, the Main Trail System and Bethayres Trail System. The Bethayres Trail is exclusively for hiking and enjoying the nature in the Bethayres Woods while the Main Trail System includes 2.5 miles of multi-use trails. Multi-use trails are open to horseback riding, bike riding and walking of leashed pets. The Pennypack Ecological Restoration Trust has been faithfully installing and maintaining educational kiosks at all of the Preserve's trailheads where rules regarding trail usage are posted.

CROSS COUNTY TRAIL

This proposed 17.5 mile trail will connect Conshohocken Borough with Bryn Athyn Borough and the Bucks County line. This trail will utilize railroad and utility corridors as well as roadways and public lands. The trail will link important commercial areas such as Willow Grove and Conshohocken as well as important natural areas such as the Wissahickon Valley Watershed Association and the Pennypack Preserve. Users of the trail will have access to public transportation at least four or more regional rail stations on the trail.

Separation of trail and railroad uses poses a significant design challenge for this trail in the Pennypack Creek Watershed in the area of Willow Grove in Upper Moreland Township.

PENNYPACK TRAIL

The Pennypack Trail will connect the Cross County Trail with the Pennypack Park trail system in Philadelphia. This proposed 6.5 mile trail will follow the unused portion of the SEPTA Fox Chase to Newtown Railroad Line (R8). This trail will link trails in Lorimer Park to the Pennypack Preserve Trails.

Challenges to the implementation of this trail include numerous road and bridge crossings as well as the fact that the rail line follows a narrow creek valley that makes accommodating both the railroad and trail difficult.

POWER LINE TRAIL

The proposed Power Line Trail will connect the Cross County Trail with Evansburg State Park. This trail will stretch 17 miles along the PECO / Excelon Energy transmission corridor and local roads. Horsham Township has an agreement with the energy company for use of the corridor and has installed a 2.5 mile segment of the trail within the Township.

This trail faces significant design challenges in the watershed in the area of the proposed connection with the Cross County Trail in Lower Moreland.

Source: Fairmount Park Commission

Figure 7.2 Map of Proposed Regional Trail Network

Environmental Educational Opportunities

There are two significant environmental education centers located in the Pennypack Creek Watershed; the Pennypack Environmental Center and the Pennypack Ecological Restoration Trust.

PENNYPACK ENVIRONMENTAL CENTER

The Pennypack Environmental Center is located at 8600 Veree Road in Philadelphia. Pennypack Environmental Center is one of three environmental education centers operated by the Fairmount Park Commission in the city. Programming includes a number of after school and school group educational activities as well as events and programming for adults. Examples of programs include naturalist-led birding walks, nature walks, service learning, school outreach, teacher training and curriculum consultation.

In addition to the Environmental Center, Fairmount Park Commission offers environmental education through a number of volunteer restoration activities. Volunteers assist park managers with natural area restorations, invasive plant removal, native tree plantings and trail maintenance. These opportunities reach a large number of volunteers and connect them to Pennypack Park in a very tangible manner. According to the Fairmount Park Commission's Fiscal Year 2005 report, 1,073 volunteers contributed 2,507 hours removing trash, planting and maintaining trees and maintaining trails between July 1, 2004 and June 30, 2005. Sixty-two percent of these volunteers were repeat volunteers.

The Friends of Pennypack Park, an independent organization of concerned citizens, contribute to environmental and historic educational activities in the watershed and in Pennypack Park. The Friends offer information on the history of the watershed and publish maps of the park. The Friends also contribute hundreds of volunteer hours removing trash, planting trees and maintaining trails in Pennypack Park.

Pennypack Environmental Center

Photo: Fairmount Park Commission

PENNYPACK ECOLOGICAL RESTORATION TRUST

Pennypack Ecological Restoration Trust, located at 2955 Edgehill Road in Huntington Valley, is an important environmental education center which occupies 720 acres of preserved land in Abington, Lower Moreland and Upper Moreland Townships and Bryn Athyn Borough. Environmental education opportunities at the Trust include educational walks and programs as well as volunteer habitat maintenance and restoration activities. The Trust hosts the monthly meetings of the Southeastern Montgomery County Chapter of Trout Unlimited which is also very active in promoting volunteer monitoring and restorations of the Pennypack Creek.

7.2 HISTORICAL/ ARCHAEOLOGICAL

Sites/Structure/Districts

The Pennypack Creek Watershed has a long record of human habitation and played an important role in the history of our state and our country. There are a number of historic buildings and archaeological sites still in existence in the watershed. These buildings represent most of the historic periods of settlement and growth in the watershed, from colonial times in the mid 1700s (Horsham Friends Meetinghouse) through the growth of the railroad suburbs in the late 1800s (Philmont Rail Road Station) to periods of suburban growth and development in the 1900s (Strawbridge and Clothier Building in Jenkintown).

The watershed is also home to architecture important to the growth of the Swedenborgian religious community that founded Bryn Athyn. Cairnwood and Glenncairn are two historic buildings in Bryn Athyn associated with the Pitcairn family who donated a good deal of resources that helped establish the religious and educational community in Bryn Athyn Borough.

In 1966, the U.S. Congress created the National Register of Historic Places. The purpose of the National Register is to serve as the country's official list of cultural resources worthy of protection. The National Register is administered by the National Park Service of the Department of the Interior. Listing in the National Register contributes to preserving historic properties in a number of ways:

- Recognition that a property is of significance to the Nation, the State, or the community.
- Consideration in the planning for Federal or federally assisted projects.
- Eligibility for Federal tax benefits.
- Qualification for Federal assistance for historic preservation, when funds are available.

There are 16 sites on the National Register of Historic Places and 27 sites deemed eligible for the National Register within the Pennypack Creek Watershed. Three of these sites are bridges and a number of the sites are school buildings. Table 7.3 lists sites in the watershed that are listed on the National Register. Table 7.4 lists sites in the Pennypack Creek Watershed that are determined to be eligible for listing on the National Register.

The Fairmount Park Commission's Pennypack Park Trail Master Plan lists significant historic resources that can be viewed from the trails in Pennypack Park. While not all of these sites are recognized by the National Register, they do represent important local resources and connections to the watershed's history.

Table 7.3 Pennypack Creek Watershed Sites Listed on the National Register of Historic Places

Site	Municipality
Abington Township High School	Abington Township
Cairnwood	Bryn Athyn Borough
Glenncairn	Bryn Athyn Borough
Loller Academy	Hatboro Borough
Union Library Company	Hatboro Borough
Horsham Friends Meetinghouse	Horsham Township
Jenkin's Town Lyceum	Jenkintown Borough
Strawbridge and Clothier Store	Jenkintown Borough
Bryn Athyn-Lower Moreland Bridge	Lower Moreland Township
Fetter's Mill	Lower Moreland Township
Lady Washington Inn	Lower Moreland Township
Joseph Brown School	Philadelphia
Fayette School	Philadelphia
Frankford Avenue Bridge	Philadelphia
Holme Avenue Bridge	Philadelphia
Knowleton	Philadelphia

Source: Pennsylvania Historic and Museum Commission (PHMC)

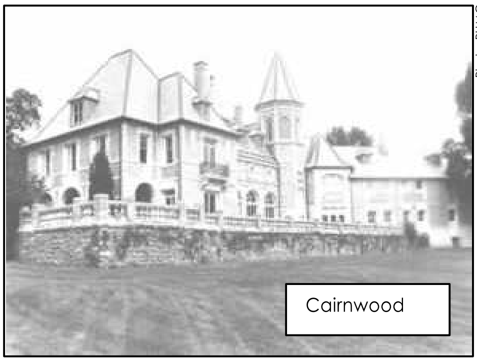


Photo: PHMC
Cairnwood

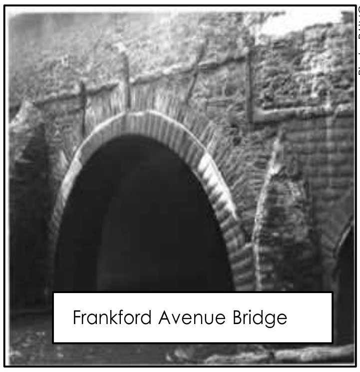


Photo: PHMC
Frankford Avenue Bridge

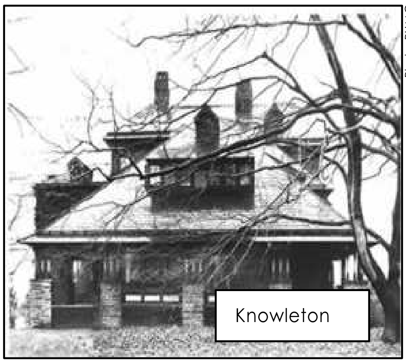


Photo: PHMC
Knowleton

Table 7.4 Pennypack Creek Watershed Sites Eligible to be Listed on the National Register of Historic Places

Site	Municipality
Abington YMCA	Abington Township
Hollywood Historic District	Abington Township
Meadowbrook Station	Abington Township
Overlook Elementary School	Abington Township
Stanley	Abington Township
Woodside	Abington Township
Fetter's Mill Historic District	Bryn Athyn Borough
Roberts and Mander Stove Company	Hatboro Borough
Blair Mill House	Horsham Township
Iredell House	Horsham Township
Kenderdine House	Horsham Township
John Lukens House	Horsham Township
William Lukens House	Horsham Township
Ely House	Lower Moreland Township
Fetter's Mill Historic District	Lower Moreland Township
Huntington Valley Historic District	Lower Moreland Township
Philmont Rail Road Station	Lower Moreland Township
Red Lion School	Lower Moreland Township
Thomas Walton House	Lower Moreland Township
Warner-Jeanes House	Lower Moreland Township
Blair Mill House	Upper Moreland Township
Molloy Historic Site	Upper Moreland Township
Chamberlain House	Upper Moreland Township
Naval Air Warfare Center Building 108	Warminster Township
Naval Air Warfare Center Building 70	Warminster Township
Naval Air Warfare Center Building 361	Warminster Township
Gilmore Building	Philadelphia
Philadelphia House of Correction	Philadelphia

Source: PHMC

As the watershed continues to grow and first ring suburbs are revitalized or redeveloped, special attention needs to be paid to the disposition of historic buildings and infrastructure. Many of these historic sites provide a tangible connection to the watershed's past. Where possible, preservation or adaptive reuse of historic structures for modern use and enjoyment should be investigated and supported.

Archaeological Resources

The Pennsylvania Historical and Museum Commission (PHMC) maintains an inventory of archaeological sites and investigations in the state. The PHMC tracks archaeological resources through Pennsylvania Archaeology Site Surveys (PASS). These site surveys assist the PHMC by cataloguing important archaeological resources and by informing planners and developers when projects may disturb identified archaeological sites.

An inventory of archaeological sites in the Pennypack Creek Watershed documents evidence of human occupation of the watershed from as far back as circa 3,000 B.C. up to a number of important modern sites from the nineteenth and twentieth centuries.

Table 7.5 identifies the PASS numbers, the county in which the resource is located and the historic period of the archaeological sites in the Pennypack Creek Watershed. The PHMC indicated that it is highly likely that there are many more undocumented sites in the watershed, especially along flat, well drained areas along the Pennypack Creek. The PHMC discourages construction projects involving ground disturbance in these areas to avoid potential adverse effects on archaeological resources.

Table 7.5 Pre-historic Resources of the Pennypack Creek Watershed

PASS Number	County	Period and date range	Archaeological evidence
36 Mg 84	Montgomery	Unknown	Rockshelter
36 Ph 41	Philadelphia	Archaic (3000-1000 B.C.) and Woodland (1000 B.C. – 1550 A.D.)	Projectile points (spear points and arrowheads)
36 Ph 42	Philadelphia	Archaic (3000-1000 B.C.) and Woodland (1000 B.C. – 1550 A.D.)	Unspecified
36 Ph 43	Philadelphia	Unknown	Lithic chipping debris (remnants of stone working)

Source:PHMC

In addition to these pre-historic sites, there are 15 historic period archaeological site surveys completed for domestic occupation sites from the nineteenth and twentieth centuries in Montgomery County. Their PASS. numbers are: 36 Mg 184, 36 Mg 192, 36 Mg 201, 36 Mg 216, 36 Mg 217, 36 Mg 218, 36 Mg 343, 36 Mg 356, 36 Mg 357, 36 Mg 359, 36 Mg 360, 36 Mg 364, 36 Mg 365, 36 Mg 366 and 36 Mg 367. Most of these sites are along major roadways and were surveyed during the infrastructure and road improvement project permitting process.

CHAPTER 8
MANAGEMENT RECOMMENDATIONS

8.1 MANAGEMENT AND IMPLEMENTATION STRATEGIES

Based on information collected for the Pennypack Creek River Conservation Plan, the planning team has developed eight management goals. These goals are consistent with the goals of conservation plans and watershed management plans developed for the other watersheds in the City of Philadelphia. These goals are also consistent with goals found in other municipal and natural resource protection plans developed for the Pennypack Creek Watershed.

In this chapter, the goals are introduced along with the planning needs, data gaps, monitoring outcomes and education needs required to implement the goals. At the end of the chapter, a Management Options Matrix identifies the implementation actions or objectives that the steering committee has developed to implement the plan's goals. Many of these objectives can help forward a number of goals and can serve as a "to do" list for watershed stakeholders.

Members of the public were given an opportunity to identify their priority implementation actions through a series of public meetings held in September and October 2005. The results of this prioritization are included in Appendix G.

Goal 1: Improve Stream Habitat and Restore Aquatic Communities

The Pennypack Creek Watershed contains 79 miles of surface water streams. Eighty-two percent of those stream miles do not support the aquatic communities that should be present in Pennypack Creek according to the state water plan and the Philadelphia Water Department's *Baseline Assessment of the Pennypack Creek Watershed*. Much of this degradation is due to the negative impacts of stormwater flows and the sediment and nutrient inputs from stormwater runoff.

Improving stream habitat will necessarily involve addressing the manner in which stormwater is managed in the watershed. Improved stormwater management practices will not only improve the overall health of the watershed's communities but will enhance overall stream habitat and create an environment for the recovery of natural biological communities in the Pennypack Creek.

PLANNING & DATA GAPS

In order to improve aquatic habitats, there is a need to first identify sections of stream channel in the watershed that are geomorphically unstable. The causes of this instability should be determined and addressed before habitat enhancement projects are planned or implemented. In stream reaches with stable urban hydrologic regimes, identification of projects that restore natural channel and floodplain geometry should be aggressively pursued. Currently the PWD is conducting a geomorphology study of the Pennypack Creek Watershed. This study will provide critical information needed to identify potential sites for stream channel and habitat restoration. PWD will use information collected during the geomorphology study and the River Conservation Plan for the basis of a Watershed Management Plan scheduled to begin in 2006/2007.

The Fairmount Park Commission's Natural Land and Environmental Education Program (NLREEP) developed a master plan for Pennypack Park. As part of the master plan, NLREEP performed habitat assessments for the Pennypack Creek within the park. NLREEP has used this assessment to prioritize and implement habitat restoration projects in the park. That plan should be used as a model for assessing habitat quality in the Pennypack Creek Watershed for natural areas and lands outside of Pennypack Park. Prioritization should consider project costs as well as the benefits to the stream environment, water quality and aquatic habitat improvements for the stream. Part of this prioritization would include the identification of the owners of large, contiguous riparian land holdings in order to encourage those landowners to implement or permit restoration activities. Stretches of the Pennypack Creek that possess good quality stream habitat should also be identified and measures should be taken to prevent the degradation of these sites.

Habitat restoration plans should include riparian buffer restoration projects. These restoration projects will ultimately help to reduce economic losses and property damage resulting from stream bank and channel instability and will benefit the quality of life of everyone who lives, works or visits the creek as well as aquatic communities.

IMPLEMENTATION

There are many positive actions that should be implemented to improve in-stream habitats and to restore aquatic communities. The removal of dams on the stream and restoring degraded stream channels to their natural condition are important objectives to restore longitudinal connectivity to the stream corridor. Implementing natural stream channel design projects, especially in areas experiencing geomorphic instability, will improve water quality and create habitat for native aquatic biological communities.

Riparian buffer restoration projects and removal of non-native plant species from the riparian corridor also play a role in restoring stream habitats. Fish and aquatic macroinvertebrates rely on riparian vegetation as sources of food and cover. Native forested riparian vegetation, which has been present in the watershed for millennia, is important because of its contribution to the stream energy cycle and food web.

MONITORING OUTCOMES

The Philadelphia Water Department's five year biomonitoring program and the PA DEP's water quality assessment provide mechanisms for monitoring in-stream habitat conditions in the Pennypack Creek. Habitat and riparian land restoration projects should be monitored for successes improving water quality and enhancing biodiversity. These restoration projects should be monitored not only for desired outcomes but also revisited to determine the long term sustainability of these efforts.

A volunteer monitoring network should be established to assist with the evaluation of habitat restoration projects. Volunteers should be trained to evaluate improvements in habitat and stream system stability to provide long term data on the benefits and sustainability of restoration projects. Well trained and equipped volunteer monitors should collect additional water quality, stream morphology and habitat data. Volunteer monitoring programs should be established to ensure data quality control and to collect data that can be used to improve the body of knowledge about the Pennypack Creek. Existing groups, such as the Southeast Montgomery County Chapter of Trout Unlimited, have trained volunteer stream monitors. This group in particular can serve as a model for future volunteer monitoring efforts.

EDUCATION

Habitat protection and enhancement projects serve as opportunities to engage the public and educate them about beneficial land-use practices and actions that they can take to improve the watershed environment. A targeted education and outreach effort for streamside property owners and institutional landowners that have large land holdings in the watershed should be developed to provide benefits to the Pennypack Creek and the watershed's habitats.

Education for municipal officials and developers regarding the interaction between land use and water resources should accompany efforts to restore stream habitats. The economic benefits of preserving natural stream corridors should be made clear to builders and municipal officials to encourage better community planning and site development.

Goal 2: Improve In-stream Flow Conditions

The nature of development patterns and extent of impervious surfaces in the watershed have resulted in streams that have low baseflow, or baseflow that consists largely of wastewater treatment plant effluent during periods of dry weather. Two primary causes of reduced stream baseflow are the reliance on groundwater wells for commercial and residential uses in the upper watershed and the presence of large areas of impervious surfaces that prevent rainwater from infiltrating into the ground and recharging groundwater aquifers. After even small storm events, stream levels rise significantly and often result in flooding conditions. These large fluctuations in stream flow impact aquatic life, streambank and channel stability, and the water quality in the Pennypack Creek Watershed. Heavy reliance on groundwater sources reduces the amount of water available in streams during periods of low flow and impervious surfaces that increase stormwater run-off cause large increases in stream water levels and stream water energy.

Dams and other structures on the creek, such as bridges and culverts, also affect stream flows. Dams prevent the natural flow of the stream and create impoundments that result in upstream sedimentation and downstream erosion. These impoundments contribute to water quality degradation and hamper fish passage. Bridges and culverts, especially if not sized properly, also restrict the flow of a stream and can contribute to flooding problems when water can not pass through the structure's opening.

Improving in-stream flow conditions will require addressing both baseflow, to provide water for aquatic organisms during dry times, and addressing constrictions on the stream channel that exacerbate flooding and stream velocity conditions during times of elevated stream flow.

PLANNING & DATA GAPS

The in-stream flow conditions of the Pennypack Creek are the result of a number of complex interactions between groundwater withdrawals, large areas of impervious surface in commercial and residential development in the watershed, wastewater discharges and many other factors. Understanding these interactions is necessary to address the large fluctuations of in-stream flows that are negatively affecting the aquatic communities in the watershed and have resulted in the stream's listing on the state's list of impaired waters.

Recommendations of the many on-going watershed planning efforts should be implemented to improve in-stream flow conditions in the Pennypack Creek Watershed. The Pennypack Creek

Watershed is in need of a comprehensive stormwater management plan, also known as an Act 167 Plan. Local land use and development controls need to be developed, in some cases, and implemented, in most cases, to ensure proper bridge and stream crossing design to prevent flow constrictions when stream crossings are built or repaired. Improved municipal cooperation that considers watershed wide impacts will not only improve the health of the Pennypack Creek Watershed but also reduce flooding and damage to the stream and property associated with elevated storm water flows. Detailed hydrologic studies, such as an Act 167 Stormwater Management Plan and the Temple University Floodplain Study of the Pennypack Creek, are critical to identifying the specific causes of flow fluctuations and properly addressing them.

Identification of locations of flow constrictions on the streams in the watershed is an important data need in this watershed. Temple University's Floodplain Study will identify structural constrictions of the Pennypack Creek and will provide a starting point to begin locating these flow constrictions. The Temple study should be utilized to encourage better planning to mitigate these conditions and ultimately reduce flooding associated with debris jams and flow constrictions.

IMPLEMENTATION

There are many opportunities to implement projects to improve in-stream flow conditions within the Pennypack Creek Watershed through retrofitting existing conventional stormwater conveyance systems. The watershed is in need of demonstration stormwater BMPs such as infiltration trenches, porous pavement parking lots and other innovative stormwater BMPS. Identifying, prioritizing and retrofitting existing stormwater BMPs to do a better job at removing pollutants and reducing stormwater discharges would also greatly benefit the in-stream flow conditions in this watershed. Finally, addressing flow constrictions on the Creek by removing dams and ensuring proper bridge and culvert design during development and redevelopment is a critical step to restoring natural flow conditions to the Pennypack Creek.

MONITORING OUTCOMES

Long term flow monitoring data is an important tool for analyzing a wide variety of water quality and physical stream characteristics. Existing USGS flow monitoring stations should be maintained to provide these data. Data from these stations may be used to track changes in in-stream flow conditions as measures are implemented to reduce flooding and increase stream baseflow.

The need for more flow monitoring stations should be investigated. Additional monitoring stations will capture flow fluctuations associated with new development and projects aimed at improving flow conditions in locations in the watershed that are undergoing rapid changes in land-use and hydrology. The Pennypack Headwaters sub-watershed would benefit from a flow monitoring station to measure the effects of land-use changes and watershed management efforts on the hydrology of this important sub-watershed.

EDUCATION

There is a need in the watershed for education for the general public and municipal officials regarding the relationship between stormwater runoff, water conservation and environmental quality of the Pennypack Creek Watershed. Officials would benefit from education about how these factors relate to federal and state regulations to promote a better understanding of the need for these regulations. A better understanding of these issues for municipal supervisors and staff would also encourage innovative municipal tools to improve the watershed environment beyond meeting minimum regulatory requirements.

Goal 3: Improve Water Quality and Reduce Pollutant Loads

Improving water quality in the Pennypack Creek Watershed is largely tied to improving stormwater management in the watershed. Much of the watershed was developed before state and federal regulations requiring stormwater management were implemented. As a result, unmanaged stormwater flow causes erosion, transports pollutants to the stream and impacts water quality.

Other areas of the watershed have been developed before regulations requiring water quality improvements to stormwater were implemented (that is before NPDES Phase II regulations). These areas generally have stormwater regulations that control peak rates at which stormwater can be discharged without consideration to pollutant loads, water quality or total volume of stormwater discharged.

Improving water quality and reducing pollutant loads means reducing erosion and sediment resulting from stormwater runoff, as well as reducing the amount of nutrients, particularly phosphorous, in non-point source pollution. These reductions will most likely result from a combination of effective public education and improvement of stormwater BMPs, both in existing developments and new development.

PLANNING & DATA GAPS

An Act 167 Plan would encourage inter-municipal cooperation regarding stormwater management, require improved stormwater BMP function and develop minimum standards for stormwater management in new developments throughout the watershed. An Act 167 Plan would also develop the complex hydrologic and flow models that could be utilized in other watershed planning and monitoring efforts. Recent Temple University Studies will provide important hydraulic and hydrologic modeling data that will benefit the Act 167 Plan process.

Long term monitoring and maintenance plans for the watershed's new and existing stormwater BMPs should be required. An inventory of existing BMPs, which note the condition of the BMP and the party who is responsible for operation and maintenance, is a good first step to addressing the quality and function of these structures. Each new BMP installed in the watershed should have a routine maintenance schedule and have an identified, fiscally responsible party, such as a homeowners association, to ensure that long term operation and maintenance plans are carried out. The Temple University Floodplain study will identify potential stormwater BMP retrofit opportunities and will be a critical starting point to improving stormwater management in developed portions of the watershed.

IMPLEMENTATION

Improving water quality in the Pennypack Creek Watershed will require reducing point and non-point source pollutant loads. Point source pollutant loads can be reduced by the continued efforts of wastewater utilities to identify and repair leaking sewer infrastructure, track and eliminate illegal sewer cross connections between storm and sanitary sewers and ongoing efforts by the City of Philadelphia to implement their cross connection program, initiated in 1995, and to reduce the occurrences of combined sewer overflows in the lower portion of the watershed.

Developing and implementing a TMDL to reduce sediment and nutrient loading to the Creek from both point and non-point source pollution is another critical step towards effectively improving water quality.

Reducing non-point source pollution inputs will require educating the community about their role in protecting water resources and implementing better land and stormwater management practices. Implementation of the recommendations of the Temple University Floodplain study to retrofit and repair stormwater BMPs in the watershed will help to improve water quality. In addition to stormwater retrofits, water quality in the Pennypack will benefit from implementation of long term operations and maintenance plans for new stormwater BMPs to ensure that these practices continue to function properly into the future. These plans should be developed to ensure continued compliance with NPDES regulations.

MONITORING OUTCOMES

Targeted water quality monitoring programs that accompany BMP retrofits or other water quality improvement projects are necessary to gauge which tools and projects offer the greatest gains and improvements to the watershed water quality. Currently there are gaps and needs for data on the benefits of water quality improvement projects' effects on water quality. Monitoring programs should be established to document the effects of stormwater BMP retrofits and other water quality projects.

Additional chemical water quality data on the watershed is also needed. Philadelphia Water Department monitoring has provided a valuable water quality snap-shot for the watershed. Data such as continuous temperature and dissolved oxygen monitoring as well as wet weather sampling data should be collected to better characterize the sources of pollutant loading on the watershed and provide a more complete picture of the range of water quality fluctuations in the Pennypack Creek and its tributaries.

EDUCATION

Since land-use in the watershed is largely residential, improvements in water quality should be made through encouraging and educating landowners, developers and municipal officials to become better watershed stewards. There are many existing resources to assist municipalities and organizations with providing this education. Meeting these educational requirements is a component of the NPDES Phase II stormwater regulations.

Education efforts should be implemented cooperatively between watershed municipalities to reduce costs, share information among the municipalities, and reinforce the concept of a watershed to residents. Benefits of an effective education program will not only meet regulation requirements but will ultimately help to reduce non-point source pollution and improve residential, municipal and construction land-use practices that contribute to water quality degradation.

Goal 4: Improve and Protect Stream Corridors

Natural stream corridors are important to the health of the stream and the ecologic community of a watershed. Riparian and floodplain land-use management can directly impact water quality, in-stream flows, economics of flooding, recreation and a number of other aspects of the River Conservation Plan. Protecting existing natural stream corridors and improving riparian and floodplain land-use practices is a major goal of this plan.

PLANNING & DATA GAPS

A large portion of the Pennypack Creek is protected by a green corridor of privately and publicly protected lands. The Montgomery County Comprehensive Plan identifies further trail and greenway connections through the watershed and along the Pennypack Creek as county priorities. The goal of extending the existing green corridor and enhancing trail connections and recreational uses of the creek should be supported by municipal open space and recreational planning. Many of the open space plans for the municipalities in Montgomery County are being updated in response to the open space bond referendum passed in 2003. These plans should identify and target parcels that assist in the establishment of greenways along the Pennypack Creek.

Cooperation among municipalities to acquire lands to implement trails and greenways that cross municipal boundaries reduces cost share requirements of the Montgomery County Open Space program and improves the likelihood of success of obtaining state funding to implement watershed wide greenways.

A database of riparian landowners, land-uses and zoning would provide an excellent planning tool for targeting efforts to extend and protect the stream corridor along the Pennypack Creek and its tributaries. Riparian parcels can be prioritized by natural resource value, value as important linkage, and danger of conversion to intensive land-use or other priority. This information can be shared among municipalities and conservation organizations to assist in greenway planning and stream corridor protection.

Natural Lands Trust has developed a “Smart Conservation” program to evaluate the relative value of preserving parcels of land. This program may be a useful tool to evaluate riparian parcels in the Pennypack Creek Watershed in terms of their conservation value.

Protection of existing stream corridors on public lands is critical to promoting this goal. Natural areas and parks in the watershed would benefit from land management plans, especially for the riparian corridor, invasive species control and deer management.

IMPLEMENTATION

Implementation of watershed wide trails and greenways and preservation of green riparian corridors on private lands is dependant on successful outreach efforts to riparian land owners. Land owners should be encouraged to establish riparian buffers on their properties through education about the benefits of riparian buffers for water quality and the environment as well as for property values. Outreach efforts should also educate riparian land owners about the mechanisms and financial benefits of donating conservation easements. There are two active land trusts in the watershed, Natural Lands Trust and the Pennypack Ecological Restoration Trust that can play key roles in this task.

Implementation of trails and greenways will also require sources of funding and community based support. Some acquisition funds are available to Montgomery County municipalities through the Montgomery County Open Space bond issue. These funds should be matched by other sources to acquire land or easements on key corridor parcels. Negotiations with SEPTA and other large institutional land owners for trail easements will be more successful if presented by broad based community coalitions such as the Pennypack Partnership.

MONITORING OUTCOMES

The success of efforts to preserve stream corridors and greenways in the watershed can be accomplished through collection of annual statistics of riparian parcels or acres preserved either through acquisition or easement by government agency or conservation organization. Stream corridor preservation efforts should be periodically evaluated to determine the most effective methods of preservation, the economic impacts of stream corridor preservation and the remaining unpreserved critical linkages for trails, greenways and wildlife corridors.

EDUCATION

Educating riparian land-owners and the general public about the benefits of natural stream corridors improves stream corridor stewardship as well as political support for greenways and open space funding. Riparian landowners should be offered educational programming and materials regarding beneficial land use practices and management as well as education about the benefits to donating conservation easements along stream corridors.

Education concerning the benefits of trails and greenways should also be targeted at the watershed municipalities and developers. These educational efforts can encourage preservation of riparian corridors during the development process and stress the importance of regional open space linkages.

Goal 5: Address Flooding

Flooding within the Pennypack Creek Watershed has cost watershed residents millions of dollars and even some lives in the past 10 years. As with many of the goals of this River Conservation Plan, reducing flooding is closely related to other goals such as improving in-stream flow conditions and protecting stream corridors. Reducing losses associated with flooding is directly related to stormwater management and to preventing development and encroachments of the creek's floodplain. A major recommendation of this plan, offered to reduce damage from flooding in the watershed, is to prevent any future development within the mapped floodplains and where possible, purchase flood prone properties to enhance the watershed wide greenway.

PLANNING & DATA GAPS

Municipal land use and land development controls are the best tool for eliminating development in the floodplain and floodplain encroachment. Currently each of the municipalities in the watershed has ordinances that control development in the Federal Emergency Management Agency (FEMA) delineated 100-Year Floodplain. Careful review of planned development's cumulative effect on the downstream watershed needs to be considered when encroachments of the floodplain are proposed. Temple University's study of the floodplain of the Pennypack Creek Watershed will result in a remapping of the FEMA floodplain to reflect the impact of suburban development on the hydrology of the watershed and identify structures that lie within the new floodplain boundary. Municipalities need to utilize this new tool to improve their floodplain management efforts.

With the completion of the Temple University Floodplain study, the Pennypack Creek Watershed will have the most current floodplain maps in the region as well as a wealth of knowledge regarding the hydrology of the watershed. Results and implications of this study and mapping need to be distributed to watershed stakeholders so that communities and watershed stakeholders can begin to implement flood mitigation projects that benefit the entire watershed.

Municipalities should work with FEMA and the PA Emergency Management Agency to develop flood emergency plans so that they are better equipped to respond to flooding, and to reduce loss of life and property. Municipalities that experience frequent flood damage should have established mechanisms to engage state and federal emergency management agencies to assist flood victims. These plan's should also include the evaluation of flooding frequency so that educated decisions can be made regarding buy-outs of flood prone properties and mitigation of constrictions to the stream that exacerbate local flooding.

IMPLEMENTATION

Reducing economic and environmental damage from flooding in this watershed will require mitigating structural constrictions on the creek, removing structures from the floodplain and preventing future encroachments on the floodplain of the Pennypack Creek.

The first task can be accomplished by identifying undersized bridges and culverts on the creek and its tributaries and redesigning or retrofitting the structures to accommodate flood flows. Mitigation efforts can be implemented when the structures are undergoing replacement or repair. Another step is to prevent future constrictions of the stream by ensuring that future bridge crossings and culverts are designed and constructed properly to allow for the passage of flood flows.

Identification of flood prone properties, removal of structures from the floodplain, and elimination of further development of floodplain areas is critical to reducing economic losses and mitigating flooding issues in the watershed.

MONITORING OUTCOMES

Floodplain encroachments should be tracked and documented to evaluate progress in implementing floodplain management strategies and protecting the watershed's floodplain. Data should be collected regarding number of permitted encroachments as well as instances where variances are granted to allow development in the floodplain. These efforts will provide information on the number of new floodplain encroachments as well as how strictly municipal floodplain protection measures are be enforced. This information can then be analyzed to create a municipal "report card" to help judge flood management efforts.

EDUCATION

Municipal officials, planning staff and commission members would benefit from education on floodplain management and protection techniques. Education materials could include updated model floodplain protection ordinances, floodplain best management techniques and information from the Temple University Floodplain Study. This information should be shared among municipalities and a clearinghouse should be created for the dissemination of new information. Education should stress the cumulative effects of allowing floodplain encroachments and granting zoning variances on downstream flooding.

Goal 6: Enhance and Improve Recreational Opportunities

The parks and open spaces in the Pennypack Creek Watershed offer many active and passive recreational opportunities, from ball fields and bike riding to bird watching and fishing. The quality and enjoyment of those facilities is often related to the quality or perceived quality of the Pennypack Creek itself. When the Creek suffers from excessive flooding, trash and debris litter the banks and stream corridors. If the creek suffers from algal blooms, odors and appearance can prevent people from using streamside trails. The watershed's streams and recreational opportunities are closely related. Enhancing these recreational opportunities not only depends on protecting the stream and its corridor but also reinforcing the connection between these amenities and water resources through improved access to the stream.

Planning & Data Gaps

Municipal park, recreation and open space planning efforts should consider the cultural and recreational value offered by the Pennypack Creek. The Pennypack Creek corridor and potential trail linkages should be incorporated into new development plans to further the goal of developing watershed wide trails and greenways. Stream access needs and stream corridor linkages need to be addressed in the watershed headwaters and at the mouth of the Pennypack Creek.

An inventory of available land for potential greenway, open space and recreational opportunities needs to be developed. Greenway linkages, access to the creek and large regional open spaces are particularly lacking in the upper watershed communities north of the Pennsylvania Turnpike. An inventory of existing opportunities to preserve open space and create recreational facilities would assist in implementation of the recreational and open space goals of this plan, the Montgomery County Comprehensive plan and municipal recreation and open space plans. This report provides a preliminary analysis of available land using available GIS data but a more in-depth evaluation of land ownership and usage needs to be performed.

Implementation

Acquisition of key open space parcels to provide linkages between the economic, cultural and environmental resources of the watershed should be a recreation priority for this plan. In addition to this implementation action, continued maintenance of existing facilities and development of programming for changing populations should be incorporated into open space and recreation plans for updated municipal open space and recreation plans.

Monitoring Outcomes

Municipal, county and regional planning commissions maintain standards for recreational lands and open space. As the watershed becomes more developed, open space will become more difficult to obtain and preserve. Gains in open space acquisition and protection should be tracked and monitored to gauge the benefits and needs of open space funding. A common protected land database should be developed for the watershed to facilitate open space and recreational planning and linking these resources together.

EDUCATION

The Pennypack Creek possess many unique natural areas, open spaces and recreational opportunities. The watershed would benefit from efforts to educate the public about these amenities both to increase recreational opportunities for all watershed residents but also to encourage stewardship and political and financial support for efforts to improve the Pennypack Creek and its watershed. Outreach efforts should include educational materials, trail maps and information on preservation and protection measures that are on-going in the watershed.

Goal 7: Enhance Quality of life for Watershed Residents

The Pennypack Creek, its tributaries, amenities and open spaces can enhance the quality of life for watershed residents and ultimately contains components of all of the other plan goals. Creek-side parks offer places to exercise, contemplate nature or simply relax. In areas where streams are neglected they can become unattractive, sources of odors and generally unwelcoming. In order for a stream to enhance residents' quality of life, the stream must be a clean, safe and accessible place to visit. In turn, as perceptions of the creek change and residents and visitors value the creek, efforts to protect the stream and its watershed gain momentum.

Enhancing the Pennypack Creek's role in watershed residents lives will require reconnecting those residents to the watershed and reinvigorating their sense of stewardship and common ownership of this resource. These efforts will necessarily include protecting the vestiges of green spaces in the watershed but also include enhancing existing amenities and making them more accessible to the general public.

PLANNING & DATA GAPS

Planning efforts to enhance the role of the Pennypack Creek in watershed residents' lives should include development of green corridors and trails along the stream to provide access to the Creek and promote the public's enjoyment of the resource. Supporting effective natural resource protection and community development planning through municipal ordinances will also improve watershed quality of life while protecting the Pennypack Creek. Good planning increases property values, protects natural resources and improves the community in general.

The effects of new stormwater ordinances and watershed protection efforts should be evaluated to determine whether these new programs and regulations have provided the anticipated benefits for the watershed. There are a number of studies and planning efforts happening concurrently in the watershed, including Temple University studies and this River Conservation Plan. The effect of these programs on the watershed and the number of implemented plan recommendations should be evaluated to guide future studies and planning efforts.

IMPLEMENTATION

Improving quality of life issues for residents of the Pennypack Creek Watershed will include maintaining the appearance and safety of parks, natural areas and the stream corridor. Regular stream clean-ups and trail maintenance activities can greatly enhance visitors' experiences with the Pennypack Creek.

Ensuring that the Willow Grove Naval Air Base is redeveloped in an environmentally sensitive manner, including contributions to community open space and protection of locations identified in the Montgomery County Natural Area Inventory as well as important historic buildings will help to maintain community quality of life.

MONITORING OUTCOMES

Continued public outreach and evaluation is a necessary part of determining whether efforts to improve the watershed are having an impact on residents' usage and enjoyment of the Pennypack Creek and its resources. Outreach will also help organizations active in watershed stewardship identify community needs and perceptions regarding the Pennypack Creek. These perceptions and continued public engagement are critical to maintaining long term momentum for watershed improvement.

EDUCATION

Each plan implementation project should contain an education and outreach component to involve the community in on-going watershed stewardship opportunities. Outreach and education efforts not only engage the public in the watershed stewardship process but give the public opportunities to shape and improve their community as well as increase their knowledge about watershed issues.

Public awareness of watershed improvement projects positively improves perceptions and enjoyment of the watershed and its resources.

Goal 8: Improve Stewardship, Communication and Coordination among Watershed Stakeholders and Residents

This goal is largely directed at encouraging coordination and cooperation among watershed stakeholders, sharing information to promote successful efforts to improve the watershed and maintaining the structure and momentum of the River Conservation Plan process. Implementing projects and ideas that impact the entire watershed requires sharing of ideas and resources, especially since the watershed encompasses all or parts of twelve municipalities in three counties. Inter-municipal and inter-agency cooperation is especially important to improving this complex watershed.

PLANNING & DATA GAPS

The Pennypack Creek Watershed would benefit from the formalization of the Pennypack Partnership or other organization charged with promoting Pennypack Creek issues, acting as a clearing house for information regarding the challenges and opportunities in the watershed. This organization should serve as a steering committee to assist in coordinating on-going efforts to improve the watershed. There are many successful models for the creation of such an organization. The important issue is that an organization evolves to lead the implementation of the River Conservation Plan objectives and promotes on-going cooperation and dialogue among watershed stakeholders.

Pennypack Creek Watershed stakeholders need to be identified when forming a watershed management organization. Many of the stakeholders in the watershed should have been identified in the formation of the Pennypack Partnership and the formation of the steering committee for this River Conservation Plan. Immigrant and minority community leaders need to be identified to increase participation in watershed planning efforts from those communities.

IMPLEMENTATION

This goal can be obtained through a myriad of education and outreach efforts. The principal vehicle for fostering cooperation and coordination of watershed protection efforts should be a watershed partnership. The partnership can take many forms but should serve as a clearinghouse of watershed information and provide support for watershed improvement efforts. A watershed partnership should foster cooperation among the many organizations and institutions working in the watershed and ultimately increase awareness of the Pennypack Creek.

MONITORING

Implementation of this River Conservation Plan's objectives should be reevaluated in five years to monitor progress towards plan goals and to make adjustment to implementation actions to reflect changing watershed conditions.

EDUCATION

Watershed awareness and education efforts are important and visible methods to maintain momentum and promote watershed improvement projects. There is a vast amount of valuable, existing information regarding watershed issues. The stakeholders of the Pennypack Creek need an accessible clearinghouse to obtain and share this information.

Municipal leaders, developers, grass roots organizations and community groups are among many of the important target audiences for educational efforts to improve the watershed and address outstanding watershed issues. These efforts need to be coordinated to reduce duplication of effort and to standardize the message being given to these groups.

8.2 Management Options Matrix

Table 8.1 is a management options matrix that identifies the River Conservation Plan goal and the conservation actions or objectives identified by the steering committee as a means to attain the stated goal. The table also identifies the primary partners who would most likely lead implementation efforts of the action and the time frame in which the action may be accomplished.

Management Options continue to grow and evolve through the River Conservation Planning process. Although many of the Management Options can serve to forward a number of goals, each option is listed only once.

Table 8.1 Pennypack Creek River Conservation Plan Management Option Matrix				
Issues and Concerns	**Conservation Action**	**Specific Locations**	**Primary Partners**	**Project Implementation**
Goal 1. Improve Stream Habitat and Protect Aquatic Resources				
Planning & Data Gaps	• Develop comprehensive stream bank and stream channel stability assessment • Adopt consistent natural resource protection ordinances for all watershed municipalities	• Work with Meadowbrook Country Club to improve natural riparian corridor	PWD, SEMCTU, TU Municipalities, CPC,PEC	• 2005-2006
Implementation	• Improve in-stream habitats through dam removal and habitat enhancement projects • Daylight buried and piped stream channels where feasible • Restore geomorphic stability through active channel restoration • Implement stream and riparian restoration recommendations of FPC Pennypack Park Master Plan	• Huntingdon Pike Dam • Restore day-lighted section of the Sandy Run • Lorimer Park Adopt-A- Stream project	FOPP, FPC, PAFBC, PERT, PWD, SEMCTU	• On-going habitat restoration projects
Monitoring	• Monitor successes of habitat and species restoration efforts through agencies, volunteers and non-profit organizations	• Monitor success of PA Fish and Boat Commission Shad restoration and dam removal program • Continue PWD Biomonitoring efforts	DRKN, FOPP, FPC, PAFBC, PWD, SEMCTU	• On-going
Education	• Work with PA DOT and municipalities to ensure proper bridge and culvert design for new and redevelopment	• PA Turnpike repairs	DVRPC, Municipalities, PA DOT, PEC, PWD	• 2006-2007
Goal 2. Improve In-stream Flow Conditions				
Planning & Data Gaps	• Develop headwater protection ordinance to assist municipalities with protection of headwater streams • Ensure enforcement of municipal natural resource protection ordinances • Identify and prioritize stormwater BMPs for retrofits that promote infiltration and reduce stream flow variation during storm events	• All municipalities	PEMA, CCD, CPC, Municipalities	• 2006-2008

Table 8.1 Pennypack Creek River Conservation Plan Management Option Matrix				
Issues and Concerns	**Conservation Action**	**Specific Locations**	**Primary Partners**	**Project Implementation**
Implementation	• Encourage large institutional landowners to implement porous pavement, infiltration trench and other on-site infiltration demonstration projects • Retrofit stormwater BMPs for biological water treatment and longer detention times • Remove headwater ponds	• Willow Grove Mall	SEMCTU, PAFBC, Korman Corp. Municipalities, PEC, PWD, TU	• 2005-2006 • On-going
Monitoring	• Establish additional flow monitoring stations on the creek	• Establish flow monitoring stations in rapidly changing sub-watersheds such as the Pennypack Headwaters	SEMCTU	• 2006-2008
Education	• Work with county conservation districts and municipal EACs to Implement rain barrel, rain garden and green roof workshops • Develop and present stormwater management workshops for homeowners, builders and municipal officials		CCD, Municipalities, PWD	• On-going
Goal 3. Improve Water Quality and Reduce Pollutant Loads				
Planning & Data Gaps	• Develop Act 167 Plan • Adopt and implement NPDES Phase II Regulations • Collect fecal coliform monitoring data to characterize sources of coliform, including wet weather sampling • Develop BMP database, including location, ownership and maintenance needs • Develop long term monitoring and maintenance plans for new and existing stormwater BMPs in the watershed		CCD, CPC, Municipalities, PWD, TU	• On-going
Implementation	• Institute stormwater BMP maintenance and monitoring program • Continue to take actions to reduce the occurrence of combined sewer overflows	• All municipalities and City of Philadelphia	CPC, Municipalities, PWD, TU	• On-going

Table 8.1 Pennypack Creek River Conservation Plan Management Option Matrix

Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Monitoring	• Implement aggressive monitoring program to track sewer infrastructure leaks and illegal cross connections • Conduct additional water quality monitoring on the watershed to characterize pollutant loading sources • Monitor water quality changes in BMP retrofits	• City of Philadelphia • All municipalities	CHD, DRKN Municipalities, PWD, Utilities	• 2006-2008
Education	• Develop homeowner's manual for pond owners in headwaters to improve water quality • Develop BMP demonstration site map and informational materials for municipalities and developers		CPC, CCD, DRKN Municipalities, PWD, TU	• 2006
Goal 4. Improve and Protect Stream Corridors				
Planning & Data Gaps	• Develop and implement deer management plans for natural areas • Develop invasive species management plans for natural areas and parks • Develop watershed wide open space/riparian corridor protection plan • Create inventory database of riparian landowners to be used for outreach and education and research • Adopt woodland protection ordinances, in watershed municipalities, that limit removal of existing vegetation and update standards for tree replacement with species that were removed from the development site • Develop tree protection standards to be used by municipalities to protect existing trees and woodlands on development sites	• Lorimer Park, municipal parks and open spaces	FPC, CPC, CPD, PERT, NLT, PEC, Municipalities	• On-going

Table 8.1 Pennypack Creek River Conservation Plan Management Option Matrix				
Issues and Concerns	**Conservation Action**	**Specific Locations**	**Primary Partners**	**Project Implementation**
Implementation	• Conduct landowner outreach and education programs to promote better riparian land management • Improv e upstream/downstream connectivity by p rotecting existing green corridors and promote new green corridors through easements, land acquisition and donations • Actively remove non-native invasive plant species from riparian areas and restore riparian habitats by revegetating with native plant species	• All along Pennypack Creek and tributaries	CCD, FPC,PAFBC, PWD	• 2007-2010
Monitoring	• Track annual statistics of open space acquired, easements donated and acres of land preserved in a common database		GSA, CPC	• On-going
Education	• Hold workshop for golf courses, homeowners, corporations and apartment building managers and other large riparian landowners on stream and riparian management.		CCD, CPC, Municipalities, PEC	• Immediately
Goal 5. Address Flooding				
Planning & Data Gaps	• Update flood emergency management plans • Develop mechanism for the removal or reconfiguration of log and woody debris jams to reduce erosion and flooding		FEMA, Municipalities, PEMA	• Immediately
Implementation	• Buy out flood prone properties to promote green river corridors • Enforce floodplain protection ordinances • Implement recommendations of Temple University Floodplain Study		FEMA, Municipalities, PEMA, PADOT	• On-going
Monitoring	• Track permitted floodplain encroachments and variances granted to allow development in the floodplain		CPC, Municipalities	• 2006

Table 8.1 Pennypack Creek River Conservation Plan Management Option Matrix				
Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation
Education	• Create clearinghouse of municipal information for repairing flood damage, protecting floodplains and floodplain best management techniques		CPC, PEMA	• 2006
Goal 6. Enhance and Improve Recreational Opportunities				
Planning & Data Gaps	• Develop maintenance and management plans for existing recreational facilities and open spaces • Investigate opportunities for new active and passive recreational facilities in the watershed • Update recreation plans to reflect demographic changes	• Investigate further development of park at the mouth of the Pennypack Creek for interpretive center and environmental education	CPC, CPRD, FPC, GSA, Municipalities, PDR	• 2006-2009
Implementation	• Implement access and trail improvement recommendations of FPC Pennypack Master Plan • Continue recreational facility upgrades and maintenance • Acquire additional community open space	• Implement Newtown Rail Trail and other identified trail linkages • Significantly upgrade Pennypack Valley Park between Torresdale Ave. and State Road to reconnect park to Delaware River	CPC, CPRD, FPC, GSA, Municipalities, SEPTA CPC, CDC, CPRD, FPC, Municipalities, PDR	• 2006-2010 • On-going
Monitoring	• Conduct surveys to gauge public interest in proposed trail networks and connections	• Bucks and Montgomery Counties	GSA, CPC	• 2006
Education	• Market watershed's recreational amenities through development of brochures, maps and other educational materials		CPC, CDC, CPRD, FPC, Municipalities, PDR	• On-going
Goal 7. Enhance Quality of Life for Watershed Residents				
Planning & Data Gaps	• Identify opportunities to improve stream access, especially in upper watershed where connection to stream is lost		GSA, CPC, Municipalities	• On-going

Table 8.1 Pennypack Creek River Conservation Plan Management Option Matrix				
Issues and Concerns	**Conservation Action**	**Specific Locations**	**Primary Partners**	**Project Implementation**

Implementation	• Conduct regular stream clean-ups
	• Conduct regular trail maintenance activities
	• Ensure environmentally sensitive redevelopment of Willow Grove Naval Air Base, should it close
	    • Set aside land for recreation
	    • Protect natural communities identified in the Natural Areas inventory
	    • Use innovative BMPs for stormwater management
		• Coordinate watershed wide clean-up day
		• Develop Adopt-A-Stream Program
			SEMCTU, PERT, FOPP, PWD
			
			CPC, Municipalities DCED
				• 2006
				
				• On-going

Monitoring	• Conduct series of surveys and public outrea ch events to evaluate success of River Conservation Plan implementation projects		PP	• 2009
Education	• Implement environmental education and program outreach to minority and immigrant groups • Implement program similar to National Institute of Health, educating people about health benefits of walking , running and bike riding in a natural setting	• Northeast Philadelphia and other areas with large immigrant populations	CHD, CPRD, FPC, PERT	• 2006-2009
Goal 8. Improve Stewardship, Communication and Coordination Among Watershed Stakeholders and Residents				
Planning & data Gaps	• Hold workshops to reduce municipal miscommunication and promote regional planning • Create an organization or other mechanism for plan implementation • Create a watershed information clearing house or web site that p romotes and coordinates stewardship activities		CPC, FPC, PEC, PWD, PP	• 2006

Table 8.1 Pennypack Creek River Conservation Plan Management Option Matrix				
Issues and Concerns	Conservation Action	Specific Locations	Primary Partners	Project Implementation

Implementation	• Promote education about buried segments of Sandy Run—similar to Wingohocking Mystery tour in Germantown
	• Develop a small scale map, brochure, or tour booklet to educate populace about watershed and reconnect headwater communities to the stream
	• Develop or implement accredited stewardship program or curriculum that meets state education standards
	• Target developers for education programs
	• Name unnamed tributaries in the watershed
	• Implement education program for residents about location, function and value of streams in their communities
	• Hold annual event to promote watershed issues
	• Present open space preservation education programs
	    • Tax benefits
	    • Tools for municipalities
	    • Benefits and methods
		• Implement Adopt-A-Stream Program	CPC, CCD, PP, PWD, PEC	• On-going

Monitoring	• Create recognition program such as municipal ecology awards to promote environmental stewardship and good ordinance development
	• Review accomplishments of plan in 5 years for
	    • Watershed Impact
	    • Implementation
			CPC, CCD, GSA, PP, PWD, PEC
			
			PP, PWD, PPSC
				• 2006
				
				• 2010

Education	• Develop and distribute education materials • Implement "Rediscover Your Watershed" Program (history, connections to natural environment		CPC, CCD, PP, PWD, PEC	• On-going

Abbreviations: CCD, County Conservation Districts; CDC, Community Development Corporations; CHD, County Health Departments; CPC, County Planning Commissions; CPRD, County Parks & Recreation Departments; DCED, Department of Community and Economic Development; DRKN, Delaware River Keeper Network, DVRPC, Delaware Valley Regional Planning Commission; FEMA, Federal Emergency Management Agency; FPC, Fairmount Park Commission; FOPP, Friends of Pennypack Park; GSA; Green Space Alliance; NLT, Natural Lands Trust; PA DOT, PA Department of Transportation; PAFBC, PA Fish& Boat Commission; PEC, Pennsylvania Environmental Council; PEMA, PA Emergency Management Agency; PERT, Pennypack Ecological Restoration Trust; PP, Pennypack Partnership; PPSC, Pennypack RCP Steering Committee; PRD, Philadelphia Department of Recreation; PWD, Philadelphia Water Department; SEMCTU, Southeast Montgomery Country Trout Unlimited; SEPTA, Southeastern PA Transportation Authority; TU, Temple University

CHAPTER 9
CONCLUSIONS

9.1 Conclusions

The Pennypack Creek Watershed is a watershed with great potential. The watershed is rich in natural, economic and intellectual resources. Much of the lower portion of the Creek is surrounded by private and public natural lands, offering one of the most natural urban stream corridors in the region. Many efforts are being conducted by agencies, organizations and institutions (such as the Philadelphia Water Department, Pennypack Ecological Restoration Trust and Temple University) to harness these resources to improve the watershed. Glimpses of the watershed's potential can be seen in the proposed greenways and trail linkages, restoration of native fish populations and the financial resources being directed into this watershed from private organizations, local, state and federal agencies for studies, planning and implementation of improvement projects.

The Pennypack Creek Watershed is also a watershed facing challenges. Over eighty percent of the stream's river miles are listed on the PA 303d list of impaired waters due to flow variation and damage to stream systems from high velocity stormwater flows. Large areas of the watershed have antiquated stormwater management systems or no stormwater controls at all. This situation, combined with vast areas of residential and commercial land uses, make this watershed susceptible to damage and economic losses from flooding. Invasive plant species and high densities of deer in parks and natural areas are disrupting natural forest regeneration and native ecosystems. Many of the watershed's streams possess degraded physical habitats, the result of erosive stormwater runoff, poor riparian management, channelization, and undersized bridge constrictions. Uncontrolled discharges from CSOs and illegal cross-connections are on-going problems that undermine the use and value of the Creek as a recreational resource. Most watershed residents, despite acknowledging the importance of watershed issues, are not actively involved in stewardship efforts.

The need for a coordinated, active, and strategic watershed restoration program is great. Without question, promoting the watershed's potential and facing the watershed's challenges will require a long- term, coordinated, and sustained effort on the part of all watershed stakeholders. This River Conservation Plan is one of a number of guiding documents that identifies positive actions to improve the watershed. Successfully accomplishing this plan's objectives will require political will and financial commitment from watershed communities, as well as investment of "sweat equity" from volunteers and residents.

The good news is that the mechanisms to accomplish these goals and objectives and to face the watershed's challenges are already in place. Organizations and volunteer groups are already very active in the watershed, implementing innovative solutions to difficult challenges. The seeds of local municipal cooperation throughout the watershed have been sown and the watershed will continue to benefit from new research and land and watershed management techniques.

The watershed issues are largely identified. Steps to improve the watershed have been proposed. The challenge now is to move forward and implement these steps, appreciate the successes and learn from the failures. Hundreds of years of land development, stream channel alterations and management efforts based on municipal versus natural boundaries have contributed to this watershed's ills. Helping the watershed to become a stable, urban stream that is healthy and a treasure to its watershed communities will likely take many years of dedicated action to accomplish. Efforts currently underway in the watershed, including this River Conservation Plan, are just the first steps in achieving this vision.

CHAPTER 10
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