SUSQUEHANNA RIVER MANAGEMENT PLAN

A management plan focusing on the large river habitats of the West Branch Susquehanna and Susquehanna rivers of Pennsylvania

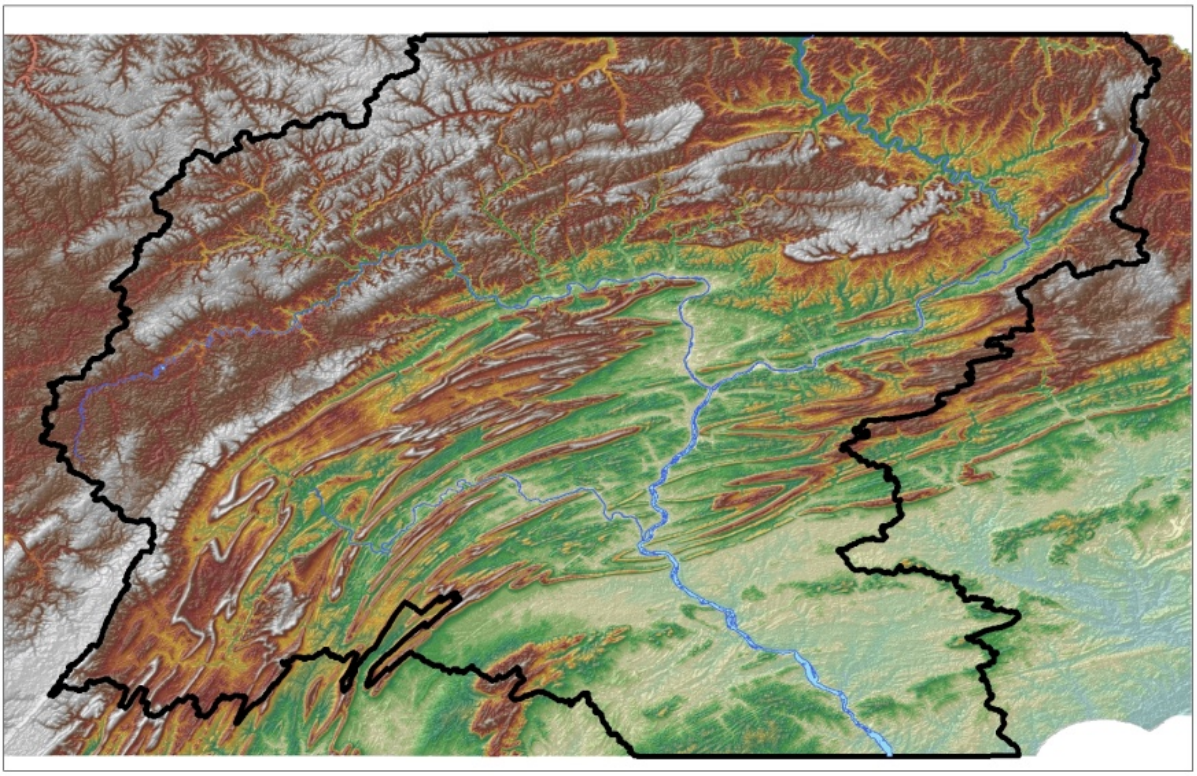

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Table of Contents

List of Tables

Appendix A

List of Tables

~Return to Table of Contents~

List of Figures

~Return to Table of Contents~

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~Return to Table of Contents~

Executive Summary

The Susquehanna River has the second largest drainage east of the Mississippi River and largest of the Atlantic Coast. Approximately 77 percent of the Susquehanna River Basin's 27,510 square miles falls within the Commonwealth of Pennsylvania. The Susquehanna River extends 444 miles from Otsego Lake, Cooperstown, New York to the Chesapeake Bay, Havre de Grace, Maryland, while the West Branch Susquehanna River originates near Carrolltown, Pennsylvania and flows 241 miles to its confluence with Susquehanna River at Northumberland, Pennsylvania. The West Branch Susquehanna and Susquehanna rivers and their respective drainages offer outdoor enthusiasts opportunities to participate in a multitude of activities including, but not limited to fishing, boating, camping, and nature viewing.

The Susquehanna River Management Plan is designed to guide future actions by the Pennsylvania Fish & Boat Commission (PFBC) and aid other stakeholders by providing information and information needs about these valuable resources. Ultimately, it is the goal of the management plan to protect, conserve, and enhance the aquatic resources of and provide fishing and boating opportunities on the West Branch Susquehanna and Susquehanna rivers. The management plan encompasses the mainstem Susquehanna River from the New York-Pennsylvania border, including the Great Bend section, to the Maryland-Pennsylvania border and the West Branch Susquehanna River.

The characteristics of the West Branch Susquehanna and Susquehanna rivers vary both within and among the rivers and are defined primarily by geologic composition and events. Tectonic plate collisions, erosions, and glaciations all had a role in shaping today's West Branch Susquehanna and Susquehanna rivers. These factors influenced channel dimensions and configuration which, in turn, influence the ecology of a river system, but they also shaped the land surrounding these great rivers. Mankind has reaped the benefits of timber and coal, farmed the fertile soils, and harnessed the power of the water to generate electricity. These rivers are again being tasked by providing water needed for natural gas extraction and mitigating the waste of these. Each of these activities has its own lasting effect on the ecosystem; some well known and others not yet realized.

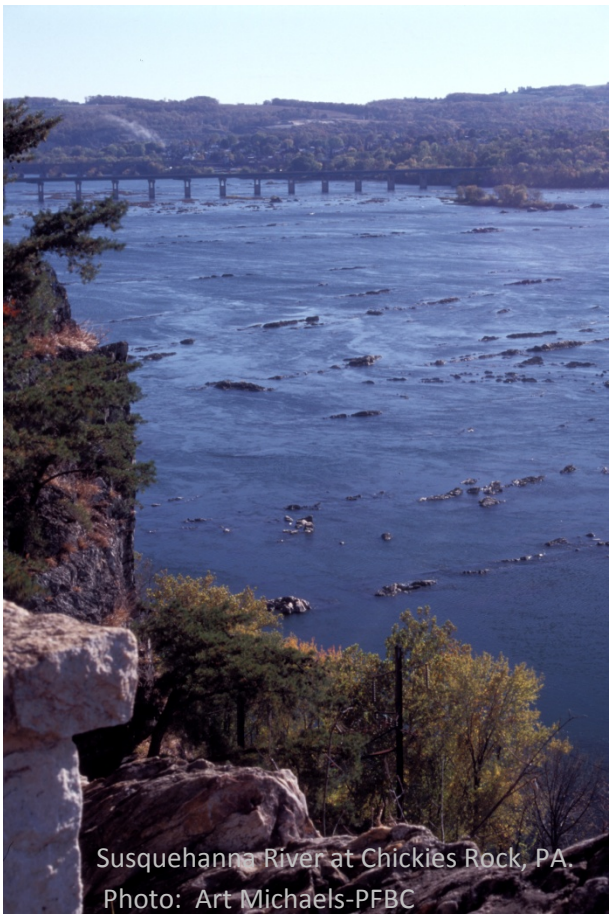
The hydrology of these waters varies over the length of each of the river systems. With the exception of the Susquehanna River downstream from York Haven Dam, both river systems function as large, free-flowing rivers with several run-of-the-river dams along their lengths. Beginning with the York Haven Dam, the Susquehanna River has four major hydropower dams and a pumped-storage reservoir that significantly alters the hydrologic conditions. As navigable waters of the United States, jurisdiction over activities associated with the West Branch Susquehanna and Susquehanna rivers is tasked to the United States Department of Defense, Army Corps of Engineers (USACE) and United States Environmental Protection Agency (USEPA) and has been delegated to the Commonwealth of Pennsylvania, Pennsylvania

Department of Environmental Protection (PADEP). The Susquehanna River Basin Commission (SRBC) has the power to acquire, construct, operate, and control projects and facilities for the storage and release of waters for regulation of flows and supply of surface and ground waters of the basin for the protection of public health, stream quality control, economic development, improvement of fisheries, recreation, dilution and abatement of pollution, the prevention of excess salinity. The Federal Energy Regulatory Commission (FERC) oversees, through licensing, the operation of the pumped storage and hydropower facilities in the lower portions of the Susquehanna River. The PFBC advises the resource agencies on hydrologic, water quality, fisheries management, recreational, on other issues related to permitting and licensing for these various forms of development. A future high priority identified by the PFBC in the River Management Plan is to work with PA DEP to determine if fisheries-based criteria can be developed that would allow for the proper classification and protection of warmwater aquatic communities. Also important is working with the owners of FERC-licensed hydropower dams to promote timely, safe and effective migratory and resident fish passage in order to restore and maintain fisheries under existing licenses, as well as to negotiate terms and conditions of renewed licenses. Finally, continued work is needed to ensure that river flows and water quality remain are adequate to sustain high-quality aquatic communities.

Susquehanna River at Montgomery's Ferry, PA. Photo: Geoff Smith

The diversity in both type and size of the habitats provide niche space for many aquatic organisms and support ecological function of the Susquehanna River system. While these habitats are not necessarily unique to the West Branch Susquehanna and Susquehanna rivers, the pattern with which they exist and the sheer volume of area they encompass within the free-flowing portions of these rivers make them unique among the major river systems of Pennsylvania. These habitats vary in size, frequency, and composition primarily due to river channel gradient and other physical landscape characteristics. The variability of habitats is vitally important to the ability of these rivers to support species of greatest conservation need such as the eastern hellbender *Cryptobranchus allegeniensis*, Chesapeake logperch *Percina bimaculata*, and the yellow and rayed lampmussels *Lampsilis cariosa* and *radiata*, respectively. While we know that the rivers support these important species, the key habitat features must be identified to ensure the conservation of these species.

The PFBC relies on revenues from license sales, a portion of federal tax dollars associated with the sale fishing gear, and the federal State Wildlife Grants program (SWG) to fund species management and habitat protection across the Commonwealth. The PFBC, is responsible for management of herptiles and aquatic invertebrates, which including: mollusks, insects, and crustaceans Fifteen species of freshwater Unionid mussels, two genera of freshwater clams, and 23 species of gastropods are known to occur in the rivers. Aside from the diversity of species present, little is known about mollusk populations. Contemporary studies will expand our existing knowledge of extant mollusk communities and changes in community composition over time, including the role that gastropods may be having in parasite infections of fish species such as smallmouth bass. Insect communities, and to a lesser extent crustacean communities, are commonly sampled for the assessment of water quality by regulatory agencies. Much is known about the density and distribution of these populations, but these data do not provide species-specific information such as the current status of the white fly *Ephoron leukon* or the impacts that the invasive rusty crayfish *Orconectes rusticus* is having on the rivers. Few of the herptiles present in the Susquehanna drainage are riverine but further information is needed about the status and distribution of riverine species present, the eastern hellbender and redbelly turtle *Psuedemys rubriventris*.



Susquehanna River at Chickies Rock, PA.
Photo: Art Michaels-PFBC

Native fish distribution in the Susquehanna River system was largely shaped by pre- and post-glacial drainage patterns. Many of the non-native game fish species found in the basin today are a result of intentional stockings by fisheries management agencies (e.g., common carp and smallmouth bass) as well as intentional and accidental introductions by others (e.g., flathead catfish). Similarly, intentional or accidental introductions from aquaria or bait buckets are common. All these factors combine to comprise the fish community that exists today in the West Branch Susquehanna and Susquehanna rivers.

The PFBC strives to maintain and optimize the recreational potential of the fisheries of this river system through establishing fishing regulations, maintaining stocking programs, characterizing angler use and harvest, and monitoring game fish and non-game fish populations. Currently, the most prominent issue affecting the Susquehanna River system is the declines in smallmouth bass densities as a result multiple years of poor recruitment and large-scale, disease-related mortality of young-of-year (YOY) fish. YOY fish are fish in their first year of life and range in size from 1 to 6 inches.

These factors have resulted in a marked decrease in the population, concerning staff biologists and anglers alike. The PFBC will continue to monitor smallmouth bass populations and expand efforts as necessary, to appropriately manage these resources. This will include evaluation and development of population thresholds to trigger management action, research into the effects that tournament angling has on smallmouth bass populations, and continued investigation into disease and intersex and their impacts on the population.

These same recent fish health issues and anecdotal reports of declines of non-game and some lesser surveyed game fish species have identified the need to study this component of the fish community. Similarly, recent introductions and range expansions of non-native species may have altered the community composition. However, shortages of baseline community data limit our ability to gauge the impacts of these introductions. In order to address these concerns, the PFBC will develop a monitoring scheme to gather baseline community data to identify trends in species' status over time and help to track and identify ecosystem-wide problems, should they arise.

Paramount in the recognition of all the resources available at the West Branch Susquehanna and Susquehanna rivers is the opportunity for public to enjoy using these resources. There are 11 marinas and 157 access points currently available to boat and fish these waters. In addition, there are state and municipal parks and several tracts of state forest and game land that adjoin the West Branch Susquehanna and Susquehanna rivers. There are also water trails, bike trails, and hiking paths for public enjoyment, and stewardship and angling organizations for people to take part in. There are several educational opportunities available including nature programs, K-12 curricula for schools, twelve colleges and universities that have course work or research initiatives related to the Susquehanna River, and a consortium of institutions currently organizing research on these waters.

The West Branch Susquehanna and Susquehanna rivers are important yet poorly understood systems. The information and management recommendations offered in the plan will help to address some of the information needs. Through the efforts of PFBC and our partners, we hope to realize the full potential of this resource through a broad, interdisciplinary approach.

~Return to Table of Contents~

1.0 Introduction

The Susquehanna River Basin is the second largest river drainage east of the Mississippi River and the largest of the Atlantic Coast (New York Department of Environmental Conservation undated). The drainage for the Susquehanna River covers 27,510 square miles (71,251 square kilometers) and falls in parts of three states: New York, Pennsylvania, and Maryland. Approximately 77% (21,032 square miles) of the Susquehanna River Basin falls within the Commonwealth of Pennsylvania. The West Branch Susquehanna and Susquehanna rivers and their respective drainages offer outdoor enthusiasts opportunities to participate in a multitude of activities including, but not limited to fishing, boating, camping, and nature viewing.

This management plan is a "living document" designed to guide future actions by the PFBC and aid other stakeholders in the identification of the information needed to gain a better understanding of these valuable resources. Ultimately it is the goal of this management plan to protect, conserve and enhance the aquatic resources of, and provide fishing and boating opportunities on the West Branch Susquehanna and Susquehanna rivers.

This management plan provides a description of the river and its watershed covering a range of topics. These issues have been combined in this plan to develop a holistic approach to addressing the system. Proposed management actions are listed within each Section of the plan and are organized in a manner that describes the West Branch and Susquehanna River aquatic resources in increasing detail beginning with the river basin features (Section 2.0) and specific river characteristics (Section 3.0). This is followed by discussions of river hydrology (section 4.0), special jurisdictions (Section 5.0), riverine habitat (Section 6.0), river biota (Section 7.0), fisheries (Section 8.0), human dimensions (Section 9.0), and a summary of the proposed actions (Section 10.0).

1.1 Mission, Vision, and Goals

Mission

The mission of the Pennsylvania Fish and Boat Commission (PFBC) is ***"to protect, conserve, and enhance the Commonwealth's aquatic resources and provide fishing and boating opportunities."*** Statutory authority to address its mission is based on the Fish and Boat Code of 1980 [Title 30, Pa. Consolidated Statutes] with fishing and boating regulations set forth in Title 58 of the Pennsylvania Code.

Vision

Created in conjunction with the Commission's strategic plan, the vision of the Commission is to "expand its knowledge and expertise, protect and improve the quality of the Commonwealth's aquatic resources, expand and enhance safe boating and fishing opportunities, and recruit and retain individuals, families, and children as anglers, boaters, and stewards of the resource". The agency's goals are detailed in the Pennsylvania Fish & Boat Commission's Strategic Plan for July 2010 through 2015.

1.2 River Management Plan Purpose and Scope

This River Management Plan was initiated to aid in the development of a comprehensive, multidisciplinary approach to manage the West Branch Susquehanna and Susquehanna rivers and to better understand the complexity of issues affecting these systems. Understanding that the expertise and effort needed to advance the understanding of these systems far exceeds that of any individual agency or organization we aim to develop a dialogue for cooperation and management of these systems with the various stakeholder agencies, organizations, and institutions with interest in these resources. As a starting point, responsible parties, collaborative opportunities, and data gaps are identified to aid in prioritization of future directives and subsequent management activities.

The scope of this management plan encompasses the mainstem Susquehanna River from the New York-Pennsylvania border, including the "Great Bend" section, to the Maryland-Pennsylvania border and the mainstem West Branch Susquehanna River from its origin to the confluence with the Susquehanna River. For the purpose of this plan, all activities and issues outside of the respective West Branch Susquehanna and Susquehanna rivers proper will be addressed only as they relate to the respective rivers.

1.3 Sources of Information

Information included in this plan was pooled primarily from federal, interstate, and state agencies including, but not limited to:

- United States Environmental Protection Agency (USEPA)
- United States Department of the Interior, United States Geological Survey (USGS)
- United States Department of the Interior, United States Fish and Wildlife Service (USFWS)
- United States Department of Energy, Federal Energy Reserve Commission (FERC)
- Susquehanna River Basin Commission (SRBC)
- Pennsylvania Department of Conservation and Natural Resources (DCNR)
- Pennsylvania Department of Environmental Protection (DEP)
- Pennsylvania Department of Transportation (PennDOT)
- Pennsylvania Game Commission (PGC)

Other sources of information presented in this plan include local, county, and municipal governments, non-government organizations, academic and research institutions, and reports submitted to resource agencies under conditions of permit requirements. All information presented in this plan, not otherwise credited to another institution or author, was compiled or otherwise held by the PFBC.

1.4 Public Process

The PFBC encourages public involvement and commentary pertaining to this management plan. Upon completion of the draft Susquehanna River Management Plan, two public

information sessions were conducted in different parts of the watershed; one upper portion of the drainage (Lewisburg) and one in the lower Susquehanna River drainage (Harrisburg). These served as an initial presentation of the document and provide an opportunity for public comment. Upon completion of the public information sessions there was a formal comment period open until April 30, 2011. Following this period, all received written commentary, either as electronic or traditional stationary, was reviewed and assessed for inclusion into the management plan. Any commentary received after the formal open comment period will not be considered for incorporation into the final plan. Given the anticipated nature of this plan as a "living" document, received commentary outside of the formal comment period will be assessed for inclusion to the existing content and or management options based on the perceived merits of the identified issues. This plan will be available through the PFBC website.

During the open public comment period, a total of 27 public comments and two agency comments were received. Of these, eight were misdirected comments about the proposed regulation change for smallmouth bass which also had an open public comment period during this time. Topics of public comments included muskellunge and walleye management, heavy metal pollution and other water quality issues, implementing more stringent smallmouth bass regulations in other reaches, changes in agricultural practices, Marcellus shale exploration, catch-and-harvest fishing tournaments, American shad restoration, longnose gar populations, law enforcement, and stocking of other game fishes. Many of the comments received demonstrated that there was confusion between the executive summary of the plan and the technical document. Many of the received comments asked questions about topics that were explicity described in the technical document. In future planning efforts, differentiation between the two must be expressly stated to avoid this confusion. Limited changes were made to the text of the document for clarification based on the recived comments. In addition, the opportunity was taken to alter the text where pending decisions were made since the draft of the document was released (e.g. smallmouth bass catch-and-immediate-release regulation).

Additional written public commentary can be submitted through formal written format via PFBC website or postal mail to:

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1.5 Timeline

The development of Large River Management Plans was initiated in July 2008 with final acceptance of the River Management Plan Outline in November 2008. Development of the initial draft of the River Management Plans commenced following acceptance of the outline with an anticipated completion date of December 31, 2009. Internal review of initial draft form of the

River Management Plans is expected to be completed by February 12, 2011 and at that point the final draft River Management Plans will be released for public comment. Following closure of public comment period on April 30, 2011, all comments will be addressed and amendments to the draft made prior to final release. Presentation of the plan to the PFBC Commissioners is anticipated at the first quarterly meeting following closure of comment period. Implementation of the plan is targeted to begin following completion of presentation of the management plan to the Board of Commissioners as indicated under Goal 2, Item B of the Strategic Plan of the Pennsylvania Fish and Boat Commission.

Updates

It is anticipated, updates to this plan will occur on a regular schedule. Major updates of new information either from accomplished worked identified by the management options within this document or from outside sources are expected to occur on a five-year cycle after the initial implementation date. However, it is understood that significant deviations from this plan may occur as major developments warrant.

~Return to Table of Contents~

2.0 River Basin Features

The general features of a river basin, both natural and anthropogenic, affect every aspect of that rivers function. The physical size (catchment), physicochemical and hydrological properties (geology and topography), and the shape and structure of the channel (topography), are all determined by the features within the basin. These features can work independently or synergistically in determining the overall characteristics of a river system. For instance, the topography and geology often determine settlement patterns of humans. Rapids or falls caused by different geologic and gradient patterns often resulted in settlement because it limited further upstream transportation. This settlement, in turn, affects other components of the river system such as hydrologic patterns and water quality. These features are the broad, general properties that are the foundation of the ecology of river systems, including the West Branch Susquehanna and Susquehanna rivers.

2.1 Catchment Area

The Susquehanna River basin drains 27,510 square miles (71,251 km^2) across portions of Maryland, New York, and Pennsylvania. Approximately 77% (21,032 mi^2; 54,474 km^2) of the basin is contained within the borders of Pennsylvania. Making up approximately 43% of the total drainage area of the Chesapeake Bay, the Susquehanna River provides 50% of the Bay's freshwater flow (SRBC 2006). The Susquehanna River basin drains all or parts of 43 of the 67 Pennsylvania counties (Figure 2.1.1).

2.2 Basin Topography

The Susquehanna River basin is comprised of parts of five physiographic provinces: Piedmont, Blue Ridge, Valley and Ridge, New England, and Appalachian Plateaus. The Piedmont region is further divided into Gettysburg-Newark Lowland, Piedmont Lowlands and Piedmont Uplands sections. The Appalachian Plateaus Province is comprised of the Allegheny Mountain, Allegheny Plateau, Deep Valleys, Glaciated High, Glaciated Low, Glaciated Pocono, High, and Pittsburgh Low sections. The Appalachian Mountain and Great Valley sections make up the Ridge and Valley Province. The Blue Ridge and New England Provinces each have single sections falling within the Susquehanna River Basin: South Mountain and Reading Prong sections, respectively (Figure 2.2.1). The highest point within the Pennsylvania portion of the basin is Blue Knob Ridge at 3,146 feet (959 m) above mean sea level. The lowest point is where the Susquehanna River flows out of Pennsylvania at the Pennsylvania-Maryland border at 39 feet (12 m) above mean sea level (Figure 2.2.2).

2.3 Basin Geology

One-hundred thirty-nine geologic formations comprising thirty-four lithological classes (rock types) occur in the Susquehanna River drainage (Figure 2.3.1). The differences in geology account for spatially different water chemical constituencies and hydrologic patterns (i.e., groundwater- versus surface water-dominated systems) throughout the basin. Generally, the upper portion of the basin consists of sandstone and shale until reaching the Ridge and Valley

and Blue Ridge provinces where the ridges are primarily sandstone and shale with fertile, limestone-dominated valleys.

2.4 History

General History of Human Use

At the time of European settlement, the Susquehanna River Basin was predominately occupied by the Susquehannock and Shawnee tribes (Pennsylvania Museum and Historical Commission 2009a). European settlement of the Basin began with Captain John Smith's exploration up the Susquehanna River in 1608 (Pennsylvania Museum and Historical Commission 2009a). In the early 1700s, colonization by German immigrants leads to development of a strong agricultural community and to expanded colonization in the basin (Pennsylvania Historical and Museum Commission 2009b). In the 1750s, immigrants moved from New England to the Wyoming Valley to establish commercial fishing operations (Susquehanna River Anadromous Fish Restoration Cooperative undated). In the early to mid-1800s, the extractive industries of lumber, coal, oil, and natural gas fueled the growing industrial economy and further colonization of the Basin occurred (Pennsylvania Historical and Museum Commission 2009c). This, in turn, influenced the locations of present day population centers and shaped the landscape.

Major Impacts

Agriculture and extractive industries have substantially impacted the Susquehanna River Basin. Agricultural practices and deforestation by the lumber industry have greatly altered the landscape and the ecology of the Basin and the Chesapeake Bay. Similarly, bituminous and anthracite coal mining activities have had enormous effects on the ecology of the West Branch Susquehanna and upper Susquehanna rivers as well as the surrounding landscape. The legacy of these practices remains and is evidenced in the established population centers where the effects of urbanization currently impact these areas.

Impoundments built to support transportation, industry, flood control, and recreation have had a lasting impact on the waterbodies and associated fauna of the Susquehanna River Basin. These structures have disrupted hydrology, altered habitat, and limited the passage of migratory fish species. As a result, many of the native and migratory fish species, as well as many of the freshwater unionid mussel species have shown a marked decline in stocks. The ecological impact of this activity has been enormous; the scope of which has yet to be fully be understood.

Significant Cultural, Historical, and Archaeological Aspects

Numerous significant historical activities have taken place in the West Branch Susquehanna River and Susquehanna River basins, as well as surrounding landscapes. Many are considered Heritage Areas collectively assembled under HeritagePA. HeritagePA is a key component of the state's tourism industry, and is administered by the Pennsylvania Department of Conservation and Natural Resources (DCNR) in conjunction with the State Heritage Areas Interagency Task Force. The Task Force is comprised of the Pennsylvania Departments of Community and Economic Development, Education, Transportation; the Pennsylvania Historic

and Museum Commission; and the Pennsylvania Council on the Arts (www.heritagepa.net 2009). Of the 12 Heritage Areas or Regions administered by the DCNR, all or parts of eight are located in the Susquehanna River Basin three of which are primarily associated with the West Branch Susquehanna and Susquehanna rivers and include Endless Mountains Heritage Region, Lumber Heritage Region, and Susquehanna Gateway Heritage Region (www.heritagepa.net 2009).

The downstream portion of the Susquehanna River Basin is among the most archeologically studied regions in the Commonwealth (Pennsylvania Historical and Museum Commission 2009d). Approximately 2,865 archaeological sites are recorded in this area (Pennsylvania Historical and Museum Commission 2009e). The lower Susquehanna River has the highest concentration of petroglyphs in the northeastern United States with 10 sites and presumed minimum of 1,000 separate carvings. These are located within a 23 mile stretch running through southern Lancaster County to just below the Maryland border. Because of the construction of hydroelectric projects on that portion of the Susquehanna River, many of these petroglyphs have been submerged or removed for preservation (Carr and Nevin 2009).

2.5 Socioeconomic profile

Population Centers

Numerous population centers are associated with the West Branch Susquehanna and Susquehanna rivers (Figure 2.5.1). Most of the present day population centers developed as a result of past lumber and mining activities and the transportation of those goods via rivers.

Major Industries/Sources of Employment

Major industries within the Susquehanna River Basin include agriculture, power generation, and government (federal, state, and local). Agricultural centers like Lancaster County, the valleys of the Ridge and Valley Physiographic Province, and the glaciated northern tier of the state fall within the basin and comprise a major portion of the agricultural market for Pennsylvania. State-wide there are approximately 63 thousand farms covering more than 7.8 million acres with a total value of $5.8 trillion, annually (United States Department of Agriculture 2008). Dairy is the predominant agricultural product with a value of nearly $1.9 trillion in 2007 (United States Department of Agriculture 2008).

Power generation is another major river-related industry associated with the Susquehanna River. Coal-fired, nuclear, and hydroelectric generation facilities are found along the West Branch Susquehanna and Susquehanna rivers. GenOn's Shawville Generating facility on the West Branch Susquehanna River and Corona Powers's Sunbury Steam Electric Station and PPL's Brunner Island facilities on the Susquehanna River utilize water from the respective rivers for cooling water in energy production. Nuclear-fueled power plants Susquehanna Steam, Three Mile Island (TMI), and Peach Bottom Atomic Power Station (PBAPS) also utilize Susquehanna River water for cooling. Hydropower generation is a significant industry on the Susquehanna. Oakland, York Haven, Safe Harbor, Holtwood, and Conowingo dams are all hydropower generating dams harnessing the Susquehanna River for electricity generation;

however, the Oakland facility is currently off-line due to structural and financial issues. The Muddy Run Pumped Storage Project in Lancaster County, owned by Exelon, pulls water from the Susquehanna River for storage in Muddy Run Reservoir and later release to provide electricity during peak demand periods.

Government is also a major industry within the Susquehanna River Basin. The federal government is the number one employer in Pennsylvania, followed by the Commonwealth of Pennsylvania (Pennsylvania Department of Labor and Industry, 2010). The bulk of the Commonwealth positions are housed within the Susquehanna River Basin, primarily in Harrisburg.

Historically, manufacturing and the extractive industries (e.g., coal, lumber) were primary industries within the Susquehanna River Basin. These have smaller roles than in the past; however, a burgeoning natural gas industry is developing in the northern portion of the Susquehanna River Basin. Approximately 72 percent of the Susquehanna River Basin is underlain by Marcellus shale (SRBC 2009a) the geologic formation which contains the natural gas, so potential for exploitation is substantial. An estimated 250 to 500 trillion cubic feet of natural gas are contained within the Marcellus shale formation in the Appalachians (Harper 2008).

Pennsylvania Department of Labor and Industry, Center for Workforce Information and Analysis, maintains employer data for the Commonwealth of Pennsylvania. Employer data are available on a state-wide or on a county-by-county basis and are updated quarterly (http://www.paworkstats.state.pa.us/).

Regional and Local Vehicular Access

Interstate Highways 70, 76, 78, 80, 81, 83, 84, 99, 176, 180, and 476 all provide access to the Susquehanna River Basin with Interstates 76, 80, 81, and 83 all crossing the West Branch Susquehanna and Susquehanna rivers at some point along their lengths (Figure 2.5.2). Primary roads that provide extensive immediate access to the West Branch Susquehanna River include United States Highway (US) 219, State Highway (SR) 969, SR 120, SR 150, US 220, SR 654, and SR 405. Primary roads that provide extensive immediate access to the Susquehanna River include SR 220, US 219, US 11, US 6, SR 92, SR 187, SR 147, US 11/15, US 22, SR 441, and SR 624.

2.6 Basin land use

Land Use

Land use patterns vary greatly within the Susquehanna River Basin, and include heavily forested areas (generally secondary successional forests) in the upstream portions of the basin, to heavily cultivated and urban centers, primarily, in the downstream portions of the basin (Figure 2.6.1). As a whole, the Susquehanna River basin is comprised of 7% urban land use, 22% agricultural, 70% forested, with a variety of other land uses comprising the remaining 1% (SRBC undated). More specifically, for the portion of the Basin downstream of the West Branch

Susquehanna River land uses are comprised of 4% urban, 47% agricultural, 47% forested, and 2 % other land uses (Lindsey et al. 1998).

Brownfield and Land Recycling

A total of 127 brownfield revitalization projects and 3,568 land recycling projects occur in the Susquehanna River Basin (PADEP) (Figure 2.6.2). The Land Recycling Program encourages the recycling and redevelopment of old industrial sites. It sets standards, by law for the first time, that are protective of human health and the environment, but which consider future use (PADEP 2009). This program is managed by the PADEP, Bureau of Waste Management, Office of Community Revitalization and Local Government Support.

Municipal Waste, Captive Hazardous Waste, and Commercial Hazardous Waste operations

A total of 1,048 recognized municipal waste operations, 1,124 captive hazardous waste operations, and 18 commercial hazardous waste operations are located within the Susquehanna River Basin (PADEP 2009) (figure 2.6.3). These activities are overseen by the PADEP, Bureau of Waste Management, Municipal Waste Program and Hazardous Waste Program.

Abandoned and Active Mines

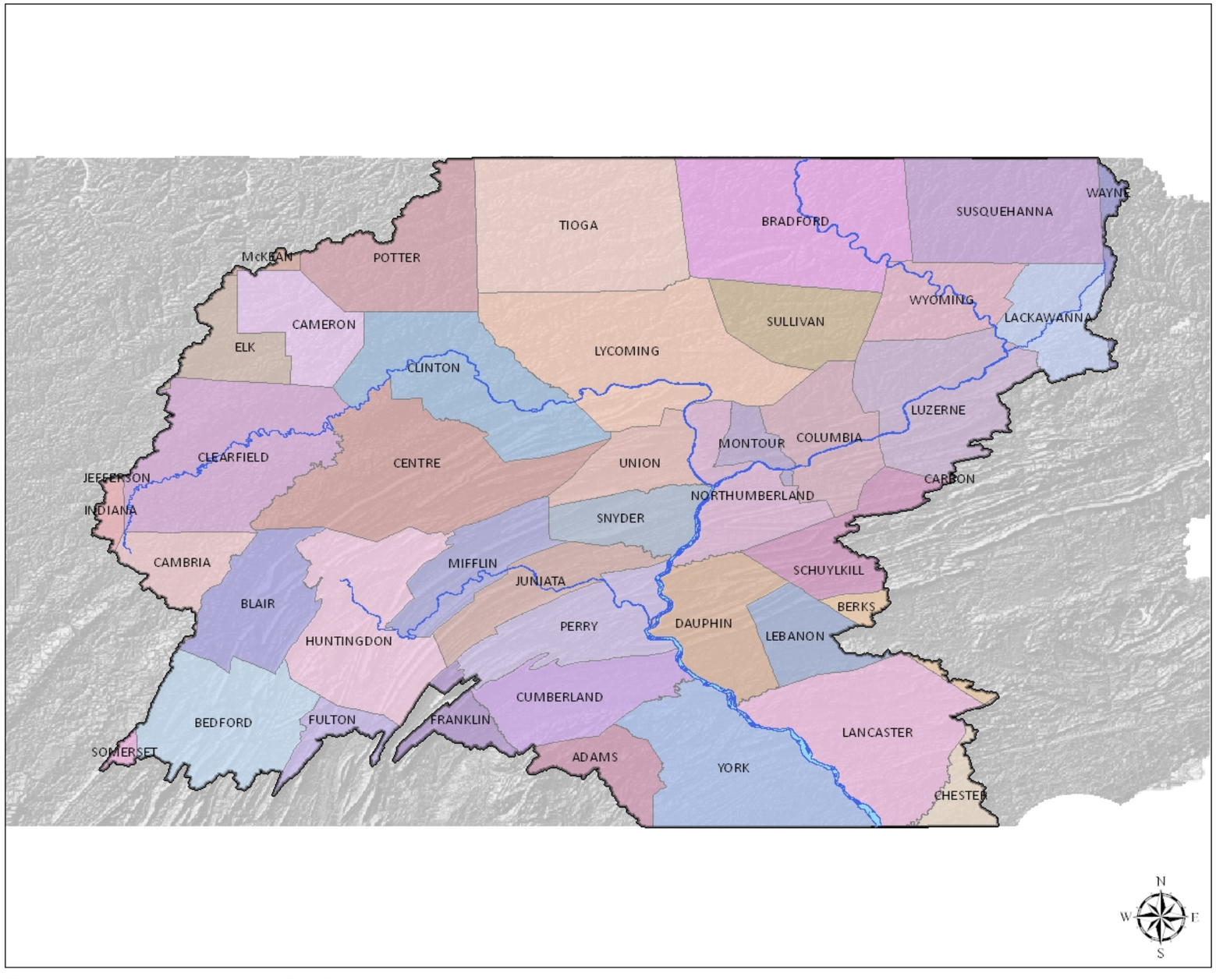
Mining operations, particularly bituminous and anthracite coal mining extraction occur throughout the Susquehanna River Basin and have had extensive impacts (Figure 2.6.4). Abandoned mine management and reclamations are overseen by PADEP, Bureau of Abandoned Mine Reclamation (BAMR) and active mining operations are under the oversight of PADEP, Bureau of District Mining Operations. There are currently 2,182 mines that are in varying degrees of activity (i.e., active, inactive, or in reclamation process) and another 4,069 abandoned mines in the Susquehanna River Basin.

Public Lands

More than 3.1 million acres of land within the Susquehanna River Basin are publically owned (Figure 2.6.5). The bulk of these are held by Pennsylvania Department of Conservation and Natural Resources (DCNR) and Pennsylvania Game Commission (PGC).

Susquehanna River Management Plan

Counties of the
Susquehanna River Basin



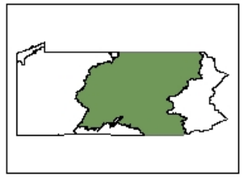


Figure 2.1.1 Counties of the Susquehanna River Basin

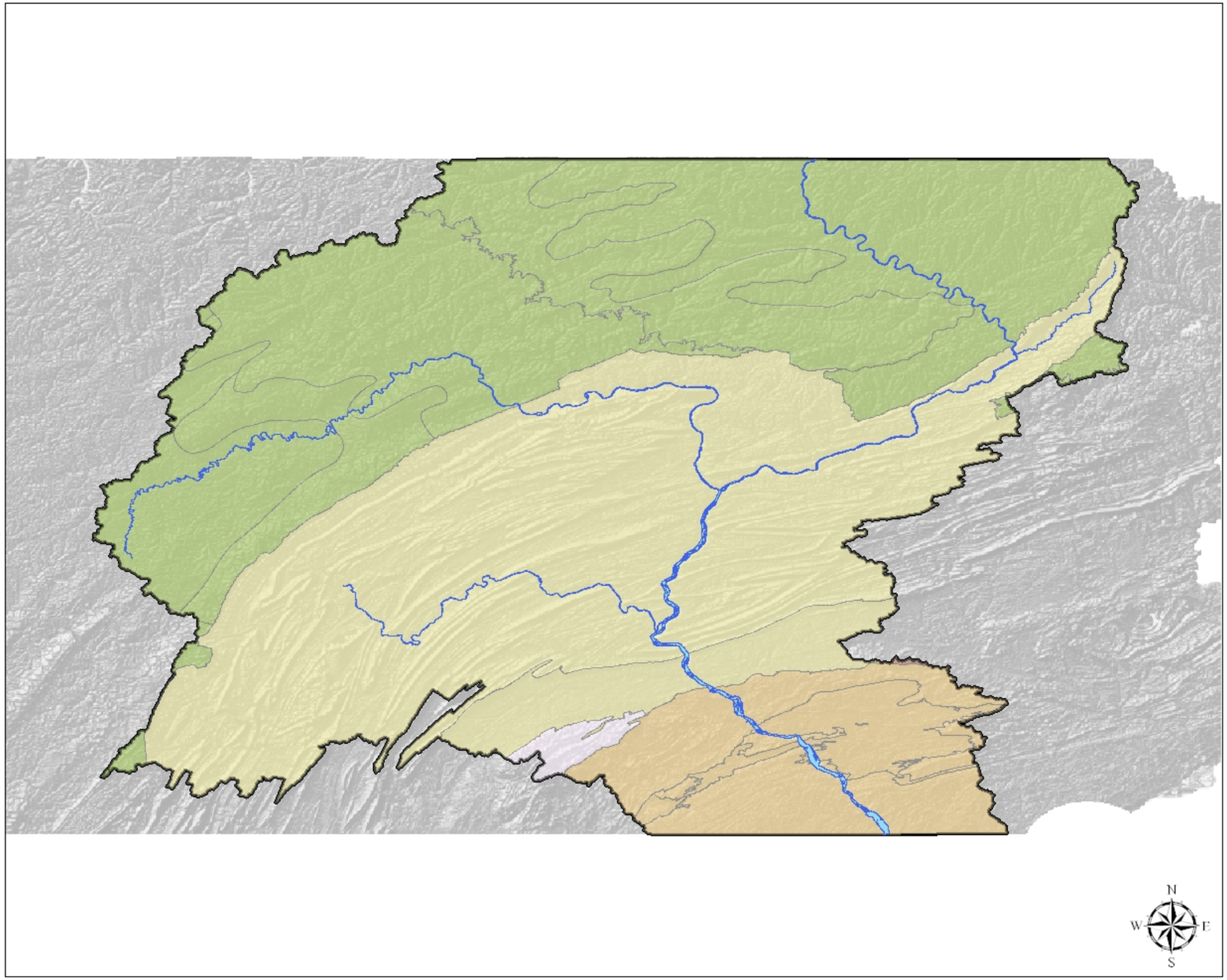


Figure 2.2.1 Physiographic provinces of the Susquehanna River Basin

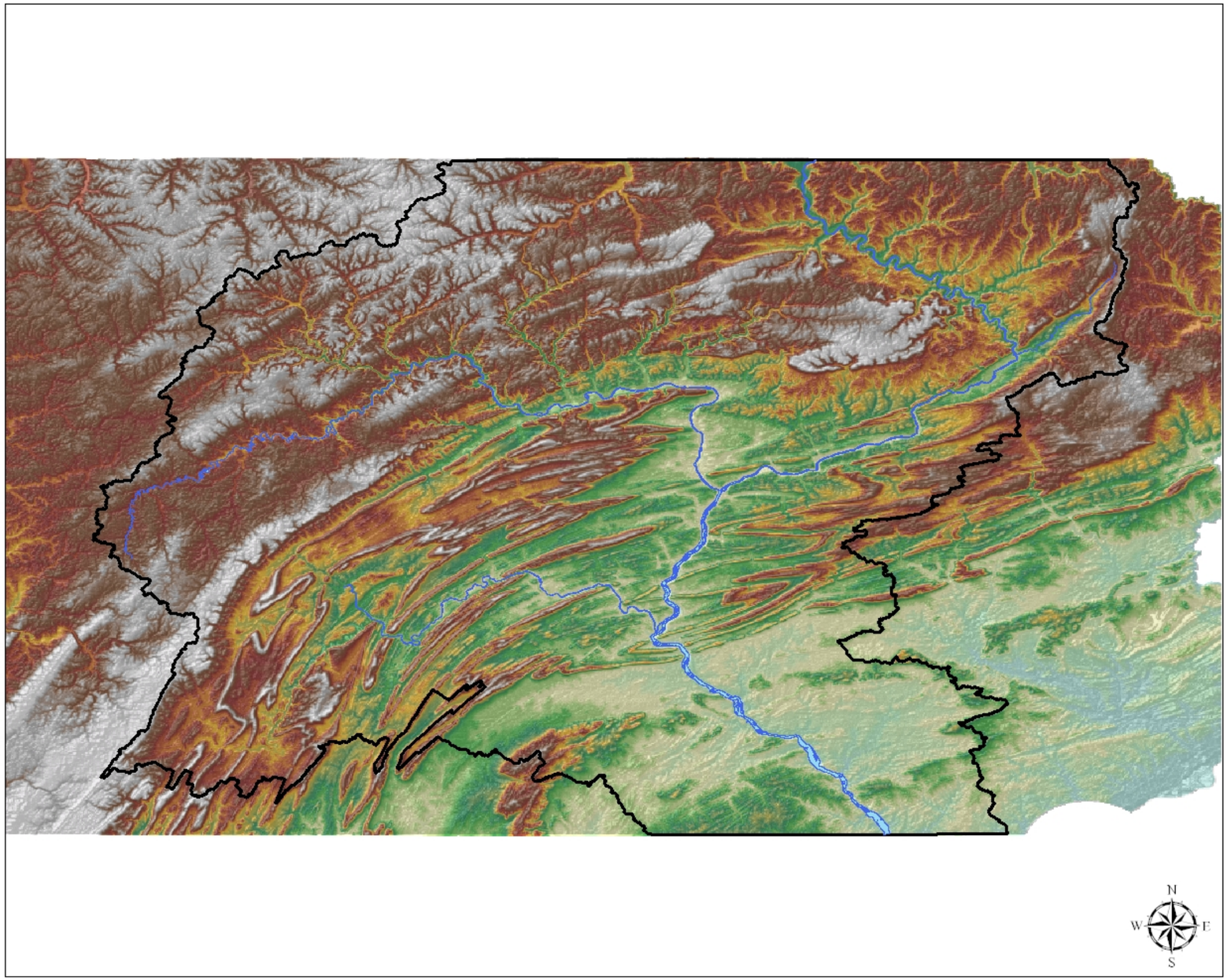


Figure 2.2.2 Topography of the Susquehanna River Basin

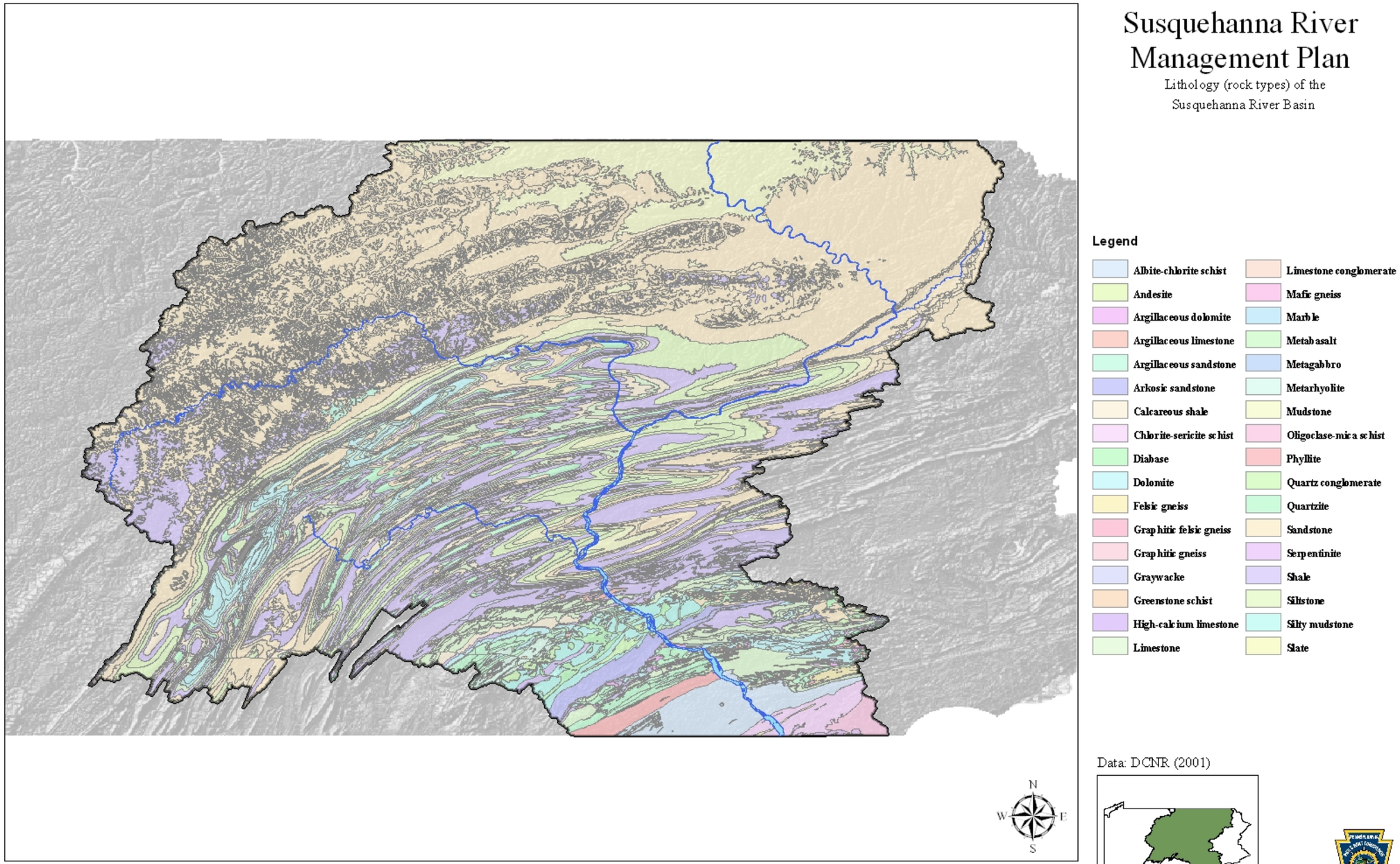
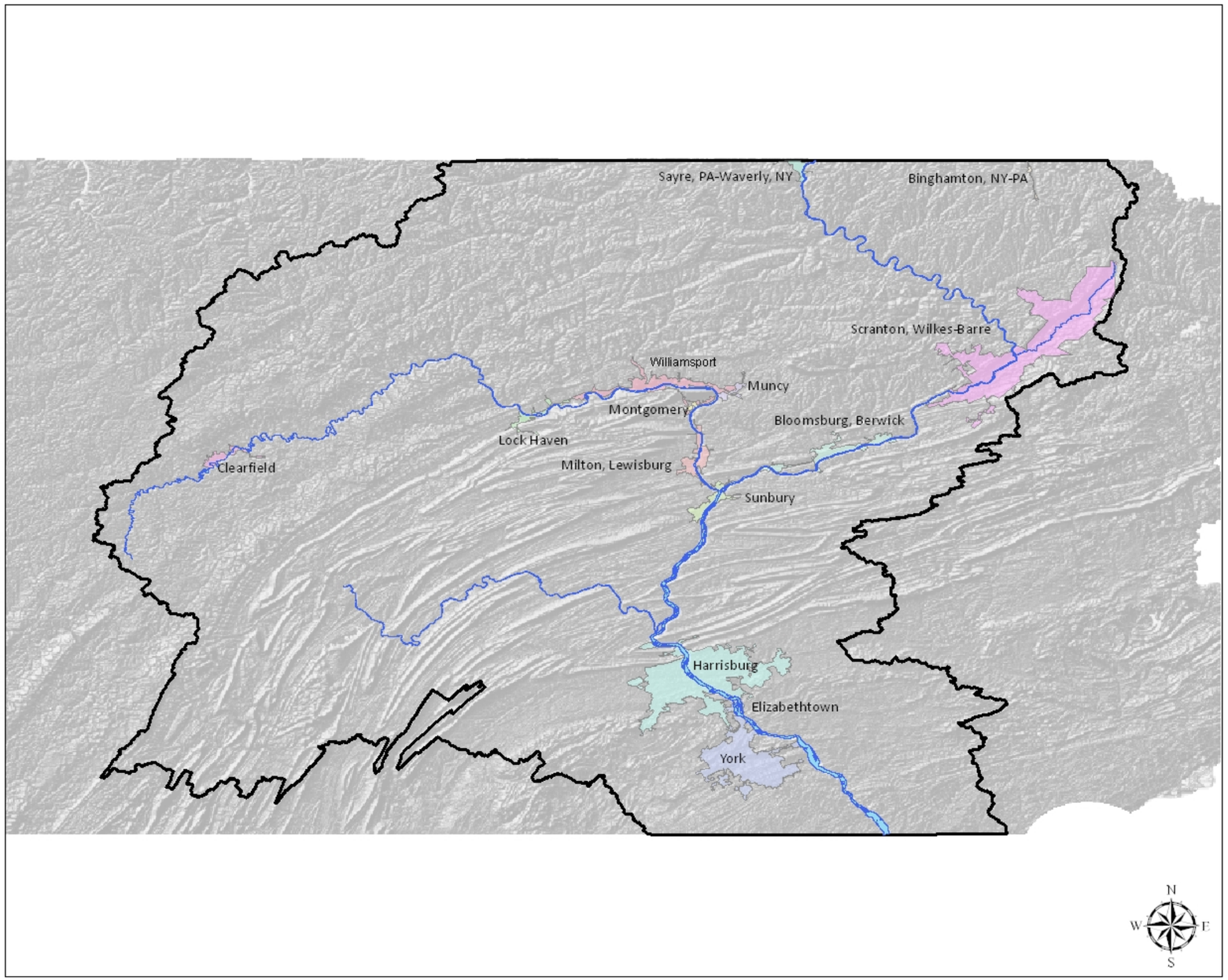


Figure 2.3.1 General lithology of the Susquehanna River Basin



Susquehanna River Management Plan

Primary population centers associated with the West Branch Susquehanna and Susquehanna rivers

Legend

- Binghamton, NY-PA
- Bloomsburg, Berwick
- Clearfield
- Harrisburg
- Lock Haven
- Milton, Lewisburg
- Montgomery
- Muncy
- Sayre, PA-Waverly, NY
- Scranton, Wilkes-Barre
- Sunbury
- Williamsport
- York

Data: PennDOT

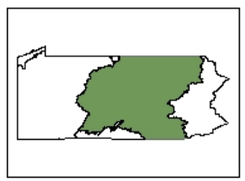
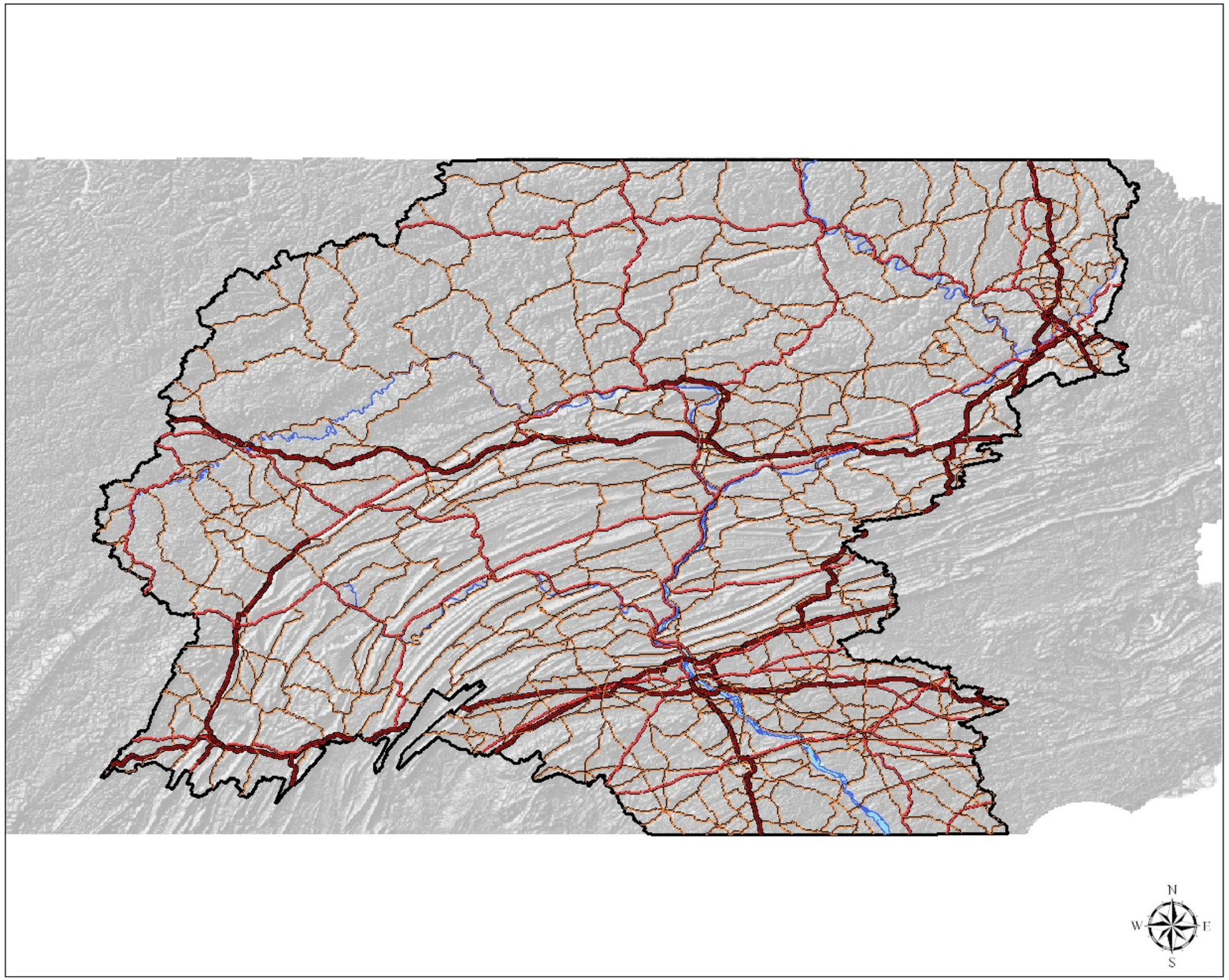


Figure 2.5.1 Primary population centers associated with the West Branch Susquehanna and Susquehanna rivers.



Susquehanna River Management Plan

Interstate, United States, and State highways located in the Susquehanna River Basin

Legend

- Interstate Highway
- State Highway
- US Highway

N
W E
S

Data: PennDOT

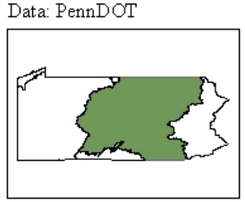


Figure 2.5.2 Interstate, United States, and State highways located in the Susquehanna River Basin

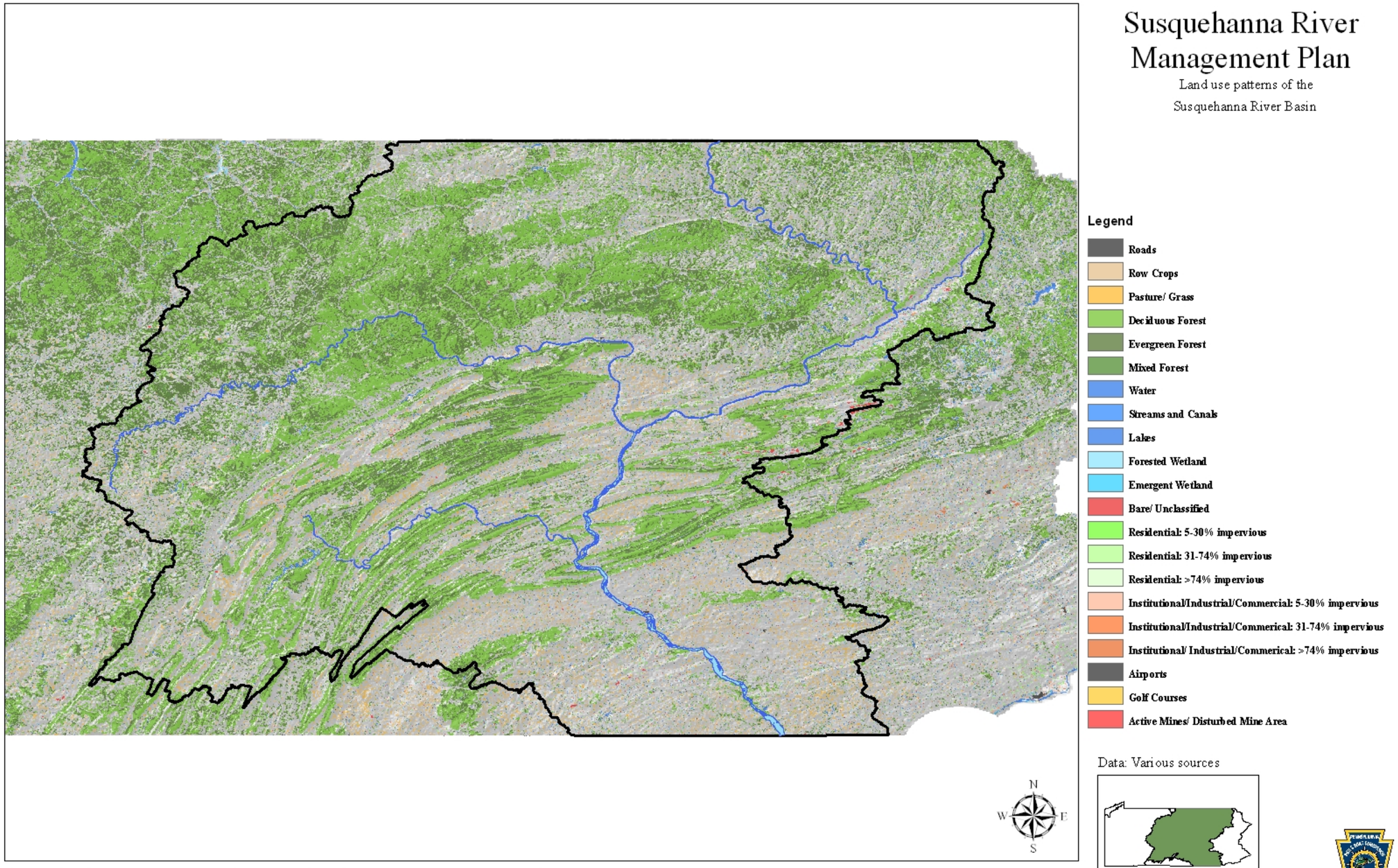


Figure 2.6.1 Land use patterns of the Susquehanna River Basin based on Anderson et al. 1979

Susquehanna River Management Plan

Brownfield revitalization and land recycling projects in the Susquehanna River Basin

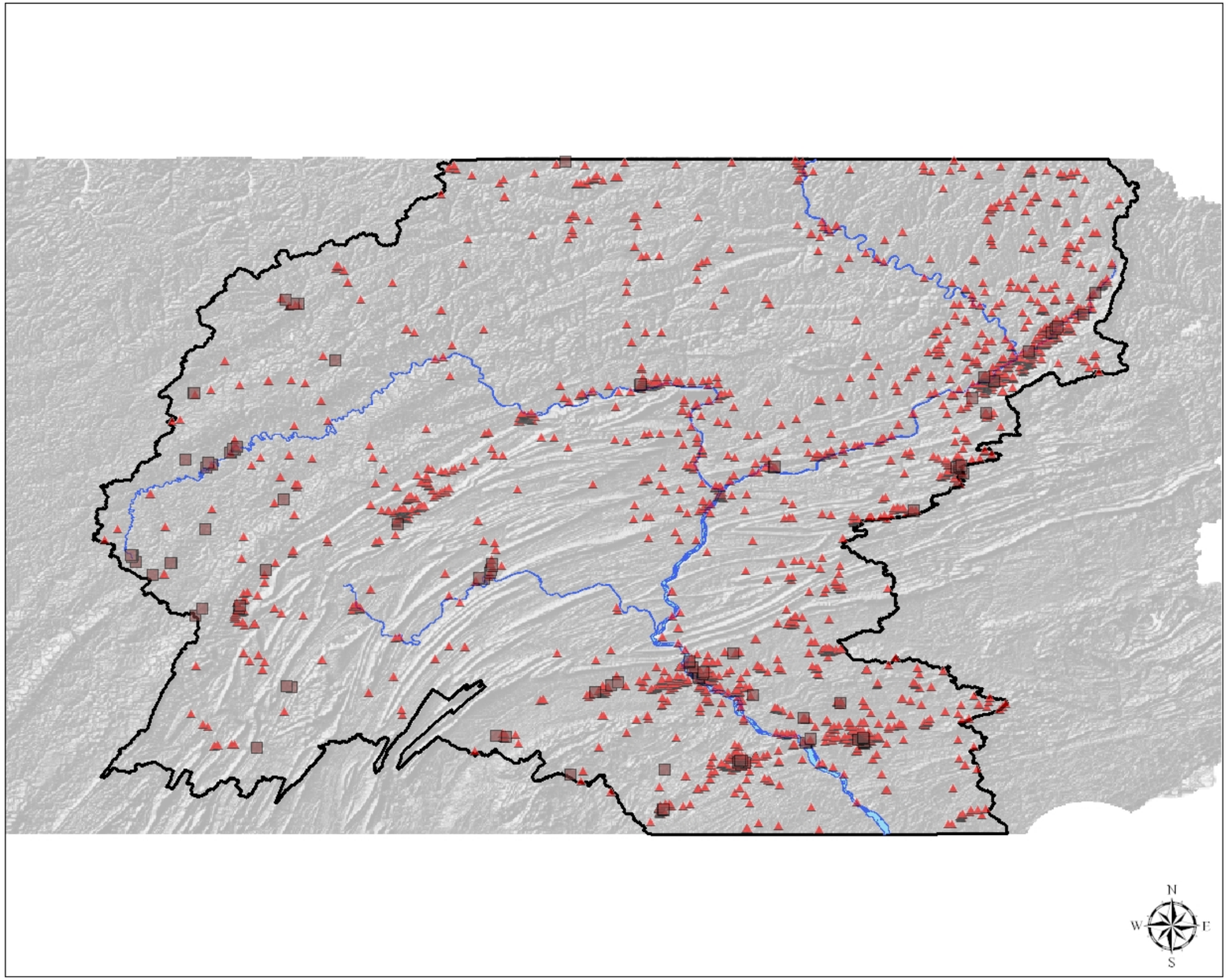


Figure 2.6.2 Brownfield revitalization and land recycling projects in the Susquehanna River Basin

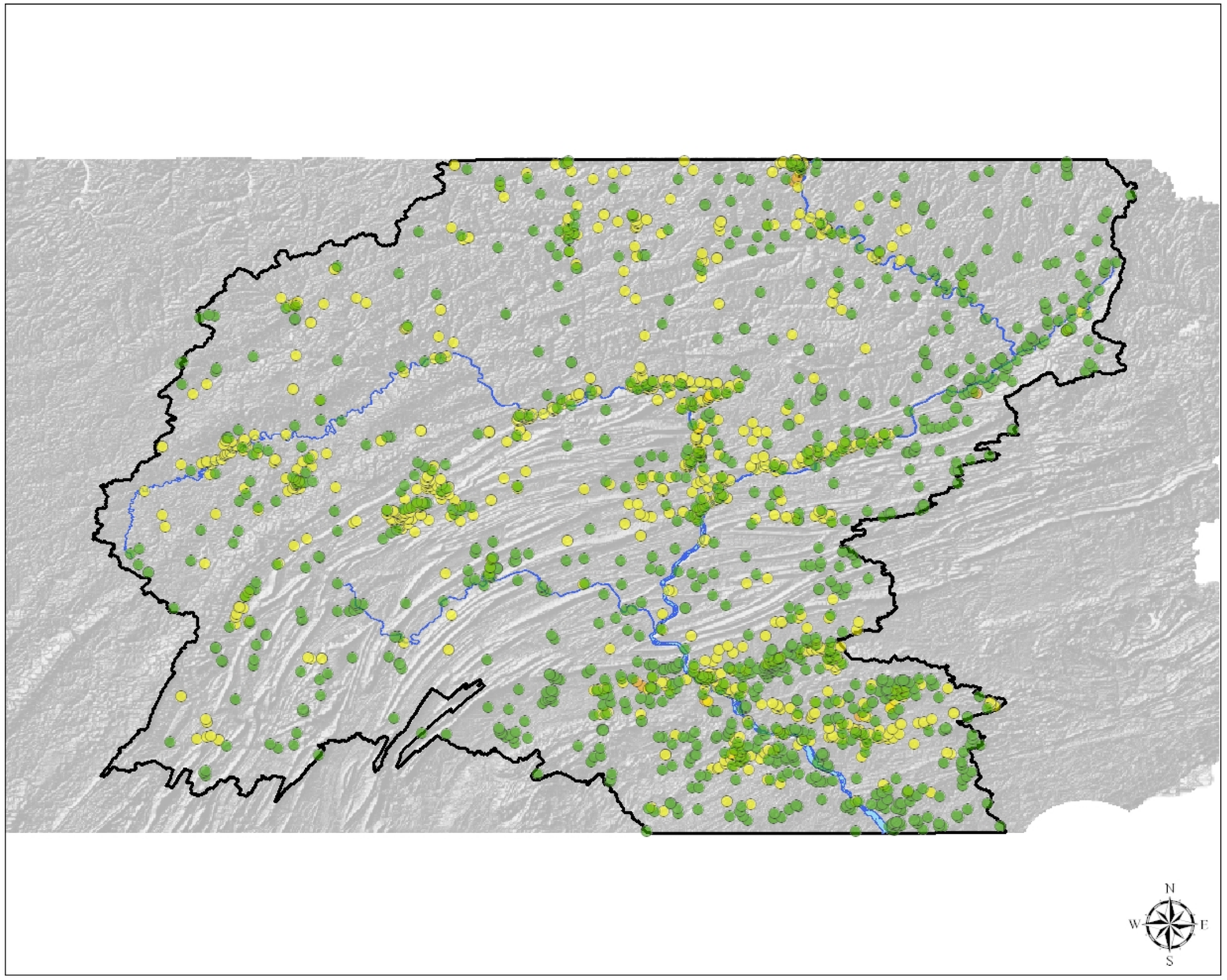


Figure 2.6.3 Municipal waste, captive hazardous waste, and commercial hazardous waste operations in the Susquehanna River Basin

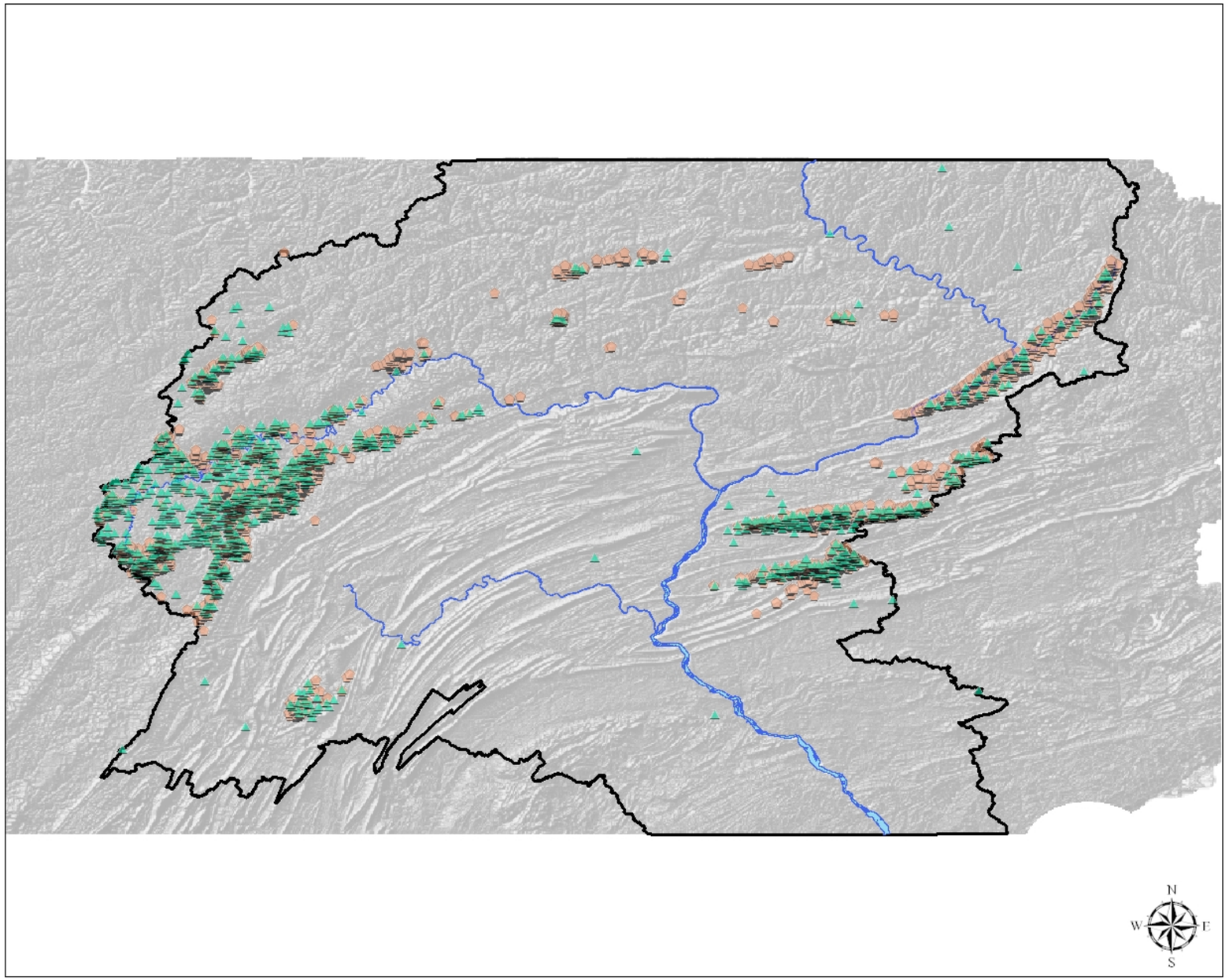


Figure 2.6.4 Active and abandoned mining operations in the Susquehanna River Basin

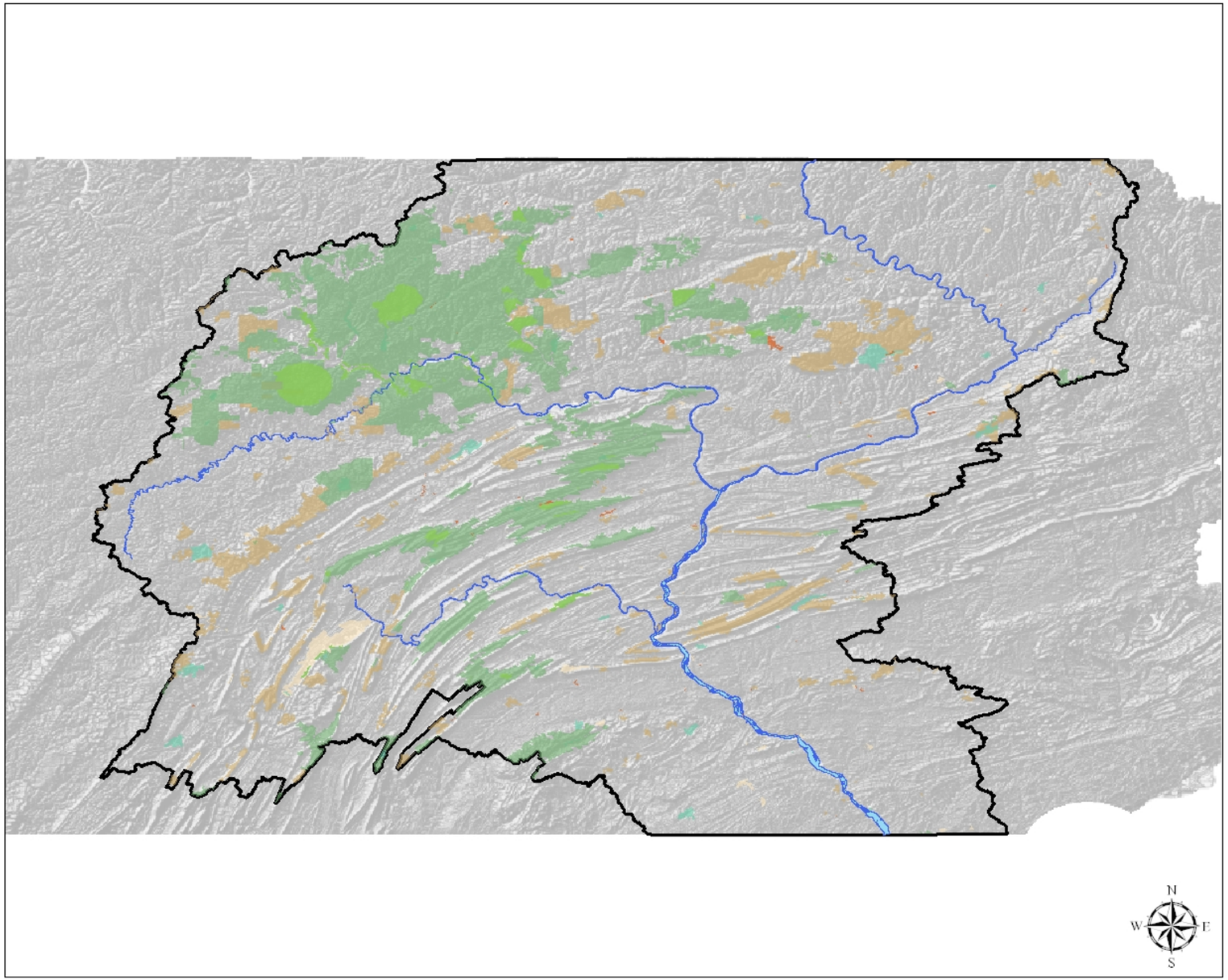


Figure 2.6.5 Public lands of the Susquehanna River Basin

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~Return to Table of Contents~

3.0 River Characteristics

The characteristics of the West Branch Susquehanna and Susquehanna rivers vary both within and among the rivers. These characteristics were defined primarily by geologic composition and events. Tectonic plate collisions creating uplift, subsequent erosions, and more recent glaciations all had a role in dictating the characteristics of the West Branch Susquehanna and Susquehanna rivers we see today. These factors influence channel dimensions and morphology which, in turn, influence the ecology of a river system.

3.1 Channel Dimensions

Stream Order

Rivers have been traditionally ranked by a classification system known as order (Strahler, 1957). This system is based on tributary input. A first order classification can be characterized as having a year-round flow but no tributary input and are commonly referred to as headwater streams. When two first order waters flow together the resulting mainstem is reclassified as a second order water; if two second order mainstems flow together they form a third order, and so on. At its origin, the West Branch Susquehanna River is classified as a first order stream based on the stream order system. The West Branch Susquehanna River becomes a second order stream at its confluence with an unnamed tributary downstream of the town of Carrolltown, Cambria County, Pennsylvania, and third order at its confluence with unnamed tributary 27279 near the village of Bakerton, Cambria County. It becomes fourth order at the confluence of Fox Run near the town of Spangler, Cambria County, and fifth order at the confluence with Shryock Run near the village of Stifflertown, Clearfield County. The West Branch Susquehanna River increases to sixth order at its confluence with Chest Creek at the village of Mahaffey, Clearfield County, and seventh order at its confluence with Sinnemahoning Creek near the village of Keating, Clinton County. The West Branch Susquehanna River remains a seventh order stream until its confluence with the Susquehanna River at the city of Sunbury, Northumberland County.

The Susquehanna River enters Pennsylvania as a sixth order stream. It increases to seventh order at the confluence with the Chenango River in Binghamton, New York. The Susquehanna River increases to eighth order at the confluence with the West Branch Susquehanna River at the city of Sunbury, Northumberland County, Pennsylvania and exits Pennsylvania at the Maryland border as an eighth order stream.

Length

The West Branch Susquehanna River originates near the town of Carroltown, Cambria County and flows approximately 241 miles to its confluence with the mainstem Susquehanna River at the city of Sunbury, Pennsylvania. The mainstem Susquehanna River is approximately 444 miles long from the outfall of Lake Otsego, at the city of Cooperstown, New York to its confluence with the Chesapeake Bay at the city of Havre de Grace, Maryland.

Width

The width of the West Branch Susquehanna and Susquehanna rivers varies greatly along their course. Average widths of both rivers exceed 30 m (99 ft), and are classified as Large Rivers by the PFBC (Table 3.1.1).

Gradient

Stream gradient, defined as the drop in elevation per unit length of channel, affects stream velocity and the availability of habitat types (Murphy and Willis 1996). Geomorphic characteristics like stream gradient influence the availability and diversity of habitats within watersheds and consequently influence the composition of the fish community as well as fish species abundance in a particular watershed or river reach (Lanka *et al.* 1987). Differences in gradient are influenced largely by physiographic region and surrounding topography. The stream gradients of the West Branch Susquehanna and Susquehanna rivers vary along their length (Table 3.1.2). The gradient of the West Branch Susquehanna River varies widely with a gradient of 4.3 m/km between Hyde, Clearfield County and the confluence of Moose Creek near Clearfield, Clearfield County and 0.1 m/km as it runs along the Allegheny Front between Lock Haven, Clinton County and Montoursville, Lycoming County. The mainstem Susquehanna River has an average gradient of 0.6 m/km but has many areas of localized steeper gradient through riffle and rapid sections.

3.2 Channel Morphology

Channel morphology is used to describe the shapes of rivers and how they change over time. The morphology of a river channel is a function of a number of processes and environmental conditions, including the composition and erodibility of the bed and banks; vegetation and the rate of plant growth; availability of sediment; the size and composition of the sediment moving through the channel; the rate of sediment transport through the channel and the rate of deposition on the floodplain, banks, bars, and bed; and regional aggradation or degradation due to subsistence or uplift.

Valley Width

Influenced by regional topography and underlying geology, the valley width, or the width of the river channel and its flood-prone area, generally increases as drainage area increases through both the West Branch Susquehanna River and Susquehanna River basins. Limited data are available for the West Branch Susquehanna and upper Susquehanna rivers (Leopold *et al.* 1992; Table 3.2.1), and we are unaware of any summarized data regarding valley width pertaining to the lower portion of the Susquehanna River.

Meander Pattern/Sinuosity

A meander is a bend in a sinuous watercourse. A meander is formed when the moving water in a river erodes the outer banks and widens its valley, which can eventually form into a series of alternating erosion/deposition areas forming various bends and turns in the mainstem that can be categorized into general types (i.e., meander pattern). Meander pattern/sinuosity varies

greatly over the lengths of the West Branch Susquehanna and Susquehanna rivers and is largely determined by underlying geology and gradient. Sinuosity is a measure of deviation of a path length from the shortest possible path and provides a numerical classification of channel meander (i.e., number of bends over a given length) and is described by a ratio of channel length to the valley length (Murphy and Willis 1996). Leopold and others (1992) describe meander wavelength for the West Branch Susquehanna River and upper Susquehanna River (Table 3.2.2), and we are unaware of any summarized data regarding meander pattern/sinuosity associated with the lower portion of the Susquehanna River.

Degree of Confinement

Degree of confinement refers to the ability of the river channel to disperse water onto the flood plain during high water events. The degree of confinement varies along the length of the West Branch Susquehanna and Susquehanna rivers based primarily on underlying geology and the surrounding topography. Furthermore, degree of confinement has also been altered through human activities such as channelization for flood control structures and road building. No data regarding degree of confinement were found for the West Branch Susquehanna and Susquehanna rivers.

Degree of Entrenchment/Incision

The concept of entrenchment or incision refers to the depth a river has cut downward through its riverbed, such as sediment or bedrock. Degree of entrenchment or incision is largely based on gradient and underlying geology. No information regarding degree of entrenchment or incision data was found for the West Branch Susquehanna and Susquehanna rivers.

Table 3.1.1. Mean width of select reaches of the West Branch Susquehanna and Susquehanna Rivers.

Waterbody	Reach	Mean Width (ft.)	Mean Width (m.)
West Branch Susquehanna River	Source to Chest Creek	67.96	20.72
West Branch Susquehanna River	Chest Creek to Hyde, PA	173.12	52.78
West Branch Susquehanna River	Hyde, PA to Moose Creek	213.86	65.20
West Branch Susquehanna River	Moose Creek to Bald Eagle Creek	302.25	92.15
West Branch Susquehanna River	Bald Eagle Creek to Loyalsock Creek	743.77	226.76
West Branch Susquehanna River	Loyalsock Creek to mouth	933.91	284.73
Susquehanna River	NY border to Oakland, PA	351.29	107.10
Susquehanna River	Oakland, PA to NY border	428.04	130.50
Susquehanna River	NY border to Sugar Creek	650.10	198.20
Susquehanna River	Sugar Creek to Towanda Creek	651.74	198.70
Susquehanna River	Towanda Creek to Meshoppen Creek	671.09	204.60
Susquehanna River	Meshoppen Creek to Lackawanna River	721.60	220.00
Susquehanna River	Lackawanna River to Exeter, PA	857.72	261.50
Susquehanna River	Exeter, PA to Wapwallopen Creek	793.40	241.89
Susquehanna River	Wapwallopen Creek to Fishing Creek	1,081.71	329.79
Susquehanna River	Fishing Creek to West Branch Susquehanna River	1,204.74	367.30
Susquehanna River	West Branch Susquehanna River to Shamokin Dam, PA	2,361.60	720.00
Susquehanna River	Shamokin Dam, PA to Juniata River	3,229.13	984.49
Susquehanna River	Juniata River to Swatara Creek	3,188.75	972.18
Susquehanna River	Swatara Creek to York Haven Dam	1,555.38	474.20
Susquehanna River	York Haven Dam to Columbia, PA	2,378.00	725.00
Susquehanna River	Columbia, PA to Safe Harbor Dam	5,605.52	1,709.00
Susquehanna River	Safe Harbor Dam to Holtwood Dam	3,139.62	957.20
Susquehanna River	Holtwood Dam to MD border	2,962.82	903.30

Data from PFBC resource database

Table 3.1.2. Gradient for select reaches of the West Branch Susquehanna and Susquehanna rivers

Waterbody	**Reach**	**Gradient** (m/ km)
West Branch Susquehanna River	Source to Chest Creek	3.5
West Branch Susquehanna River	Chest Creek to Hyde, PA	1.2
West Branch Susquehanna River	Hyde, PA to Moose Creek	4.3
West Branch Susquehanna River	Moose Creek to Bald Eagle Creek	1.0
West Branch Susquehanna River	Bald Eagle Creek to Loyalsock Creek	0.1
West Branch Susquehanna River	Loyalsock Creek to mouth	0.4
Susquehanna River	NY border to Oakland, PA	0.6
Susquehanna River	Oakland, PA to NY border	0.7
Susquehanna River	NY border to Sugar Creek	0.7
Susquehanna River	Towanda Creek to Meshoppen Creek	0.4
Susquehanna River	Meshoppen Creek to Lackawanna River	0.3
Susquehanna River	West Branch Susquehanna to Lake Clarke	0.5
Susquehanna River	Lake Clarke to mouth	0.9

Data from PFBC database and Pazzaglia and Gardner 1993

Table 3.2.1. Valley width for select reaches of the West Branch Susquehanna and upper Susquehanna rivers as reported by Leopold *et al.* 1992.

Waterbody	**Reach**	**Valley width** (ft)
West Branch Susquehanna River	Above Good, PA	178
West Branch Susquehanna River	Near Curwensville, PA	178
West Branch Susquehanna River	Clearfield Creek to Lick Run	450
West Branch Susquehanna River	Shawville,PA to Frenchville Station, PA	450
West Branch Susquehanna River	Little Bougher, PA to Karthaus, PA	300
West Branch Susquehanna River	Glen Union, PA to Hyner, PA	1,260
West Branch Susquehanna River	Great Island to Avis	984
West Branch Susquehanna River	Near Williamsport, PA	1,000
Susquehanna River	North of Scranton, PA	615

Table 3.2.2. Meander wavelength for select reaches of the West Branch Susquehanna and upper Susquehanna rivers as reported by Leopold *et al.* 1992.

Waterbody	**Reach**	**Wavelength** (ft)
West Branch Susquehanna River	Above Good, PA	5,600
West Branch Susquehanna River	Near Curwensville, PA	5,000
West Branch Susquehanna River	Clearfield Creek to Lick Run	3,700
West Branch Susquehanna River	Shawville,PA to Frenchville Station, PA	9,000
West Branch Susquehanna River	Little Bougher, PA to Karthaus, PA	6,000
West Branch Susquehanna River	Glen Union, PA to Hyner, PA	13,000
West Branch Susquehanna River	Great Island to Avis	14,000
West Branch Susquehanna River	Near Williamsport, PA	27,000
Susquehanna River	North of Scranton, PA	19,000

~Return to Table of Contents~

4.0 Special Jurisdictions

As navigable waters of the United States, jurisdiction over activities associated with the West Branch Susquehanna and Susquehanna rivers is tasked to the United States Department of Defense, Army Corps of Engineers (USACE) and United States Environmental Protection Agency (USEPA) (*see sub-section 4.3 below*) and has been delegated to the Commonwealth of Pennsylvania. Management of specific areas and functions of many river systems and adjoining lands can reside with entities that are not part of the general jurisdictional power. For the purpose of this management plan, these areas and functions will be referred to as special jurisdictions since the areas and activities are out of the direct control of the Commonwealth of Pennsylvania. The PFBC provides commentary and support to parties who hold special jurisdictions in the West Branch Susquehanna and Susquehanna rivers to ensure sound management of resources in order to protect, conserve, and enhance aquatic resources.

4.1 Governmental

4.1.1 Federal

The United States Department of Defense, Army Corps of Engineers (USACE) holds regulatory jurisdiction over all projects associated with navigable waters of the United States, including the West Branch Susquehanna and Susquehanna rivers. The USACE, Baltimore District, District Reservoir Control Center (DRCC) is responsible for directing gate operations of all flood control projects under their control in the Susquehanna River Basin; directly and indirectly controlling flow regulation in the West Branch Susquehanna and Susquehanna rivers under flood emergency operations (United States Army Corps of Engineers, 1974a,b).

In addition to flow regulation, land areas associated with flood control projects on the rivers are under federal special jurisdiction. The United States Department of Defense, United State Army Corps of Engineers (USACE) maintains jurisdiction over the land area and the operation of the Curwensville Dam project upstream of the Curwensville, Pennsylvania. The USACE also maintains jurisdiction over land areas associated with flood protection projects at Lock Haven, Pennsylvania and Williamsport, Pennsylvania at the West Branch Susquehanna River and at Sunbury, Pennsylvania and in the vicinity of Wilkes-Barre, Pennsylvania at the Susquehanna River. The PFBC coordinates with the USACE regarding management activities associated with USACE Curwensville Dam and other flood control facilities on an as-needed basis.

4.1.2 Multi-state and other

The SRBC is given the power to effectuate plans, policies, and projects relating to the water resources of the basin; including adoption and promotion of uniform and coordinated policies for water resources conservation and management in the Susquehanna River Basin (Susquehanna River Basin Compact, Article 3, 1972). The PFBC provides commentary and supports efforts of the SRBC regarding flow regulation activities associated with the rivers.

4.2 Flow Rate Management Regulations

The Susquehanna River Basin Commission (SRBC), under section 4.2(a) of the Susquehanna River Basin Compact (1951) has the power to acquire, construct, operate,and control projects and facilities for the storage and release of waters for regulation of flows and supply of surface and ground waters of the basin for the protection of public health, stream quality control, economic development, improvement of fisheries, recreation, dilution and abatement of pollution, the prevention of excess salinity, among other purposes. In addition, SRBC has been developing water supply storage capacity at key reservoirs in the Susquehanna River Basin, including the West Branch Susquehanna and Susquehanna rivers, for release during low flow periods. SRBC currently reserves approximately 38,500 acre-feet of water storage available from USACE Projects at Curwensville Lake, Cowanesque Lake, and Whitney Point Lake (http://www.srbc.net/programs/waterstorageprojects.htm, A. Dehoff, SRBC, Personal Communication). It is anticipated that, additional storage will be available from the Barnes & Tucker Mine pool for flow management of the West Branch Susquehanna River in the near future (A. Dehoff, SRBC, personal communication). The PFBC provides commentary on flow rate management of the West Branch Susquehanna and Susquehanna rivers to SRBC water resources programs on an as-needed basis.

SRBC applies passby flows in the Susquehanna basin associated with surface-water, spring and ground-water withdrawals under §803.44 and §803.43 of SRBC regulations. Passby flows function the same as conservation releases to assure that a minimum amount of water is available in a stream for protection of aquatic life. When the passby flow is reached, withdrawals cannot occur until additional flow is restored. Withdrawals from surface waters, springs and wells that impact stream flow more than ten percent of the 7-day 10-year drought flow ($Q_{7\text{-}10}$) when water withdrawals at a point are considered cumulatively and passby flows are applied as stated in SRBC Passby Flow Policy No. 2003-01 (SRBC 2002).

The USACE, Baltimore District and SRBC are coordinating with The Nature Conservancy (TNC) to design and facilitate a process to set basin-wide ecosystem flow goals that can be implemented within the subwatersheds of the Susquehanna River. The PFBC provides commentary and support for TNC modeling efforts to develop basin-wide ecosystem flow targets for the SRBC and USACE. A more in-depth description of these activities can be found in Section 5.2.5; Hydrologic modeling.

4.3 Navigable Waters

Both the West Branch Susquehanna and Susquehanna rivers are recognized by the federal government as navigable waters despite barriers to transportation resulting from hydropower and run-of-the-river dams. These rivers, and subsequently their tributaries, are deemed navigable waters by the USACE under Title 33 Code of Federal Regulations Part 329 (Title 33 U.S.C.) due to their past potential to conduct interstate commerce. This definitions gives the federal regulatory jurisdiction (USEPA and USACE) to the ordinary high water mark under Section 404 of the Federal Water Pollution Control Act (P.L. 92-500) and Section 10 of the Rivers and Harbors Act (33 U.S.C. 403: Chapter 425, March 3,1899; 30 Stat. 1151),

respectively. In the case of the USEPA, these regulatory powers have been delegated to the PADEP for the areas within the boundaries of the Commonwealth.

4.4 Resource Extraction

Resource extraction activities have had a lasting mark on the West Branch Susquehanna and Susquehanna rivers. Historic logging and coal mining activities in northeastern and north central Pennsylvania have drastically altered the landscape and ecology of the rivers. Some areas are still degraded by past resource extraction practices, while others have been or are in the process of being remediated. Some of the most recent concerns as they relate to water quality and quantity impacts from newly recognized natural gas extraction possibilities associated with Marcellus shale formations.

Dredge and fill activities

The PFBC provides commentary regarding the protection of trust resources through the Bureau of Fisheries, Division of Environmental Services as they related to dredge and fill activities within the Commonwealth. Presently, no dredge and fill activities occur in the West Branch Susquehanna and Susquehanna rivers.

Oil and gas

Natural gas exploration in the Marcellus shale formation has brought resurgence in resource extraction activity throughout the Commonwealth. Approximately 72 percent of the Susquehanna River Basin is underlain by the Marcellus shale formation (SRBC 2009). Oversight of Marcellus shale drilling (hydrofracturing) and all other on-site operations, including waste water disposal, are under the jurisdiction of the PADEP, Bureau of Oil and Gas Management. All water withdrawals associated with Marcellus shale operations in the Susquehanna River Basin are required to be permitted by the SRBC. The PFBC, Bureau of Fisheries, Division of Environmental Services provides commentary on oil and gas operations within the Commonwealth as they relate to the resources under the PFBC's purview and supports regulatory efforts by PADEP and SRBC as they relate to oil and natural gas extraction activities that effect the West Branch Susquehanna and Susquehanna rivers. The PFBC also provides on-the-ground monitoring of water quality and aquatic communities through the Bureau of Law Enforcement and Bureau of Fisheries, divisions of Environmental Services and Fisheries Management for areas of the West Branch Susquehanna and Susquehanna rivers where oil and natural gas extraction activities occur.

Commercial sand and gravel dredging

The PFBC provides commentary regarding the protection of trust resources through the Bureau of Fisheries, Division of Environmental Services as they relate to commercial sand and gravel dredging activities within the Commonwealth. Presently, no commercial sand and gravel dredging operations are taking place in the West Branch Susquehanna and Susquehanna rivers.

Coal extraction

Numerous active and abandoned coal mining operations are located throughout the West Branch Susquehanna River and Susquehanna River basins (Figure 2.6.4). Historic coal operations have had a marked effect on the landscape and ecology of these basins. All coal mining activities are managed by the PADEP, Bureau of District Mining Operations and Bureau of Abandoned Mine Reclamations (BAMR).

Recent efforts by SRBC, PADEP BAMR, PFBC, Bureau of Fisheries, Division of Environmental Services, Trout Unlimited (TU), and local watershed groups have made substantial gains in remediation of abandoned mine drainage pollution, especially in the West Branch Susquehanna River drainage. As part of these efforts, SRBC has developed the Abandoned Mine Drainage Restoration Strategy for the West Branch Susquehanna Watershed (2008) to prioritize remediation efforts to improve water quality of the West Branch Susquehanna River.

4.5 Hazardous Waste Sites

The Comprehensive Environmental Response Compensation and Liability Act (CERCLA, colloquially referred to as Superfund) identifies hazardous waste sites and provides funding for remediation of associated impacts through the USEPA. A total 1,124 captive hazardous waste operations and 18 commercial hazardous waste operations are located within the Susquehanna River Basin as identified by PADEP (Figure 2.6.3). The PADEP, Bureau of Waste Management, Municipal Waste Program and Hazardous Waste Program oversee these activities. Sites with the highest hazard ranking are directly regulated as Superfund sites by USEPA with input from the Commonwealth. A list of Superfund sites in Pennsylvania can be found via USEPA website: http://www.epa.gov/reg3hwmd/super/pa.htm. The PFBC supports regulatory efforts of the USEPA and PADEP and provides commentary on an as-needed basis regarding hazardous waste sites that affect the West Branch Susquehanna and Susquehanna rivers.

4.6 Historic Water Channels

Historically, a series of canals located in the West Branch Susquehanna River and Susquehanna River basins were built for local and interstate commerce. The Susquehanna and Tidewater Canal from Wrightsville, York County, Pennsylvania to Havre de Grace, Harford County, Maryland was completed in 1839 and was 43 miles in length complete with 28 lift locks (PA Canal Society 2009). The Pennsylvania Canal System operated three divisions associated with the Susquehanna River: Susquehanna Division, Northern Branch Division, and West Branch Division (American Canal Society 2009a). The North Branch Division, completed during three phases (1828-1831, 1831-1834, and 1836-1856), covered 169 miles from the New York border to the city of Northumberland, Northumberland County, Pennsylvania, and included 43 locks, five dams to provide slack water and water supply, 29 aqueducts, and 229 bridges (American Canal Society 2009a). The West Branch Division covered 73 miles from the city of Lock Haven, Clinton County, Pennsylvania to the city Northumberland, Northumberland County, Pennsylvania and included 23 locks and 15 aqueducts along its length (American Canal Society 2009b). The Susquehanna Division covered 41 miles from the city of Northumberland,

Northumberland County, Pennsylvania to the city of Duncannon, Perry County, Pennsylvania and was comprised of 12 locks (American Canal Society 2009c).

~Return to Table of Contents~

5.0 River Hydrology

The hydrology of the West Branch Susquehanna and Susquehanna rivers vary over the length of each of the river systems. With the exception of the Susquehanna River downstream from York Haven Dam, both river systems function as large, free flowing rivers with several run-of-the-river dams along their lengths. Downriver of York Haven Dam, the mainstem Susquehanna River has three major hydropower dams and a pumped-storage reservoir that significantly alter the hydrologic conditions of this portion of the River. The PFBC provides commentary on hydrologic issues related to the West Branch Susquehanna and Susquehanna rivers and supports resource agencies tasked with managing these issues including the Susquehanna River Basin Commission (SRBC), Pennsylvania Department of Environmental Protection (PADEP), Pennsylvania Department of Conservation and Natural Resources (DCNR), Federal Energy Regulatory Commission (FERC), and United States Department of Defense, Army Corps of Engineers (USACE).

5.1 Hydrologic Regime

The PFBC strives to ensure sound management of the hydrologic regime of the West Branch Susquehanna and Susquehanna rivers in order to protect conserve and enhance aquatic resources by providing commentary and supporting efforts of agencies tasked with managing these resources. The hydrologic regimes of the West Branch Susquehanna and Susquehanna rivers are similar in overall trends but differ greatly in terms of magnitude as one progresses downstream. These differences are further altered by hydropower impoundments whose hydrologic regimes within the pools and accompanying tailraces are controlled by seasonal flows, storage, and releases for power generation. These hydrologic differences require that the rivers be characterized in smaller units within this section.

5.1.1 Discharge

5.1.1.1 West Branch Susquehanna River

The flow pattern of the West Branch Susquehanna River from its origin to the confluence with the Susquehanna River is characteristic of large streams or small rivers of similar magnitude. Discharge typically corresponds to seasonal variations characteristic of free flowing systems with elevated discharge conditions in the late-fall through mid-spring followed by base flow conditions from late-spring through early-fall. Discharge through this reach (Figure 5.1.1.1), like most free flowing systems, is strongly related to precipitation. The United States Department of the Interior, United States Geological Survey (USGS) maintains stream gages near Bower, Pennsylvania (USGS 01541000); at Curwensville, Pennsylvania (USGS 01541200); Karthaus, Pennsylvania (USGS 01542500); Renovo, Pennsylvania (USGS 01545500); Lock Haven, Pennsylvania (USGS 01545800); Jersey Shore, Pennsylvania (USGS 01549760); Williamsport, Pennsylvania (USGS 01551500); West Milton, Pennsylvania (USGS 01553240); and Lewisburg, Pennsylvania (USGS 01553500) in cooperation with National Oceanic and Atmospheric Administration, National Weather Service (NOAA, NWS), PADEP and USACE that

provide discharge data for the West Branch Susquehanna River within this river reach. Base flow conditions of this reach are typical of free flowing streams or rivers of similar magnitude and generally occur between June and October, annually, depending upon meteorological events. Peak flow and flood events of this reach are commonly correlated with spring snow melt, significant frontal rain events, or major meteorological events such as remnants of hurricanes, tropical storms, or tropical depressions and are mitigated to some degree by flood storage reservoirs on the West Branch Susquehanna River (USACE Curwensville Dam) and on tributaries Sinnemahoning Creek (DCNR George B. Stevenson Dam (operated by USACE)), Kettle Creek (USACE Alvin R. Bush Dam), Bald Eagle Creek (USACE Foster Joseph Sayers Dam), and Little Pine Creek (DCNR Little Pine Dam).

5.1.1.2 Susquehanna River, PA-NY state line to confluence with West Branch Susquehanna River (including "Great Bend" section)

The flow pattern of the Susquehanna River through the Great Bend region to the confluence with the West Branch Susquehanna River at Sunbury, Pennsylvania can be characterized as similar to large, free-flowing rivers similar in size. Discharge typically follows seasonal variations characteristic of free flowing systems with elevated discharge conditions in the late fall through middle spring and then dropping to base flow conditions late spring through early fall. Discharge through this reach (Figure 5.1.1.2), like most free flowing systems, is strongly related to precipitation. The Unites States Department if the Interior, United State Geological Survey (USGS) maintains stream gages at Waverly, New York (USGS 01515000); Towanda, Pennsylvania (USGS 01531500); Meshoppen, Pennsylvania (USGS 01533400); Wilkes-Barre, Pennsylvania (USGS 01536500); Bloomsburg, Pennsylvania (USGS 01538700); and Danville, Pennsylvania (USGS 01540500) in cooperation with National Oceanic and Atmospheric Administration, National Weather Service (NOAA, NWS), PADEP and USACE. Base flow conditions of the Susquehanna River through this reach are typical of free-flowing rivers of this size and occur between June and October, annually, depending upon meteorological events. Peak flow and flood events of the Susquehanna River through this reach are commonly tied to spring snow melt, significant frontal rain events, or major meteorological events such as remnants of hurricanes, tropical storms, or tropical depressions. These events can differ in magnitude and duration from those of the West Branch Susquehanna River depending on weather patterns in the respective watersheds. Peak flows within this reach are somewhat mitigated by flood storage reservoirs USACE Whitney Point Lake, Chenango River drainage, USACE Almond Lake and Arkport Dam, Chemung Drainage and on tributaries Ouleout Creek (USACE East Sidney Lake),Tioga River (USACE Tioga-Hammond Lakes, USACE Cowanesque Lake) Lackawanna River (USACE Aylesworth Creek Lake, USACE Stillwater Lake).

5.1.1.3 Susquehanna River, Confluence with West Branch Susquehanna River to Safe Harbor Dam.

The flow pattern of the Susquehanna River from the confluence of the West Branch Susquehanna River to the Safe Harbor Dam can be characterized as similar to large, free-

flowing rivers similar in size. The York Haven Dam falls within this reach and despite being used for hydropower production, functions, essentially, as a run-of-river dam and has little effect on flow patterns. Discharge typically follows seasonal variations characteristic of free flowing systems with elevated discharge conditions in the late fall through middle spring and then dropping to base flow conditions late spring through early fall. Discharge through this reach (Figure 5.1.1.3), like most free flowing systems, is strongly related to precipitation. The Unites States Department of the Interior, United State Geological Survey (USGS) maintains a stream gages at Sunbury, Pennsylvania (USGS 01554000) in cooperation with PADEP, USACE, and the city of Sunbury; Harrisburg, Pennsylvania (USGS 01570500) in cooperation with the Federal Energy Regulatory Commission (FERC), PADEP, and USACE ; and at Marietta, Pennsylvania (USGS 01576000) in cooperation with the FERC, NOAA, NWS, and PADEP. Base flow conditions of this reach are typical of free-flowing rivers of this size and occur between June and October, annually, depending upon meteorological events. Peak flow and flood events of this reach are commonly tied to spring snow melt, significant frontal rain events, or major meteorological events such as remnants of hurricanes, tropical storms, or tropical depressions. Peak flows within this reach are somewhat mitigated by flood storage reservoirs in other portions of the watershed including the USACE Raystown Lake on the Raystown Branch Juniata River, a primary tributary to the Juniata River which is a major contributor in this reach.

5.1.1.4 Susquehanna River, Safe Harbor Dam to Holtwood Dam

The flow pattern through this reach of the Susquehanna River is largely controlled by hydroelectric power generation at both the upstream (Safe Harbor) and downstream (Holtwood) dams. Both facilities store and release water based upon energy demands. Safe Harbor has high hydraulic capacity (110,000 cfs) compared to Holtwood (31,500 cfs), thus, when Safe Harbor operates, Holtwood is often forced to spill. Safe Harbor has no minimum flow requirements. Holtwood recently received an amended FERC license and PA DEP 401 certification. The amended license allows Holtwood to increase generation from 31,500 cfs to 61,500 cfs, provides for improved fish passage facilities and other, resources agency mandates. In addition, the Holtwood project now has minimum flow requirements. Minimum flow requirements include (among others): a release, including leakage, on a daily volumetric basis equivalent to 98.7 percent of the minimum flows required by FERC to be released at the Conowingo Hydroelectric Facility; if net inflow to Lake Aldred, the impoundment formed by Holtwood Dam, is less than the minimum stream flow (MSF) requirement established above, the Amended Project shall achieve a MSF release on a daily volumetric basis equal to the net inflow to Lake Aldred; an hourly release equal to the lesser of (a) 800 cfs, or (b) the hourly net inflow to Lake Aldred, with allowances for lake evaporation and other estimated quantities as authorized to by the SRBC; minimum stream flows and limited irrigation spills in the spillway area to maintain and protect existing and designated uses and protect endangered plants (sticky goldenrod and white doll's daisy); minimum stream flows in the tailrace and continuous minimum release of 200 cfs into the Piney channel; and during times of upstream anadromous fish passage, a MSF in the spillway channel and Piney Channel to attract American shad to the fish passage system entrance (PADEP 2009a). Presently, there are no publicly available gaging locations within this reach to document discharge; however, Safe Harbor does maintain

a private gage at the dam. All storage and release data occurring at Safe Harbor and Holtwood dams is considered proprietary data and is not available for public release.

Base flow conditions of this reach are tied to storage and release activities associated with power production at both of these facilities. Natural base flow conditions are not easily determined and are significantly altered by construction and operation of hydropower facilities. There are no gaging locations within this reach of the Susquehanna River. Conditions are similar to upstream gaging location at Marietta, Pennsylvania and can be used for reference to peak flow activities.

5.1.1.5 Susquehanna River, Conowingo Reservoir

The flow pattern through the tailwater section of Holtwood Dam through the Pennsylvania-portion of Conowingo Reservoir (Pond) is tied to storage and release activities associated with power production at the Safe Harbor, Holtwood and Conowingo dams and the Muddy Run Pumped Storage Project. FERC license agreements mandate that daily releases must, at a minimum, equal to the 24-hour discharge measured discharge at the USGS gage at Marietta, Pennsylvania (L. Miller, USFWS, Personal Communication). Releases from these projects are episodic and tied to peak power generation. Conowingo Dam and the resultant pool is required to maintain a pool elevation of 101.2 feet to support various usages and allows normal fluctuation between 101.2 and 110.2 ft National Geodetic Vertical Datum (NGVD) 1929 (FERC No 405). Conowingo Hydroelectric Station operations are scheduled to take advantage of periods of high electricity demand, maintain FERC-established minimum flow requirements, and maintain Conowingo Pool levels which permit operation of the Muddy Run Pumped Storage facility and Peach Bottom Atomic Power Station.

Base flow condition of this reach is tied to storage and release activities associated with power production at both the Holtwood and Conowingo dams and to a lesser extent by the Muddy Run Pump Storage Facility. Natural base flow conditions are not easily determined and are significantly altered by construction and operation of hydropower facilities. There are no mainstem gaging locations within this reach of the Susquehanna River. Conditions are similar to upstream gaging location at Marietta, Pennsylvania and can be used for reference to peak flow activities.

5.1.2 Material Transport

Sediment

The West Branch Susquehanna and Susquehanna rivers transport large volumes of sediment to the Chesapeake Bay. Schubel (1968, 1972) estimated that the Susquehanna River discharged 600,000 metric tons of suspended sediment during a period from April 1966 to

March 1967 and 320,000 metric tons during calendar year 1969 to the Chesapeake Bay. Schubel (1968) also indicated that approximately seventy percent of the sediment discharged to the bay is transported during the peak flow period of February and March. During the period from 1966 to 1976, 50 million metric tons of sediment was transported from the Susquehanna River to the upper Chesapeake Bay (Grant *et al*. 1978). Two flood events associated with Hurricanes Agnes (1972) and Eloise (1975) accounted for approximately 40 million metric tons of sediment (Grant *et al*. 1978). Recent estimates calculate that the Susquehanna River transports 3 million short tons (tons) annually, depositing 2 million tons behind Conowingo Dam with the remaining 1 million tons deposited in the Chesapeake Bay. Langland (2009) estimates that 14.7 million tons of sediment was deposited in the three hydropower impoundments between 1996 and 2008 with the bulk being deposited in the Conowingo Reservoir (12 million tons). Long-term sediment storage in Safe Harbor and Holtwood dams is currently in a state of equilibrium with no net gain of sediment occurring behind these two impoundments. Conowingo Reservoir has approximately 30 million tons of remaining storage capacity and at current rates of deposition, that capacity could be met within 15 to 20 years (Langland 2009).

5.1.3 Tributaries

Major Tributaries (fifth order and larger)

Major tributaries, although limited in number, have a substantial bearing on the characteristics of the rivers. The West Branch Susquehanna River has thirteen tributaries categorized as fifth order or larger The Susquehanna River has 24 tributaries categorized as fifth order or larger

Minor Tributaries (fourth order and smaller)

The minor tributaries are numerous but the overall effects on the hydrologic characteristics of these rivers are likely restricted to the vicinity of the point of entry. The West Branch Susquehanna River has 306 direct tributaries that are classified as fourth order and smaller. One hundred and fifty-seven of them are unnamed. The Pennsylvania-portion of the Susquehanna River has 367 tributaries that are classified as fourth order and smaller. Two hundred twenty-eight are unnamed.

5.2 Flow Modification

Flow modification of these rivers dates back to early European colonization and has changed greatly in scale and scope over time, including a recent campaign to revert stream systems to free-flowing conditions by removing flow modification structures such as dams and diversions. Presently, impoundments on these rivers serves to provide flood storage, water supply and increased water surface elevation for recreation, power generation, and to supply diversion channels.

A potentially significant threat to aquatic communities in the Susquehanna River Basin is increased consumptive use (CU) of water to meet expanding societal demands for water. CU is defined by SRBC as water that is used in a way it is not returned to the basin, including through evaporation, irrigation, use in products and diversions out of the Susquehanna watershed.

Consumptive water use regulation, adopted by the SRBC in 1976 and most recently updated in November 2010, requires project sponsors to provide mitigation, either through providing compensatory water or fees, for their water use during low flow events. The maximum current use potential in the basin is estimated to be 882.5 million gallons per day (mgd) and is projected to increase to 1,202.2 mgd by 2025 of which, mitigation is needed for 116.7 mgd and 390.3 mgd, respectively. Historically, actual usage falls somewhat below the actual permitted usage, but management based on permitted values allows for more conservative estimates for resource protection (SRBC 2008).

The bulk of CU falls into five major categories: utilities (water supply diversions and power generation), recreation, manufacturing, mining, and education (Figure 5.2.1). These uses account for 98.5% of approved CU in the Susquehanna River Basin with the greatest CU (98%) occurring in the West Branch Susquehanna, middle Susquehanna and lower Susquehanna subbasins (Figure 5.2.2). Nearly half of the annual CU occurs during the typical low flow period of July through November but peak CU (July) does not coincide with the critical low flow period which most commonly occurs in September.

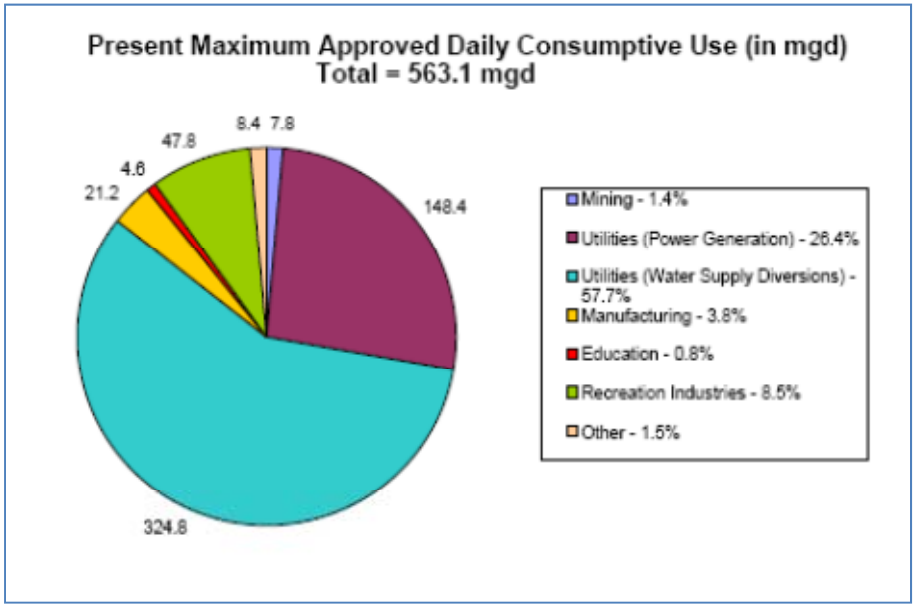

Figure 5.2.1. Categorization of maximum approved daily consumptive use by purpose in the Susquehanna River Basin (SRBC 2008).

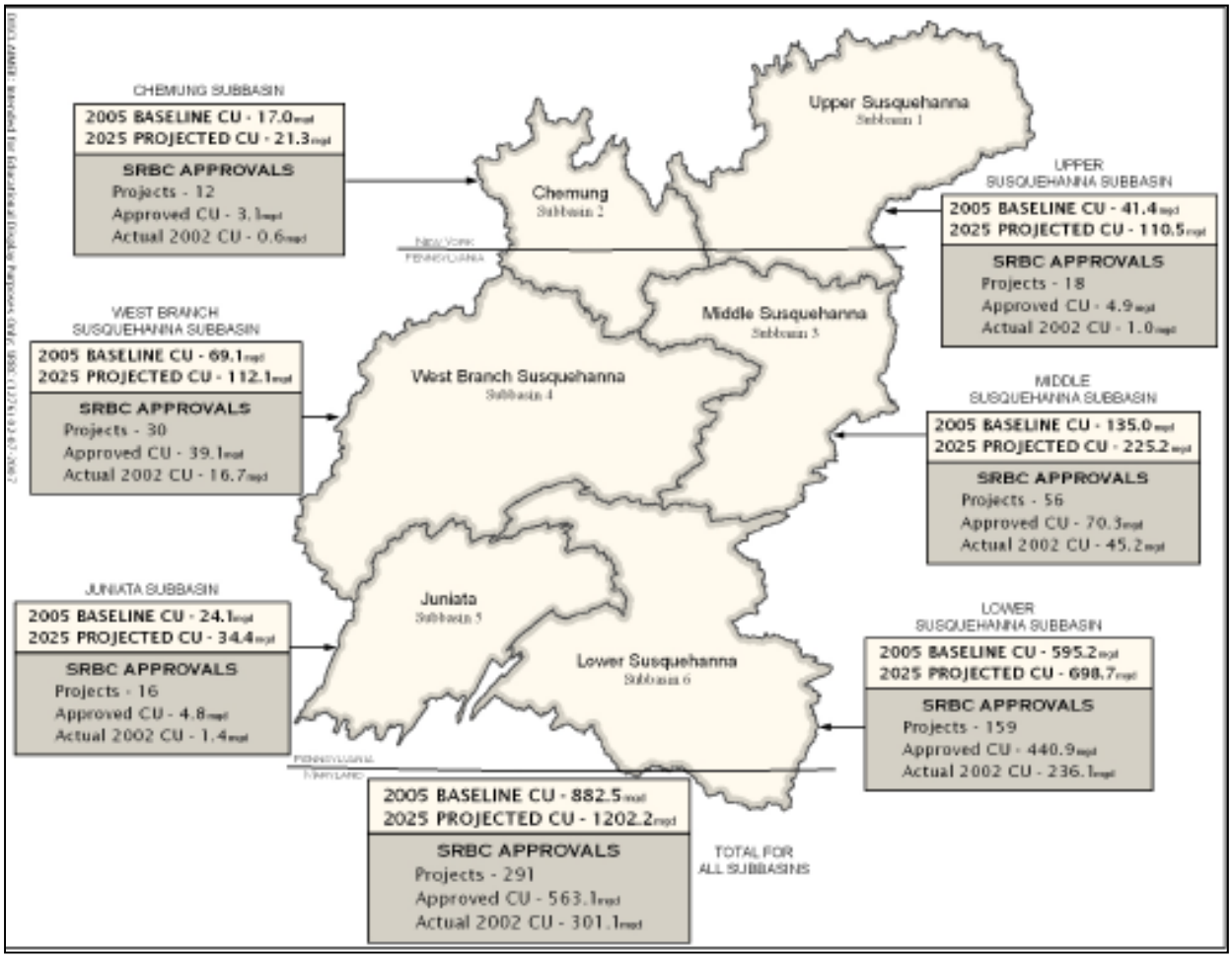

Figure 5.2.2. Consumptive use by subbasin within the Susquehanna River Basin (SRBC 2008).

The most recent CU mitigation plan has recognized the need for revised mitigation thresholds from the historic Q7-10 threshold to be more responsive to demonstrated aquatic and riparian resource needs, potentially including recently observed disease-related mortality of smallmouth bass and largemouth bass in the Susquehanna River and major tributaries. The 2008 Plan quantifies the need to secure more storage to achieve mitigation flows at the permitted levels, and the SRBC is currently working with partners to develop and acquire innovative storage options in order to meet more protective/responsive CU mitigation goals (SRBC 2008).

The PFBC provides commentary to SRBC on a number of issues including consumptive use plans and most recently worked with the SRBC, USACE, and The Nature Conservancy (TNC) on development of their ecosystem flow recommendations (DePhilip and Moberg 2010). The PFBC needs to continue to work with these entities to maintain sound, ecologically-based streamflow management for protection of aquatic resources.

5.2.1 Impoundments

The PFBC, Bureau of Fisheries, works with resource agencies, non-government organizations (NGO), and dam owners and operators to limit construction, and where feasible, remove dams and diversion structures in the West Branch Susquehanna and Susquehanna rivers. For those dams and diversions where removal is not feasible, the PFBC works with dam owners and operators directly and through partnerships like SRAFRC to implement and improve fish passage and limit use of operational activities that compromise aquatic resources.

5.2.1.1 USACE Curwensville Dam, Curwensville

Curwensville Dam is located on the West Branch Susquehanna River approximately 0.6 miles upstream from the town of Curwensville, Pennsylvania. The earthfill dam is 2,850 feet long and rises 131 feet above the streambed. A gated outlet and spillway control the water level behind the dam. The reservoir has a storage capacity of 124,200 acre-feet at spillway crest and the resulting pool extends 14 miles upriver when filled to capacity. The impoundment provides flood protection by capturing 365 square miles of drainage;98 percent of the total drainage at Curwensville, Clearfield County and 75 percent at Clearfield, Clearfield County. The project reduces flood heights throughout the West Branch Susquehanna River downstream from the dam, and provides for lake recreational opportunities. Fifty-seven percent of the conservation storage capacity, or the volume held by the impoundment not designated for flood protection storage, is allocated for water supply storage, and has been acquired by SRBC from the USACE. SRBC continues to pay a prorated portion of project annual operation and maintenance costs (http://www.nab.usace.army.mil/EOC/Stats/curwensville.html).

5.2.1.2 Irvin Park Dam, Curwensville

The Irvin Park Dam is a 4.5-foot high, low-head, run-of-the-river dam located in the West Branch Susquehanna River at the Borough of Curwensville, Pennsylvania.

5.2.1.3 Raftman's Memorial Dam, Clearfield

The Raftman's Memorial Dam is a five-foot high, low-head, run-of-the-river dam located in the West Branch Susquehanna River at the Borough of Clearfield, Pennsylvania.

5.2.1.4 Shawville Generating Station Dam, Shawville

The Shawville Generating Station Diversion is a six-foot high, low-head dam in the West Branch Susquehanna River used to increase pool elevation to support GenOn's intake structure near the town of Shawville, Pennsylvania. The facility operates four coal-fired steam units and three diesel units with a capacity of 572 megawatts. This facility is currently in the process of renewing a NPDES permit. The original NPDES permit included no thermal limits because of the absence of aquatic life in the in this reach of the river at the time of facility completion.

5.2.1.5 Grant Street Dam, Lock Haven

Located in the West Branch Susquehanna River at the city of Lock Haven, Pennsylvania the Grant Street Dam is a six-foot high, low head dam owned and maintained by the City of Lock Haven. The run-of-the-river dam supports a small recreational pool. A Denil fishway capable of passing 50,000 American shad annually has been designed for the Grant Street Dam. Construction of this fishway is anticipated to cost $1.2 to $1.8 million and is contingent upon available funding.

5.2.1.6 Hepburn Street Dam, Williamsport

The Hepburn Street Dam, located in the West Branch Susquehanna River at the city of Williamsport, Pennsylvania is an 11-foot high low head dam owned and maintained by the Pennsylvania Department of Conservation and Natural Resources (DCNR). The run-of-the-river dam supports a recreational pool upstream of the City of Williamsport. A redesign of the existing vertical slot fishway to correct for excessive velocities and weir head height that limit fish passage was completed in 2008 with construction anticipated to cost between $4 and $6 million and is contingent upon funding.

5.2.1.7 DCNR Adam T. Bower Memorial Dam, Sunbury

The Adam T. Bower Memorial Dam, at the city of Sunbury, Pennsylvania is an inflatable dam spanning the mainstem Susquehanna River approximately two miles downstream from the confluence of the West Branch Susquehanna River. The dam is inflated in spring to create a recreational pool (Lake Augusta) that is part of the DCNR-owned Shikellamy State Park. The dam is deflated in the fall to limit storage and minimize flooding during high flow events and allow for fish passage. A nature-like fishway is slated for construction in 2011 on the west side of the dam and discussions are underway for design and construction of a fishway on the east side of the dam to allow for fish passage to the mainstem Susquehanna River.

5.2.1.8 Oakland Hydroelectric Project, Oakland

The Oakland Hydroproject is currently owned by River Bounty and operated by American Hydro Power Company. The dam spans the Susquehanna River near the town of Oakland, Pennsylvania. The facility has not been operating at full capacity since flood related damage in 2006 resulted in a partial breech of the structure. Currently, the license for this facility is under review by the Federal Energy Regulatory Commission (FERC). In 2007, PFBC made a request to FERC that fish passage be provided at this dam.

5.2.1.9 Corona Power Sunbury Stream Electric Station Dam, Shamokin Dam

The Corona Power Sunbury Steam Electric Station Diversion is an eight-foot high, low-head dam in the mainstem Susquehanna River used to increase pool elevation to support the Corona Power Sunbury Steam Electric Station's intake structure near the town of Shamokin Dam, Pennsylvania. The facility operates four coal-fired steam units requiring 459 cfs of river water, and is capable of generating 363 megawatts (Weston 1978).

5.2.1.10 Dock Street Dam, Harrisburg

The Dock Street Dam, owned and operated by the City of Harrisburg, is a low-head, run-of-the-river dam. The dam creates a small pool used for recreation and the associated downstream tailrace accommodates a highly targeted fishery. Efforts to expand the dam for hydropower generation (1988) and to create a larger upstream recreational pool (1996) were denied. A notch located in the east end of dam promotes fish passage.

5.2.1.11 York Haven Project, York Haven

The York Haven Power Company, LLC (YHPC) owned by Olympus operates the York Haven Project in the Susquehanna River at York Haven, York County, Pennsylvania. The project has 20 generating units and is capable of generating 19.65 megawatts. The York Haven Dam consists of a 3,000-foot headrace wall that averages 20 feet high, a 4,970-foot main dam that averages 10 feet high with a maximum crest height of 17 feet, an east channel dam that extends 950 feet with an average height of 10 feet and a 630-foot forebay bulkhead that is located on either side of the powerhouse facility. The dam creates Lake Frederic, a 3.5-mile long, 1,849-acre pool that is popular for recreational activities. The project operates with a minimum year round flow requirement of 1,000 cfs and an average daily flow requirement of 2,500 cfs or the volume of water entering Lake Frederic, whichever is less. The project also operates a vertical slot fishway constructed in 2000 in the East Channel Dam to facilitate fish passage (YHPC 2009).

5.2.1.12 Safe Harbor Hydroelectric Project, Safe Harbor

The Safe Harbor Hydroelectric Project is owned and operated by the Safe Harbor Water Power Corporation. The Safe Harbor Dam is 75 feet high and 4,869 feet long. It impounds the Susquehanna River near the town of Conestoga, Pennsylvania. The resulting impoundment (Lake Clarke) extends 10 miles upstream and encompasses 7,360 acres. Effective generation capacity of the project is 417,500 kW and is utilized primarily to meet peak demands. The Safe Harbor Hydroelectric Project operates a fish lift with an expanded capacity of 2.5 million American shad, annually (Safe Harbor Water Power Corporation undated).

5.2.1.13 Holtwood Hydroelectric Project, Holtwood

The Holtwood Hydroelectric Project is owned and operated by PPL Holtwood LLC, a subsidiary of PPL Generation LLC. The Holtwood Dam is 55 feet high and 2,392 feet long spanning the Susquehanna River near the town of Holtwood, Pennsylvania. The project operates 10 power generating units with a combined capacity of 108 megawatts. The dam forms the 2,400-acre Lake Aldred, a popular recreational pool. The project operates a fish lift with two hoppers at the dam to facilitate fish passage of resident and migratory fishes (PPL Corporation 2009). Project expansion is currently under construction and will double the hydraulic capacity of the project, and provide improved fish passage, recreational angler access, and recreational boat launch capacity.

5.2.1.14 Conowingo Hydroelectric Project, Conowingo Village, Maryland

The Conowingo Hydroelectric Project is owned and operated by Exelon Power, a subsidiary of Exelon. Conowingo Dam impounds the Susquehanna River 10 miles upriver from the Chesapeake Bay in Cecil and Harford counties, Maryland. The station utilizes 11 turbines to generate 573 megawatts at full operating capacity. The dam is 94 feet high and 4,648 feet across. The resulting Conowingo Pond extends 14 miles upstream to the Holtwood Project and encompasses 9,000 acres. The Conowingo Project operates two fish lifts: the East and West Lifts. The East Lift is used to pass migratory and resident fishes into Conowingo Pond while the West Lift is used to collect fish for research purposes under an agreement with the USFWS (Exelon 2009a).

5.2.2 Diversions

5.2.2.1 Muddy Run Pump Storage Facility, Drumore

The Muddy Run Pump Storage Facility is a pumped storage generating station owned and operated by Exelon. This facility is capable of generating 1,071 megawatts of electricity by releasing water from their 1,000 acre storage reservoir during periods of peak demand and passing it through four Francis-type turbines (Exelon 2009b). Water is then pumped back into the storage reservoir from the Susquehanna River during periods of low demand. The license for this facility is currently under review by FERC for anticipated relicensing in 2014.

5.2.3 Navigational Channels

Historically, navigational channels were constructed as canals along nearly the entire length of the Susquehanna River in Pennsylvania and the West Branch Susquehanna River upstream to the city of Lock Haven, Pennsylvania. A cursory breakdown of the various canal operations is detailed in subsection 4.6 Historic Water Channels. Presently, there are no commercial navigation channels maintained on the West Branch Susquehanna and Susquehanna rivers.

5.2.5 Hydrological Monitoring and Modeling

The PFBC, Bureau of Fisheries, divisions of Environmental Services, Fish Production Services, and Fisheries Management provides commentary and support, as needed, to agencies and organizations such as the SRBC and USACE who undertake hydrologic modeling efforts to better manage aquatic resources within the Susquehanna River Basin.

Susquehanna Basin Early Warning System

The Susquehanna Basin Early Warning System (EWS) provides a framework for innovative partnerships and protocols to foster communication and data sharing among water suppliers, state and local government and the emergency response community for the purpose of enhancing drinking water protection efforts. The current EWS enhances protection of public drinking water supplies cumulatively serving more than one million people and provides a monitoring network to help minimize the impact from contaminant spills. Additionally, the EWS provides data to improve day-to-day treatment operations to further ensure a continuous and

safe supply of drinking water. Furthermore, the heightened national security concerns has made SRBC's EWS an important tool for participating water suppliers and emergency management officials (A. Dehoff, SRBC, personal communication).

Susquehanna Flood Forecast and Warning System (SFFWS)

In 1986, the SRBC in partnership with the National Weather Service (NWS), USGS, and others initiated an enhanced flood warning system for the Susquehanna River Basin. The Susquehanna Flood Forecast and Warning System (SFFWS) is a state-of-the-art, technological system utilizing radar and a network of stream and rain gages to provide data used by NWS to forecast river levels and issue more timely and accurate flood warnings. The SFFWS provides its users – communities and businesses – with early flood warning so they can secure their property and get themselves to safer locations. Community and emergency management officials rely on the SFFWS to make good flood preparedness decisions, including notifying their residents of expected flooding and what actions they should take to protect themselves and whether emergency officials need to activate evacuation procedures.

Daily river stage forecast guidance is issued by the Middle Atlantic River Forecast Center (MARFC), which provides specific estimates of flood crest stages at selected locations on rivers and major tributaries in the Susquehanna River Basin. The forecast stages are based on model results incorporating large amounts of hydrometeorological data, including precipitation measured at a number of gages, precipitation estimates from several weather radars, and quantitative precipitation forecasts prepared by support offices of the NWS. The forecasts generated by MARFC are disseminated to NWS offices in State College, PA; Binghamton, NY; and Mount Holly, NJ. Those offices in turn are responsible for issuing flood and flash flood watches and warning in the Susquehanna River Basin. Watches indicate there is potential for flooding and warnings indicated that flooding is imminent. The NWS forecast offices disseminate the information to state emergency management agencies to distribute to the counties, and the counties thene distribute the information to local emergency management officials and others who need the forecast.

Daily Flow Model for Consumptive Use Mitigation Plan

Anthropogenic activities such as water demand for public water supplies, industry, agriculture, energy development, recreation and other uses reduce base flows of the major rivers in the basin. These demands can be managed to prevent severe localized impacts such as dewatering, but the cumulative impact of thousands of uses is felt downstream by the aquatic resources, hydroelectric dams, and water supply intakes, among others, that rely on water. This management plan recognizes those impacts and recommends strategies to restore and improve river flows during periods of base flow. Various mitigation, operational alternatives and impact assessments have been and will continue tobe conducted using SRBC's daily flow hydrologic model, developed through OASIS software. The model simulates flow on major rivers and tributaries in the basin, in conjunction with proposed operations of large reservoirs and other major water demands. Inflows to the Chesapeake Bay can also be considered.

Susquehanna Basin Low Flow Management Study

The USACE, Baltimore District and SRBC are coordinating, with The Nature Conservancy (TNC), to design and facilitate a process to set basin-wide ecosystem flow goals that can be implemented within the subwatersheds of the Susquehanna River basin. The process will follow the general model of other successful basin-scale projects that the TNC has been engaged in on large rivers such as the Savannah River (Richter *et al.* 2006) and the Delaware River. An interdisciplinary scientific team has been assembled to compile and interpret existing information from the basin, and similar river systems, on ecological conditions in relation to water flow management. This will include building on existing TNC-led projects to link ecological conditions to flow alteration in the Pennsylvania portion of the Susquehanna River basin. This work is funded by the PADEP. The process will culminate in a scientific workshop where relevant information and best professional judgment will be used to set ecosystem flow goals specific to the range of habitat conditions across the basin.

The outcome of this process will be to define ecosystem flow needs (and associated mitigation gaps) at subwatersheds (e.g. at the USGS HUC-8 scale) throughout the Susquehanna River basin paying particular attention to subwatersheds with existing consumptive uses that require mitigation and/or where storage exists that could be used as mitigation. Seasonal ecosystem-based flow goals will be set to account for the range of flow conditions relevant to reservoir management and ecosystem protection such as drought flows, seasonal base flows and some high flow conditions. Additionally, the process will also consider frequency and duration of varied flow conditions and the degree to which these conditions should occur in relation to modeled unregulated flows.

The results of this study will allow for initial prioritization of sub-basins that require flow mitigation. In addition, it will allow water managers to take advantage of proposed strategies such as pooling and release water to offset the growing demands and consumptive uses of water in the basin. This work under Section 729 of Water Resources Development Act (WRDA) of 1986 (100 Stat. 4164) will provide essential information for use in considering long-term changes to flow release schemes for basin reservoirs, environmental restoration, flows to better sustain aquatic habitat and conservation strategies to offset the rising demands.

5.3 Water Quality

Maintenance of water quality in the Commonwealth of Pennsylvania has been delegated to the PADEP by the United States Environmental Protection Agency (USEPA) through the provisions of the Federal Water Pollution Control Act (Clean Water Act). In addition, the SRBC assists federal, state, and local water quality management by performing monitoring and assessments, and as well as implementing water quality restoration and protection projects.

5.3.1 Chapter 93 Designations

Title 25, Chapter 93 of the Pennsylvania Code (Chapter 93) identifies specific aquatic life use designation for all waters of the Commonwealth. Each use designation carries with it specific water quality criteria for protection of that specific use. The PFBC, Bureau of Fisheries, Division of Environmental Services provides support and commentary to PADEP regarding aquatic life use designations and changes to those designations for the West Branch Susquehanna and

Susquehanna rivers, as needed. Under Chapter 93, the West Branch Susquehanna and Susquehanna rivers are classified into six management reaches for use designation (Table 5.3.1).

No special protection or antidegradation designated uses are presently identified for the West Branch Susquehanna or Susquehanna rivers.

Table 5.3.1. Use designations for the West Branch Susquehanna and Susquehanna Rivers under Title 25, Chapter 93 of the Pennsylvania Code.

Waterbody	Reach description	Designated Use
West Branch Susquehanna River	Origin to Mouth	Warm-water fishery (WWF), Migratory Fishery (MF)
Susquehanna River	NY-PA state line to NY-PA state line (Great Bend)	Warm-water fishery (WWF), Migratory Fishery (MF)
Susquehanna River	NY-PA state line to Lackawanna River	Warm-water fishery (WWF), Migratory Fishery (MF)
Susquehanna River	Lackawanna River to West Branch Susquehanna River	Warm-water fishery (WWF), Migratory Fishery (MF)
Susquehanna River	West Branch Susquehanna River to Juniata River	Warm-water fishery (WWF), Migratory Fishery (MF)
Susquehanna River	Juniata River to MD-PA state line	Warm-water fishery (WWF), Migratory Fishery (MF)

5.3.2 Water Quality Criteria/Regulated Parameters

Water quality criteria applied in each reach of the West Branch Susquehanna and Susquehanna rivers are based on specific use designations identified in Chapter 93. Only those parameters that have been determined to be relevant to the identified aquatic life use designation have applicable criteria. All reaches of the West Branch Susquehanna and Susquehanna rivers are recognized as warmwater fisheries (WWF) and migratory fisheries (MF). Regulated parameters specific to these uses include alkalinity, ammonia nitrogen, dissolved oxygen, total recoverable iron, osmotic pressure, pH, temperature and total residual chlorine. Water quality criteria for warmwater fishes (WWF) and migratory fishes (MF) are detailed in 25 Pa. Code § 93.7. There currently is no ranking system within the existing WWF criterion to account for a higher-level designation for further protection under this definition. Presently, every warmwater fishery falls into a single, catch all definition allowing some higher quality fisheries to go under protected. The need exists for a fisheries-based measure of warm water fishery quality to set a high quality (HQ) or other upgraded protection level to account for the differences that exist between warm water fisheries within the Commonwealth, including the West Branch Susquehanna and Susquehanna rivers.

SRBC employs water quality standards for physicochemical (Appendix A,Table 5.3.2) and biological parameters (Hoffman 2006) to assess water quality of the West Branch Susquehanna and Susquehanna rivers through their Large Rivers Monitoring Program. The program focuses on seventeen sites in the Pennsylvania-portion of the Susquehanna River and one site in the West Branch Susquehanna River (Hoffman 2006). Through the programs history, the documented water quality of the West Branch Susquehanna River and Susquehanna River has been stable and fairly good with only very few limit violations, primarily temperature and total sodium (Hoffman 2006, Hoffman 2008, and Shenk 2009). Similarly, macroinvertebrate communities have been stable with indices reflecting mostly nonimpaired and slightly impaired conditions with a small number of moderately impaired and no severely impaired conditions (Hoffman 2006, Hoffman 2008, and Shenk 2009).

A recent USGS study funded by PFBC, PADEP and PPL Electric (Chaplin *et al.* 2009) documented that instantaneous dissolved oxygen concentrations in river margin habitat of the Susquehanna River fell below the 4.0 mg/L minimum standard established by PADEP on several occasions, while adjacent main channel concentrations did not fall below the minimum standard. Recent mortality of juvenile smallmouth bass residing in the Susquehanna River known to primarily utilize river margin habitat suggests the possibility that the existing minimum standard may not be protective enough of warmwater fisheries. In conducting the data review, it was immediately evident that the volume and type of data necessary for characterization of existing and historic water quality conditions was lacking. The West Branch Susquehanna and Susquehanna rivers lack long-term, instantaneous water quality data that would be useful in characterizing water quality conditions within the system. The Susquehanna River drainage is the only major river in the eastern United States to not have at least one water quality sonde in operation. Installation and identified long-term funding to support a series of water quality sondes at these waterbodies will help in future water quality determinations and provide background data for future analysis should the need arise.

As a result, an appeal was made by PFBC to PADEP to review existing criterion for dissolved oxygen in an effort to be more protective of coolwater/ warmwater fisheries. Presently, guidance provided from USEPA recommends a daily minimum dissolved oxygen concentration of 5.0 mg/L; however, the present criterion applied by the PADEP for this designated use is a daily minimum concentration of 4.0 mg/L or a daily average concentration of 5.0 mg/L.

5.3.3 Nonpoint Source Pollution Inputs

Nonpoint source pollution is undoubtedly the largest contributor of pollutants to the West Branch Susquehanna River and Susquehanna River basins. Nonpoint source contributors such as mining, agricultural and urban sources are known to be dominant inputs within the basin. The PADEP, Office of Watershed Management, Bureau of Watershed Management is tasked with nonpoint source pollution management.

Mining

The impact of mining on the West Branch Susquehanna River and portions of the mainstem Susquehanna River is substantial. Approximately 113 miles of the West Branch Susquehanna

River and 36 miles of the Susquehanna River are impaired from abandoned mine drainage (AMD; PADEP 2008). The West Branch Susquehanna River drainage has a total of 1,205 miles of waterways impaired by AMD (SRBC 2008). It is estimated that initial capital costs to treat all AMD impacts of the West Branch Susquehanna River drainage could range from $279 - $464 million, not including annual operation and maintenance costs of the facilities (SRBC 2008). Recently, SRBC with project partners Trout Unlimited and the West Branch Susquehanna Restoration Coalition has developed a restoration strategy to prioritize mitigation activities within the West Branch Susquehanna River drainage.

Agriculture

Agricultural nonpoint source contributions of sediment and nutrient are substantial pollutants to the West Branch Susquehanna River, Susquehanna River and subsequently the Chesapeake Bay. It is estimated that the Susquehanna River accounts for approximately 66 percent of the nitrogen load and 40 percent of the phosphorus load attributable to all non-tidal portions of the Bay drainage (Langland 2009). Under normal flow conditions, the Susquehanna River contributes about 25 percent of the sediment load from all non-tidal areas of the Bay drainage (Langland 2009). Approximately 52 percent of nitrogen and 50 percent of phosphorus loads to the Chesapeake Bay originate from agricultural sources within Pennsylvania (EPA 2009a). Trends of total nitrogen, total phosphorus and suspended sediment concentrations have steadily declined in the Susquehanna River since 1985 but declines of total phosphorus concentrations leveled off in recent years (McGonigal 2008). Increases in concentrations of dissolved inorganic phosphorus (DIP) or dissolved orthophosphate (DOP) in the West Branch Susquehanna and Susquehanna rivers has been realized in recent years despite continued reductions in total phosphorus, total nitrogen, and suspended sediment concentrations. (Langland 2006 and McGonigal 2009).

Urbanization

Urbanization and development are contributors of nonpoint source pollution. Larger areas of impervious surface result as urbanization increases. Impervious surfaces limit the amount of rainfall that infiltrates into the ground and subsequently increases the volume of water that flows directly into streams during rainfall events. Erosion increases as the existing stream channels are insufficient to handle the increased volumes of storm water. In addition, storm water flowing over impervious surfaces also picks up contaminants and debris that have been deposited on them during dry periods and deposit them in the river systems. Developed areas of the watershed contribute about 20 percent of the nitrogen load and 12 percent of the phosphorus load to the upper Chesapeake Bay (EPA 2009a).

303(d) Listing

Streams not attaining their designated life use criteria under Chapter 93 designation are identified in the semiannual Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Integrated List) produced by PADEP (Appendix A,Tables 4.3.3.1-4.3.3.4). This list is then used to prioritize mitigation activities through the Total Maximum Daily Load (TMDL) process.

5.3.4 Point Source Pollution Inputs

Point source pollution inputs contribute large volume of pollutants to the West Branch Susquehanna and Susquehanna Rivers directly or indirectly through tributary discharges. As authorized by the Clean Water Act (CWA), the National Pollution Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States (USEPA 2009). PADEP is authorized by the USEPA to administer NPDES permits within the Commonwealth of Pennsylvania. Within PADEP, Office of Watershed Management, Bureau of Watershed Management is tasked with administering NPDES permits. PADEP's regulations for administering NPDES permits are detailed in Pennsylvania Code Chapter 92.

Combined Sewer Overflows

Combined Sewer Outflows (CSO) are sewers that collect storm water runoff, domestic sewage and industrial wastewater in the same pipe. There are 772 CSO systems operating in the United States, eight of which discharge to the West Branch Susquehanna or Susquehanna River (EPA 2008). CSO discharging to the West Branch Susquehanna River include Clearfield Municipal Authority and Williamsport Sanitary Authority – Central. CSO discharging to the Susquehanna River include Berwick Area Joint Sanitation Authority, Harrisburg Authority, Wyoming Valley Sanitary Authority, Sunbury City Municipal Authority, Marysville Municipal Authority and Tri-Boro Municipal Authority.

Stormwater Systems

Stormwater systems are managed through NPDES permits by the PADEP, Office of Watershed Management, Bureau of Watershed Management, Stormwater Program. Larger urban areas subject to storm water discharge permits are required to adhere to Municipal Separate Storm Sewer (MS4) stormwater management programs. The cities of Harrisburg, Scranton, and Williamsport, Pennsylvania are urban areas associated with the West Branch Susquehanna and Susquehanna rivers that are part of the MS4 Program.

Wastewater Treatment Facilities

Wastewater treatment plant discharges requiring NPDES permits fall under the jurisdiction of the PADEP, Office of Watershed Management, Bureau of Wastewater Management. Fifty industrial, 62 municipal, and 22 non-municipal wastewater facilities are permitted through the NPDES system to discharge to pipes and unnamed tributaries (UNT) leading to or directly entering the West Branch Susquehanna and Susquehanna rivers (PADEP 2009b).

5.4 Management Options

Priority 1: (*on-going activities or recommendations to be implemented in first year of management plan*)

- Continue to work with owners of FERC-licensed hydropower dams to promote timely, safe and effective migratory and resident fish passage to restore and maintain fisheries under existing licenses and negotiate terms and conditions of renewed licenses.
- Continue to work with SRBC and other agency partners to ensure that river flows are adequate to sustain quality, aquatic communities.
- Continue to coordinate with partner agencies to determine feasibility of installation of real-time water quality monitoring stations (temperature, dissolved oxygen, pH, and specific conductance) in association with at least a subset of existing stream gages at the West Branch Susquehanna and Susquehanna rivers.

Priority 2: (*recommendations with implementation date in years 2-3 of management plan*)

- Work with PADEP to identify fisheries-based criteria to create a high-quality warm-water fisheries designation for inclusion in their existing criteria.

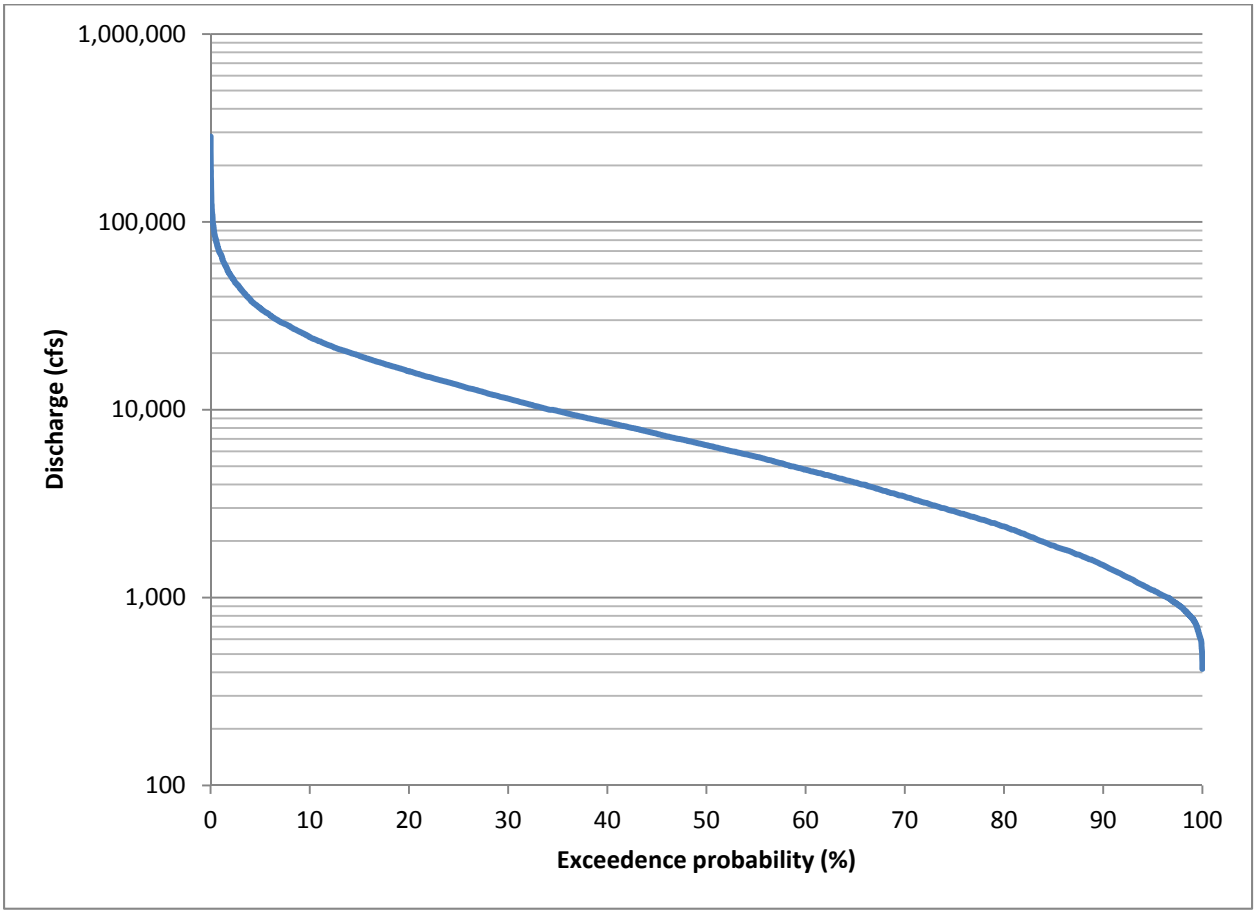

Figure 5.1.1.1. Flow duration curve for the West Branch Susquehanna River at Lewisburg, Pennsylvania (USGS 01553500) for the period October 1, 1939 to December 31, 2010.

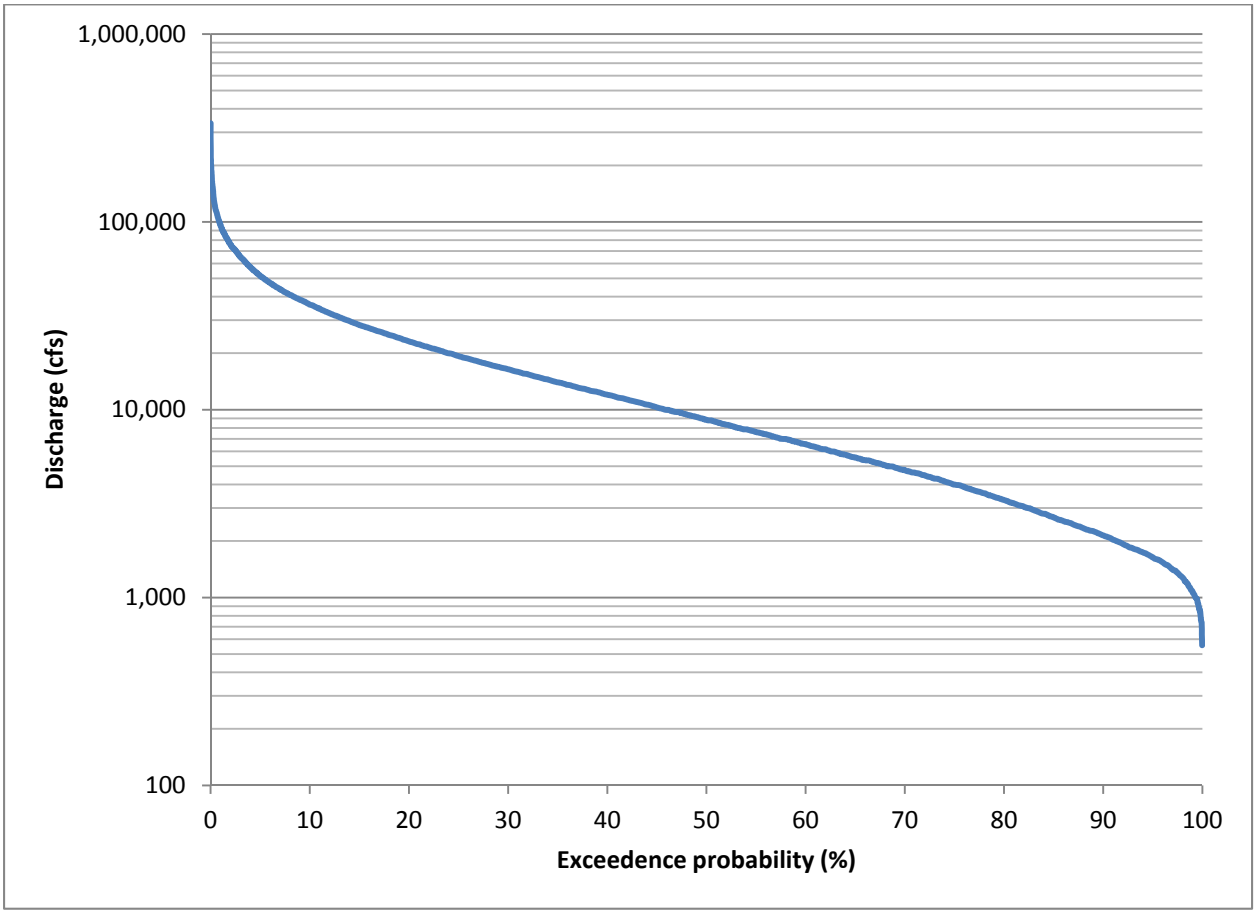

Figure 5.1.1.2. Flow duration curve for the Susquehanna River at Danville, Pennsylvania (USGS 01540500) for the period January 1, 1923 to October 1, 2009.

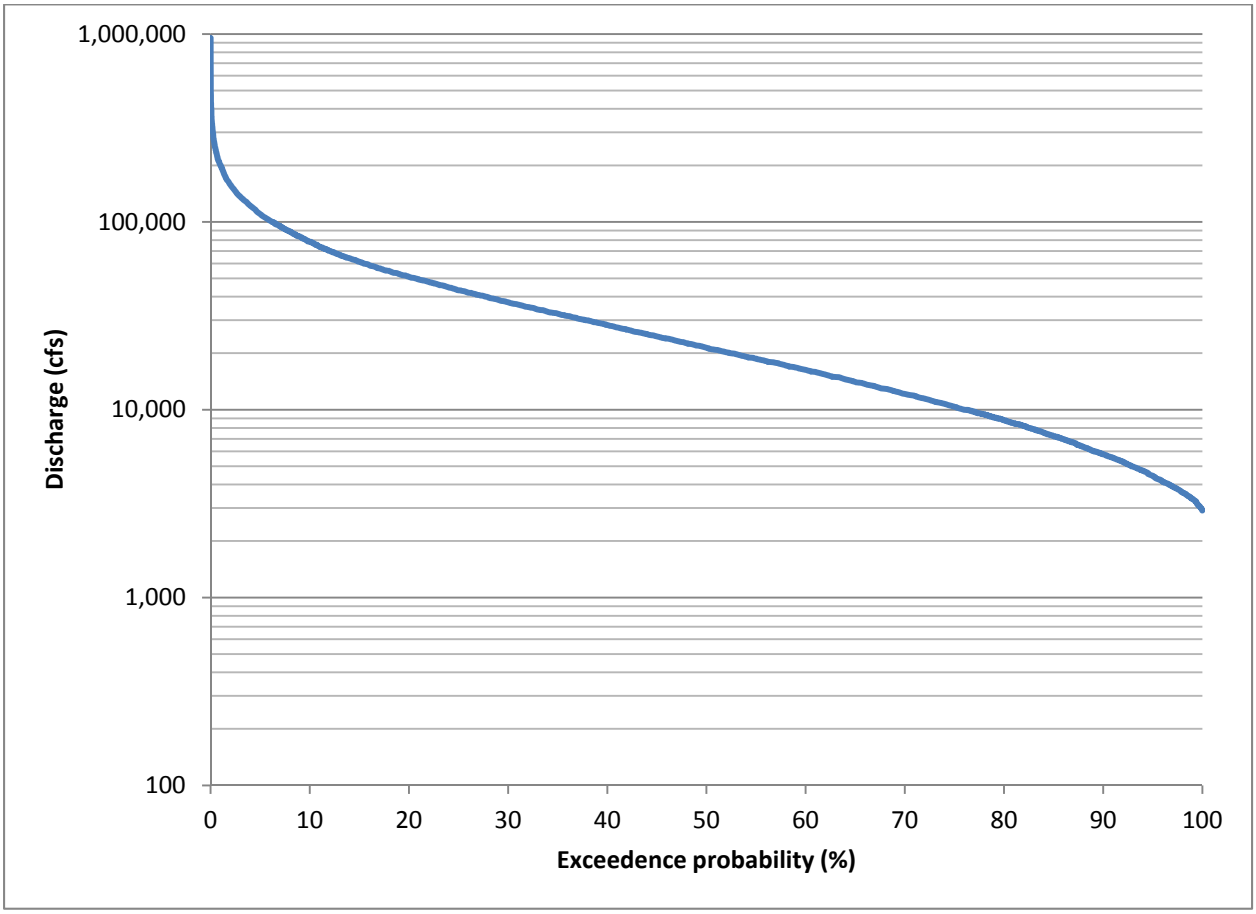

Figure 5.1.1.3. Flow duration curve for the Susquehanna River at Harrisburg, Pennsylvania (USGS 01570500) for the period January 1, 19213 to December 31, 2010.

PFBC D.C. Electrofishing rig. Photo: PFBC

~Return to Table of Contents~

6.0 River Habitats

The PFBC, in concert with other resource agencies, strives to ensure sound management of riverine habitats in order to protect, conserve, and enhance the aquatic resources that inhabit them**.** The diversity in both type and size of the habitats provide niche space for a number of aquatic organisms and support ecological function of the Susquehanna River system. While these habitats are not necessarily unique to the West Branch Susquehanna and Susquehanna rivers, the pattern with which they exist and the sheer volume of area they encompass within the free-flowing portions make them unique among the major river systems.

6.1 Macrohabitats

The West Branch Susquehanna and Susquehanna rivers are dominated by riffle-pool habitat, typical of most free flowing river systems of comparable size. With the exception of the USACE Curwensville Dam and run-of-the-river dams to support recreational activities at Lock Haven, Pennsylvania and Williamsport, Pennsylvania on the West Branch Susquehanna River and Sunbury, Pennsylvania on the Susquehanna River, the majority of these systems function as free-flowing rivers along most of their length until reaching the hydropower impoundments in the mainstem Susquehanna River downstream from the city of Harrisburg, Pennsylvania. The upstream sections of the rivers are dominated by riffle-run-pool-glide macrohabitat types or geomorphic channel units (GCU) and make up the bulk of the habitat variability. Riffles are shallow, low-gradient channel units with moderate current velocities and are characterized by some partially exposed substrate (Murphy and Willis 1996). Runs and glides are characterized by relatively shallow water that flows over a variety of substrates that lack turbulence (Murphy and Willis 1996). They differ in that runs are associated with downstream section of riffles as they lose velocity and glides with the downstream section of pools as they gain velocity entering a riffle. Pools are deep, low gradient, low velocity stream units (Murphy and Willis 1996).

6.1.1 Riffles/Runs

Riffle and run macrohabitats vary in size, frequency, and composition along the lengths of the West Branch Susquehanna and Susquehanna rivers primarily due to river channel gradient and other physical landscape characteristics. Other geomorphic features such as islands and point bars resulting from sediment deposition from tributaries also influence riffle and run formation in these rivers. Typically, riffles and runs in these rivers are expansive and are primarily composed of gravel, cobble, and boulder substrates. As the geology changes through the Ridge and Valley and Blue Ridge physiographic provinces, standard riffle complexes are mixed in with bedrock ridges which create more rapid-run macrohabitat types. These rapids are often deeper than riffle habitat and formed as water flows over, around, and between bedrock outcrops formed when the river eroded through the uplifting ridges. Present riffle and run complexes throughout the West Branch Susquehanna and Susquehanna rivers are also influenced by anthropogenic activity. Large-scale erosion and deposition attributable to deforestation, construction of dams and canals, and other activities have altered the power and

energy flow of the river systems and subsequently the characteristics of riffle and run habitat types.

We are unaware of definitive geomorphologic studies focusing on riffle and run frequency, spacing, size and composition for the West Branch Susquehanna and Susquehanna rivers. This type of geomorphic assessment is increasingly common in many tributaries of the watershed; however, it does not appear that these practices have been applied to the large rivers of the Susquehanna River Basin.

6.1.2 Pools/Glides

Similar to the variability among riffle and run macrohabitats, pool and glide macrohabitats vary in size, frequency, and composition along the lengths of the West Branch Susquehanna and Susquehanna rivers primarily due to the river channel gradient in the specific area. Pools and glides in these rivers are primarily composed of gravel and cobble because frequent high velocity flow events keep fine sediment from depositing in these areas long term. Substrates in the impoundments created by hydroelectric facilities at the downstream reaches of the Susquehanna River do, however, consist of higher volumes of fine sediment (Langland 2009). As the geology changes through the Ridge and Valley and Blue Ridge physiographic provinces, standard pool-glide complexes become widely dispersed and more variable in size and frequency. As with riffle and run complexes, present pool-glide habitat throughout the West Branch Susquehanna and Susquehanna rivers have been influenced by anthropogenic activity. Large-scale erosion and deposition attributable to deforestation, construction of dams and canals, and other activities have altered the power and energy flow of the river systems and subsequently the characteristics of pool-glide habitat types.

We are unaware of any definitive geomorphologic studies focusing on pool and glide frequency, spacing, size, and composition for the West Branch Susquehanna and Susquehanna River. This type of geomorphic assessment is increasingly common in many tributaries of the Susquehanna River Basin; however, it does not appear that these practices have been applied to the large rivers of the Susquehanna River Basin.

6.2 Substrates

6.2.1 Organic

Large woody debris

Large woody debris is an important ecosystem component of river systems; however, it is relatively limited in its distribution in the Susquehanna River. Frequent high flow events preclude large volumes of large woody debris from accumulating in main channel areas of the West Branch Susquehanna and Susquehanna rivers. Large woody debris is primarily relegated to sloughs, side channels, and backwater areas commonly associated with the numerous islands. In these areas, large woody debris serves as a vital component of the ecosystem as it

is the primary cover feature for fish as well as an important substrate and source of nutrients for macroinvertebrate communities.

Root wads/mats

Root wads and root mats have a very limited presence in the mainstem West Branch Susquehanna and Susquehanna River systems. In each river system, root wads and root mats tend to occur in areas immediately surrounding river margins of the banks and islands; however, it is common for them to become disconnected from the river system during extreme low flow periods. Root mats of rooted aquatic plants such as water willow have substantial effects on nutrient processing and sediment deposition and although expansive stands are present during late spring and summer months, their coverage in terms of the scope of the entire Susquehanna River is limited.

Course Particulate Organic Matter/ Fine Particulate Organic Matter

Course particulate organic matter (CPOM) and fine particulate organic matter (FPOM) are present in varying degrees in the West Branch Susquehanna and Susquehanna River systems. Due to the limited area of the channel that is covered by trees and leafy plants, CPOM presumably plays a small role in the mainstem of these river ecosystems. Sizable contributions of CPOM could occur from tributaries during high flow events and build in depositional areas; however, these contributions are episodic and limited in their availability to accumulate in quiescent areas. We are unaware of any studies quantifying the role of CPOM as it relates directly to these rivers.

Fine particulate organic matter (FPOM) likely has a larger role in the West Branch Susquehanna and Susquehanna River ecosystems. Contribution of FPOM from material processing in lower order tributaries in the drainage is a key nutrient source in similar river systems. Aside from instream production by periphyton and macrophytes, FPOM is likely the primary source of nutrients to these riverecosystems. We are unaware of any studies quantifying the role of FPOM as it relates directly to these rivers.

6.2.2 Inorganic

Bedrock

Bedrock formations are an important habitat feature, especially in the downstream portions of the West Branch Susquehanna River and Susquehanna rivers. Large bedrock outcroppings resulting from the rivers cutting through the ridges of the Valley and Ridge, Blue Ridge, and Piedmont provinces have created riffle and rapid habitat that in most cases span the entire width of the river in these areas. We are unaware of any studies detailing quantitative values for the amount of bedrock habitat known to occur in these rivers.

Boulder

Boulder habitat (diameter greater than 256 mm) is limited throughout the West Branch Susquehanna and Susquehanna rivers. Boulder habitat, where available, is an important cover

feature for many fish species throughout the Susquehanna River system. Its contribution to the overall instream habitat available though is presumed to be limited. We are unaware of any studies quantifying the amount of boulder habitat in these rivers.

Cobble/gravel/sand/silt

The substrates of the West Branch Susquehanna and Susquehanna rivers are predominantly characterized by cobble (diameter = 64-256 mm), gravel (4-64 mm), sand (0.0625 – 2 mm) and silt (0.0039 – 0.0625 mm). Cobble and gravel are the predominant substrate types in the riffle and pool habitats throughout both rivers. Sand and silt are largely limited to the backwaters, river margins, and other depositional areas of these rivers. Due to the frequent high flow events that occur, turnover rates of sand and silt particles are likely high. Qualitative measures for cobble, gravel, sand and silt are common measurements taken as part of habitat assessments during macroinvertebrate collections; however, these measures are focused primarily on erosional areas, such as riffles, and are not necessarily representative of all available habitats and as such were not included. We are unaware of any studies quantifying these substrate types for the West Branch Susquehanna and Susquehanna rivers.

6.2.3 Sediment Quality/Contamination

Management of sediment quality and contamination are tasked to the United States Environmental Protection Agency (USEPA) and the Pennsylvania Department of Environmental Protection (PADEP). Anthropogenic activities throughout the basin have resulted in varying levels of sediment contamination in the Susquehanna River system. Sediment studies in the Susquehanna River have identified several contaminants such as organocholorine insecticides (Ott *et al.* 1989, Lindsey *et al.* 1998), polycholorinated byphenyls (PCB) (Ott *et al.* 1989), radionuclides (Olsen *et al.* 1981), and polycyclic aromatic hydrocarbons (PAH) associated with combustible fossil fuels (Ko *et al.* 2007). Further information regarding sediment contamination in the West Branch Susquehanna and Susquehanna rivers can be obtained by contacting USEPA or PADEP.

6.3 Shallow Water Habitats

Embayments

Embayments and other quiescent areas are important habitats in the West Branch Susquehanna and Susquehanna rivers. These areas are often critical habitat for different lifestages of fish and other aquatic organisms. These areas are among those first dewatered or disconnected from the stream channel during low stream flow periods.

Backchannels

Backchannel habitats are common in the West Branch Susquehanna and Susquehanna rivers, especially in areas where wider floodplains and islands exist. As with embayments, these habitats usually provide relief from higher velocities associated with the main channel and often provide critical habitat for different lifestages of fish and other aquatic organisms.

Stream mouths

Stream mouth habitat serves multiple roles throughout the Susquehanna River system. In heavily polluted reaches, these areas often provide freshwater refugia or enough dilution to allow aquatic organisms to reside within the plume. Similarly, these areas are also areas of colder temperature water that can be can also provide thermal refuge for riverine fish when temperature conditions in the river are stressful. Stream mouths often provide spawning habitat or access to spawning habitat for potadromous species of fish – those species that undertake breeding or dispersal migrations wholly within freshwater (e.g., gizzard shad, walleye). Similar to embayments and backchannel habitats, stream mouths commonly serve as areas of relief from high velocities in the main river channel associated with high flow events. Often these areas experience high flow events that are both shorter in duration and magnitude in comparison to main river areas or unaffected by events that occur in areas outside of their drainage while still affecting the river.

6.4 Islands

Islands are an important habitat component of the West Branch Susquehanna and Susquehanna rivers. There are numerous island located throughout both rivers and most provide important shallow water habitat around their margins as well as backchannel (slough) habitat cutting through and among islands. Island habitat is important to terrestrial organisms in addition to aquatic organisms. Several islands within the Susquehanna River have been identified as critical nesting habitat for various species of birds and are identified as propagation areas protected through the Pennsylvania Game Commission's State Game Lands program.

6.5 Man-made habitats

Habitat improvement structures

Primarily due to logistical difficulties associated with working in large river systems, habitat improvement has been limited in these systems; however, numerous habitat improvement projects that have been conducted in the tributaries. A single habitat improvement project was conducted in the Lake Augusta section of the mainstem Susquehanna River by the Pennsylvania Fish and Boat Commission, Division of Habitat Management and consisted of a series of boulder piles to provide cover habitat for game fish species within this reach.

Fish passage structures

Fish passage structures, designed primarily to pass anadromous American shad, alewife, and blueback herring, were constructed at the four lower Susquehanna River hydropower dams, as well as at a DCNR low-head dam at the city of Williamsport, Pennsylvania on the West Branch Susquehanna River. The Conowingo and Safe Harbor dams each operate a single, fish lift systems to pass fish during the spring spawning runs. The Holtwood Dam currently operates a single facility with two operating lifts. The York Haven Dam utilizes a vertical slot fish ladder, a pool-and-weir fishway that uses vertical openings to pass fish that do not utilize a leaping

strategy for moving upstream from pool to pool, to pass fish. Similarly, the DCNR-owned low-head dam on the West Branch Susquehanna River operates a vertical slot fish ladder.

Currently, construction of a nature-like fishway, an engineered stream channel that mimics a natural stream channel of similar slope, is planned for the DCNR Adam T. Bower Memorial Dam (inflatable dam) at Sunbury. A vertical slot fishway has been designed for the east-side of the inflatable dam at Sunbury to provide passage of fish wishing to continue up the mainstem Susquehanna River. A Denil fishway, a flume structure with a series of U-shaped baffles to reduce overall water velocity and provide resting pools as fish negotiate the grade, has been designed for the Grant Street Dam in the West Branch Susquehanna River at Lock Haven, Pennsylvania. A redesign of the previously mentioned vertical slot structure at Williamsport, Pennsylvania has been completed by the USFWS to correct grade and velocity issues and debris accumulation at the upstream portion of the fishway. These three projects are currently waiting funding for construction.

The PFBC, Bureau of Fisheries, divisions of Fisheries Management, Habitat Management, and Fish Production Services, Anadromous Fish Restoration Unit currently coordinate with partner organizations and stakeholder agencies to promote utilization of fish passage structures at dams in the West Branch Susquehanna and Susquehanna rivers. This includes participation in FERC relicensing negotiations for hydroelectric power generating facilities, SRAFRC policy and technical committees, fishway technical committees for York Haven, Safe Harbor, Holtwood, and Conowingo dams, Chesapeake Bay Program fish passage workgroup, and Atlantic States Marine Fisheries Commission (ASMFC) fish passage working group.

6.6 Estuarine Habitats

No estuarine habitats occur in the Pennsylvania portions of the Susquehanna River. The head of tide of the Susquehanna River is located downstream of Conowingo Dam in the vicinity of Conowingo Falls, Maryland.

6.7 Riparian Habitats

Stream banks

Stream bank areas and associated riparian habitats vary along the lengths of the West Branch Susquehanna River and Susquehanna River. These areas are often critical habitat for herptile, bird, and plant species. Some stream banks are completely vegetated; others have light residential encroachment like yards and small parks while others have completely engineered areas to limit flooding such as the West Branch Susquehanna River at Lock Haven and Williamsport.

Floodplains

Floodplain habitat also varies throughout the respective river systems. The types and expanse of the associated floodplains is often controlled by the regional topography. These areas provide critical habitat for many species of herptiles, birds, and plants. Many of these floodplain

areas have been utilized for agricultural practices due to the presence of fertile soils deposited during historic flood events. Construction of flood walls has impaired the functionality of the floodplain at several locations in the basin (*e.g.* Scranton/Wilkes-Barre, Lock Haven, Williamsport).

6.8 Important Habitats/ Habitats of Special Concern

The Pennsylvania State Wildlife Action Plan identifies the need to document and protect habitats associated with the identified species of special concern (Table 7.7.1). It is presumed that as more effort is focused on characterizing habitats, several important habitats or habitats of special concern will be identified for the West Branch Susquehanna River and Susquehanna River. Presently, the Pennsylvania Natural Heritage Program, Pennsylvania Natural Heritage Inventories focuses on identifying important habitats for protection and documenting habitats associated with species of concern including documenting natural communities of special concern.

Issue 2, Subgoal D of the PFBC Strategic plan identifies the need to facilitate or complete population and home range inventories of 10% of state-listed endangered, threatened, or candidate species as identified in the State Wildlife Action Plan (SWAP), annually. The proporotion of these species which reside in the Susquehanna River system is quite small; however, a few of the Susquehanna stocks of these species make up substantial portions of the extant populations. Of these, only a few have had contemporary presence/ absence surveys conducted including eastern hellbender *Cryptobranchus alleganiensis alleganiensis,* Chesapeake logperch *Percina bimaculata* and freshwater mussel species yellow lampmussel *Lampsilis cariosa* and rayed lampmussel *Lampsilis radiata.* Since contemporary surveys have documented their presence, follow up surveys to document populations and determine habitat requirements are presecribed under the SWAP in order to elucidate future manangement strategies for conservation.

6.9 Management Options

Priority 3: (*recommendations with implementation date in years 4-5 of management plan*)

- Facilitate or complete studies to identify habitat preferences of eastern hellbender *Cryptobranchus alleganiensis alleganiensis,* Chesapeake logperch *Percina bimaculata,* yellow lampmussel *Lampsilis cariosa* and rayed lampmussel *Lampsilis radiata*.

~Return to Table of Contents~

7.0 Riverine Biota

The PFBC, PGC, and DCNR are jointly tasked with protecting, conserving and enhancing the riverine biota of the Commonwealth, including those residing in the waters of the West Branch Susquehanna and Susquehanna rivers. The PFBC and PGC rely on revenues from license holders, federal tax rebates associated with sales of hunting and fishing gear, and the federal State Wildlife Grants Program (SWG) to fund species management and habitat protection across the Commonwealth. DCNR is primarily funded by the Commonwealth of Pennsylvania general fund and federal programs.

7.1 Fish Communities

The management of fish communities of the West Branch Susquehanna and Susquehanna rivers is the responsibility of the PFBC's Bureau of Fisheries, Division of Fisheries Management. These waterbodies have fish communities typical of warmwater streams and rivers of the Atlantic Slope including native and non-native game and non-game species, as well as migratory fishes (Table 7.1). Native fish species distribution was largely shaped by pre- and post-glacial drainage patterns. The freshwater connection of the Susquehanna River with the rest of the Chesapeake Bay tributaries during the last glacial minima allowed uninhibited dispersal followed by a period of isolation during the glacial maxima and contributed to the homogeneity among the tributaries of the Chesapeake Bay and Atlantic Slope drainages. Another substantial factor contributing to fish species distribution of these waters was the reversals of flow associated with the last glacial maxima and the subsequent glacial retreat that added a large portion of what is now the upstream portion of the Susquehanna River system (Cooper 1983, Smith 1985). This glacial retreat also resulted in stream capture events, erosive process by which a stream contacts and takes water and biota from a stream on the opposite side of a divide, on the periphery of the drainage (Hocutt *et al.* 1978, Cooper 1983, Smith 1985, Jenkins and Burkhead 1994). The presence of many of the non-native fishes in the Susquehanna River system comes from different anthropogenic origins. Many of the non-native game fish species found in the basin today are the result of intentional stockings by fisheries management agencies (e.g., common carp and smallmouth bass) as well as individuals looking to develop a recreational fisheries for certain species (e.g., flathead catfish). Similarly, intentional or unintentional introductions from aquaria or via bait bucket from anglers are common. Canal passage through the Chemung and Chenango canals in New York, which connected the Susquehanna River basin to the St. Lawrence drainage, also served as a likely means for interbasin transfer (Smith 1985). This section will detail the present status of each of these species groups in the West Branch Susquehanna and Susquehanna rivers. The focus of this section is those species documented from the large river habitats of the West Branch Susquehanna and Susquehanna rivers. It is possible to encounter any of the species documented from the Susquehanna River Basin in either of the rivers; however, for the purpose of this plan we are focusing only on resident species or species for which the river plays a critical role in their life history. A contemporary review of the ichthyofauna of the Susquehanna River Basin has been completed by Snyder (2005) and is inclusive of all known fish species of the basin.

One priority of the PFBC, Bureau of Fisheries, Division of Fisheries Management (DFM) is to optimize game fish populations by conducting species-specific management efforts within the waters of the Commonwealth. The DFM carries out a number of management efforts including developing angling regulations, characterizing angler use and harvest of particular waterbodies, monitoring of game fish populations and stocking of certain game fish species to meet and maintain recreational angling demands and restore recreational fishing potential in areas where they are declining or have been lost. In *Section 8.0 – Recreational Fisheries*, the recreational fisheries management activities undertaken by the DFM will be discussed in depth for each management section of the West Branch Susquehanna and Susquehanna rivers. Presently, some game fish populations in the West Branch Susquehanna and Susquehanna rivers are managed solely as naturally reproducing populations while others are maintained through stocking to provide an adequate recreational fishery.

Table 7.1. Fishes of the West Branch Susquehanna and Susquehanna rivers.

Common name	Scientific name	Residency status	West Branch Susquehanna River	Upper Susquehanna River	Middle-lower Susquehanna River
Lampreys	**Petromyzontidae**				
sea lamprey*	*Petromyzon marinus*	Native			X
Sturgeons	**Acipenseridae**				
shortnose sturgeon*	*Acipenser brevirostrum*	Native			X
Atlantic sturgeon*	*Acipenser oxyrhynchus*	Native			X
Gars	**Lepisosteidae**				
longnose gar	*Lepidosteus osseus*	Native			X
Bowfin	**Amiidae**				
bowfin	*Amia calva*	Native			X
Eels	**Anguillidae**				
American eel*	*Anguilla rostrata*	Native	X	X	X
Herrings	**Clupeidae**				
gizzard shad	*Dorosoma cepedianum*	Native	X	X	X
blueback herring*	*Alosa aestivalis*	Native			X
alewife*	*Alosa pseudoharengus*	Native			X
American shad*	*Alosa sapidissima*	Native	X	X	X
Pikes	**Esocidae**				
chain pickerel	*Esox niger*	Native	X	X	X
muskellunge	*Esox masquinongy*	Introduced	X	X	X
northern pike	*Esox lucius*	Native	X	X	
tiger muskellunge	*Esox lucius x Esox masquinongy*	Introduced	X		X
Minnows	**Cyprinidae**				
goldfish	*Carassius auratus*	Introduced			X
common carp	*Cyprinus carpio*	Introduced	X		X
golden shiner	*Notemigonus crysoleucas*	Native	X	X	X
rosyside dace	*Clinostomus funduloides*	Native			X
longnose dace	*Rhinichthys cataractae*	Native	X	X	X
eastern blacknose dace	*Rhinichthys atratulus*	Native	X	X	X
central stoneroller	*Campostoma anomalum*	Native	X	X	X
fallfish	*Semotilus corporalis*	Native	X		X
creek chub	*Semotilus atromaculatus*	Native	X	X	X
river chub	*Nocomis micropogon*	Native	X	X	X
cutlips minnow	*Exoglossum maxillingua*	Native	X	X	
satinfin shiner	*Cyprinella analostana*	Native		X	X

Table 7.1. Fishes of the West Branch Susquehanna and Susquehanna rivers (continued).

Common name	Scientific name	Residency status	West Branch Susquehanna River	Upper Susquehanna River	Middle-lower Susquehanna River
Minnows (*cont.)*	**Cyprinidae**				
spotfin shiner	*Cyprinella spiloptera*	Native	X	X	X
common shiner	*Luxilus cornutus*	Native	X	X	X
rosyface shiner	*Notropis rubellus*	Native	X	X	X
comely shiner	*Notropis amoenus*	Native	X	X	X
spottail shiner	*Notropis hudsonius*	Native	X	X	X
mimic shiner	*Notropis volucellus*	Introduced		X	X
swallowtail shiner	*Notropis procne*	Native	X	X	X
fathead minnow	*Pimephales promelas*	Introduced			X
bluntnose minnow	*Pimephales notatus*	Native	X	X	X
Killifishes	**Fundulidae**				
eastern banded killifish	*Fundulus diaphanus*	Native	X	X	X
Mosquito fishes	**Poeciliidae**				
mosquito fish	*Gambusia affinis*	Introduced			X
Sculpins	**Cottidae**				
mottled sculpin	*Cottus bairdii*	Native		X	
slimy sculpin	*Cottus cognatus*	Native	X		
Suckers	**Catostomidae**				
northern hog sucker	*Hypentelium nigricans*	Native	X		X
white sucker	*Catostomus commersonii*	Native	X		X
shorthead redhorse	*Moxostoma macrolepidotum*	Native	X		X
quillback	*Carpiodes cyprinus*	Native	X		X
Catfishes	**Ictaluridae**				
margined madtom	*Notorus insignis*	Native	X	X	X
white catfish	*Ameiurus catus*	Native			X
brown bullhead	*Ameiurus nebulosus*	Native	X		X
yellow bullhead	*Ameiurus natalis*	Native	X		X
channel catfish	*Ictalurus punctatus*	Introduced	X		X
flathead catfish	*Pylodictis olivaris*	Introduced			X
Temperate Basses	**Moronidae**				
striped bass*	*Morone saxatilis*	Native			X
hybrid striped bass	*Morone saxatilis x Morone chrysops*	Introduced			X

Table 7.1. Fishes of the West Branch Susquehanna and Susquehanna rivers (continued).

Common name	Scientific name	Residency status	West Branch Susquehanna River	Upper Susquehanna River	Middle-lower Susquehanna River
Sunfishes	**Centrarchidae**				
bluegill	*Lepomis macrochirus*	Introduced	X		X
green sunfish	*Lepomis cyanellus*	Introduced	X		X
pumpkinseed	*Lepomis gibbosus*	Introduced	X		X
redbreast sunfish	*Lepomis auritus*	Native	X		X
black crappie	*Pomoxis nigromaculatus*	Introduced	X		X
white crappie	*Pomoxis annularis*	Introduced	X		X
rock bass	*Ambloplites rupestris*	Introduced	X	X	X
largemouth bass	*Micropterus salmoides*	Introduced	X	X	X
smallmouth bass	*Micropterus dolomieu*	Introduced	X	X	X
Perches	**Percidae**				
Chesapeake logperch	*Percina bimaculata*	Native			X
shield darter	*Percina peltata*	Native	X	X	X
greenside darter	*Etheostoma blennioides*	Introduced	X	X	X
banded darter	*Etheostoma zonale*	Introduced	X	X	X
tessellated darter	*Etheostoma olmstedi*	Native	X	X	X
fantail darter	*Etheostoma flabellare*	Native	X		
yellow perch	*Perca flavescens*	Native	X	X	X
walleye	*Sander vitreus*	Introduced	X	X	X

* Migratory fish species that spend some portion of their life cycle in the Susquehanna River system.

The protection and management of non-game fish species is identified as one of the primary goals of the federal State Wildlife Grants Program and is detailed in the Pennsylvania State Wildlife Action Plan (SWAP). Primarily, these activities are tasked to the PFBC's divisions of Fisheries Management, Environmental Services' Natural Diversity Section, and Habitat Management.

Distributional information regarding non-game species in the West Branch Susquehanna and Susquehanna River systems is available from a number of different sources. Surveys conducted by the PFBC Division of Fisheries Management document the presence of the non-game component of the fish communities during directed game fish survey efforts; however, these are not quantitative. One of the more substantial, long-term data sources that exist for non-game fish species are the surveys conducted by the permitted power generation facilities that intake water from and discharge water to these rivers. These facilities have permit conditions that require annual sampling and reporting of fish community data to the PFBC, Division of Environmental Services to document the effects of these activities on the residing

fish community. Some facilities have comprehensive records of fish communities dating back thirty or more years, utilizing numerous collection methodologies. Collections made by various academic institutions, either through research efforts or course-based demonstrations, also provide a substantial amount of non-game fish information. Fish species occurrence data collected by non-agency personnel are coordinated and documented through the PFBC Division of Environmental Services, Natural Diversity Section's Scientific Collectors Permit process as part of the permit requirements.

Recent fish health issues and anecdotal reports of declines of non-game and some lesser surveyed game fish species have identified the need to qualify and quantify this component of the community. Similarly, recent introductions and range expansions of non-native species may have altered the community composition in reaches of the West Branch Susquehanna and Susquehanna rivers and absence of baseline community measures has limited the ability for PFBC to gauge impacts of these introductions. Future development of baseline community data will help identify trends in species' status over time and help to identify and track ecosystem-wide problems should they arise.

7.1.1 Migratory Fish Species

The PFBC was founded in 1866 to protect migratory fish populations (Table 7.1.1), specifically American shad, in the Susquehanna River as populations decreased as a result of overfishing, water quality and habitat degradation, and impediments to movement which precluded access to spawning grounds. Presently, the PFBC works with the Atlantic States Marine Fisheries Commission, a stake-holder group comprised of federal and Atlantic coastal state agencies, to manage and restore migratory fish populations in the Atlantic coastal areas. More locally, the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC), composed of technical and policy committees has been formed to deal with migratory fish populations in the Susquehanna River basin. Internally, the Bureau of Fisheries, divisions of Fisheries Management, Habitat Management, and Fish Production Services' Anadromous Fish Restoration Unit work cooperatively to restore migratory fish populations in the Susquehanna River basin.

More in-depth discussion of issues concerning migratory fish restoration activities are detailed in Sections 4.2.1 (impoundments), 6.5 (man-made habitats), 8.1.3 (stocking program), and 8.4 (fish population restoration).

Table 7.1.1. Migratory fish species historically or presently found in the Susquehanna River system.

Species (common)	Species (scientific)	Residency status	Comment
Lampreys	**Petromyzontidae**		
sea lamprey	*Petromyzon marinus*	Native	
Sturgeons	**Acipenseridae**		
shortnose sturgeon	*Acipenser brevirostrum*	Native	Likely restricted to estuarine portions
Atlantic sturgeon	*Acipenser oxyrhynchus*	Native	
Eels	**Anguillidae**		
American eel	*Anguilla rostrata*	Native	
Herrings	**Clupeidae**		
gizzard shad	*Dorosoma cepedianum*	Native	Potadromous species
blueback herring	*Alosa aestivalis*	Native	
alewife	*Alosa pseudoharengus*	Native	
hickory shad	*Alosa mediocris*	Native	
American shad	*Alosa sapidissima*	Native	
Trout and Salmon	**Salmonidae**		
Atlantic salmon	*Salmo salar*	Native	Uncertain whether anadromous populations historically visited the Susquehanna system or not
Temperate Basses	**Moronidae**		
striped bass	*Morone saxatilis*	Native	

7.1.2 Major Tributary Fish Species

Connectivity and habitat similarities between the West Branch Susquehanna and Susquehanna rivers and their major tributaries result in similar fish communities. The primary differences in fish communities that exist between the major tributaries and the respective rivers are associated with the groundwater-fed systems of Ridge and Valley and Blue Ridge provinces which often support coldwater communities. As a result of the hydrogeology of these areas these tributaries are high volume and are often the single source of surface water emanating from these valleys.

7.2 Mollusca

Protection and management of the mollusk populations of the Commonwealth has been tasked to the Pennsylvania Fish and Boat Commission under Title 30 of the Pennsylvania Code (30 Pa.C.S.A). These include both bivalve (clams and mussels) and aquatic gastropod (limpets, slugs, and snails) populations. The PFBC, Bureau of Fisheries, Division of Environmental Services, Natural Diversity Section in cooperation with the Pennsylvania Natural Heritage

Program (PNHP) is tasked with protection of these species. All survey and data management activities are presently funded by the federal State Wildlife Grants (SWG) program in cooperation with PNHP partners.

Bivalves are the most widely described group of all the mollusk communities present within the Commonwealth. Presently, 15 species of Unionid mussels are known to occur in the West Branch Susquehanna and Susquehanna rivers (Table 7.2.1) (Bogan and Proch 2004, W. Lellis, USGS, personal communication, M. Walsh, Western Pennsylvania Conservancy (WPC), personal communication). Knowledge of the Atlantic slope mussel populations is less extensive than that of Ohio River populations and has played a small role in management of the West Branch Susquehanna and Susquehanna River systems. Little knowledge about Unionid mussel distribution in the Pennsylvania portion of the Susquehanna River system exists despite being one of the major river systems of the Atlantic slope and a key component of Chesapeake Bay restoration efforts. Wide-scale surveys have been conducted by Bogan and Proch (1997) and more recently by USGS (W. Lellis) and WPC (E. Myers and M. Walsh). Publication of these studies will expand our knowledge of extant mussel communities in the West Branch Susquehanna and Susquehanna rivers and the changes in community composition that have occurred over time.

Far less is known regarding the distribution and community structure of gastropod species in the Susquehanna River system. Information regarding gastropods comes largely from bycatch during sampling efforts and is handled as such or is overlooked completely in collection efforts. Common sampling techniques for aquatic invertebrates, such as United States Environmental Protection Agency's (USEPA) Rapid Bioassessment Protocols (RBP) frequently capture gastropods, but they are not typically taxonomically identified due to the difficulty in correctly determining species and the perceived limited relevancy that this group has in determination of water quality conditions, the primary focus of these collections. Only directed sampling efforts targeting gastropod communities, which are extremely limited in both scale and frequency, provide the level of investigation necessary to determine the extent of the species present. Recent efforts by the PNHP (Evans and Ray 2008; Ray, PHNP, personal communication) have produced state-wide taxa lists for lotic gastropod species (Table 7.2.2).

Recent fish health isssues have identified a number of parasites infecting fish that utilize snails as intermediate hosts. Limited information about the historic distribution and densities of this species group within the system warrants further investigation to role they may be playing into fish health issues as well as to develop baseline data.

Table 7.2.1 Freshwater bivalves historically or presently found in the West Branch Susquehanna and Susquehanna rivers.

Species (common)	Species (scientific)	Residency status	Comment
zebra mussel	*Dreissina polymorpha*	Introduced	
Asiatic clam	*Corbiula fluminea*	Introduced	
finger-nail clams	*Sphaerium spp.*	Native	
pea clams	*Pisidium spp.*	Native	
dwarf wedge mussel	*Alasmidonta heterodon*	Native	
elktoe	*Alasmidonta marginata*	Native	
triangle floater	*Alasmidonta undulata*	Native	
brook floater	*Alasmidonta varicosa*	Native	
eastern floater	*Pyganodon cataractae*	Native	
alewife floater	*Anodonta implicata*	Native	
cylindrical papershell	*Anodontoides ferrussacianus*	Native	
eastern elliptio	*Elliptio complanata*	Native	
northern lance	*Elliptio fisheriana*	Native	
yellow lampmussel	*Lampsilis cariosa*	Native	
rayed lampmussel	*Lampsilis radiata*	Native	
green floater	*Lasmigona subviridis*	Native	
tidewater mucket	*Leptodea ochracea*	Native	
squawfoot	*Strophitus undulatus*	Native	
paper pondshell[$]	*Utterbackia imbecilis*	N/A	
rainbow shell[^]	*Villosa iris*	Native	believed to be introduced via stream capture

Data from Bogan and Proch 2004 and PFBC, Division of Environmental Services, Natural Diversity Section, Scientific Collectors database unless otherwise noted

$ Robbins and Mathur 1977

^ Arthur Bogan, Personal communication,

7.3 Insects and Crustaceans

Protection and management of the insect and crustacean populations of the Commonwealth, including the West Branch Susquehanna and Susquehanna rivers has been tasked to the PFBC under Title 30 of the Pennsylvania Code (30 Pa.C.S.A). The bulk of the data pertaining to this species group comes from collections of benthic macroinvertebrate associated with water quality determinations. USEPA RBP methodologies (Barbour *et al.* 1999) are used by federal, state, and interstate agencies, NGO, and watershed groups for water quality determinations, and provide much of the data regarding the status of insect and crustacean populations in the West Branch Susquehanna and Susquehanna rivers (Appendix A, Tables 7.3.1-7.3.2). In addition, these or similar practices are also applied by academic institutions for research on population trends of these species groups. Presently, collection of

insects and crustaceans are managed by the PFBC under the “fishbait” classification in the general regulations for license holders. Scientific collectors permits issued through the Division of Environmental Services, Natural Diversity Section are required for collection of invertebrates and crustaceans for all scientific purposes.

Table 7.2.2. Freshwater gastropods historically or presently found in the West Branch Susquehanna and Susquehanna rivers.

Species (common)	Species (scientific)	Residency status	Comment
mud amnicola	*Amnicola limosus*	Native	
Chinese mysterysnail	*Cipangopaludina chinensis*	Introduced	
pointed campeloma	*Campeloma decisum*	Native	
piedmont elimia	*Elimia virginica*	Native	
creeping ancylid	*Ferrissia rivularis*	Native	
watercress snail	*Fontigens nickliniana*	Native	
rock fossaria	*Fossaria modicella*	Native	
golden fossaria	*Fossaria obrussa*	Native	
pygmy fossaria	*Fossaria parva*	Native	
two-ridge rams-horn	*Helisoma anceps*	Native	
dusky ancylid	*Laevapex fuscus*	Native	
crested mudalia	*Leptoxis carinata*	Native	
	Lymnaea humilis	N/A	
squat duskysnail	*Lyogyrus granum*	Native	
bugle sprite	*Micromenetus dilatatus*	Native	
European physa	*Physella acuta*	Introduced	
	Physa gyrina	Native	
marsh rams-horn	*Planorbella trivolvis*	Native	
mimic lymnaea	*Pseudosuccinea columella*	Native	
big-eared radix	*Radix auricularia*	Introduced	
shale pebblesnail	*Somatogyrus pennsylvanicus*	Native	
woodland pondsnail	*Stagnicola catescopium*	Native	
marsh pondsnail	*Stagnicola elodes*	Native	

Data from Evans and Ray 2008

Recently, there has been public concern over the status of the burrowing mayfly *Ephoron leukon*, the white fly, in the West Branch Susquehanna and Susquehanna rivers. Differeing anecdotal reports on the status in white fly hatches in the basin have been given but no definitive studies of the Susquehanna population’s status has been conducted. Collection methodologies, such as USEPA RBP used by for water quality monitoring often fail to adequately collect this species based on its preference for the hyporheic (sub-surface) portion of the river channel. Since these surveys provide the bulk of the invertebrate information that exists for the West Branch Susquehanna and Susquehanna rivers, further study is necessary to

accurately determine the status of this species. These mayflies serve as a major role in the mid- to late summer food web of the large river systems and the status of this population is crucial in the Susquehanna River system.

The increase in density and rapid range expansion of the invasive rusty crayfish, *Orconectes rusticus*, has raised several questions about the impacts of this species and the status of the other species of West Branch Susquehanna and Susquehanna rivers. There is much in the scientific literature about the impacts of the rusty crayfish on native crayfish populations; however, there are no published studies on the role rusty crayfish have played in the West Branch Susquehanna River and Pennsylvania portions of the Susquehanna River. A literature review or study of present diversity and distribution of resident crayfish fauna of the large river portions of the Susquehanna River system is necessary to determine current ranges of all species prior to even further range expansion of rusty crayfish potentially leads to their extirpation.

7.4 Amphibians and Reptiles

Protection and management of the amphibian and reptile populations of the Commonwealth, including the West Branch Susquehanna and Susquehanna rivers has been tasked to the PFBC under Title 30 of the Pennsylvania Code (30 Pa.C.S.A). Harvest of a number of species of amphibians and reptiles is permitted under Title 58 of the Pennsylvania Code (*Fish and Boat Code)* with possession of a valid license or a valid license in combination with a scientific collectors permit issued through the PFBC, Bureau of Fisheries, Division of Environmental Services, Natural Diversity Section. Lists of species permitted for harvest is updated and printed in the Title 58 of the Pennsylvania Code (*Fish and Boat Code)* or in the *Pennsylvania Summary of Fishing Regulations and Laws* distributed annually with license purchase.

Contemporary surveys of amphibian and reptile populations in the West Branch Susquehanna and Susquehanna rivers are limited (Table 7.4.1). Numerous studies have been conducted throughout the basin but have been limited to tributaries, wetlands and terrestrial areas outside of the river proper as there are few riverine herptile species. Some specific surveys, such as eastern hellbender *Cryptobranchus alleganiensis alleganiensis* surveys, have been conducted in portions of the West Branch Susquehanna and Susquehanna rivers (P. Petokas, *personal communication*, K. Gipe, *personal communication*) but large-scale herpetofaunal surveys have not been conducted.

Table 7.4. Amphibian and reptile species found in the West Branch Susquehanna and Susquehanna rivers and the immediate vicinity.

Species (common)	Species (scientific)
Jefferson salamander*	*Ambystoma jeffersonianum*
spotted salamander*	*Ambystoma maculatum*
marbled salamander*	*Ambystoma opacum*
eastern hellbender	*Cryptobranchus alleganiensis*
dusky salamander*	*Desmognathus fuscus*
mountain dusky salamander*	*Desmognathus ochrophaeus*
two-lined salamander*	*Eurycea bislineata*
longtail salamander*	*Eurycea longicauda*
spring salamander*	*Gyrinophilus porphyriticus*
redback salamander*	*Plethodon cinereus*
slimy salamander*	*Plethodon glutinosus*
red salamander*	*Pseudotriton ruber*
eastern newt*	*Notophthalmus viridescens*
American toad	*Bufo americanus*
Fowler's toad	*Bufo fowleri*
northern cricket frog	*Acris crepitans*
gray treefrog*	*Hyla versicolor*
spring peeper*	*Hyla crucifer*
eastern spadefoot	*Scaphiopus holbrookii*
bullfrog	*Rana catesbeiana*
green frog	*Rana clamitans*
pickerel frog	*Rana palustris*
northern leopard frog	*Rana pipiens*
wood frog*	*Rana sylvatica*
snapping turtle	*Chelydra serpentina*
eastern painted turtle*	*Chrysemys picta picta*
spotted turtle*	*Clemmys guttata*
wood turtle	*Glyptemys insculpta*
northern map turtle	*Graptemys geographica*
redbelly turtle	*Pseudemys rubriventris*
eastern box turtle*	*Terrapene carolina*
stinkpot*	*Sternotherus odoratus*
eastern fence lizard	*Sceloporus undulatus*
five-lined skink*	*Eumeces fasciatus*
broad-headed skink	*Eumeces laticeps*
worm snake*	*Carphophis amoenus*

Table 7.4. Amphibian and reptile species found in the West Branch Susquehanna and Susquehanna rivers and the immediate vicinity *(continued).*

Species (common)	Species (scientific)
black racer*	*Coluber constrictor*
ringneck snake*	*Diadophis punctatus*
rat snake*	*Elaphe obsoleta*
milk snake*	*Lampropeltis triangulum*
northern water snake	*Nerodia sipedon*
rough greensnake	*Opheodrys aestivus*
brown snake*	*Storeria dekayi*
eastern ribbon snake*	*Thamnophis sauritus*
common garter snake*	*Thamnophis sirtalis*
smooth green snake*	*Liochlorophis vernalis*
copperhead*	*Agkistrodon contortrix*
timber rattlesnake	*Crotalus horridus*

**Species believed to reside in defined area but specific location data not available at time of report*
Data provided by PFBC, Division of Environmental Service, Natural Diversity Section

7.5 Nonjurisdictional Vertebrates

Protection and management of the bird and mammal populations of the Commonwealth has been tasked to the Pennsylvania Game Commission (PGC) under Section 103 of the Pennsylvania State Game and Wildlife Code (34 Pa.C.S.A).

Birds

The West Branch Susquehanna and Susquehanna rivers are important resources for a number of resident and migratory bird species (Appendix A, Table 7.5). The Audubon Society has indentified seven Important Bird Areas (IBA) and other vital resources associated with the West Branch Susquehanna and Susquehanna Rivers. These areas are known to have exceptional concentrations or diversity of birdlife, substantial populations of state or federally-listed species, significant population of one or more Pennsylvania species of special concern, unique habitats and associated species or sites associated with long-term avian research or monitoring (pa.audubon.org/iba/faq.html 2009). These include the Southern Sproul State Forest Important Bird Area (IBA 30), Bald Eagle Ridge Important Bird Area (IBA 32), Sheets Island Archipelago Important Bird Area (IBA 46), Susquehanna Riverlands Important Bird Area (IBA 50), Conejohela Flats Important Bird Area (IBA 56), Lower Susquehanna River Gorge Important Bird Area (IBA 57) and the Blue Mountain/ Kittatinny Ridge (pa.audubon.org/iba/facts_info_site_conservation.html 2009). Conservation plans have been drafted for Sheets Island Archipelago IBA (Johnson and Cohen 2004), Susquehanna Riverlands

IBA (Gross 2004), Conejohela Flats IBA (Cohen 2004a), and Lower Susquehanna River Gorge IBA (Cohen 2004b).

7.6 Plants and Vegetation

Protection and management of the plant populations of the Commonwealth has been tasked to the DCNR, Bureau of Forestry. This includes management on the species level as well as recognized plant communities

7.7 Species of Greatest Conservation Need (federal and state)

The PFBC and PGC collectively manage those species identified in the State Wildlife Action Plan (SWAP) as being of special conservation concern (Table 7.7.1). These include species identified for both federal protection under the National Environmental Protection Act (NEPA), Endangered Species Act (ESA) and state-level protection based upon recommendations of the PFBC and PGC. Through designation in the SWAP, funds are available for research and management measures through the State Wildlife Grants Program (SWG).

Table 7.7. Identified Species of Greatest Conservation Need (SGCN) documented as associated with the West Branch Susquehanna and Susquehanna rivers.

Common name	Scientific name	Species group	Federal status	State status
dwarf wedgemussel	*Alasmidonta heterodon*	mollusc	endangered	endangered
eastern lampmussel	*Lampsilis radiata*	mollusc	none	endangered
least brook lamprey	*Lampetra aepyptera*	fish	none	candidate
shortnose sturgeon	*Acipenser fulvescens*	fish	endangered	endangered
Atlantic sturgeon	*Acipenser oxyrhynchus*	fish	candidate	endangered
longnose gar^	*Lepisosteus osseus*	fish	none	none
bowfin	*Amia calva*	fish	none	candidate
hickory shad	*Alosa mediocris*	fish	none	endangered
bridle shiner	*Notropis bifrenatus*	fish	none	endangered
brook stickleback	*Culaea inconstans*	fish	none	candidate
eastern hellbender	*Cryptobranchus alleganiensis*	herptile	none	
eastern spadefoot	*Scaphiophus holbrookii*	herptile	none	endangered
timber rattlesnake	*Crotalus horridus*	herptile	none	candidate
American bittern	*Botaurus lentiginosus*	bird	none	endangered
great egret	*Casmerodius albus*	bird	none	endangered
piping plover	*Charadrius melodus*	bird	endangered/ threatened	endangered/ threatened
black tern	*Chilidonias niger*	bird	none	endangered
sedge wren	*Cistothorus platensis*	bird	none	threatened

Table 7.7. Identified Species of Greatest Conservation Need (SGCN) documented as associated with the West Branch Susquehanna and Susquehanna rivers *(continued)*.

Common name	Scientific name	Species group	Federal status	State status
peregrine falcon	*Flaco peregrinus*	bird	none	endangered
common moorhen	*Gallinula chloropus*	bird	partial status	
bald eagle	*Haliaetus leucocephalus*	bird	partial status*	endangered
least bittern	*Ixobrychus exilis*	bird	none	endangered
yellow-crowned night heron	*Nyctanassa violacea*	bird	none	endangered
osprey	*Pandion haliaetus*	bird	none	threatened
king rail	*Rallus elegans*	bird	none	endangered
common tern	*Sterna hirundo*	bird	none	endangered
wapiti (elk)	*Cervus elaphus*	mammal	partial staus	
Allegheny woodrat	*Neotoma magister*	mammal	none	threatened

***** *currently listed as threatened, proposed for delisting*

^ *recently delisted*

7.8 Invasive Species

The PFBC, PGC, DCNR, Department of Agriculture (DOA), Department of Health (DOH) and Department of Transportation (PennDOT) are collectively tasked with managing identified invasive species (Table 7.8) within each of their respective disciplines under the Governor's Pennsylvania Invasive Species Council's Aquatic Invasive Species Management Plan (Pennsylvania Invasive Species Council 2007). Within the PFBC, management of aquatic invasive species (AIS) or aquatic nuisance species (ANS) is jointly managed through the Bureau of Fisheries, divisions of Fish Production Services, Environmental Services, and Fisheries Management. Additionally, Pennsylvania SeaGrant (PASG) operates an office in Harrisburg, Pennsylvania focusing on the Susquehanna River watershed to address issues including preventing the introduction and spread of aquatic invasive species, working with municipalities to promote water-based planning efforts, and advancing knowledge about the connection between environmental and human health concerns in coordination with the resource agencies (S. Whitney, PASG, personal communication). PASG provides grants for research projects involving aquatic invasive species, develops and disseminates education and training materials for use by the general public and key private sector audiences, promotes technology transfer to the public sector and encourages coordination and dialogue on statewide and regional AIS issues (Pennsylvania Invasive Species Council 2007).

Table 7.8. Invasive species documented as being associated with the West Branch Susquehanna and Susquehanna rivers.

Species (common)	Species (scientific)	Species group
zebra mussel	*Dreissina polymorpha*	mollusc
Asiatic clam	*Corbiula fluminea*	mollusc
big-eared radix	*Radix auricularia*	mollusc
Chinese mysterysnail	*Cipangopaludina chinensis*	mollusc
European physa	*Physella acuta*	mollusc
rusty crayfish	*Orconectes rusticus*	crustracean
common carp	*Cyprinus carpio*	fish
goldfish	*Carassius auritus*	fish
mimic shiner	*Notropis volucellus*	fish
flathead catfish	*Pylodictis olivaris*	fish
greenside darter	*Etheostoma blennioides*	fish
banded darter	*Etheostoma zonale*	fish
red-eared slider	*Trachemys scripta*	herptile
Norway rat	*Rattus norvegicus*	mammal
house sparrow	*Passer domesticus*	bird
European starling	*Sturnus vulgaris*	bird
Norway maple	*Acer platanoides*	plant
tree of heaven	*Ailanthus altissima*	plant
fiveleaf Akebia	*Akebia petiolata*	plant
garlic mustard	*Allaria officinalis*	plant
garlic mustard	*Alliaria petiolata*	plant
cow parsley	*Anthriscus sylvestris*	plant
common mugwort	*Artemisia vulgaris*	plant
Japanese barberry	*Berberis thunbergii*	plant
European barberry	*Berberis vulgaris*	plant
Asiatic bittersweet	*Celastrus orbiculatus*	plant
crown vetch	*Coronilla varia*	plant
orange day-lily	*Hemerocallis fulva*	plant
Dame's rocket	*Hesperis matronalis*	plant
Japanese hops	*Humulus japonicus*	plant
common privet	*Ligustrum obtusifolium*	plant
common privet	*Ligustrum vulgare*	plant
Japanese honeysuckle	*Lonicera japonica*	plant
bush honeysuckle	*Lonicera maackii*	plant

Table 7.8. Invasive species documented as being associated with the West Branch Susquehanna and Susquehanna rivers *(continued).*

Species (common)	Species (scientific)	Species group
bush honeysuckle	*Lonicera morrowii*	plant
purple loosestrife	*Lythrum salicaria*	plant
Japanese stilt-grass	*Microstegium vimineum*	plant
Japanese knotweed	*Polygonum cuspidatum*	plant
bamboo	*Pseudosasa japonica*	plant
kudzu	*Pueraria lobata*	plant
callery "Bradford" pear	*Pyrus calleryana*	plant
lesser celandine	*Ranunculus ficaria*	plant
jetbead	*Rhodotypos scandens*	plant
multiflora rose	*Rosa multiflora*	plant
wineberry	*Rubus phoenicolasius*	plant
water chesnut	*Trapa natans*	plant
wild basil	*Clinopodium vulgare*	plant
ground ivy	*Glechoma hederacea*	plant
dames rocket	*Hesperis matronalis*	plant
paleyellow iris	*Iris pseudacorus*	plant
moneywort	*Lysimachia nummularia*	plant
reed canarygrass	*Phalaris arundinacea*	plant

Twenty eight percent of all fish species within the Susquehanna River drainage are introduced: the third highest percentage among 21 major basins in the Appalachians and central Atlantic Coastal Plain (Snyder 2005). These introductions have resulted from stocking efforts, bait-bucket releases, stream capture events, and unintentional releases. Species such as the mimic shiner *Notropis volucellus*, banded darter *Etheostoma zonale*, and greenside darter *Etheostoma blennioides* have all been introduced to the Susquehanna River basin, likely as a result of bait-bucket introductions. While the long-terms effects of these introductions are not yet known, colonization of these and similar species pose risks to the conservation status of native fish species (Neely and George 2006). The flathead catfish *Pylodictis olivaris* is a recent invader of the Susquehanna River and is recognized by the USFWS as its highest priority among invasive animal species (Brown *et al.* 2005). The first records of flathead catfish in the Susquehanna River were from angler catches in 2002 between Holtwood Dam and Danville, Pennsylvania (Brown *et al.* 2005). The flathead catfish is a highly sought game fish within its native range and was likely introduced by anglers wishing to establish a recreational fishery. The ecological implications of the introductions due to its large size and highly piscivorous diet are well documented and severe: drastically altering existing fish assemblages and stocks in waters where it is introduced (Brown *et al.* 2005). One of the largest concerns exists over the flathead catfish's potential to negatively affect ongoing migratory fish restoration efforts in the Susquehanna basin. Studies in North Carolina have shown that flathead catfish actively feed

on juvenile and adult American shad (Ashley and Buff 1987, Kwak *et al.* 2004) and modeling efforts have suggested that they could reduce juvenile shad biomass by about 25% (Kwak *et al.* 2004, Pine 2003). As metioned previously, inclusion of quantitative, community-based survey would provide vital information to track range expansion over time and impacts that non-native species are having on the native fauna. More focused effort on non-game species will help to quantify the cryptic (e.g., mimic shiners) and non-target species that commonly get overlooked but play a role in management of the resource.

Aquatic invasive species in the Susquehanna drainage are not limited to fish; the rusty crayfish *Orconectes rusticus* is a recent invader of the Susquehanna basin and its affects have been widespread and severe. Although there are no definitive records of introduction, unpublished reports indicated it was common in Otsego Lake, the headwaters of the Susquehanna River in the early 1970s (Kuhlmann and Hazleton 2007). It was first documented in the Susquehanna River upstream of the Conowingo Dam in Maryland in 2007 (J. Killian, MDDNR, personal communication) and in Pennsylvania at Hill Island as early as 1976 (D. Lieb, Pennsylvania State University, personal communication). The rusty crayfish has been known to completely displace all native or established crayfishes and exists at higher densities than the species it replaces. As a result it can impact the rest of the aquatic community through consumption, disturbance and other effects (Kuhlmann and Hazleton 2007) including reductions or elimination of rooted aquatic plants (Lodge and Lorman 1987). The rusty crayfish was banned from sale, barter, possession and transportation in the Commonwealth of Pennsylvania on October 12, 2005. Currently there is little information on the density, current range, and range expansion with the West Branch Susquehanna and Susquehanna rivers. As an ecosystem engineer, the impacts that it can have on the native communities can be extensive. Research is needed into the impacts that rusty crayfish are having in the West Branch Susquehanna and Susquehanna rivers, including current distribution, rates of expansion, and effects that severe densities are having on basal resources in the mainstem portions of the West Branch Susquehanna and Susquehanna rivers.

Some other widely recognized invasive species have had less impact or have not yet been documented from the Pennsylvania portions of the Susquehanna River but are considered serious threats. Zebra mussels *Driessena polymorpha* were documented in New York and Pennsylvania portions of the upper Susquehanna River in 2007. In 2008, zebra mussels were found in the Muddy Run Pumped Storage Reservior and larvae (veligers) were found at the Peach Bottom Atomic Power State in 2009 in Lancaster County (S. Grisé, PASG, personal communication) as well as in the Maryland portion of the Conowingo Pool (Maryland Department of Natural Resources, 2008). Didymo *Didymosphenia geminata,* commonly referred to as “rock snot”, is an invasive algae recently documented in the West and East Branch Delaware rivers and the Delaware River in Pennsylvania. The primary mechanism for transport appears to be any equipment that comes in contact with water where didymo is found, including fishing gear and boats (Pennsylvania Fish and Boat Commission 2009). It is recommended that all users of waters where didymo, zebra mussels and other invasive species are found decontaminate all gear using methods suggested by the PBFC (http://fishandboat.com/water/habitat/ans/didymo/faq_didymo.htm) prior to usage in another water. All PFBC staff are required to prescribe to biological control measures identified by the

PFBC, Bureau of Fisheries, Division of Fish Production Services for all field gear used to limit spreading aquatic invasive species.

7.9 Animal and Plant Health/ Disease

The Pennsylvania Department of Agriculture is tasked with managing animal and plant health issues throughout the Commonwealth in cooperation with the respective agencies tasked with managing those resources: the PFBC, the PGC, and the DCNR. Undoubtedly, the most dramatic animal health issue associated with the West Branch Susquehanna and Susquehanna rivers has been the wide-spread mortality of juvenile smallmouth bass *Micropterus dolomieu.* Beginning in 2005, large-scale mortality of juvenile smallmouth bass occurred throughout sections of these rivers. A workgroup group has been formed, headed by the PFBC in conjunction with the PADEP and the USEPA, to try to identify the source of and possible solution to these fish kills. The workgroup is presently working with the USGS, Pennsylvania Water Science Center on a water quality study of indefinite length to try to identify likely parameters which may be leading to stressful conditions for smallmouth bass that could be predisposing them to the infections. This program is designed to characterize differences in water quality in juvenile smallmouth bass habitat in comparison with other areas of the Susquehanna River as well as similar waterbodies that have not seen the presence of the condition. It is currently believed that poor water quality is increasing stress levels and decreasing immune response, specifically in those areas identified as critical juvenile smallmouth bass habitat, which leads to infection. The presence of the condition, at least at some level, has lead to declines in the population of smallmouth bass in some sections of the Susquehanna River.

Beginning in 2009, histopathological analysis of infected fish has been contracted to the USGS National Fish Health Laboratory. These analyses will better define these and other conditions observed in resident smallmouth bass populations with the aim of identifying and alleviating the condition.

Intersex condition

Recent studies have shown that a high proportions of male smallmouth bass residing in the Susquehanna River display intersex condition (having both male and female gametes in male reproductive organs). To date, no definitive correlations have been identified regarding the specific pollutants causing this condition but the presence of intersex fish has been correlated with urban development and agricultural land uses. It is believed that this condition does limit the reproductive potential; however, the extent is not yet known. Studies currently underway by the USFWS and USGS National Fish Health Laboratory will provide a better understanding of this condition in the future.

Largemouth bass virus

Recent collections of smallmouth bass from the Susquehanna River as part of a larger national wild fish health survey conducted by the USFWS have identified the presence of largemouth bass virus (LMBv) in a portion of smallmouth bass captured (V. Blazer, USGS, personal

communication). Smallmouth bass are known to be carriers of LMBv, but are not known to display symptoms of the disease.

Spring Viremia of Carp

Spring viremia of carp (SVC) is a contagious viral disease found in common carp *Cyprinus carpio* and other related species. Outbreaks can cause substantial loss with mortality rates as high as 90% in juvenile fish. Outbreaks in wild fish have been documented in Wisconsin and Illinois in 2002 and in the Upper Mississippi River in 2007 (Center for Food Security and Public Health 2007). SVC has not been documented in the Susquehanna River system to date (C. Yamashita, PFBC, personal communication).

Koi Herpes Virus

Koi Herpes Virus (KHV) is a highly contagious viral disease that can cause substantial morbidity and mortality in common carp. The condition has been known to affect koi and common carp but does not appear to affect goldfish *Carassius auratus* or grass carp *Ctenopharyngodon idella* (Institute of Food and Agricultural Sciences Extension 2008). KHV has not been documented in the Susquehanna River system to date (C. Yamashita, PFBC, personal communication)

7.10 Management Options

Priority 1: (*on-going activities or recommendations to be implemented in first year of management plan*)

- Develop a monitoring scheme to gather baseline community fisheries data to identify trends in species status over time and help to track and identify ecosystem-wide problems, should they arise.
- Continue investigation into disease and intersex within the Susquehanna River smallmouth bass population and determine their impacts on the population.

Priority 2: (*recommendations with implementation date in years 2-3 of management plan*)

- Develop a study through the state wildlife grants program to determine the current status of the white fly *Ephoron leukon* in the West Branch Susquehanna and Susquehanna rivers
- Determine the impacts of the invasive rusty crayfish *Orconectes rusticus* and implications of future range expansion.
- Develop study to determine the role that gastropods may be having in parasite infections of fish species such as smallmouth bass.

Priority 3: (*recommendations with implementation date in years 4-5 of management plan*)

- Develop a study through the state wildlife grants program to determine the status and distribution of riverine herptile species the eastern hellbender *Cryptobranchus allegeniensis* and redbelly turtle *Psuedemys rubriventris.*

- Work with key cooperators to further define the scope of largemouth bass virus (LMBv) within the Susquehanna River Basin, determine role it has, if any, in the health of other centrarchid species, and potential ramifications of the presence of the virus.

~Return to Table of Contents~

8.0 Recreational Fisheries

One of the primary goals of the PFBC is to offer anglers a variety of recreational fishing experiences through the protection, conservation, and enhancement of aquatic resources throughout the Commonwealth. It is the aim of the Bureau of Fisheries, Division of Fisheries Management (DFM) to optimize these experiences through applied fisheries management. To maintain and optimize recreational potential, the DFM carries out a number of management efforts that include setting angling regulations, maintaining stocking programs, characterizing angler use and harvest and monitoring game- and non-gamefish populations.

This section of the management plan provides an in-depth discussion of recreational fisheries management activities undertaken by the DFM for each management section of the West Branch Susquehanna and Susquehanna rivers. Sectioning strategies are defined by the PFBC, Bureau of Fisheries to more appropriately manage the waters of the Commonwealth (Marcinko *et al.* 1986). Waterbodies are typically divided into three kilometer or longer sections based on a combination of biological, social, and chemical and physical characteristics with each section is managed as a single unit. The West Branch Susquehanna River is divided into six management sections and the Susquehanna River is divided into 18; 10 upstream of the confluence of the West Branch Susquehanna River and eight downstream (Figure 8.1; Appendix A, Tables 8.1.1-8.1.2).

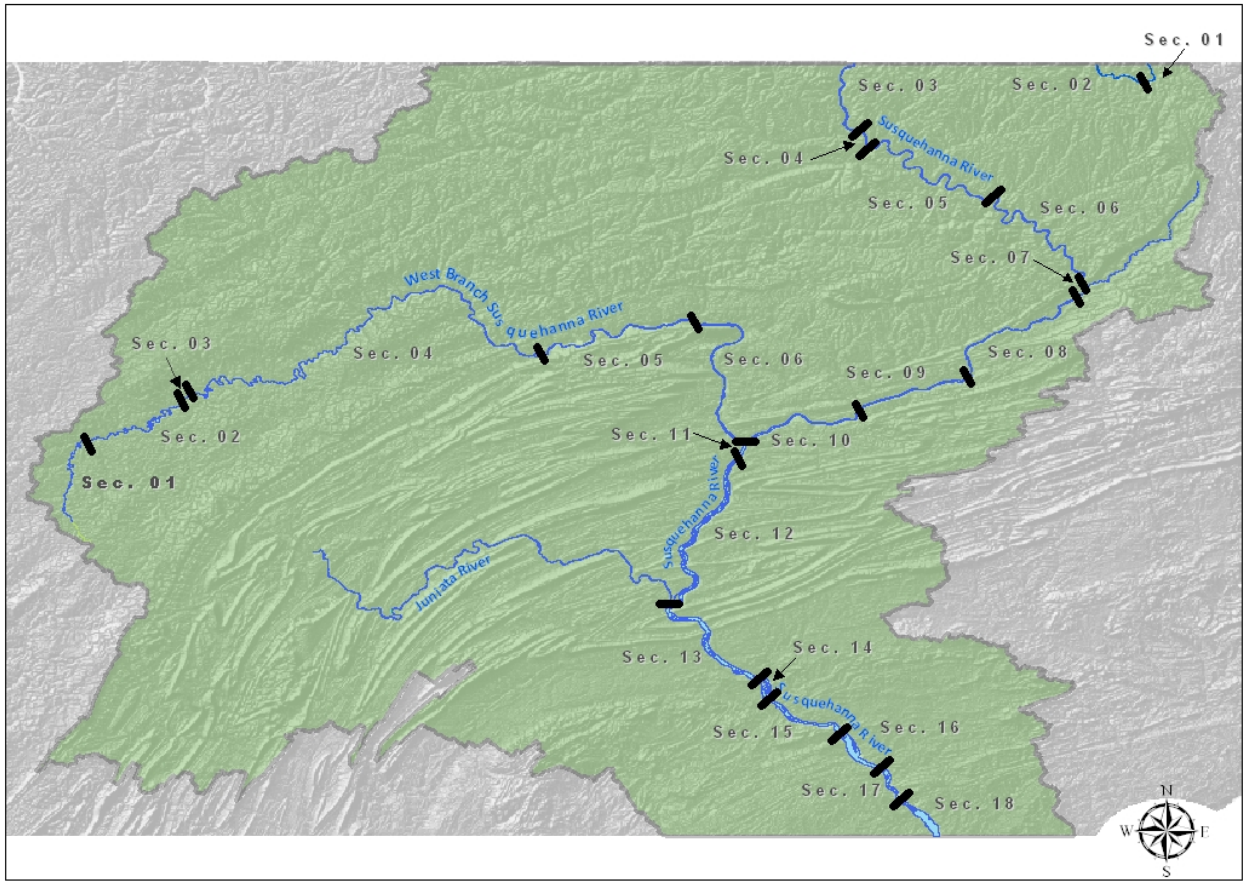

Figure 8.1 Sectioning strategy employed by PFBC, Bureau of Fisheries, Division of Fisheries Management for management of game fish species at the West Branch Susquehanna and Susquehanna rivers.

8.1.1 Current recreational fisheries

Several species of fish are commonly targeted by recreational anglers in the West Branch Susquehanna and Susquehanna rivers. The species known to occur in each of the respective management sections of the rivers have been documented by PFBC staff through routine fish sampling efforts (Tables 8.1). These species are presently managed through a combination of techniques including recreational fishing regulations, natural reproduction, and supplemental stocking. Routine biological monitoring allows PFBC biologists to make necessary changes in management strategies when conditions are warranted.

Table 8.1. Game fishes of the West Branch Susquehanna and Susquehanna rivers.

Common name	Scientific name	Residency status	West Branch Susquehanna	Upper Susquehanna River	Middle-lower Susquehanna River
Gars	**Lepisosteidae**				
longnose gar	*Lepisosteus osseus*	Native			X
Herrings	**Clupeidae**				
blueback herring	*Alosa aestivalis*	Native			X
alewife	*Alosa pseudoharengus*	Native			X
hickory shad	*Alosa mediocris*	Native			X
American shad	*Alosa sapidissima*	Native	X	X	X
Pikes	**Esocidae**				
northern pike*^	*Esox lucius*	Introduced	X	X	X
muskellunge**	*Esox masquinongy*	Introduced	X	X	X
tiger muskellunge[$]	*Esox lucius x Esox masquinongy*	Introduced		X	X
chain pickerel	*Esox niger*	Native	X	X	X
Minnows	**Cyprinidae**				
common carp	*Cyprinus carpio*	Introduced	X	X	X
fallfish	*Semotilus corporalis*	Native	X	X	X
Suckers	**Catostomidae**				
quillback	*Carpiodes cyprinus*	Native	X	X	X
northern hog sucker	*Hypentelium nigricans*	Native	X	X	X
shorthead redhorse	*Moxostoma macrolepidotum*	Native	X	X	X
white sucker	*Catostomus comersoni*	Native	X	X	X
Catfishes	**Ictaluridae**				
channel catfish	*Ictalurus punctatus*	Introduced	X	X	X
white catfish	*Ameiurus catus*	Native		X	X
yellow bullhead	*Ameiurus natalis*	Native	X	X	X
brown bullhead	*Ameiurus nebulosus*	Native	X	X	X
flathead catfish	*Pylodictus olivaris*	Introduced			X
Trout and Salmon	**Salmonidae**				
brook trout*	*Salvelinus fontinalis*	Native	X	I	I
brown trout**	*Salmo trutta*	Introduced	X	I	I
rainbow trout**	*Oncorhynchus mykiss*	Introduced	X	I	I
Temperate Basses	**Moronidae**				
striped bass	*Morone saxatilis*	Native			X
hybrid striped bass[$]	*Morone chrysops x Morone saxatilis*	Introduced			X

Table 8.1. Game fishes of the West Branch Susquehanna and Susquehanna rivers.

Common name	Scientific name	Residency status	West Branch Susquehanna River	Upper Susquehanna River	Middle-lower Susquehanna River
Sunfishes	**Centrarchidae**				
rock bass	*Ambloplites rupestris*	Introduced	X	X	X
black crappie	*Pomoxis nigromaculatus*	Introduced	X	X	X
white crappie	*Pomoxis annularis*	Introduced	X	X	X
smallmouth bass	*Micropterus dolomieu*	Introduced	X	X	X
largemouth bass	*Micropterus salmoides*	Introduced	X	X	X
green sunfish	*Lepomis cyanellus*	Introduced	X	X	X
redbreast sunfish	*Lepomis auritus*	Native	X	X	X
bluegill	*Lepomis macrochirus*	Introduced	X	X	X
pumpkinseed	*Lepomis gibbosus*	Native	X	X	X
redear sunfish***	*Lepomis microlophus*	Introduced			X
Perches	**Percidae**				
walleye*	*Sander vitreus*	Introduced	X	X	X
yellow perch	*Perca flavescens*	Native	X	X	X

** historically stocked, now managed through natural reproduction*

^ thought to be introduced based on absense from historic records; however, possibly native based on flow reversals following most recent glaciation

$ presently stocked, not reproductively viable

*** managed through annual stocking although some natural reproduction may occur but presumed insufficient to support recreational fishery*

**** historically stocked and not documented recently*

I *temporary resident, likely does not permanently reside in the mainstem rivers year round.*

8.1.2 Fishing regulations

Recreational fishing regulations are applied by the PFBC to all waters under the jurisdiction of the Commonwealth. These regulations are published annually as part of Title 30 of the Pennsylvania Consolidated Statutes, otherwise known as the Fish and Boat Code. An abridged version of these regulations, Summary of Fishing Regulations and Laws, is distributed each year to anglers upon purchase of a fishing license. These regulations are enacted to help the PFBC protect, conserve and enhance the aquatic resources of the Commonwealth. The PFBC, Bureau of Fisheries, DFM monitors game fish populations and reviews relevant contemporary

literature to periodically evaluate the success of regulations and to determine if amendments to the regulations are necessary. Occasionally, circumstances warrant the development of novel regulatory mechanisms to best promote recreational fishing opportunities and maintain ecologically sound gamefish populations.

Largely, the waters of the West Branch Susquehanna River and the Susquehanna River are managed with regulations applicable to all Commonwealth inland waters. There are special regulations in place; however, that are exceptions to the general Commonwealth inland waters regulations (Table 8.1.2.1). The Susquehanna River and its tributaries are part of a basin-wide special regulation that places a closed season on American shad *Alosa sapidissima*, alewife *Alosa pseudoharengus*, and blueback herring *Alosa aestivalis* as restoration measures are in place for declining populations of each of these species. As of January 1, 2011, an executive order was inacted to place year-round catch-and-immediate release regulations on this reach of the Susquehanna River from the Adam T. Bower Memorial Dam (inflatable dam) in Sunbury, Pennsylvania downstream to the Holtwood Dam in response to declining number of adult smallmouth bass after years of poor recruitment resulting from disease related mortality of juvenile fish. These regulations were put in place to limit stress to existing black bass populations until the population can rebound. This order is effective for one year from date of inception. Official rule making to institute this regulation for an indefinite period of time was made by the Board of Commissioner in April 2011 following a 60-day public comment period to extend the special regulation beginning in January 2012. Additional regulatory measures concerning black bass populations in this reach are currently under review by the Board of Commissioner.

Table 8.1.2.1. Special designation and special regulation areas on the West Branch Susquehanna and Susquehanna rivers.

Waterbody	Section	Applicable Regulation
West Branch Susquehanna River	3	Approved Trout Waters[$]
Susquehanna River	11	Special Regulations: Catch and Immediate Release
	12	Special Regulations: Catch and Immediate Release
	13	Special Regulations: Catch and Immediate Release
	14	Special Regulations: Catch and Immediate Release
	15	Special Regulations: Catch and Immediate Release
	16	Special Regulations: Catch and Immediate Release
	17	Special Regulations: Catch and Immediate Release
	18	Special regulations: Conowingo Reservoir

[$] *Commonwealth inland waters regulations for this designation apply (regular season)*

8.1.3 Stocking Program

The PFBC stocks sections of the West Branch Susquehanna and Susquehanna rivers to enhance recreational fishing opportunities for the license holding public and to restore limited or extirpated fish populations to levels capable of supporting a recreational fishery. Typically, stocking occurs in river sections characterized by modified or altered habitats where natural reproduction of a particular species is not sufficient to provide adequate recreational fishing opportunities for the species of interest. Some altered habitats yield conditions that are favorable for non-native sport-fish populations. The most substantial of these in the West Branch Susquehanna and Susquehanna rivers are impoundments formed by run-of-the-river, flood control, and hydroelectric dams. The effect that each of these dams has on the riverine habitat is two-fold: not only does it create a physical change in habitat; it also fragments fish communities and restricts movement to and utilization of suitable habitat. In these cases, fish species have been introduced that have only a limited ecological effect on native fauna and have life history characteristics that better utilize the altered habitat type than indigenous species.

The PFBC presently utilizes three stocking strategies in the management of waters of the Commonwealth of Pennsylvania: maintenance, supplemental and restoration stocking; all of which are utilized to some extent in these rivers. The most common of these stocking categories is maintenance stocking. In maintenance stocking, fish are stocked periodically (usually annually) to sustain a population where that species has shown no documented natural reproduction or whose reproduction would not maintain a population that would be suitable for recreational angling. Under this category, there are two classifications that relate to how and when these fish are stocked: put-take and put-grow-take. Put-take stocking is used in situations where water quality and or available habitat limit the ability for a particular species to survive from year to year, and as a result, have limited opportunity to develop an adequate population. In these cases, adult fish are stocked into a system to provide seasonal angling opportunities. It is assumed that outside of this seasonal window, survival of these fish is negligible and that the functional population is zero. The spring trout fishery that exists in Section 03 of the West Branch Susquehanna River is one example of a maintenance-stocked, put-take fishery and is the only fishery of its type on the West Branch Susquehanna and Susquehanna rivers. Put-grow-take stocking is the primary maintenance stocking technique utilized in these rivers. In put-grow-take fisheries, introduced fish survive from year to year and grow to legal (harvestable) length in numbers adequate to meet management objectives and provide quality recreational fishing opportunities; however, some factor such as water quality or availability of suitable habitat limits their ability to reproduce in numbers that perpetuate the population and create an adequate recreational fishery. In this scenario, juvenile fish are introduced as either fry or fingerlings and allowed to grow naturally in a system. This process is more economically feasible in most cases when dealing with warm/coolwater species than the put-take scenario, and literature suggests that growth and survival is better in the wild for these species than in aquaculture facilities or captive situations. Put-grow-take stocking strategies are also utilized to stock hybridized species. As a result of hybridization, these species are functionally sterile,

allowing even greater management control of the fishery, whereas, in their pure state, they have the capacity to dominate a fishery. Examples include tiger muskellunge *Esox lucius x Esox masquinongy* and the historically-stocked hybrid striped bass *Morone chrysops x Morone saxatilis* in the lower reaches of the Susquehanna River.

The second most common stocking strategy utilized by the PFBC is supplemental stocking. In this scenario, fish are stocked into an existing, naturally reproducing population to supplement a weak year-class to maintain adequate recreational fishing opportunities for a particular species in hopes of further bolstering the population. Historically, supplemental plants of chain pickerel *Esox niger*, channel catfish *Ictalurus punctatus,* bluegill *Lepomis macrochirus*, smallmouth bass *Micropterus dolomieu*, and walleye *Sander vitreus* have been conducted in the West Branch Susquehanna and Susquehanna rivers by the PFBC.

Restoration stocking is presently utilized by the PFBC in an effort to revitalize diadromous fish populations native to the West Branch Susquehanna and Susquehanna rivers. The primary goal of this stocking strategy is to reestablish migratory fish populations in reaches fragmented by dams located throughout the watershed, specifically the hydroelectric and run-of-the-river dams on the lower reaches of the Susquehanna River. These dams have adversely affected the ability of migratory fishes to access previously utilized habitats required for spawning activities and have resulted in relative extirpation of these species from the basin. Presently, in cooperation with partner agencies, restoration stockings of American shad, hickory shad *Alosa mediocris* and American eel *Anguilla rostrata* have been taking place at locations across the basin.

The PFBC presently stocks muskellunge *Esox masquinongy* in the Susquehanna River downstream to the confluence of Swatara Creek and tiger muskellunge in the Susquehanna River between the confluence of Swatara Creek and the SR 462 bridge between Columbia and Wrightsville, PA (Section 14 and 15). Currently, higher densities of fingerling muskellunge are being stocked between the inflatable dam in Sunbury, Pennsylvania and the PPL diversion dam in Shamokin Dam, Pennsylvania (Section 11) and tiger muskellunge between the confluence of Swatara Creek and the York Haven Dam (Section 14) to support destination fisheries for those species. The West Branch Susquehanna River is managed as a naturally reproducing muskellunge fishery. A state-wide muskellunge management plan is scheduled for release in 2011. This document will provide further guidance on management activities of muskellunge in the West Branch Susquehanna and Susquehanna rivers.

Beginning in 2008, the PFBC discontinued stocking fry and fingerling walleyes throughout the riverine systems of the Commonwealth to assess the contribution of natural reproduction of walleye to the fishery. Review of historic population trends and population levels during the study period will be used to determine whether management of walleye as a naturally reproducing species is sufficient to support the recreational fishery. A state-wide walleye management plan is scheduled for release in 2011. This document will provide further guidance on management activities of walleye in the West Branch Susquehanna and Susquehanna rivers.

A comprehensive list of recent and historical stockings for the West Branch Susquehanna and Susquehanna rivers is detailed in Appendix A, Tables 8.1.3.1 – 8.1.3.3.

8.1.4 Angler Use and Harvest

Characterization of fisheries

The PFBC, Bureau of Fisheries, Division of Fisheries Management utilizes angler use and harvest surveys and angler opinion surveys to provide information on targeted species, methods of fishing, and rates of catch and harvest to facilitate better management of fisheries. The West Branch Susquehanna and Susquehanna rivers offer the public a multitude of opportunities for recreational angling. In recent years, angler opinion and creel surveys were conducted on these rivers to further characterize angler use and harvest. Angler opinion surveys were conducted at the West Branch Susquehanna and Susquehanna rivers (1994), Susquehanna and Juniata rivers (2006), and West Branch Susquehanna River (1990, 1994, and 2007). Creel surveys were conducted at the West Branch Susquehanna River in 2007 and 2008 and on the at the Susquehanna River near the towns of Towanda, Bradford County and Mehoopany, Wyoming County (1966) in Bradford and Wyoming counties (1986), in the vicinity of Lake Frederic (1985), and at the Susquehanna and Juniata rivers (2007).

Large-scale angler use and harvest surveys are expensive in both resources and capital, resulting in large periods of time between surveys. This is most noticible in the amount of time since the most recent surveys of the upper Susquehanna River mentioned above. The Division of Fisheries Management, Warmwater Unit is interested in evaluating the feasibility of focused, angler use and harvest surveys that are smaller in scope. These surveys would be intensive surveys in smaller areas (e.g., a management section or block of sections) that would rotate around a waterbody on a periodic basis. The aim of these surveys would be to keep our understanding of trends in angler behavior up-to-date with periodic, high resolution surveys while reducing demand on resources by limiting the scope (i.e., area) of the surveys. Further, the rotating design would maintain a contemporary view of angler behaviors across a large waterbody, such as the Susquehanna River, reducing or eliminating the need for large-scale surveys and allowing adaptive management to shifts in angler behavior.

Daniels (1967) conducted a two-day creel survey and angler count at two sections of the Susquehanna River in conjunction with the opening weekend of the black bass *Micropterus* sp. season in 1966. The two reaches surveyed included a three-mile reach near Towanda, Pennsylvania and a downstream reach between the towns of Mehoopany, and Tunkhannock, Wyoming County, Pennsylvania. River conditions were high and turbid and angler use was limited. Most anglers who took part in the survey had traveled from outside of the immediate area and were unaware of the conditions prior to arriving. Catch rates were low and comprised mainly of smallmouth bass and rock bass. Most of the bass caught were below nine-inch legal length (76%) and were subsequently released. The use of live baits compared to artificial baits was 3:1 and live bait anglers had the highest catch rates during the survey period. The author indicated that this survey was not necessarily characteristic of use in this area due to the hydrologic conditions.

Hoopes and Cooper (1985) analyzed angler use and harvest data gathered by consultants hired by GPU Nuclear Corporation at the Susquehanna River at Lake Frederic and the tailwaters of Red Hills and York Haven dams for the time periods of 1974 to 1980 and 1981 to 1984. The data came from periods before and after a regulation change enacted during 1981 that increased the minimum harvestable length limit of smallmouth bass from 9 inches to 10 inches and allowed harvest of smallmouth during the months of April and May which were historically closed to harvest. During the study period both angler use of the resources and catch rates of smallmouth bass increased significantly, while the proportion of fish harvested decreased. Despite the increase in minimum length limit from 9 inches to 10 inches, the overall number of smallmouth bass harvested remained unchanged. The bulk of the annual harvest shifted to April and May from June, July, and October following the implementation of the new regulations that allowed harvest of smallmouth bass in April and May. This period of time corresponds with smallmouth bass spawning activity. This is a time when smallmouth bass are often more susceptible to angler harvest.

During the 1989, Hoopes and others (1989) conducted a fishing assessment by roving creel survey at the Susquehanna River in fisheries management sections 05 and 06 (Bradford and Wyoming counties) prior to implementation of a black bass regulation change that increased minimum length limit to 12 inches, set a daily creel limit of six fish, and a closed season during the spawning period. Of the anglers interviewed, the highest percentage of individuals targeted walleye, followed by any species, and smallmouth bass. During the survey, these sections of the river received substantial recreational angling pressure with 1,314 anglers interviewed over the 182-day survey period and an estimate of 59 angler trips taken to this reach per day. Catch rates of fish were high, with the estimated catch during the survey totaling 120,429 fish. This corresponds to 2.5 fish per hour. Harvest rates in this reach were also high, with an estimated harvest of 31,836 fish or 0.7 fish per hour. Sixty-seven percent of anglers indicated they would harvest legal-length fish if caught, clearly indicating that the intent of fishing was harvest for consumption. During the survey period, the angler population was dominated by males (90%) holding resident licenses (88%). Senior anglers comprised 5% of surveyed individuals and juniors (who did not require a license) comprised 3% of angling populations. Non-resident anglers only constituted 4% of the angler population surveyed.

The Susquehanna River Basin 1994 Angler Opinion Survey (Lorantas and Burman 1995) evaluated angler support for the possible expansion of the Big Bass program from its original bounds between the Dock Street Dam in Harrisburg, Pennsylvania and Holtwood Dam established in 1991 and 1992. This program increased minimum length limits for black bass to 15 inches, decreased daily creel limits to four fish, and imposed a closed season during the spawning period. Roving surveys were conducted along the West Branch Susquehanna and Susquehanna rivers in areas managed by the conventional, basin-wide smallmouth bass regulations and the recently adopted Big Bass regulations. Overall, anglers who fished the newly designated Big Bass areas were in favor of those regulations. Those individuals fishing the West Branch Susquehanna River and sections of the Susquehanna River still under conventional regulations were in favor of extending the coverage of the Big Bass regulations. The majority of those who took part also indicated that they would allocate most of their fishing time to reaches managed with Big Bass regulations or more restrictive regulations.

The 2006 Susquehanna River and Juniata River smallmouth bass angler opinion survey (Miko 2006) was conducted to determine the opinion of anglers in regards to temporary implementation of more restrictive regulations on harvest of smallmouth bass in areas affected by poor recruitment as a result of *Flavobacterium columnare* (columnaris) infection related mortality in juvenile smallmouth bass. A vast majority of anglers fishing the middle and lower Susquehanna River (86% and 88%, respectively) expressed interest in implementation of a catch-and-release fishery for smallmouth bass until spawning success improved; however, the majority of anglers interviewed already practiced catch-and-release. The anglers interviewed also indicated that they would not change their fishing habits as a result of implementation of more restrictive regulations. Smallmouth bass angler use was high at the middle and lower portions of the Susquehanna River with estimates of 33 and 39 days spent on the river each year, respectively. Present practices and attitudes of the anglers using the Susquehanna River indicated that little harvest was occurring and the implementation of the regulation would likely have little effect because those practices were largely already in place. Based on these results, catch-and-release regulation for smallmouth bass was not instituted.

Miko and others (2007) conducted an angler opinion survey to assess angler interest in expanding the Big Bass program to include the West Branch Susquehanna River from the city of Lock Haven, Clinton County to the mouth at the city of Sunbury, Northumberland County. This expansion would add 127 kilometers (79 miles) to the existing program reach extending from the inflatable at the city of Sunbury, Pennsylvania to Holtwood Dam at the town of Holtwood, Pennsylvania. The anglers interviewed expressed interest and were receptive to expansion of the Big Bass regulations or possibly even more restrictive regulations. Anglers interviewed harvested few bass under the current regulations. Due to this low harvest rate, harvest (fishing mortality) likely is not a crucial factor relative to natural mortality at the population level; therefore, implementation of Big Bass regulations would not likely affect population size and structure. Regulation modification in this instance would be more a social issue than a biological issue, and, at the time, was unwarranted. Further studies of both the smallmouth bass population and angler exploitation are necessary before regulation changes should be considered.

Smucker and others (2009) conducted the Juniata/Susquehanna River Creel Survey in 2007 to characterize the recreational fishery in the Susquehanna River between the inflatable dam at Sunbury and Holtwood Dam. By utilizing a modified access point creel survey and an augmented aerial survey the authors estimated angler effort, catch, and harvest of smallmouth bass, largemouth bass, walleye, and other recreationally targeted species. An estimated 92,715 angler trips accounting for 334,867 angler-hours were spent recreationally angling on the Susquehanna River during the study period of May through October 2007. Smallmouth bass were the most targeted species during the survey and comprised an estimated 264,159 hours during 61,733 trips on both the Juniata and Susquehanna rivers. Walleye were the second most targeted species generating an estimated 49,484 hours of effort spread over 12,710 trips. The estimated total catch over the entire study period was 366,133 fish, which included 210,569 smallmouth bass, 22,728 walleye, and 58,884 channel catfish from the Susquehanna River. An estimated 21,393 fish were harvested from the Juniata and Susquehanna rivers during the study period. Of the primary game fish harvested, nearly half

were channel catfish (10,100), followed by smallmouth bass (4,725), walleye (2,915), and rock bass (1,589). This represented approximately six percent of all fish caught.

Tournament angling

Tournament angling on the West Branch Susquehanna and Susquehanna rivers comprise a substantial component of the recreational fishery. Presently, organized events of 10 participants or larger are required to receive a special activities permit (SAP) through the PFBC, Bureau of Law Enforcement in cooperation with the Bureau of Fisheries, DFM. Sponsors of permitted tournaments are required to report catch and harvest data for the tournaments which is tracked by the DFM Warm-Water Unit. Tournaments are not permitted to be held during closed seasons or during "no harvest" periods for targeted species. Informal tournaments with smaller numbers of participants also occur in these waterbodies but are not presently tracked.

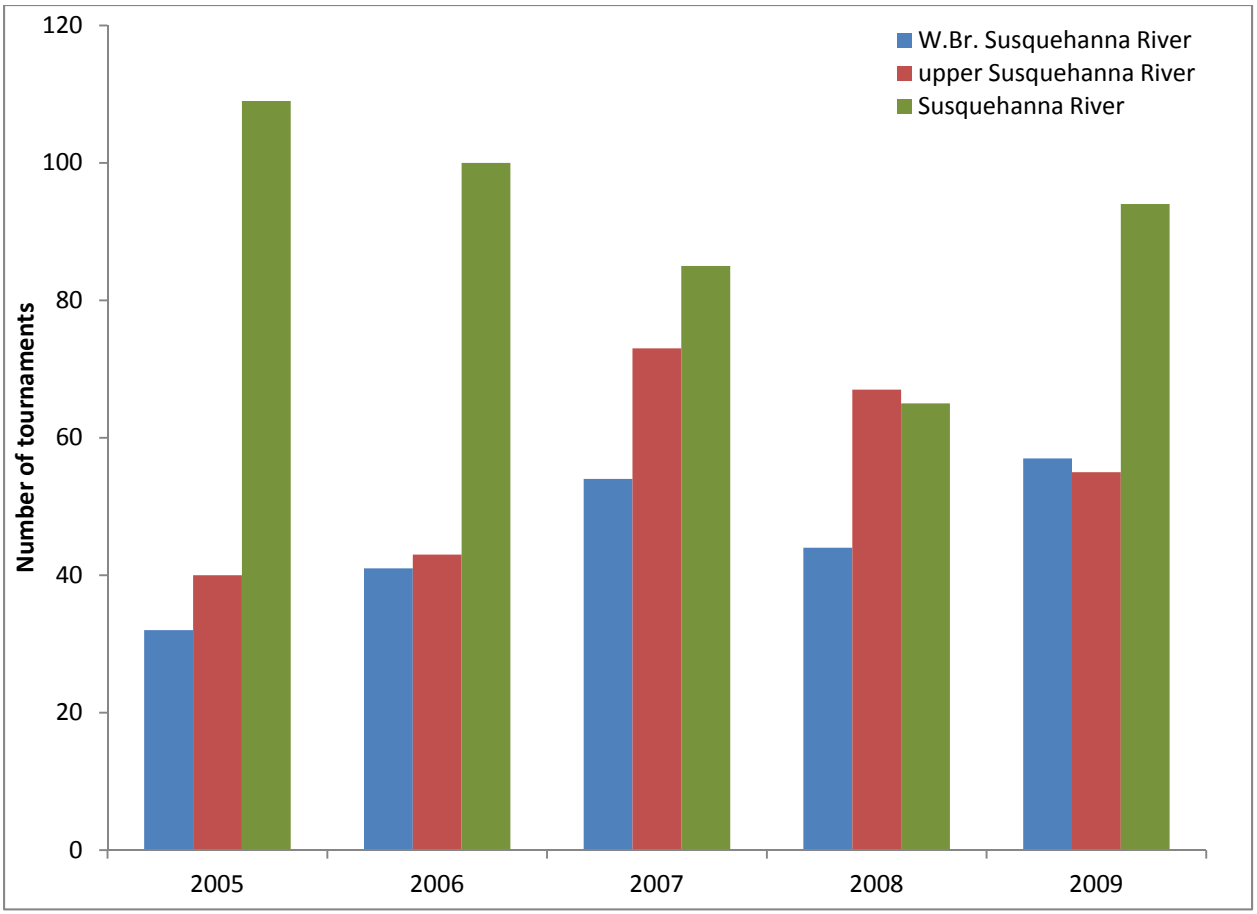

Figure 8.1.4.1. Frequency of organized angling tournaments on different reaches of the Susquehanna River system reported through the PFBC Special Activities Permit (SAP) system for the period of 2005 through 2009.

Tournament usage has varied in recent years across each of the major reaches of the West Branch Susquehanna and Susquehanna rivers. While the numbers of organized tournaments

on the upper and middle-lower Susquehanna River have fluctuated, the number of organized tournaments held on the West Branch Susquehanna River has increased. This coincides with the improvement in water quality and the subsequent increase in game fish populations (Figure 8.1.4.1). The West Branch Susquehanna River averages 45.6 tournaments annually while the upper Susquehanna and Susquehanna River average 55.6 and 90.6 tournaments per year, respectively. Tournaments conducted on the West Branch Susquehanna and Susquehanna rivers predominately target black bass with smallmouth bass comprising the majority of the reported catch (Figure 8.1.4.2). Other permitted tournaments have been held targeting channel catfish, common carp (*Cyprinus carpio*), walleye, or simply all recreational species. Recent regulation changes calling for catch and immediate release in the Susquehanna River between the confluence of the inflatable dam at Sunbury and Holtwood Dam will change the manner in which tournament organizers conduct their tournaments. This may affect the number organized tournaments held within that reach in the near future.

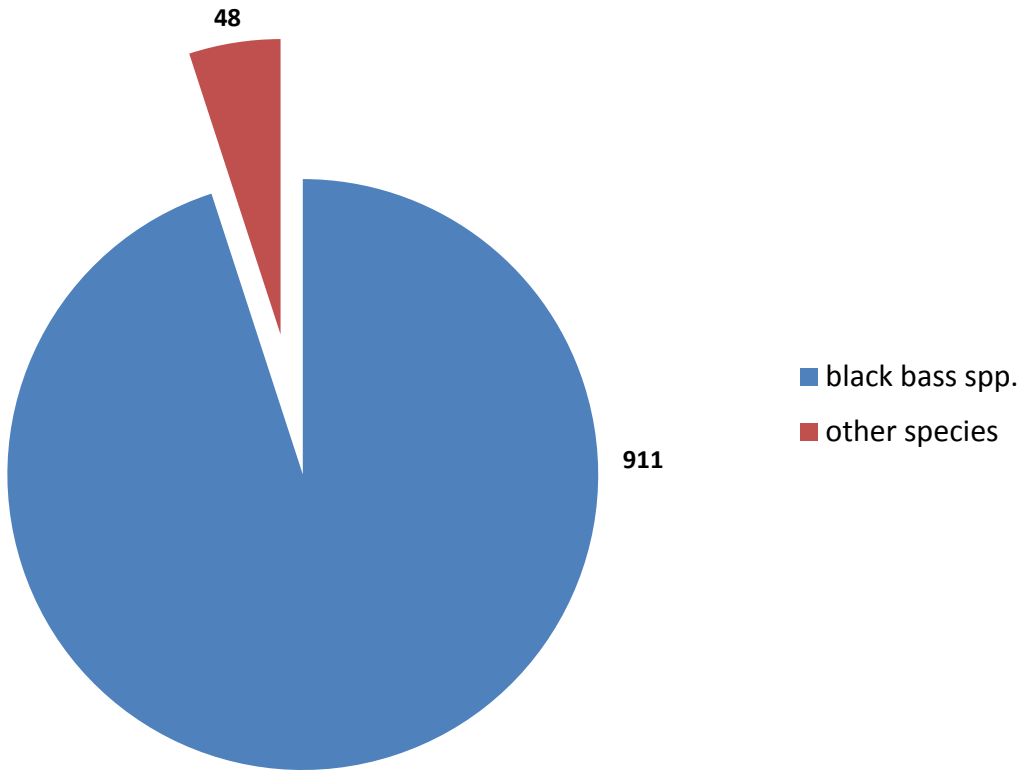

Figure 8.1.4.2. Distribution of organized tournaments by target species reported through the PFBC Special Activities Permit (SAP) systems for all reaches of the West Branch Susquehanna and Susquehanna rivers for the period of 2005 through 2009.

Angler logbooks

The PFBC asks that anglers record their activities in Angler Logbooks to provide Commission staff with information about angler use and exploitation at various waterbodies around the Commonwealth. To date, no water-specific Angler Logbooks have been issued for the West Branch Susquehanna or Susquehanna rivers. Presently, the PFBC is utilizing two Angler Logbook methodologies for data gathering purposes: a general angler logbook which is in use on the Delaware River and a Muskellunge Angler Logbook, a new state-wide effort to collect angler use and harvest data pertaining to muskellunge angling.

It is anticipated that an electronic angler log will be available in the future at the PFBC webpage (www.fish.state.pa.us) that will allow anglers to log catches into an online database. This will also allow anglers to view and print their own results and keep track of their catches. Also, data compilation and analysis will be streamlined by limiting data entry needs and reducing overhead costs.

Economic value

The Juniata/Susquehanna River Creel Survey 2007 provided an estimate of the economic importance of recreational angling for the portion of the Susquehanna River from Sunbury, Pennsylvania to the Holtwood Dam (Shields 2009). The economic contribution or the total economic output generated and supported by all anglers, and related spending totaled $2.309 million and supported 49 full time equivalent jobs in the economy through direct (38 jobs) and ripple effects (11 jobs). The economic impact or the amount of money attributable to angling alone, for this section of the Susquehanna River is estimated to be $1.9 million dollars annually.

Estimates of the economic value for other sections of the West Branch Susquehanna River and Susquehanna River were not determined. A general estimate of recreational value of the West Branch Susquehanna Watershed was generated by Hansen and others (2008) in an economic benefits analysis of the watershed in the context of AMD remediation; however, this included the West Branch Susquehanna River watershed and not just the river itself.

8.1.5 Fish Consumption Advisories

Fish consumption advisories are developed each year through an interagency workgroup lead by the Pennsylvania Department of Environmental Protection (PADEP) in conjunction with the PFBC, Department of Agriculture, and the Department of Health. These advisories are conservative estimates designed to protect the most susceptible portion of the population: pregnant women, women of childbearing age, and young children. A meal is considered one half pound (8 oz.) of fish for every 150 pounds of body weight.

The West Branch Susquehanna and Susquehanna rivers fall under the state-wide blanket advisory that calls for a one meal per week restriction based on mercury concentrations. Outside of the blanket advisory for mercury, there are very few advisories in place for these waterbodies (Tables 8.1.5.1-8.1.5.2).

Table 8.1.5.1. Fish consumption advisories in place for the West Branch Susquehanna River.

Section	Species (common)	Meal frequency	Contaminant	Comment
All	All gamefish species	one meal per week	mercury	state-wide recommendation
5	channel catfish	one meal per month	PCB	
6	channel catfish	one meal per month	PCB	extends to Interstate 80 bridge

Table 8.1.5.2. Fish consumption advisories in place for the Susquehanna River.

Section	Species (common)	Meal frequency	Contaminant	Comment
All	All gamefish species	one meal per week	mercury	state-wide recommendation
3 - 10	channel catfish	one meal per month	PCB	
6 - 10	common carp	one meal per month	PCB	begins at Rt. 92 bridge (Falls)
1 - 2	fallfish	two meals per month	mercury	
6 - 10	quillback	one meal per month	PCB	begins at Rt. 92 bridge (Falls)
1 - 2	smallmouth bass	two meals per month	mercury	
6 - 7	smallmouth bass	two meals per month	mercury	begins at Rt. 92 bridge (Falls)
8 - 10	smallmouth bass	one meal per month	mercury	
6 - 10	sucker species	DO NOT EAT	PCB	begins at Rt. 92 bridge (Falls)
3 - 6	walleye	one meal per month	mercury	ends at Rt. 92 bridge (Falls)
6 - 10	walleye	one meal per month	PCB	begins at Rt. 92 bridge (Falls)

8.2 Commercial Fishing and Guided Fishing Industry

Commercial fishing industry

There are no conventional commercial fisheries presently operating on these rivers. Historically, there were substantial commercial fisheries in operation for American shad in the Susquehanna River extending as far north as the New York state border. Records indicate that the first commercial shad fishery in the Susquehanna River was created in the Wyoming Valley in the 1750s. These fisheries flourished into the early 1800s and were said to be the most valuable crop for this portion of the state. The initial decline of the commercial fishery began during the early 1800s with construction of dams to service mills and canals. American shad were functionally eliminated from the drainage after the construction of Conowingo Dam in 1928. Despite a slight resurgence around the turn of the 20th century with the breaching of many canal dams as railroads became more prominent, the general trend in catch rates during that period were declining until the fishery's ultimate collapse in the 1920s. Recent efforts are underway to reestablish American shad populations to levels that will allow recreational fishing but a commercial fishing industry will likely not be reestablished (SRAFRC undated). To a lesser extent, commercial fisheries existed for American eels and Atlantic sturgeon. Like the American shad fisheries, these two fisheries collapsed largely due to the fragmentation of habitat created by the construction of dams in the lower Susquehanna River and overharvesting (USFWS Chesapeake Bay Field Office, 2009).

Guided fishing industry

Beginning January 1, 2006, all commercial charter boat operators and fishing guides are required to obtain a permit in order to operate in the waters of the Commonwealth of Pennsylvania (Act 159 of 2004 (House Bill 2155)). The PFBC is tasked with regulating and issuing these permits. Guides and charter boat operators are required to apply for a permit annually. The PFBC maintains the list of permitted guides and charter boat operators for public viewing on its website (www.fish.state.pa.us) and also provides this list to tourism promotion agencies, chambers of commerce, and convention and visitors bureaus for distribution to potential clientele.

Numerous guides (Appendix A, Table 8.2.1) presently operate on the West Branch Susquehanna and Susquehanna rivers and this practice has become a substantial part of the fishery and local economies. The number of guides permitted by the PFBC varies annually. Most commonly, guides on these waterbodies target smallmouth bass; however, in recent years there has been an increased popularity in walleye, muskellunge, and common carp.

Economic value

Shields (2009) description of the economic impact of recreational angling for the Susquehanna River from Sunbury, Pennsylvania to the Holtwood Dam does not assign a specific value to commercial fisheries.

8.3 Stock assessment and monitoring

8.3.1 Historic stock assessments and monitoring

Stock assessment and monitoring have been conducted by the Bureau of Fisheries, Division of Fisheries Management or other divisions within the PFBC dating back to the 1930s. This subsection describes historic stock assessments and monitoring surveys by general, river reach.

West Branch Susquehanna River

The earliest record of surveys related to management of recreational fisheries in the West Branch Susquehanna River were conducted by Sorenson in 1931and 1932 These surveys assessed the feasibility of stocking warmwater fishes within the limits of Cambria and Clinton counties in what are currently sections 01 and 04 – 05, respectively. Sorenson's survey in Cambria County (1931a) documented pollution, presumably abandoned mine drainage (AMD) This pollution problem coupled with limited angler access were the primary reasons for not recommending stocking this area at that time. Sorenson (1931a) noted that the West Branch Susquehanna River was void of fish with the exception of a "few catfish" in Susquehanna Dam and that recreational angling in this area did not occur. Sorenson's survey in Clinton County (1932) corresponds to a large portion of present Section 04 and a small portion of Section 05. Based on these results, the West Branch Susquehanna River flowing through Clinton County was not approved for stocking of any fish species due to pollution by "sulfur water". No fish were documented during the Sorenson (1932) survey.

Fisheries biologists have utilized toxicants, such as rotenone, to sample fish populations since the 1930s (Bettoli and Maceina 1996). Trembley and Bielo (1957) performed a spot rotenone treatment at the northern shore of the West Branch Susquehanna River immediately downstream from the confluence of Pine Creek in what is currently Section 05. Eight fish species were collected during the survey. Game fish species included smallmouth bass, rock bass *Ambloplites rupestris*, white suckers *Catostomus commersoni*, and northern hog suckers *Hypentelium nigricans*. Relative abundance was reported as "scarce" or "light" for each species collected. It was reported that a strong chemical odor emanating from the water at the survey location was noted and the cause of the odor may have resulted in the low abundance of fish collected. Additionally, it was believed that some of the fish captured may have emigrated from Pine Creek and were likely not residents of the mainstem.

Reed (1970) surveyed a backwater channel of the tailrace of Curwensville Reservoir on July 12, 1970 in response to public observations about increased occurrences of acute AMD pollution events. Backpack electrofishing yielded chain pickerel, brown bullheads *Ameiurus nebulosus*, golden shiners *Notemigonus crysoleucas*, white suckers, pumpkinseeds *Lepomis gibbosus*, and common carp. During a previous survey conducted April 15, 1969, the same species were captured and no mortalities as a result of changes in water quality were noted during either of the two surveys.

Hollender and others (1981) surveyed historical Sections 06 and 07 (presently the downstream portion of Section 02 and all of Section 03) in June 1980 to evaluate the existing fish community

and to determine whether game fish populations were sufficient to require management. A total of 19 species of fish were captured during the survey, including eight species of game fish. Catch rates for all species were low. The most abundant game fish species were chain pickerel (8.5 fish/hr), fallfish (numbers not presented), rock bass (10 fish/hr), and black crappie *Pomoxis nigromaculatus* (4.2 fish/hr). Conditions appeared favorable for smallmouth bass and tiger muskellunge and a trial stocking was recommended. Additionally, it was recommended to discontinue northern pike *Esox lucius* stocking as they did not appear to be reproducing as expected. Finally, with recent changes to management of this section and trial introductions of new species, it was further recommended that inventories be conducted every five years. Hollender and Wilberding (1986) reinventoried this reach in 1985 to evaluate the response of the trial introductions of smallmouth bass and tiger muskellunge. The survey yielded 16 smallmouth bass of three age classes in 2.2 hours of sampling (7.27 fish/hr). Smallmouth bass from each of the 1982 and 1983 year-classes were collected during the reinventory as well as young-of-year (YOY) individuals, suggesting that natural reproduction had occurred. Growth rates of adult smallmouth bass were similar to populations residing in the downstream sections of the West Branch Susquehanna River. Tiger muskellunge were common in this reach despite only one stocking; however, the authors indicated that these individuals could have emigrated from Curwensville Reservoir, which received several plants of tiger muskellunge during this timeframe. Additionally, channel catfish were captured during the survey for the first time in this section of the West Branch Susquehanna River, and likely emigrated from Curwensville Reservoir. Channel catfish were stocked in the reservoir in 1976 but there are no records of plants in the West Branch Susquehanna River. Also captured during this survey were fallfish *Semotilus corporalis*, yellow perch *Perca flavescens*, pumpkinseed, bluegill, white crappie *Pomoxis annularis*, rock bass, chain pickerel, northern pike, largemouth bass *Micropterus salmoides*, brown bullhead, brown trout *Salmo trutta* and rainbow trout *Oncorhynchus mykiss*. The results of this survey suggested that smallmouth bass had established a low-density, naturally reproducing population and tiger muskellunge emigration from the annual plants at Curwensville Reservoir would be sufficient to maintain an adequate recreational fishery for those species. As such, it was recommended to discontinue stocking of both smallmouth bass and tiger muskellunge in this reach.

Weber and Hollender (1992) surveyed the West Branch Susquehanna River near the confluence of Hogback Run, in what is currently Section 03, to determine the feasibility of creating a put-and-take catchable trout fishery. The impetus for exploring this management option was recent anecdotal reports of improved water quality, as well as, mitigation for lost trout fishing opportunities due to the recent removal of nearby streams from the catchable trout stocking program. The survey documented both low species diversity and abundance due to chronic AMD pollution. Common carp, white suckers, and rock bass were the only species captured during the survey. Based on these results it was not recommended to implement a catchable stocked trout program for this section of the West Branch Susquehanna River due to potential loss or movement of stocked trout from this section in response to both periodic and chronic poor water quality conditions.

Weber and Hollender (1992) surveyed walleye and muskellunge populations in the West Branch Susquehanna River between Jersey Shore, Pennsylvania and the mouth, (downstream portions

of Section 05 and the entirety of Section 06) to evaluate the potential of a fishery for both species. During the survey, a total of 13 muskellunge (322 mm-1130 mm total length (TL), 0.53 fish/hr)) and 17 adult walleye (225 mm – 600 mm TL, 0.69 fish/hr) were captured. No YOY walleye were captured but comparison of aged fish to stocking records indicated that natural reproduction was occurring, and survival of both naturally reproducing populations and stocked populations was also low. Similar to walleye, no YOY muskellunge were captured. All muskellunge captured were purebred muskellunge, not tiger muskellunge stocked by the PFBC. As a result, it was believed that muskellunge were reproducing in the river naturally and survival of stocked fingerling tiger muskellunge was low. Based on these results, it was recommended to increase stocking rates of walleye fry to 10 million individuals annually and evaluate survival during fall, while continuing to monitor adult and YOY walleye populations. Additionally, it was recommended to discontinue tiger muskellunge stocking and to manage the naturally reproducing population of muskellunge by enacting more restrictive size and creel limits. Hollender and others (1992) surveyed Section 06, between Montoursville, Pennsylvania and the mouth, during summer and fall 1992 to evaluate the survival of summer stocked walleye fry; the status of the adult walleye stocks; and to monitor muskellunge stocks. Monitoring was done at four locations in August and nine locations in October. During both surveys, no YOY walleye were captured. The August survey yielded 37 adult walleye (300 mm – 650 mm TL, 7.25 fish/hr) and two adult muskellunge (485 mm and 1054 mm TL, 0.39 fish/ hr). The October survey yielded 39 adult walleye (325 mm – 700 mm TL, 4.43 fish/hr), three muskellunge (294 mm, 627 mm, 1013 mm TL, 0.34 fish/hr) and 3 tiger muskellunge (225 – 249 mm TL, 0.23 fish/hr). Scale analysis indicated that walleye captured in this section of the West Branch Susquehanna River were growing more rapidly than the state-wide average and reached the legal length of 15 inches (381mm) in their second or third year of life. Muskellunge captured in this reach were growing at a rate similar to the state-wide average. It was recommended to annually monitor walleye stocks to further assess the efficacy of management changes including the increase of stocking rates of walleye fry to 10 million individuals annually. However, in 1995, stocking of walleye fry was discontinued and walleye fingerlings were stocked due to apparent low survival of walleye fry (Kristine 1994). Kristine and Hollender (1996) found that walleye fingerlings also failed to produce detectable numbers of YOY during fall sampling and stocking of any lifestage of walleye in Section 06 was discontinued with no additional stocking in Section 06 from 1996 to present. Kristine and Hollender (1996) also recommended increasing the minimum size limit for muskellunge to 1016 mm (40 in.) and reducing the daily creel limit to one per day. While this recommendation was not approved, the minimum size limit and daily creel limit for muskellunge have recently been changed to 1016 mm (40 in.) and one per day on all Commonwealth waters.

Hollender and Kristine (1999) inventoried the West Branch Susquehanna River between Bower, Pennsylvania and the confluence of Chillisquaque Creek near Northumberland, Pennsylvania (Sections 02-06) during June and July 1998. The survey was conducted in response to requests from the city of Lock Haven, Pennsylvania to improve fish passage at the Grant Street Dam and consider stocking to support a seasonal trout fishery in the vicinity of Clearfield and Curwensville, Pennsylvania. A total of 45 fish species were collected during the survey and ranged from four to 28 species at any one site. A region of poor diversity between Clearfield, Pennsylvania and Hyner, Pennsylvania was attributed to severe AMD pollution. Smallmouth

bass (CPUE = 32.17 fish/hr., range = 0.00 – 166.67 fish/hr.), rock bass (CPUE = 15.45fish/hr., range = 0.00 – 73.33 fish/ hr.), and common carp (CPUE = 12.45fish/hr., range = 0.00 – 51.11 fish/hr.) were the most frequently captured game fish species during the inventory. Age and growth analysis of smallmouth bass and rock bass indicated growth at upstream locations (Bower to Hyner) was slower than downstream locations (Great Island to Chillisquaque Creek). Smallmouth bass reached legal length (300 mm, 12 in.) at age-5+ in the upstream locations and at age 4+ in downstream reaches. Similarly, rock bass reached desirable size (180 mm, 7 in.) at approximately age 5 in upstream locations and approximately age 4 in downstream reaches. Based on the results of the inventory, recommendations were made to divide the West Branch Susquehanna River into their current management sections (Table 8.1.1), stock catchable trout on a limited basis in the vicinity of Clearfield (Section 03), delay fish passage at Grant Street Dam as a result of severe AMD pollution upstream, utilize electrofishing methodologies exclusively for riverine sampling, and extend inventory to include Section 01. Hollender and Kristine (2000) surveyed the West Branch Susquehanna River from the source down to the confluence of Chest Creek (Section 01) in 1999 as a follow-up to the inventory completed the previous year at sections located further downriver. They documented the presence of 27 fish species in low to moderate densities. The three most prevalent game fish throughout Section 01 were fallfish (30.11 fish/hr), white sucker (27.90 fish/hr) and rock bass (16.55 fish/hr). Game fish populations occurred in low densities for all species and were characterized by slow growth rates when compared to state-wide averages. The results indicated that the fish community was considerably more extensive than revealed during the historic inventory and suggests that water quality improved over time, although was still being impacted by AMD and siltation.

Hughey (2003) conducted surveys of the West Branch Susquehanna in the vicinity of the Reliant Energy, Shawville Power Generating Station during spring 2002 and 2003 to assess possible impacts from the plant to the biota residing in the West Branch Susquehanna River. Surveys were conducted upriver from the plant (RM 165), immediately downriver of the plant (RM 164) and at a site further downriver of the plant (RM 160). During these surveys, a total of 16 fish species were captured, including 14 game fish species. Catch rates of game fish were low, with the highest densities of game fish documented at the site nearest the plant (RM 164). The most abundant game fishes at this site were yellow perch (30.89 fish/hr), bluegill (8.58 fish/hr), rock bass (4.50 fish/hr) and smallmouth bass (4.50 fish/hr). It is presumed that the warm water effluent from the plant attracted fishes during this period of the year (spring) and that populations sampled were likely transient. Sampling at river miles 160 and 164 yielded low numbers of fish with a total of 62 fish captured representing 9 species over 4.55 hours of electrofishing.

Detar and Hollender (2006) inventoried smallmouth bass in Section 05 in 2005 as part of a larger re-inventory of game fish populations in the downstream sections of the West Branch Susquehanna River. Sites surveyed were located near the towns of McElhattan, Pennsylvania (RM 61.3), Jersey Shore, Pennsylvania (RM 54.5), and Linden, Pennsylvania (RM 45.1), and were sampled at night using boat electrofishing. Numbers of adult smallmouth bass were low in this reach and catch rates ranged between 4 and 14 individuals per hour. Due to poor habitat and limited populations, it was recommended that these sites be re-inventoried every five years. Detar and Hollender (2006) re-inventoried smallmouth bass and muskellunge populations in

Section 06 during 2005. Historic sampling locations in the vicinity of the towns of Montoursville, Pennsylvania (RM 34.4), Watsontown, Pennsylvania (RM 15.1), and Chillisquaque, Pennsylvania (RM 5.0) were sampled for YOY and adult smallmouth bass. During 2005, adult smallmouth bass catch rates (9-19 fish/hr) were approximately 40% of the 1991-2005 mean for that river reach. Catch rates of YOY smallmouth bass were higher during 2005 at 5-17 individuals per 50 m reach when compared to mean catch rates for the period of 1990-2005 of 4-7 individuals per 50 m reach. Wide-scale *Flavobacterium columnare* (columnaris) infections of YOY smallmouth bass were first documented by the PFBC during 2005 at other locations in the Susquehanna River basin; however, during this survey of the West Branch Susquehanna River, low prevalence of infection of adults (3 of 40) and no infection of YOY smallmouth bass were observed. Two YOY smallmouth bass exhibiting signs of infection were captured during adult surveys outside of the normal YOY index period later in the summer. In addition to smallmouth bass, two muskellunge (919 mm and 975 mm, 0.50 fish/hr) were captured in this reach. Catch rates of muskellunge were similar to previous surveys. This survey, although broader in scope as it included other West Branch Susquehanna River sections, was part of the historic trend-based sampling (Table 8.3.6.1).

Susquehanna River from the New York-Pennsylvania border, including the "Great Bend", downstream to the confluence of the West Branch Susquehanna River

The earliest records of fisheries management activity in the Susquehanna River upriver of the confluence of the West Branch Susquehanna River were surveys conducted by Shoemaker and Sorenson in 1931 and 1932. Shoemaker (1931a) surveyed the Susquehanna County portion of this reach to determine the feasibility of stocking several game fish species. The quality of this reach and the angling opportunities it provided to resident and non-resident fishermen was noted. The presence of black bass, channel catfish, walleye, pickerel, rock bass, sunfish, and yellow perch was documented. Shoemaker recommended stocking black bass, walleye, yellow perch, catfish, and sunfish due to abundant forage. Shoemaker (1931b, 1931c) conducted surveys to determine the feasibility of stocking the Susquehanna River in Bradford County with smallmouth bass and walleye. During the surveys, black bass, walleye, rock bass, yellow perch, catfish, sunfish, suckers, and pickerel were collected and black bass, rock bass, and walleye were most abundant. Based on the results of these surveys, it was recommended to stock black bass, walleye, yellow perch, catfish, sunfish, and suckers to support the high degree of angling pressure exerted at this section of the Susquehanna River by resident and non-resident fishermen. Shoemaker (1931d, 1931e, 1931f) surveyed the portion of the Susquehanna River in Wyoming County to assess the feasibility of managing the fishery for walleye and black bass. Game fish collected during the surveys included walleye, black bass, rock bass, sunfish, pickerel, yellow perch, catfish, suckers, black crappie, and common carp. Walleye, black bass, and rock bass were the most abundant species collected during the survey. Additionally, angler use by resident and non-resident anglers in this area was very high. Based on the results of these surveys, this reach was approved for stocking of black bass (presuming smallmouth bass) and walleye.

Shoemaker (1931g, 1931h, 1931i) surveyed the Susquehanna River in Luzerne and Lackawanna counties for feasibility of managing the fishery for yellow perch, catfish, sunfish,

black bass, and walleye. Angler use in this area was very high and included usage by non-resident anglers. Game fish noted in the surveys include walleye, black bass, rock bass, sunfish, pickerel, yellow perch, catfish, suckers, and carp. As a result of the surveys, these waters were approved for stocking of black bass (presuming smallmouth bass), yellow perch, catfish, sunfish and walleye. Shoemaker (1931j, 1931k, 1931l, 1932a) surveyed the Susquehanna River in Columbia County for feasibility of managing the fishery for yellow perch, catfish, bass, black bass, and walleye. Angler use in this area was low as a result of extensive pollution upstream of Berwick, Columbia and Luzerne counties but angler usage was heavier approaching Bloomsburg, Pennsylvania. Game fish noted in the surveys include walleye, black bass, rock bass, sunfish, pike, yellow perch, catfish, suckers, and common carp. As a result of the surveys, these waters were approved for stocking of black bass (presuming smallmouth bass), yellow perch, catfish, and walleye. Shoemaker (1931m, 1931n, 1932b) commented that angler use in the Montour County portion of this reach was increasing as water quality conditions improved. Game fish targeted by anglers included walleye and black bass. As a result of the surveys, these waters were approved for stocking of black bass (presuming smallmouth bass), yellow perch, catfish, sunfish, and walleye. Sorenson (1931b, 1931c) and Shoemaker (1932c) surveyed the Northumberland County portions of Section 10 for management of black bass and walleye. Sorenson's surveys of this reach in 1931 stated that pollution is abated prior to reaching the county and commented that populations of bass of walleye were present. Sorenson recommended stocking black bass and walleye within this reach. Shoemaker's survey in 1932; however, stated that as a result of pollution and "constant coal operations" between Danville, Pennsylvania and Sunbury, Pennsylvania the "stream is practically unfit for life of fish" and that depressed populations resulted in little fishing pressure. The author did state that black bass, walleye, suckers, catfish, sunfish, and yellow perch were present in the reach.

Campbell (1951) conducted a seine net survey at 27 sites along the Susquehanna River between the New-York Pennsylvania border and a point approximately three miles downstream of Shickshinny, Pennsylvania documenting the relative abundance of game fish captured. Game fish abundance varied throughout the reach with even the most abundant species, smallmouth bass, ranging from very abundant at the most upstream sites down to a single individual in an impacted area near West Pittston, Pennsylvania. Campbell also commented on the abundance of bluegill (not present – rare), common carp (not present – rare), largemouth bass (not present – rare), rock bass (not present - abundant), northern hog suckers (not present – common), white crappie (not present – common), white sucker (not present-common), and yellow perch (not present – abundant). Campbell commented that fish diversity and abundance was affected by pollution through the Wyoming Valley citing that the water "was dirty in appearance" with an "oily scum" and sewage was "noticeable in appearance and smell". However, game fish populations began to rebound in a downriver direction with Campbell stating that anglers indicated that fishing was actually good through that area despite the limited catches in the author's surveys. Anglers cited catches of smallmouth bass, common carp, and bullheads.

Daniels (1967) conducted a survey of the Susquehanna River in the vicinity of the Procter and Gamble Company plant near Mehoopany, Pennsylvania as it neared completion. The survey

yielded 32 species of fish, including 15 species of game fish. This appears to be only a presence-absence survey as numbers of fish captured or effort were not reported. The only comment was that smallmouth bass, rock bass, and fall fish were the most abundant species. Kennedy (1969) reported in a memorandum the results of a another survey conducted by the Academy of Natural Sciences in Philadelphia in the vicinity of the Proctor & Gamble plant in Mehoopany, Pennsylvania. This survey was conducted following completion and initial operation of the plant. The author commented that YOY smallmouth bass were "extremely abundant" and that evidence of walleye reproduction was also occurring near Tunkhannock, Pennsylvania. Eleven species of game fish were collected during this survey but they were not enumerated in the memorandum. A curious species record for the Great Lakes catfish (*Ictalurus nigricans*) was provided in this memorandum. It is thought be a misidentification or an invalid name for the channel catfish but no records of the synonymy could be found. Shiffer and others (1971) surveyed the Susquehanna River in September 1971 in what is now Section 06 pursuant to concerns from local anglers about reduced recruitment of smallmouth bass. The survey found that smallmouth bass recruitment through this reach was strong, with nearly 85% of the 219 captured smallmouth bass being YOY fish. Total electrofishing catch rates for smallmouth bass during this survey was 378 fish/hr. Other game fishes captured during this survey were fallfish, white sucker, northern hog sucker, rock bass, bluegill, pumpkinseed, and walleye.

Daniels and others (1981a) surveyed the Great Bend portion of the Susquehanna River (currently Sections 01 and 02) as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section. The authors enumerated catch of seven species of game fish and only documented presence of 17 non-game fish species within the two sections. Catch rates were calculated for chain pickerel (2.27 fish/hr), rock bass (37.73 fish/hr), pumpkinseed (5 fish/hr), bluegill (1.82 fish/hr), smallmouth bass (54.55 fish/hr), yellow perch (3.64 fish/hr), and walleye (7.27 fish/hr) at Section 01. Catch rates were calculated for muskellunge (0.63 fish/hr), rock bass (6.35 fish/hr), pumpkinseed (0.56 fish/hr), smallmouth bass (16.19 fish/hr), largemouth bass (0.16 fish/hr), yellow perch (1.27 fish/hr), and walleye (4.76 fish/hr) at Section 02. The authors commented that one of the major complaints received was that the abundance of sub-legal length walleyes that appeared similar to over-fishing pressure; however, they believed that it was more likely that the forage base in Section 02 of the river was lacking. Scale analysis indicates that both smallmouth bass and walleye are growing at a rate below the state-wide average. The authors recommend discontinuing the stocking of warmwater species, with the exception of muskellunge, as reproductive potential is more than adequate to sustain populations. Muskellunge stocking was recommended for once every five years with an additional stocking of forage fishes to help sustain those populations. Recommendations were also made to develop periodic evaluations of smallmouth bass and walleye growth and abundance.

Daniels and colleagues (1981b) surveyed Section 03 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section Thirteen game fish species and 26 non-game fish species were captured during the survey. Catch rates were calculated for northern pike (0.33 fish/hr), chain pickerel (0.67 fish/hr), rock bass (34.29 fish/hr), redbreast sunfish *Lepomis auritus* (0.86

fish/hr), pumpkinseed (7.01 fish/hr), bluegill (3.35 fish/hr), smallmouth bass (60.63 fish/hr), largemouth bass (0.70 fish/hr), white crappie (1.54 fish/hr), black crappie (0.17 fish/hr), yellow perch (1.37 fish/hr), walleye (11.10 fish/hr) and channel catfish (0.19 fish/hr). As with the Great Bend portion, anglers commonly complained about the high abundance of sub-legal length walleyes, due to what was perceived to be the result of over fishing; however, the stunted walleye population was more likely attributable to a shortage of forage in this section of the river. Scale analysis indicated that both smallmouth bass and walleyes were growing at a rate below the state-wide average. Based on the results of this survey, it was recommended to discontinue plants of warmwater fishes, with the exception of muskellunge, as natural reproduction was adequate to sustain those populations. Muskellunge was recommended to be stocked every five years accompanied by plants of forage fishes. Additionally it was recommended to periodically evaluate smallmouth bass and walleye growth and abundance.

Daniels (1981) surveyed Section 04 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section. Six species of game fish and 17 species of non-game fish were captured during the survey. Catch rates were calculated for rock bass (28.30 fish/hr), green sunfish *Lepomis cyanellus* (0.60 fish/hr), pumpkinseed (1.1 fish/hr), bluegill (0.60 fish/hr), smallmouth bass (112.2 fish/hr), and walleye (5.00 fish/hr). As with the upriver reaches, anglers commonly complained about the high abundance of sub-legal length walleyes, due to what was perceived to be the result of over fishing; however, the stunted walleye population was more likely attributable to a shortage of forage in this section of the river. Scale analysis indicates that both smallmouth bass and walleyes were growing at a rate below the state-wide average. Based on the results of this survey, it was recommended to discontinue plants of warmwater fishes, with the exception of muskellunge, as natural reproduction was adequate to sustain those populations. Muskellunge was recommended to be stocked every five years accompanied by plants of forage fishes. Additionally it was recommended to periodically evaluate smallmouth bass and walleye growth and abundance.

Daniels (1983a) surveyed Section 05 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section. Twelve species of game fish and 20 non-game fish species were captured during the survey. Catch rates were calculated for chain pickerel (0.38 fish/hr), tiger muskellunge (0.20 fish/hr), rock bass (25.08 fish/hr), redbreast sunfish (0.80 fish/hr), green sunfish (0.40 fish/hr), pumpkinseed (2.94 fish/hr), bluegill (3.38 fish/hr), smallmouth bass (70.84 fish/hr), largemouth bass (0.20 fish/hr), black crappie (0.30 fish/hr), yellow perch (0.30 fish/hr), and walleye (1.56 fish/hr). As with upstream sections, anglers commonly complained about the high abundance of sub-legal length walleyes, due to what was perceived to be the result of over fishing; however, the stunted walleye population was more likely attributable to a shortage of forage in this section of the river. Scale analysis indicates that both smallmouth bass and walleyes were growing at a rate below the state-wide average. Based on the results of this survey, it was recommended to discontinue plants of warmwater fishes, with the exception of muskellunge, as natural reproduction was adequate to sustain those populations. Muskellunge was recommended to be stocked every five years accompanied by plants of forage fishes.

Additionally it was recommended to periodically evaluate smallmouth bass and walleye growth and abundance.

Daniels (1983b) surveyed Section 06 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section. Ten game fish and 18 non-game fish species were captured during the survey. Catch rates were calculated for chain pickerel (0.13 fish/hr), rock bass (93.75 fish/hr), redbreast sunfish (0.75 fish/hr), green sunfish (0.25 fish/hr), pumpkinseed (4.88 fish/hr), bluegill (2.75 fish/hr), smallmouth bass (CPUE = 78.50 fish/hr), black crappie (0.38 fish/hr), yellow perch (0.63 fish/hr), and walleye (2.00 fish/hr). As with upstream reaches, anglers commonly complained about the high abundance of sub-legal length walleyes, due to what was perceived to be the result of over fishing; however, the stunted walleye population was more likely attributable to a shortage of forage in this section of the river. Scale analysis indicates that both smallmouth bass and walleyes were growing at a rate below the state-wide average. Based on the results of this survey, it was recommended to discontinue plants of warmwater fishes, with the exception of muskellunge, as natural reproduction was adequate to sustain those populations. Muskellunge was recommended to be stocked every five years accompanied by plants of forage fishes. Additionally it was recommended to periodically evaluate smallmouth bass and walleye growth and abundance.

Daniels (1983c) surveyed Section 07 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section Five species of game fish and 14 non-game fish species were captured during the survey. Catch rates were calculated for rock bass (3.50 fish/hr), pumpkinseed (0.50 fish/hr), bluegill (0.50 fish/hr), smallmouth bass (25.00 fish/hr), and walleye (2.50 fish/hr). Both diversity and catch rates were lower than neighboring sections as this reach is rebounding from a legacy of pollution. The authors commented that there had been no reports made of catches of both sub-legal length walleyes and smallmouth bass in this section but historically little angling activity took place as a result of the depressed fish community. Scale analyses for age and growth were not available as there was little existing data available for this section. The authors recommended management of this section as a warmwater fishery sustained by natural reproduction.

Daniels (1983d) surveyed Section 08 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section. Smallmouth bass and rock bass were found to be the primary fishery in this reach with walleye and muskellunge also being highly targeted species by recreational anglers. Ten species of game fish 17 non-game fish species were captured during the survey. Catch rates were calculated for chain pickerel (0.25 fish/hr), rock bass (10.25 fish/hr), green sunfish (1.5 fish/hr), pumpkinseed (2.25 fish/hr), bluegill (3.00 fish/hr), smallmouth bass (15.00 fish/hr), largemouth bass (0.50 fish/hr), black crappie (0.25 fish/hr), yellow perch (1.00 fish/hr), and walleye (0.50 individuals per hour). Catch rates of smallmouth bass and walleye, two of the most targeted game fish species, were lower than the immediate upstream section likely as a result of chronic pollution. As with some other reaches, anglers commonly complained about the high abundance of sub-legal length walleyes. Walleye surveys yielded too few individuals of

each age class to develop a catch curve to determine the reason fish were not reaching legal length. Scale analyses for age and growth were not available as there was little existing data available for this section. The authors recommended management of this section as a warmwater fishery sustained by natural reproduction.

Daniels (1984a) surveyed Section 09 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section. Smallmouth bass and rock bass were found to be the primary fishery in this reach with walleye and muskellunge also being highly targeted species by recreational anglers. Eleven species of game fish and 14 non-game fish species were captured during the survey. Catch rates were calculated for chain pickerel (0.50 fish/hr), muskellunge (1.00 fish/hr), rock bass (27.25 fish/hr), redbreast sunfish (0.75 fish/hr), green sunfish (0.25 fish/hr), pumpkinseed (1.00 fish/hr), bluegill (0.75 fish/hr), smallmouth bass (11.50 fish/hr), largemouth bass (0.25 fish/hr), black crappie (0.25 fish/hr), and walleye (1.00 fish/hr). Catch rates of smallmouth bass and walleye, two of the most targeted game fish species, were lower than far upstream sections (01-05) likely attributable to chronic pollution. At the time of the survey, anglers commonly complained about the abundance of sub-legal length walleyes as well as a decrease in overall numbers, thought to be a result of the construction of the inflatable dam at Sunbury, Northumberland County. Smallmouth bass and walleye surveys yielded too few individuals of each age class to develop a catch curve to determine the reason fish were not reaching legal length. Scale analyses for age and growth were not available as there was little existing data available for this section. The authors recommend management of this section as a warmwater fishery sustained by natural reproduction.

Daniels (1984b) surveyed Section 10 of the Susquehanna River as part of the Warmwater River and Stream Inventory Program to characterize the resource prior to initiation of fisheries management by section. Smallmouth bass and rock bass were found to be the primary fishery in this reach with walleye and muskellunge also being highly targeted species by recreational anglers. Ten species of game fish and 18 non-game fish species were captured during the survey. Catch rates were calculated for rock bass (5.67 fish/hr), redbreast sunfish (3.67 fish/hr), green sunfish (3.17 fish/hr), pumpkinseed (4.83 fish/hr), bluegill (3.93 fish/hr), smallmouth bass (20.33 fish/hr), largemouth bass (0.17 fish/hr), black crappie (0.67 fish/hr), yellow perch (0.50 fish/hr) and walleye (1.67 fish/hr). Catch rates of smallmouth bass and walleye, two of the most targeted game fish species, were lower than far upstream sections (01-05); likely a result of chronic pollution and channel disruption from coal fine dredging. At the time of the survey, anglers commonly complained about the abundance of sub-legal length walleyes as well as a decrease in overall numbers, thought to be a result of the construction of the inflatable dam at Sunbury, Pennsylvania. Fishing pressure during this time increased substantially and over-fishing appeared to result in an abundance of sub-legal length walleyes. Sunfish catch rates in this reach during the time of survey were higher than in all other sections and suggested modest populations. Scale analyses for age and growth were not available as there was little existing data available for this section. The authors recommended management of this section as a warmwater fishery sustained by natural reproduction.

The Academy of Natural Sciences of Philadelphia, Division of Environmental Research (1984) conducted a survey of the Susquehanna River in the vicinity of the Procter and Gamble Company plant near Mehoopany, Pennsylvania to determine what, if any, effects the plant and its wastewater effluent had on the biota of the Susquehanna River. The survey yielded 21 species of fish, including nine species of game fish. The dominant game fish captured in their survey was fallfish, which surpassed the next two most dominant species, northern hog suckers and smallmouth bass, by an order of magnitude. Young-of-year smallmouth bass which are usually abundant during their surveys were rare and believe to be tied to the lack of algal mats and weeds that they usually use as shelter or warm water temperatures.

Weston (1987) conducted an investigation of Section 04 of the Susquehanna River to assess the impacts of the discharge from GTE Products Corporation near Towanda, Pennsylvania. A total of 33 species of fish, including 17 game fish species were collected during the survey. Smallmouth bass, fallfish, white sucker, and rock bass were the most abundant game fish species captured. Effort was not reported so catch rates were not calculated for comparisons to other years and locations.

Copeland and others (1997) surveyed Sections 07 and 08 of the Susquehanna River as part of a larger effort to obtain current fish population data; gather baseline data for prediction of effects of proposed inflatable dam near Wilkes-Barre, Pennsylvania; update species occurrence; and assess natural reproduction of existing walleye populations. Three locations were sampled as part to of this effort: near Pittston, Pennsylvania; Kingston, Pennsylvania; and Shickshinny, Pennsylvania. Seine hauls in pool margins showed abundant young-of-year smallmouth bass. Adult smallmouth bass were not enumerated due to the amount of time spent processing the young-of-year fish. Walleye (65.41 fish/hr), rock bass (24.75 fish/hr), and white sucker (6.54 fish/hr), and were the most abundant game fish species captured during night electrofishing activities. Despite high catch rates of walleyes, the proportion of this catch attributable to legal length individuals (those 15 inches or greater) was low (4.17 fish/hr).

Susquehanna River, confluence of the West Branch Susquehanna River downstream to the Maryland-Pennsylvania border

The earliest surveys of this portion of the Susquehanna River were conducted by Shoemaker during 1931 and 1932. Shoemaker's survey of Northumberland County downstream from the confluence of the West Branch Susquehanna River (1932d) cites the presence of black bass, walleye, yellow perch, catfish, and suckers. At the time of the survey it was not recommended to stock any species of fish due to low angler use attributable to poor water quality resulting from sewage discharge from Sunbury, Northumberland County and abandoned mine drainage from Shamokin and Mahanoy creeks on the east side of the river, however, it was noted that fishing occurred on the west side of the river. Shoemaker (1932e) surveyed the Susquehanna River in Perry County to determine the feasibility of management for walleye. The survey documented the presence of smallmouth bass, walleye, sunfish, catfish, yellow perch, and suckers. Based on the survey results, stocking of smallmouth bass, walleye, yellow perch, catfish, sunfish, and suckers was recommended, but no indication of numbers of fish to be stocked or locations were given. Shoemaker (1932e) also surveyed the portion of the Susquehanna River flowing through Cumberland County to determine the feasibility of

managing this water for walleye. The survey documented the presence of smallmouth bass, walleye, suckers, rock bass, catfish, carp, and sunfish, and it was recommended to stock walleye, smallmouth bass, yellow perch and catfish in this portion of the river. At the time of the survey, fishing pressure was high in this area and was restricted to the Cumberland County portion of the river due to "coal pollution" emanating from the eastern shore. Additionally, Shoemaker (1931o, 1931p, 1932f, undated) surveyed the portion of the Susquehanna River flowing through York and Lancaster counties to provide insight regarding the management of black bass and walleye. The survey encompassed portions or the entirety of what are present day Sections 14-18; however, several comments regarding stocking focused on the river in the vicinity of the towns of Columbia, Pennsylvania and Marietta, Pennsylvania. High angler use occurred in this section of river from anglers targeting black bass, walleye, yellow perch and pickerel. Noted were the presence of previously mentioned species as well as black crappie, rock bass, sunfish, catfish, suckers, carp, and eels. Stocking of black bass and walleye was approved based on survey results, and it was additionally recommended to stock catfish, sunfish, and yellow perch due to high angler use and availability of suitable habitat.

Jackson and others (1986a) surveyed Section 11 of the Susquehanna River as part of an inventory and classification of warm-water fisheries. In total, 20 species of fish were captured during this survey with 15 of these being game fish species. Catch rates were calculated for rock bass (2.63 fish/hr), smallmouth bass (16.84 fish/hr), and black crappie (6.84 fish/hr). Neither walleyes nor muskellunge were captured during the survey despite anecdotal reports of angler catches. At the time of the survey, suitable gamefish habitat was very limited in this section of the Susquehanna River which was reflected by the relatively depressed fishery. It was recommended to provide annual supplemental stockings of walleyes at a density of 25 individuals per hectare (ha) (2,380.95 per km) for five consecutive years until a re-inventory was conducted to evaluate the success of these plants. Additionally, it was recommended to stock fingerling muskellunge on an alternate year basis at a density of 199.5 per ha (47 per km) to provide a trophy esocid fishery for local anglers.

Jackson and others (1986b) surveyed Section 12 of the Susquehanna River as part of the initial inventory and classification of warm-water fisheries. In total, 32 species of fish were captured in Section 12 including 15 species of game fish. The results were analyzed from paired sampling sites on each side of the river, and there were no statistical difference between game fish populations sampled from the eastern and western shores. The three most prevalent game fish species were redbreast sunfish (16.89 fish/hr), smallmouth bass (14.30 fish/hr), and rock bass (9.18 fish/hr). Neither walleyes nor muskellunge were captured during this survey, but these species were represented during previous surveys within this section. Catch rates of smallmouth bass were significantly lower than during a similar survey in 1979, likely due to differences in sampling timeframe (i.e., September – October 1979 versus July-August 1984). Based on the survey results, it was recommended that fingerling muskellunge stocking continue on an alternate-year basis at a rate of 0.64 per ha (62 per km) and that walleye fry be stocked annually at a rate of 517.4 per ha (50,675 per km) for five years and the success of these plants be evaluated during re-inventory.

Jackson and others (1986c) surveyed Section 13 of the Susquehanna River as part of an initial inventory and classification of warm-water fisheries. During the survey, a total of 26 species were collected including thirteen sport fish species. The three most prevalent sport fish species were smallmouth bass (62.63 fish/hr), rock bass (3.35 fish/hr), and redbreast sunfish (2.64 fish/hr). During the survey, no walleyes and only one muskellunge were captured. It was recommended to stock fingerling muskellunge on an alternate year basis at a rate of 0.6 per ha (62 individuals per km) and to annually stock walleye fry at a density of 519.5 per ha (54,054 individuals per km) for five years and the success of these plants be evaluated during a re-inventory.

Jackson and others (1986d) surveyed Section 14 of the Susquehanna River in 1984 as part of the initial inventory and classification of warm-water fisheries. During the survey, a total of 16 species were collected including thirteen species of sport fish. The fishery was sampled using trap nets and boat electrofishing gear as most of the study reach was impounded by York Haven Dam. Trap nets yielded low catch rates (1.58 fish/hr), which was consistent with other studies conducted in the vicinity. The three most prevalent sport fish species were smallmouth bass (22.00 fish/hr), rock bass (3.35 fish/hr), and redbreast sunfish (2.64 fish/hr). Smallmouth bass electrofishing catch rates were lower than the statewide average for major rivers (28.3 fish/hr); however, catch rates of larger fish were similar to or higher than the statewide average. During the survey, no walleyes or muskellunge were captured; however, those species were represented during previous surveys. Based on the survey, it was recommended to stock fingerling muskellunge on an alternate year basis at a rate of 2.6 individuals per ha (123.3 per km) and to annually stock walleye fry and fingerlings at a density of 971 individuals per ha (46, 044.5 per km) and 10.2 individuals per ha (483.7 per km), respectively, for five years until evaluation could be conducted. Additionally, it was recommended to discontinue plants of hybrid striped bass as the forage base present in this reach was limited during the time of the survey, but reinstituting plants should be considered in the future should the forage base rebound.

Jackson and Shiels (1993) conducted a survey to determine effects of regulation changes on the smallmouth bass population. Sites at Clemson Island and Rockville were sampled as part of a paired control site upstream from areas under the influence of newly imposed Big Bass regulations and compared to sites at Dock Street Dam and the Pennsylvania Turnpike Commission Bridge that were subject to regulation under Big Bass regulations. Catch rates at upriver sites were reported for 1990 (76.14 fish/hr) before imposition of regulations and in 1991, 1992, and 1993 (209.21, 210.1, and 164.04 fish/hr, respectively) after imposition of regulations. Catch rates for downriver locations were reported for 1990 (114.74 fish/hr) before imposition of regulations and in 1991, 1992, and 1993 (267.92, 257.71, and 277.94 fish/hr, respectively) after imposition of regulations. Based on these results it was recommended to continue Big Bass regulations at the portion of the Susquehanna River from Dock Street Dam to Holtwood Dam and to expand Big Bass regulations upriver to the inflatable dam in Sunbury, Pennsylvania. Additionally, an alternative regulation to increase the minimum harvestable length limit to 17 inches (432 mm) was proposed, contingent upon angler opinion, essentially eliminating legal harvest of 97.7-99.1% of the population.

Acres International Corporation (2004) surveyed YOY walleye abundance both upriver of and within Lake Clarke to evaluate the effects that increasing pool elevation would have on walleye recruitment. An upriver control site located upstream from Chickies Rock and a treatment site located within the impoundment of Lake Clarke were sampled. Catch rates of YOY walleyes were 3.00 fish per hour at the Chickies Rock site. While not the target age group, adult walleye catch rates were reported at 1.00 individual per hour. Other game fish species captured during this survey were smallmouth bass (9.0 fish/hr), rock bass (2.5 fish/hr), green sunfish (2.5 individuals per hour), channel catfish (3.0 fish/hr), common carp (2.5 fish/hr), and white suckers (1.0 fish/hr). Catch rates for YOY walleyes was 0.5 fish per hour at the Lake Clarke treatment site. While not the target age group, adult walleye catch rates were also reported at 0.5 individuals per hour. Other game fish species during this survey were smallmouth bass (3.0 fish/hr), pumpkinseed (3.5 fish/hr), green sunfish (1.5 fish/hr), channel catfish (0.5 fish/hr), common carp (3.0 fish/hr), and brown bullhead (0.5 fish/hr).

Several survey reports were completed annually pertaining to a reach comprised of the series of hydropower impoundments as part of permit requirements for the PPL Brunner Island Steam Generating Facility, the York Haven, Safe Harbor and Holtwood dams and their respective power generating facilities, and the Peach Bottom Atomic Power Station. These comprise a large portion of the published fisheries data for this reach of the Susquehanna River. These reports included multiple gear and multiple habitat surveys and focused primarily on fish community assemblage information. These survey reports documented catch of game fish species, but did not report levels of effort, limiting accurate computation for stock assessments and trend monitoring. Due to the format of the data and the survey methodologies employed, these data will be addressed in the *Riverine Biota* portion of this management plan (Section 7.1, Fish Communities).

On-going stock assessments and monitoring

The PFBC, Bureau of Fisheries, DFM staff currently conduct annual surveys in the downriver section of the West Branch Susquehanna River and throughout the Susquehanna River to track trends in game fish populations. Directed surveys for YOY smallmouth bass, adult smallmouth bass, and YOY walleye are focused on habitats and conditions that allow for representative and comparable results on which to base management actions. Although not the target of directed sampling events, all game fish species are collected during these surveys to provide quantitative estimates of the populations of those species as well. YOY smallmouth bass surveys are conducted in late-June to mid-July annually as part a larger effort to develop a statewide recruitment index for black bass species. More recently, this sampling has filled a dual role in that it also provides vital information about prevalence and distribution of disease within smallmouth bass populations. Adult smallmouth bass are surveyed at different reaches of the rivers at different periods of time based on the historic data set. These surveys gather information on the relative abundance of catchable-size smallmouth bass and are used as guidance for management actions. Beginning in autumn 2008, surveys for YOY walleyes were instituted to determine the levels of natural reproduction that were occurring in the flowing waters of the Commonwealth. These surveys will be used to evaluate whether or not natural

reproduction is sufficient to sustain recreational fisheries for walleye or whether supplemental stocking of fingerling walleyes will be necessary to support the fishery.

West Branch Susquehanna River

Only the portion of the West Branch Susquehanna River downstream of Loyalsock Creek, Montoursville, Pennsylvania is currently surveyed to track gamefish populations. This historically, has been the most productive reach; however, it is still recovering from a legacy of abandoned mine pollution and other anthropogenic activities. Annual, trend-based surveys are conducted at ten locations within this reach as part of the development of the statewide recruitment index. This reach has variable reproduction of YOY smallmouth bass (Figure 8.3.1.1). The historic catch rate of YOY smallmouth bass is 4.5 fish/ 50 m. Since 2005, three of the six years have seen above average catch rates. Since the onset of disease within the smallmouth bass populations, prevalence of disease in the West Branch Susquehanna River has been variable but 2008 and 2010 levels were among the highest observed. Future surveys of adult smallmouth bass will provide better understanding of the affects that disease had on the catchable smallmouth bass populations in this reach of the West Branch Susquehanna River.

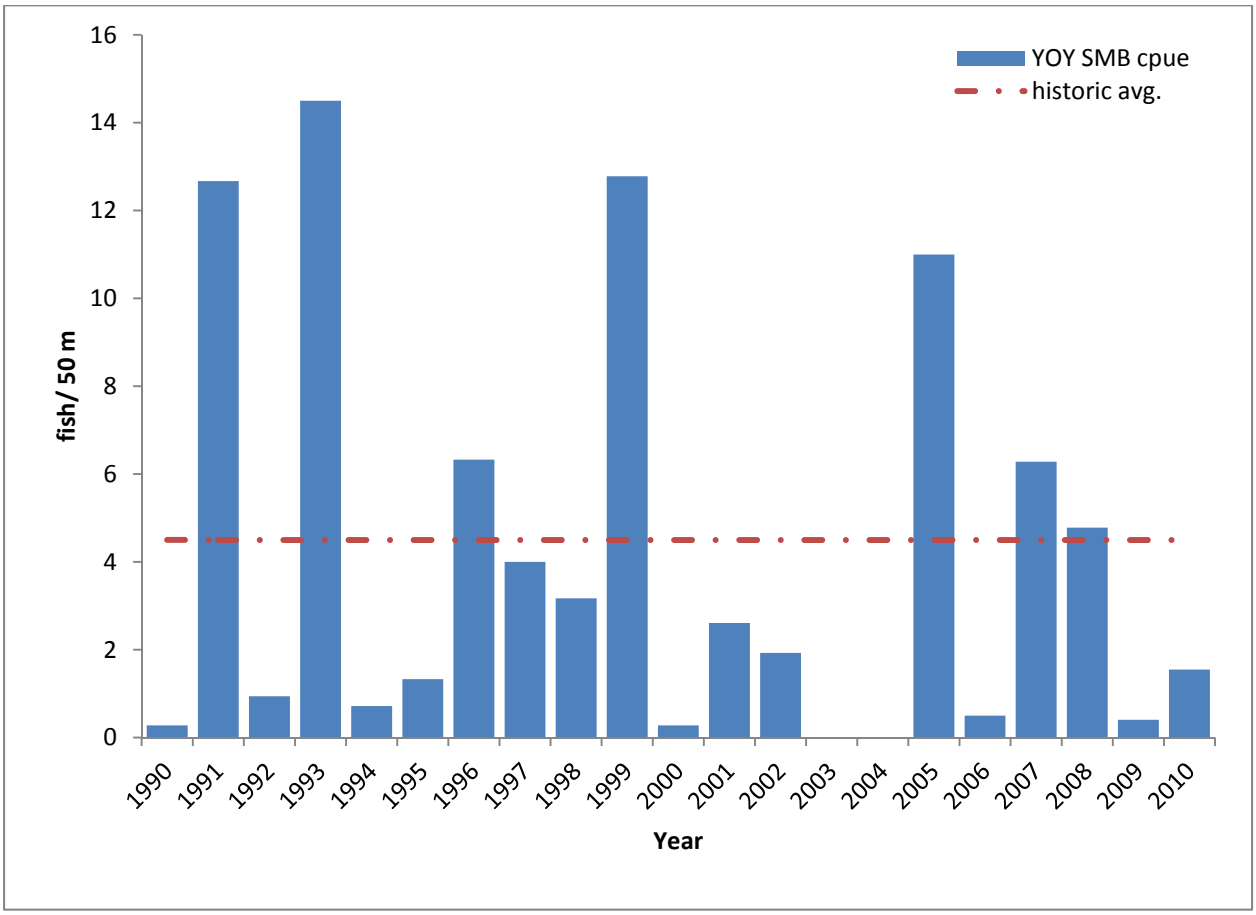

Figure 8.3.1.1. Catch rates of YOY smallmouth bass at the West Branch Susquehanna River for the period of 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

Adult smallmouth bass (older than age-1) are surveyed annually at three locations in this reach to track abundance of catchable-size smallmouth bass. Catch rates within this reach have been variable; however, recent years have seen catch rates at or near the historc average (Figure 8.3.1.2). Electrofishing catch rates of large smallmouth bass, 15 inches and larger, have been above the historic average for three of the last six years (Figure 8.3.1.3).

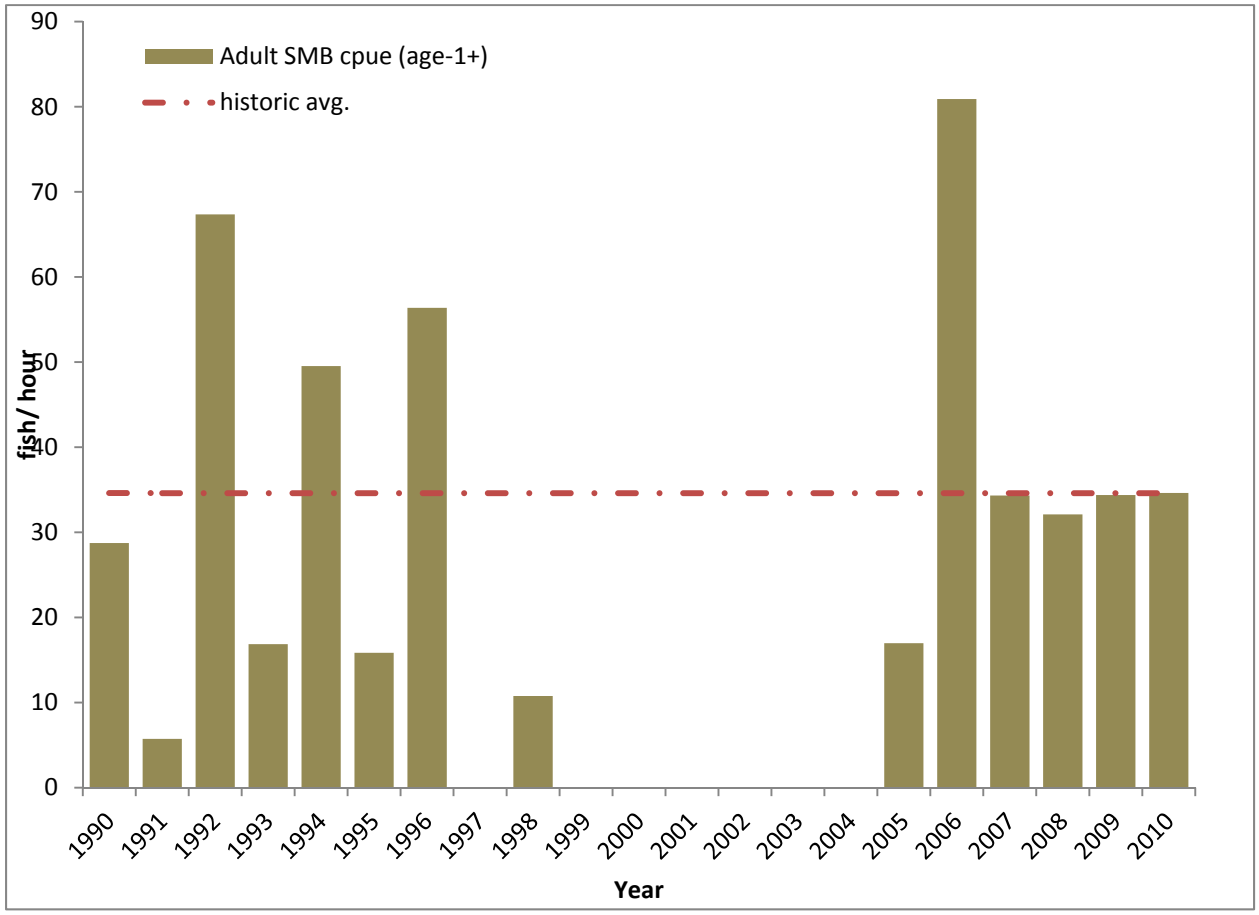

Figure 8.3.1.2. Catch rates of adult smallmouth bass at the West Branch Susquehanna River for the period 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

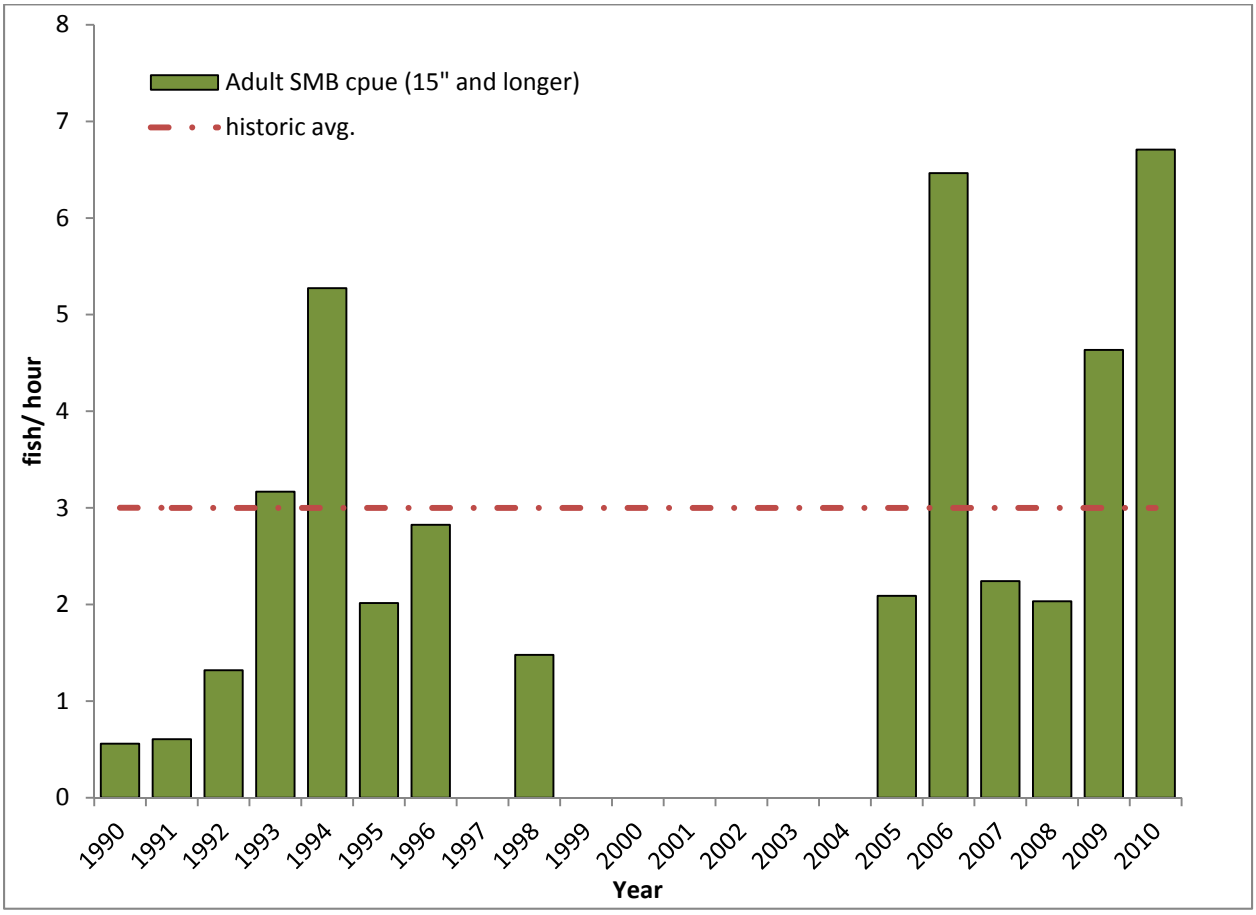

Figure 8.3.1.3. Catch rates of large, adult smallmouth bass (15" and longer) at the West Branch Susquehanna River for the period 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

Walleye populations are surveyed as part of the adult smallmouth bass surveys in mid-July. As such, YOY walleyes are rarely collected as they are residing in different habitats at that point in the year. Walleye catch rates at the West Branch Susquehanna River have been stable the past few years, averaging 7.17 fish/ hour (Figure 8.3.1.4). Future directed surveys may look at different times of the year to determine rates of walleye natural reproduction in the West Branch Susquehanna River.

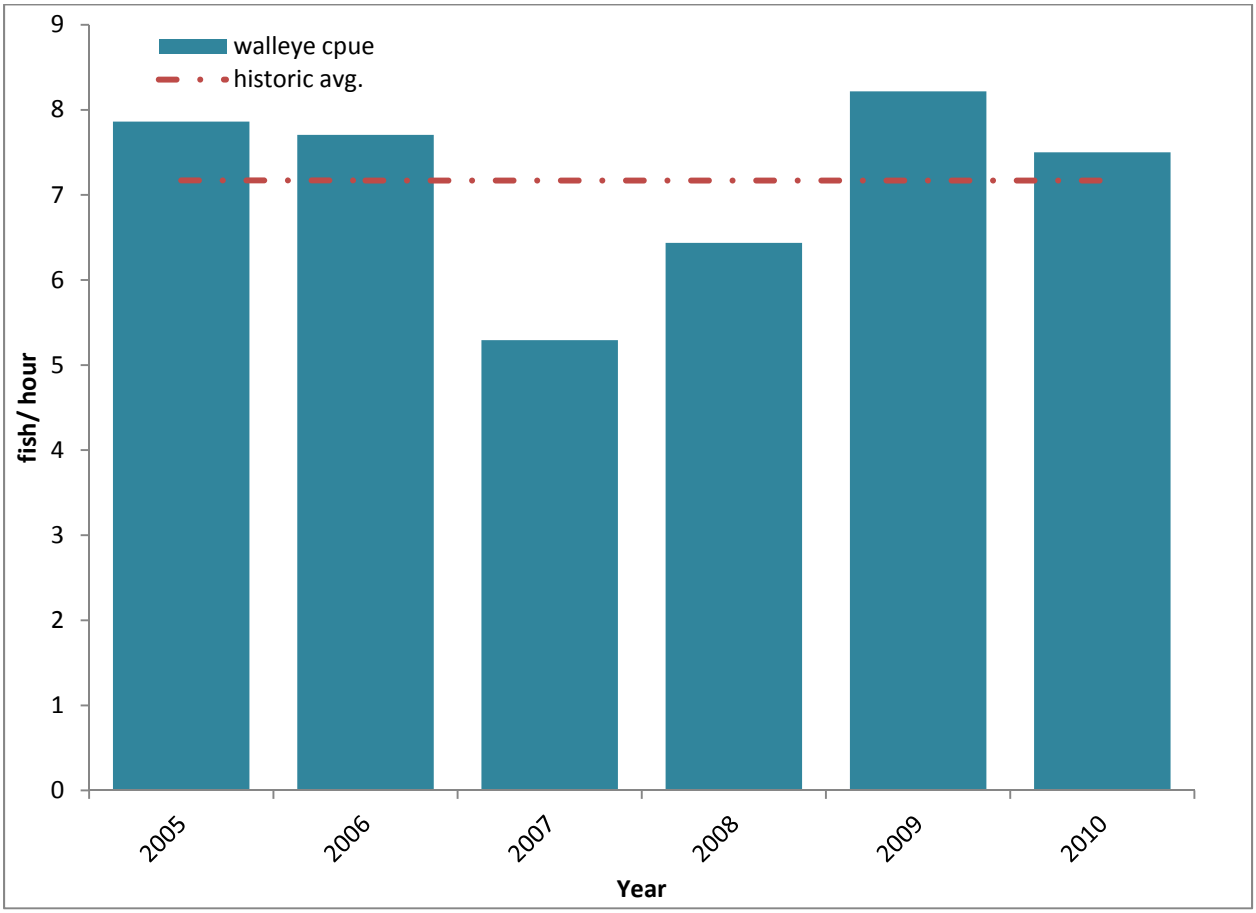

Figure 8.3.1.4. Catch rates of walleyes at the West Branch Susquehanna River for the period 2005 through 2010.

As water quality conditions improve in the West Branch Susquehanna River and fish populations expand, directed game fish stock assessments will similarly expanded in scope to cover areas outside of the currently surveyed lower reach.

Susquehanna River from the New York-Pennsylvania border, including the "Great Bend", downstream to the confluence of the West Branch Susquehanna River

Annual, trend-based surveys are conducted at ten locations within this reach as part of the statewide recruitment index. This reach continues to have strong reproduction of YOY smallmouth bass (Figure 8.3.2.1). The historic catch rate of YOY smallmouth bass is 8.2 fish/ 50 m, the highest for all reaches. Since 2007, three of the four years have seen above average catch rates with 2007 and 2010 being the highest and third highest catch rates on record, respectively. Since the onset of disease within the smallmouth bass populations, this reach of the Susquehanna River has remained the least impacted by the condition. Qualitatively, disease prevalence in this reach in 2010 was higher than in past years; however, the peak fell after quantitative sampling was conducted and an accurate measure of prevalence can not be reported. Future surveys of adult smallmouth bass will provide better understanding of the

affects that disease had on the 2010 year class of smallmouth bass in this reach of the Susquehanna River.

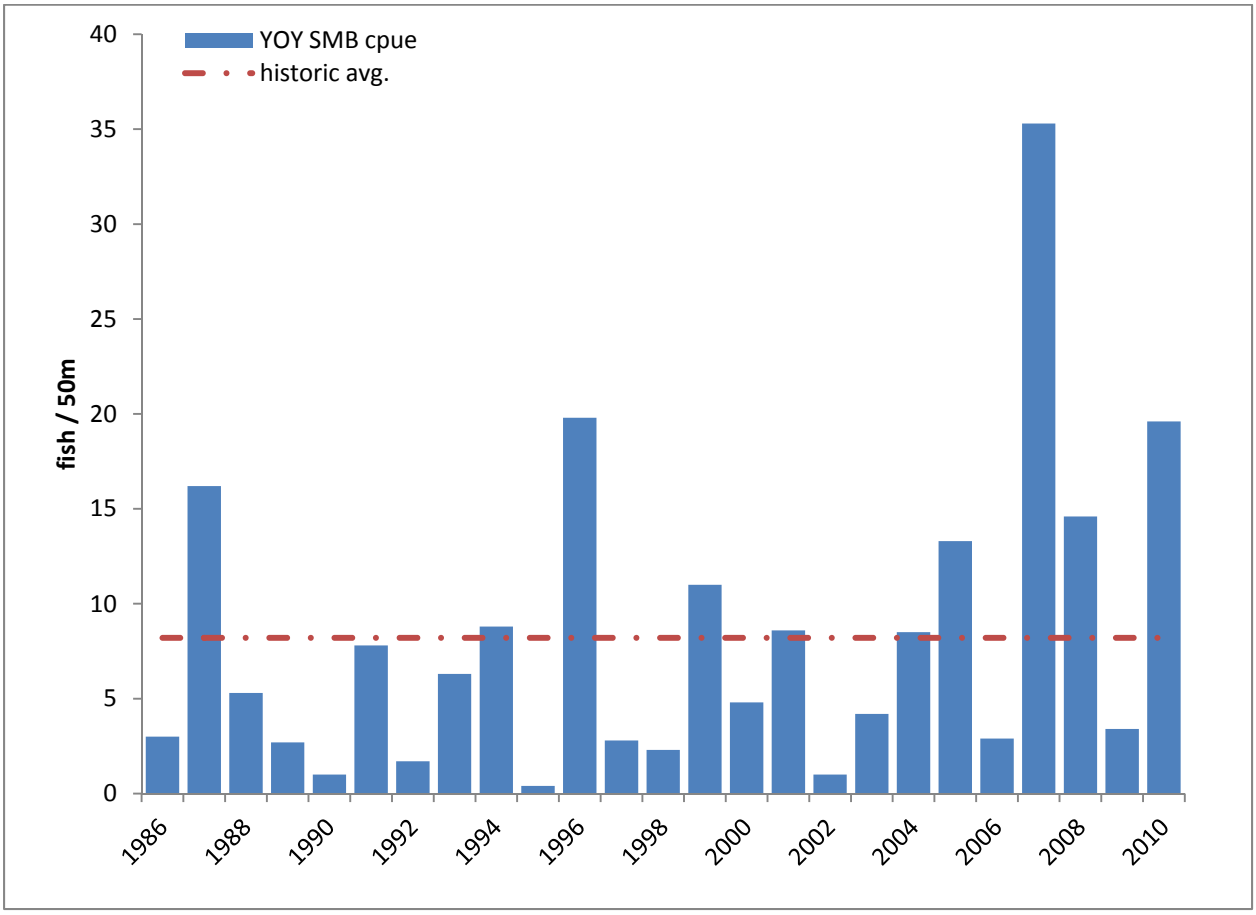

Figure 8.3.2.1. Catch rates of YOY smallmouth bass at the upper Susquehanna River for the period of 1986 through 2010.

Similarly, adult smallmouth bass are surveyed annually at six locations in this reach to track abundance of catchable-size smallmouth bass. Catch rates within this reach have been variable, but still the highest of all surveyed West Branch Susquehanna and Susquehanna River reaches (Figure 8.3.2.2). Despite producing the highest catch rates of all reaches, more recent catch rates have been near or below the historic average (94.9 fish/ hr) and below the catch rates of the early- to mid-1990s. Electrofishing catch rates of large smallmouth bass, 15 inches and larger, have been above the historic average for much of the last decade. This trend has also been noticed in angler catch as well as expressed at public meetings held in spring 2010.

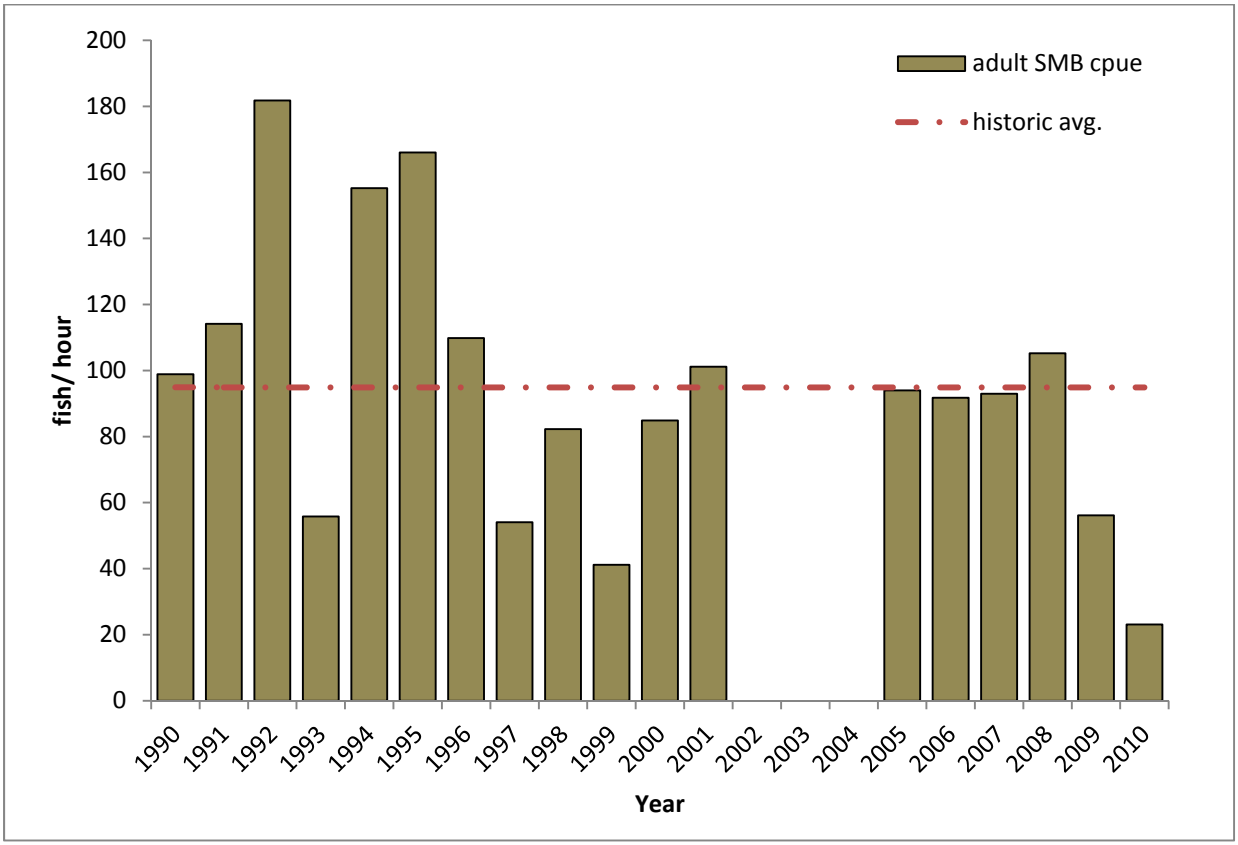

Figure 8.3.2.2. Catch rates of adult smallmouth bass at the upper Susquehanna River for the period 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

The upper Susquehanna River has the longest record of YOY walleye data; dating back to 1995 at some locations. Since the cessation of stocking of fingerling walleyes in 2007, this reach as provided the highest catch rates of YOY walleyes in autumn electrofishing surveys (Figure 8.3.2.3), including the second highest catch rate of record, 181.97 fish/ hour in 2010. Catch rates of YOY walleyes within this reach have exceeded the mean historic catch rate of 62.93 fish/ hour three of the past four years.

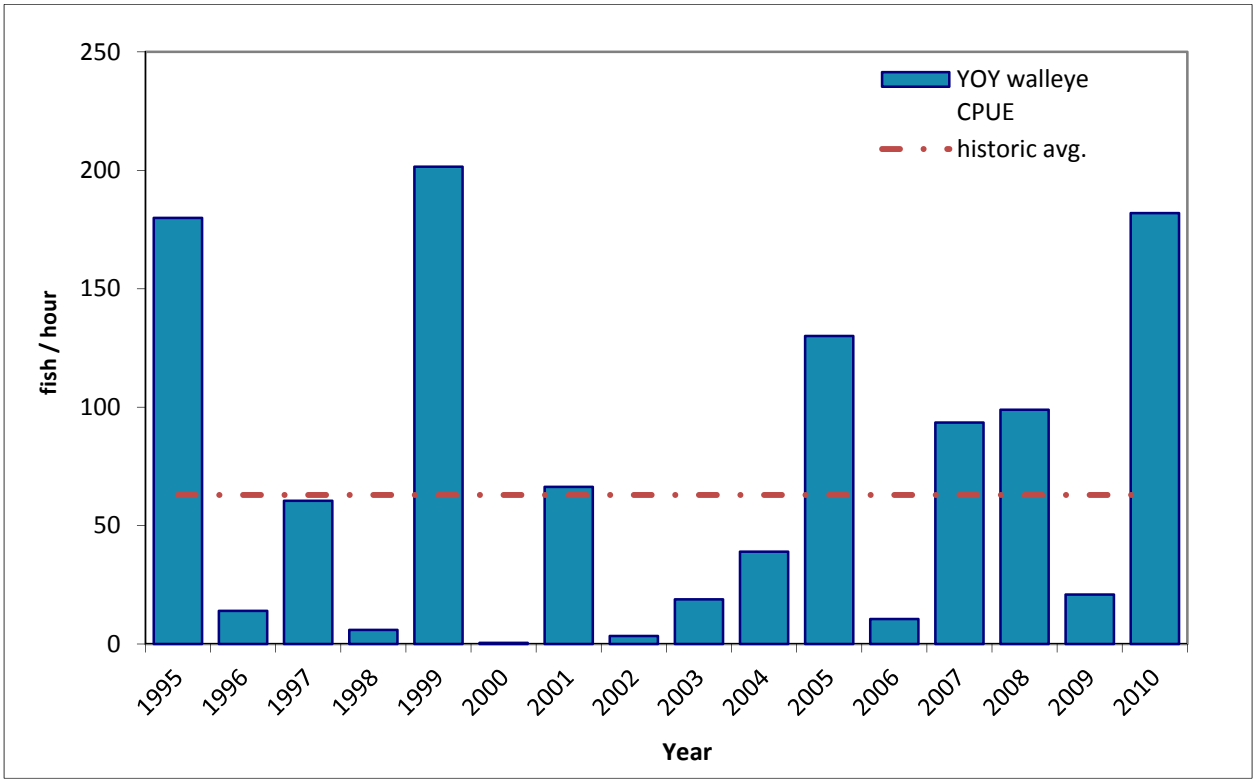

Figure 8.3.2.3. Catch rates of YOY walleyes at the upper Susquehanna River for the period 1995 through 2010.

Susquehanna River, confluence of the West Branch Susquehanna River downstream to the York Haven Dam

This reach of the Susquehanna River, commonly referred to as the middle Susquehanna River, extends from the confluence of the West Branch Susquehanna River downstream to the York Haven Dam. Annual, trend-based surveys of YOY smallmouth bass are conducted at six locations within this reach as part of the statewide recruitment index. This reach has recently seen low survival of YOY smallmouth bass as a result of disease-related mortality and low production in years with high flow events following the spawn (Figure 8.3.3.1). The historic catch rate of YOY smallmouth bass is 7.8 fish/ 50 m. Historically, this reach was the most productive reach for smallmouth bass; however, recent spawns have not realized the past potential. Since the onset of disease within the smallmouth bass populations, this reach of the Susquehanna River has been the most impacted by the condition, with the last six years having below average catch rates. Future surveys of adult smallmouth bass will provide better understanding of the affects that disease had on the smallmouth bass population at this reach of the Susquehanna River.

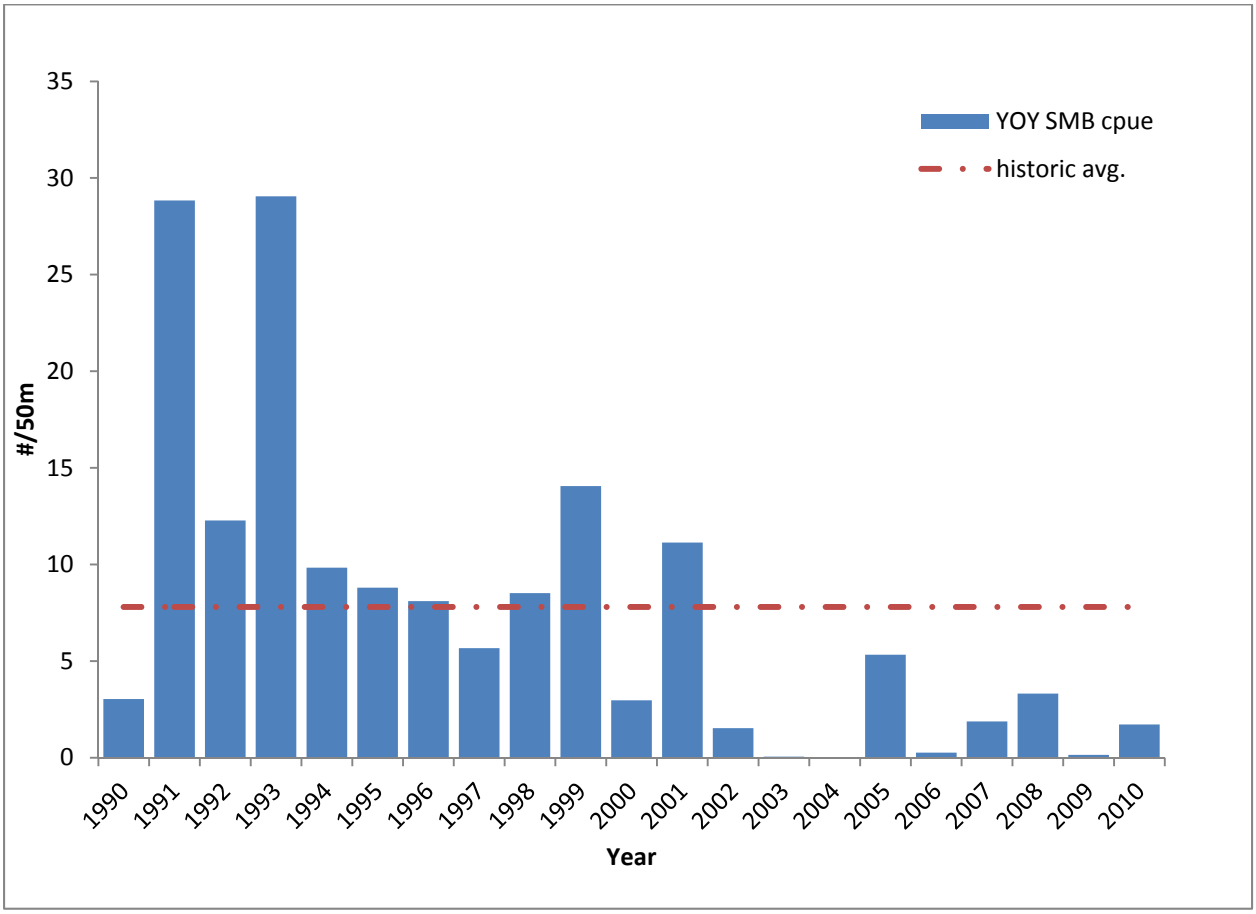

Figure 8.3.3.1. Catch rates of YOY smallmouth bass at the middle Susquehanna River for the period of 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

Adult smallmouth bass (older than age-1) are surveyed annually at four locations in this reach to track abundance of catchable-size smallmouth bass. Catch rates within this reach have been variable, with a noticible decline in recent years (Figure 8.3.3.2). Recent catch rates are far below the exceptionally high catch rates of the early- to mid-1990s. This is an artifact of poor recruitment of YOY to the population between 2005 and 2010 due to disease related mortality and poor reproduction resulting from high flow events. Electrofishing catch rates of large smallmouth bass, 15 inches and larger, have been above the historic average for three of the last five years (Figure 8.3.3.3). The years of poor recuritement had skewed the population to be comprised largely of older fish, concerning biologists about future population levels.

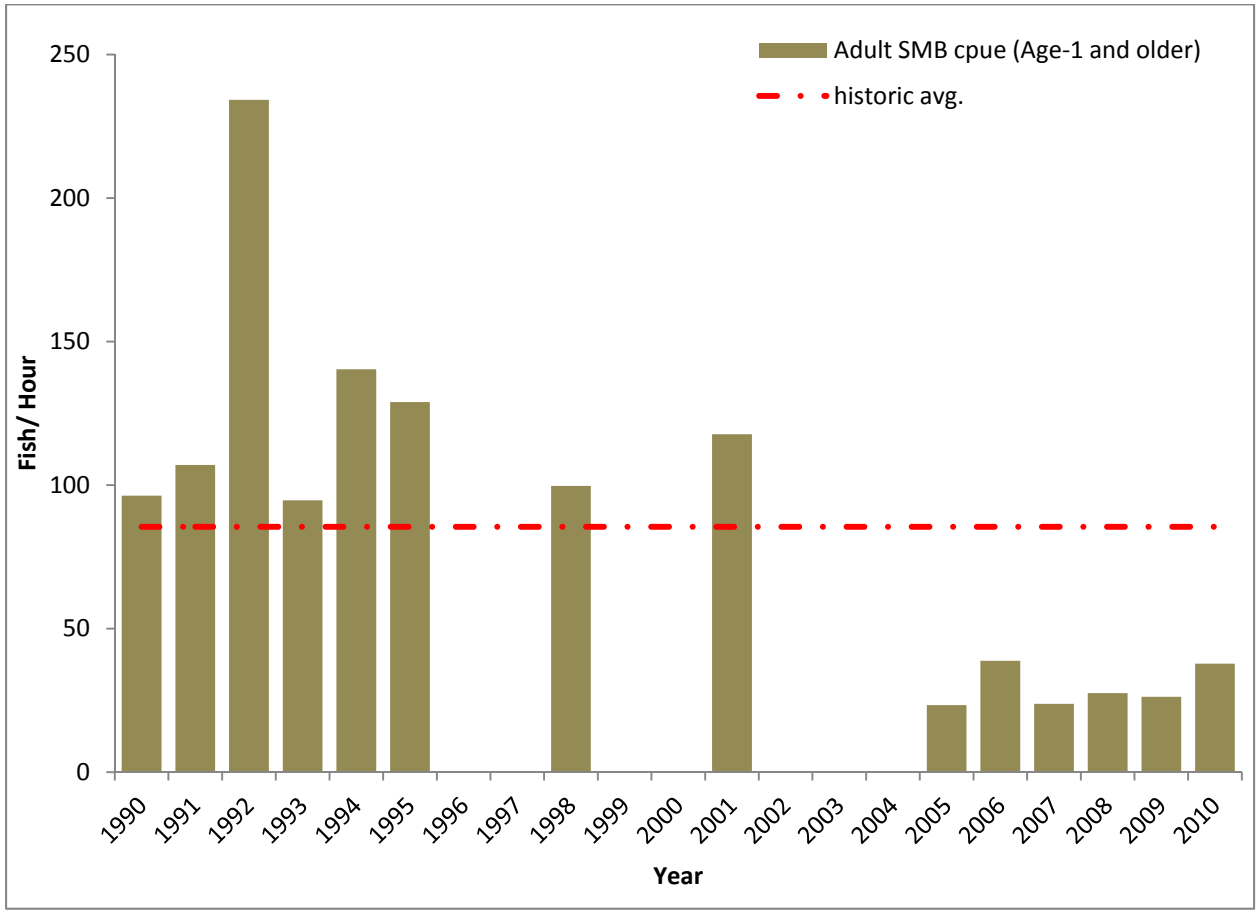

Figure 8.3.3.2. Catch rates of adult smallmouth bass at the middle Susquehanna River for the period 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

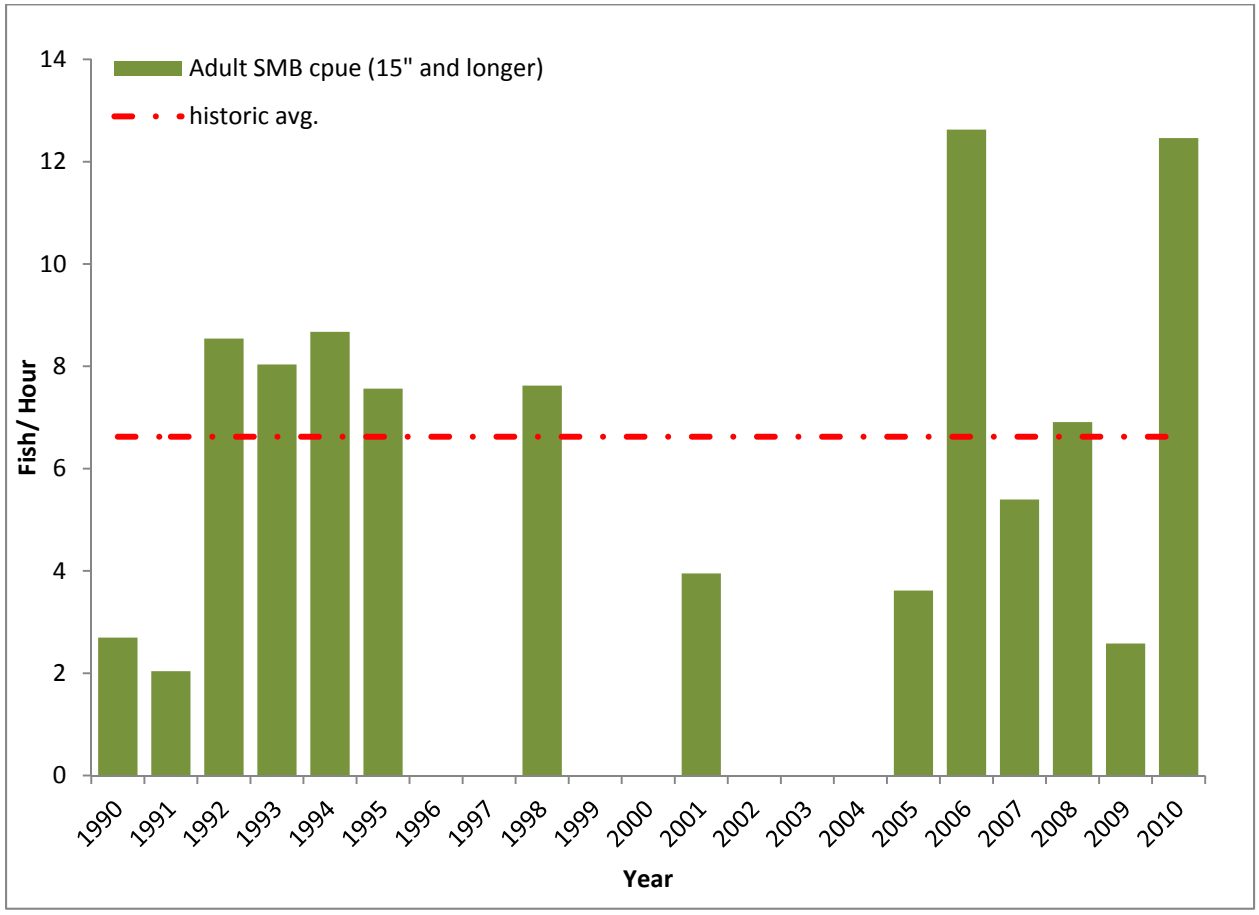

Figure 8.3.3.3. Catch rates of large, adult smallmouth bass at the middle Susquehanna River for the period 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

Surveys for YOY walleyes have only been recently instituted in the middle Susquehanna River as part of a study to determine the contribution that natural reproduction was providing to walleye fisheries in flowing waters. Since the cessation of stocking of fingerling walleyes in 2007, this reach has provided variable catch rates of YOY walleyes in autumn electrofishing surveys (Figure 8.3.3.4). These catch rates appear to be consistently below those seen prior to the cessation of stocking; however, more data is needed before a final determination can be made following the 2012 sampling season.

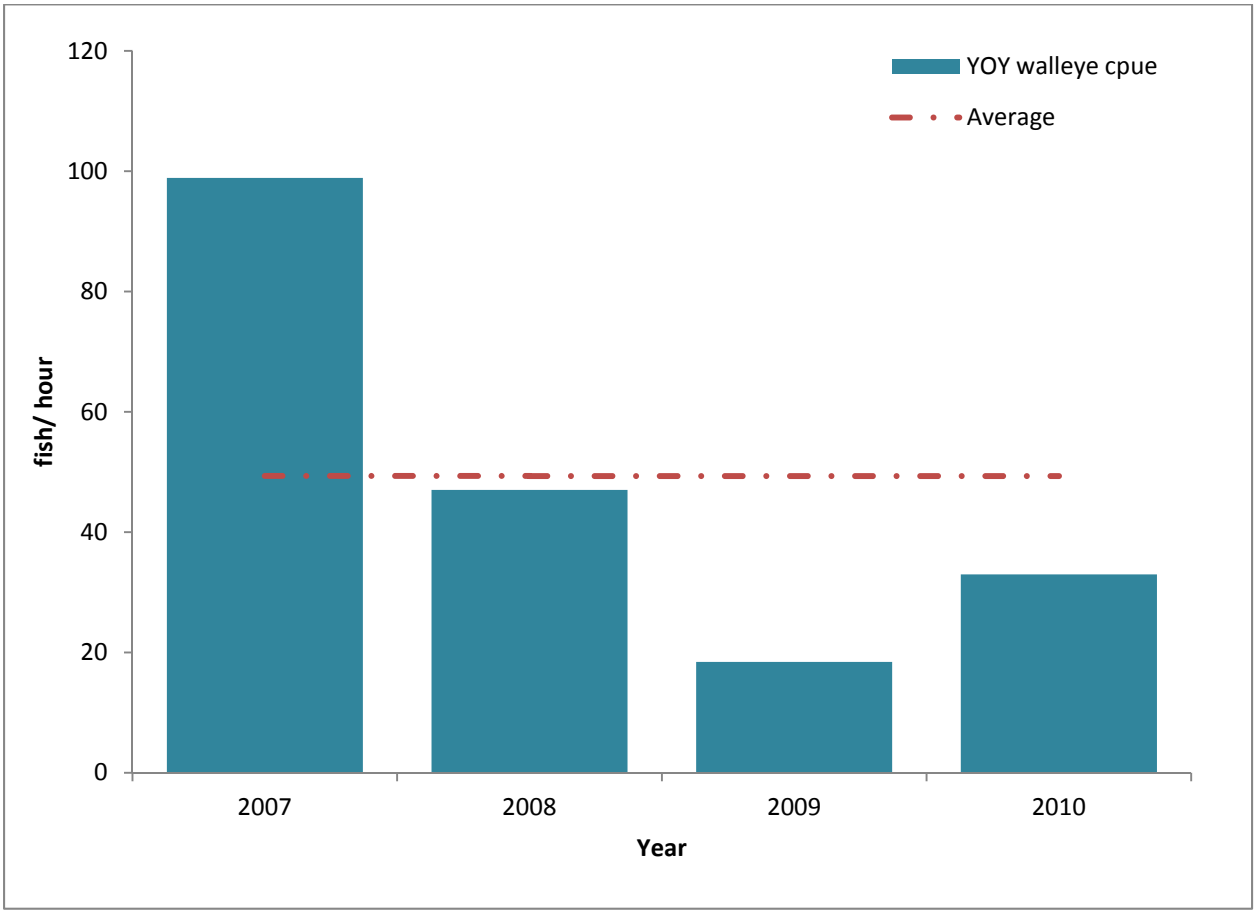

Figure 8.3.3.4. Catch rates of YOY walleyes at the middle Susquehanna River for the period 2007 through 2010.

Susquehanna River, confluence York Haven Dam downstream to Holtwood Dam

This reach of the Susquehanna River, commonly referred to as the lower Susquehanna River, extends from the York Haven Dam downstream to the Holtwood Dam. Downstream of Holtwood Dam, game fish management is delegated to the Maryland Department of Natural Resourses. Annual, trend-based surveys of YOY smallmouth bass are conducted at four locations within this reach as part of the statewide recruitment index. This reach has recently seen low survival of YOY smallmouth bass as a result of disease-related mortality and low production in years with high flow events following the spawn (Figure 8.3.4.1). The historic catch rate of YOY smallmouth bass is 2.9 fish/ 50 m. Since the onset of disease within the smallmouth bass populations, this reach of the Susquehanna River has been one of the most impacted by the condition, with the last six years having below average catch rates. Future surveys of adult smallmouth bass will provide better understanding of the affects that disease had on the smallmouth bass population at this reach of the Susquehanna River.

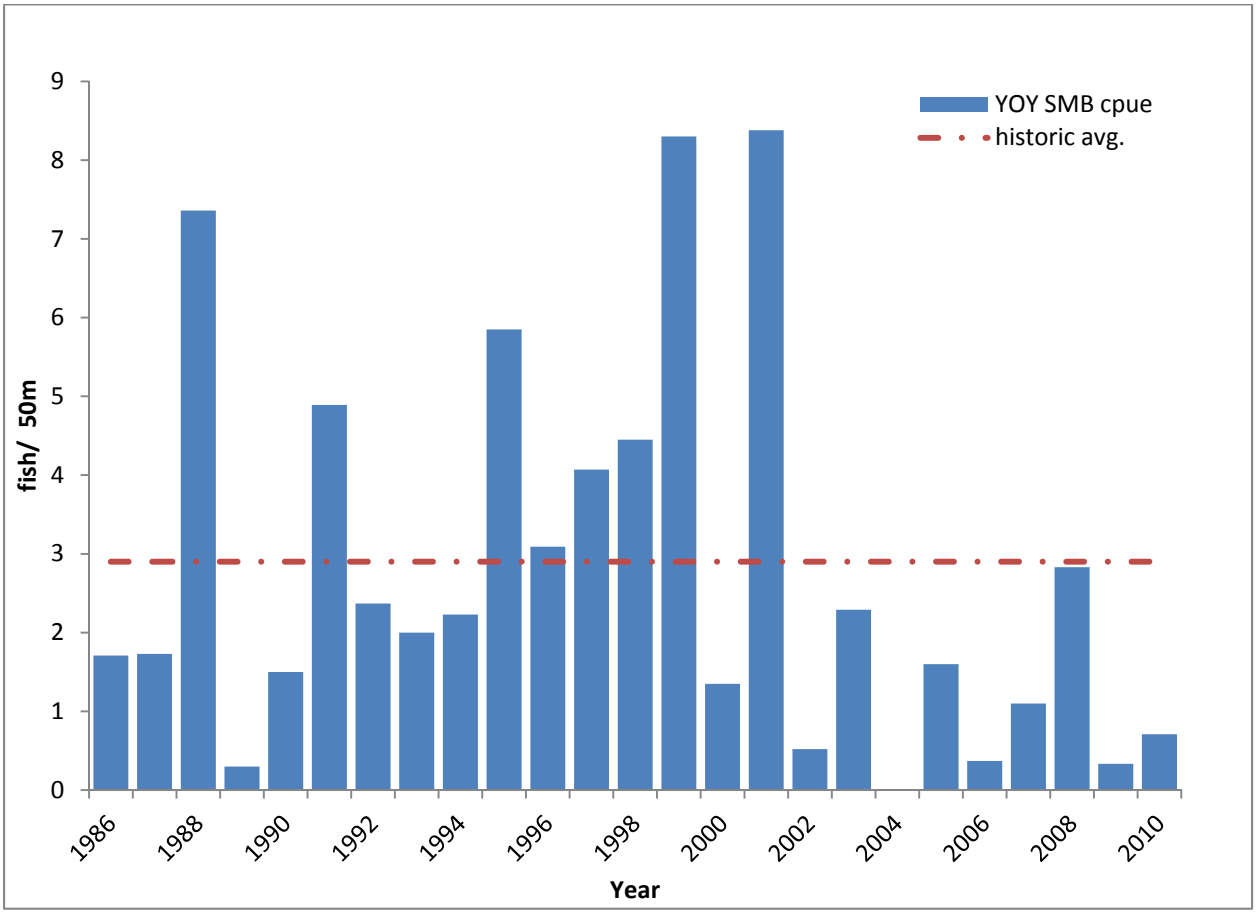

Figure 8.3.4.1. Catch rates of YOY smallmouth bass at the lower Susquehanna River for the period of 1990 through 2010. Blank values indicate years in which no surveys were conducted, not zero values.

Adult smallmouth bass (older than age-1) are surveyed annually at five locations in this reach to track abundance of catchable-size smallmouth bass. Catch rates within this reach have been variable, with a noticible decline in recent years (Figure 8.3.4.2). Like the middle Susquehanna River, recent catch rates are far below the exceptionally high catch rates of the early- to mid-1990s. This is an artifact of poor recruitment of YOY to the population between 2005 and 2010 due to disease related mortality and poor reproduction resulting from high flow events. Electrofishing catch rates of large smallmouth bass, 15 inches and larger, have been above the historic average for four of the last five years (Figure 8.3.4.3). The years of poor recuritement had skewed the population to be comprised largely of older fish, concerning biologists about future population levels.

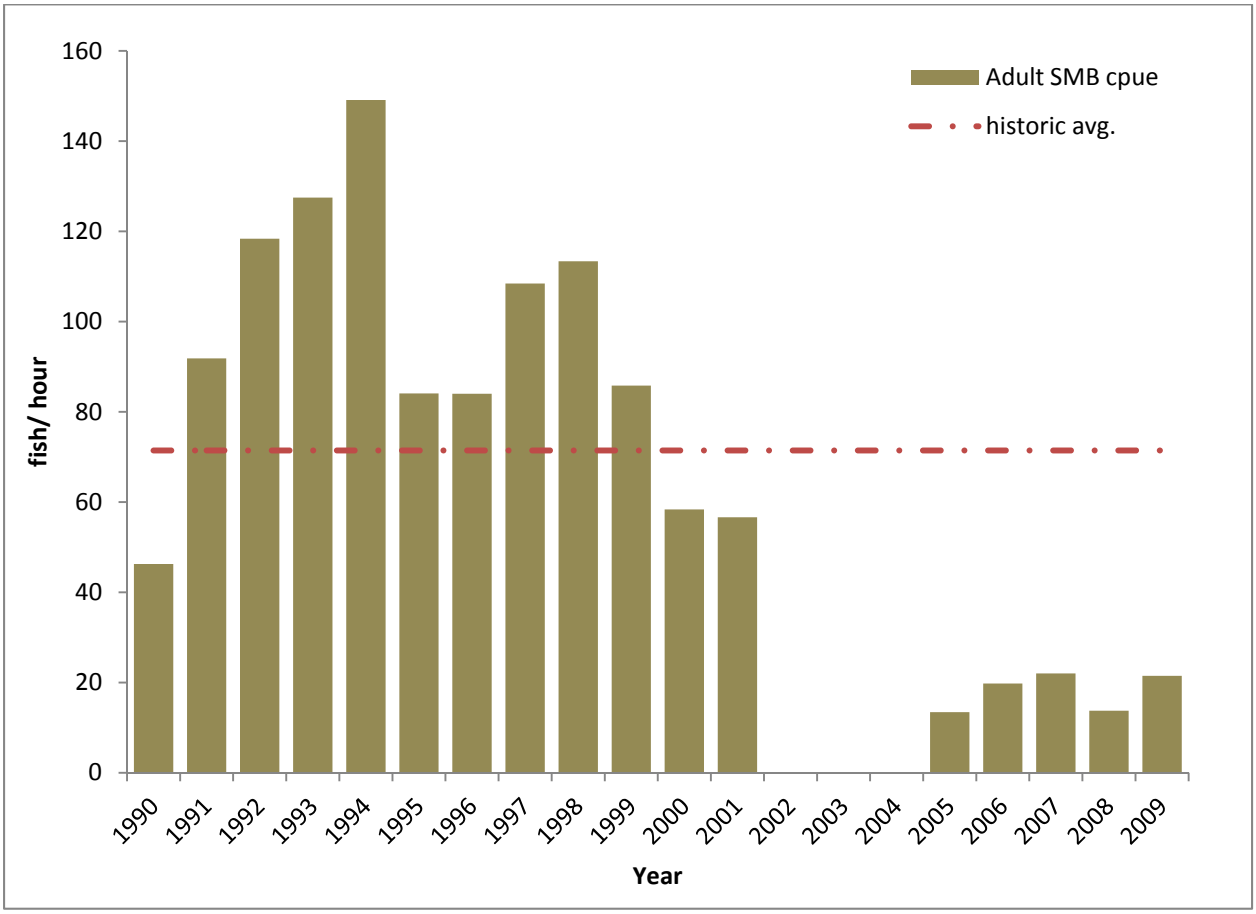

Figure 8.3.4.2. Catch rates of adult smallmouth bass at the lower Susquehanna River for the period 1990 through 2009. Blank values indicate years in which no surveys were conducted, not zero values.

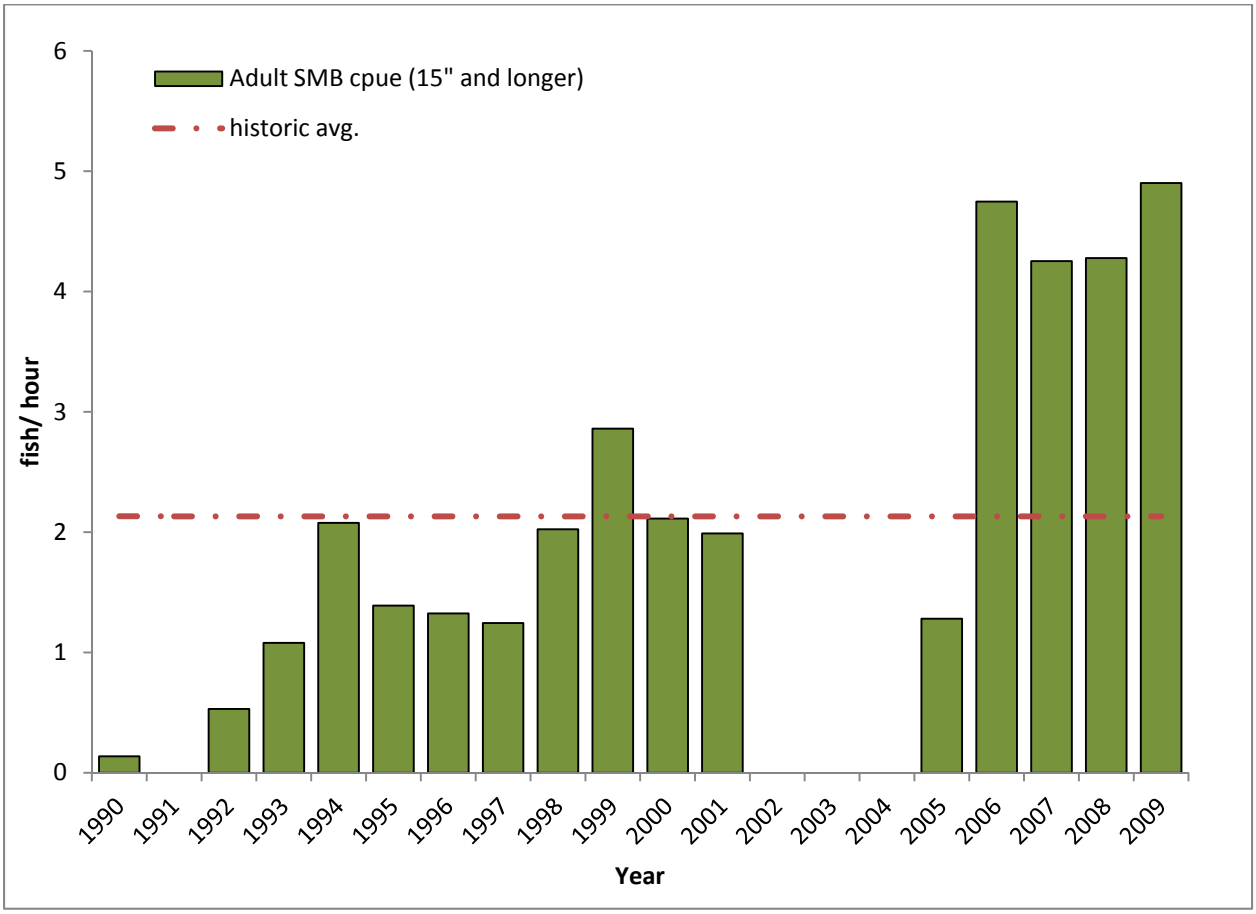

Figure 8.3.4.3. Catch rates of large, adult smallmouth bass at the lower Susquehanna River for the period 1990 through 2009. Blank values indicate years in which no surveys were conducted, not zero values.

Annual surveys for walleyes are conducted at the lower Susquehanna River as part of autumn adult smallmouth bass collections. The data record for walleye catch rates is among the largest for the Susquehanna River. In recent years, catch rates of walleyes have been above the historic average of 18.49 fish/ hour. Since the cessation of stocking of fingerling walleyes in 2007, this reach as provided above average catch rates of walleye in autumn electrofishing surveys (Figure 8.3.4.4). These catch rates appear to be consistent with those seen prior to the cessation of stocking; however, more data is needed before a final determination of the sustainability of this fishery through natual reproduction can be made following the 2012 sampling season.

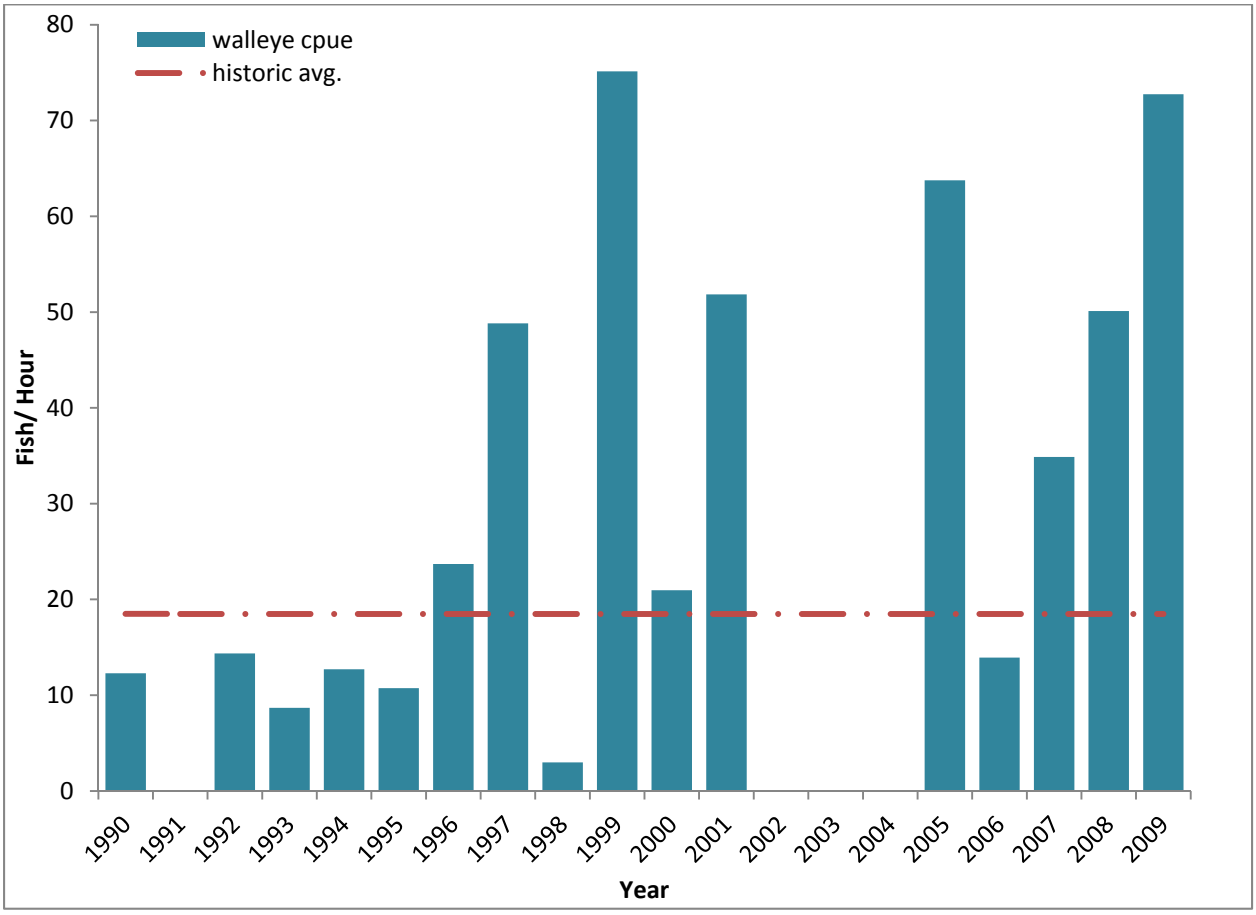

Figure 8.3.4.4. Catch rates of walleyes at the lower Susquehanna River for the period of 1990 through 2009. Blank values indicate years in which no surveys were conducted, not zero values.

8.4 Fish Population Restoration

The PFBC works with other agencies and non-governmental organizations (NGO) to help restore stocks of native fishes that have declined or been extirpated from Pennsylvania's waters. The Pennsylvania Commission of Fisheries, the early predecessor of the PFBC, was created by the Pennsylvania legislature in 1866 to restore migratory fish populations to the Susquehanna River. Several measures are used to protect, conserve, and enhance migratory fishes, including rearing and stocking programs both internally and in cooperation with other groups, enhancement and maintenance of fish passage, habitat enhancement, and protection of at risk populations through the use of regulations.

American shad runs vary from year to year but have seen declines in recent years (Figure 8.4.1). Since the operation of the fish lifts at Conowingo Dam, the peak American shad passage at Conowingo Dam was 193,574 individuals (2001). Several factors are thought to be affecting the size of the American shad runs in the Susquehanna River as well as other Atlantic Slope rivers. As such, it is believed that the there may be severe issues once the American shad reach the open, coastal waters. These include predation by striped bass and other

predatory fish; offshore fisheries in federal waters, where anecdotal information suggests significant numbers of shad may be caught; and subtle changes in ocean temperatures or currents. In addition to these larger, coast-wide impacts, more local factors such as water quality, habitat degradation, and fish passage efficiency are still limiting the successful restoration of Susquehanna Basin American shad stocks.

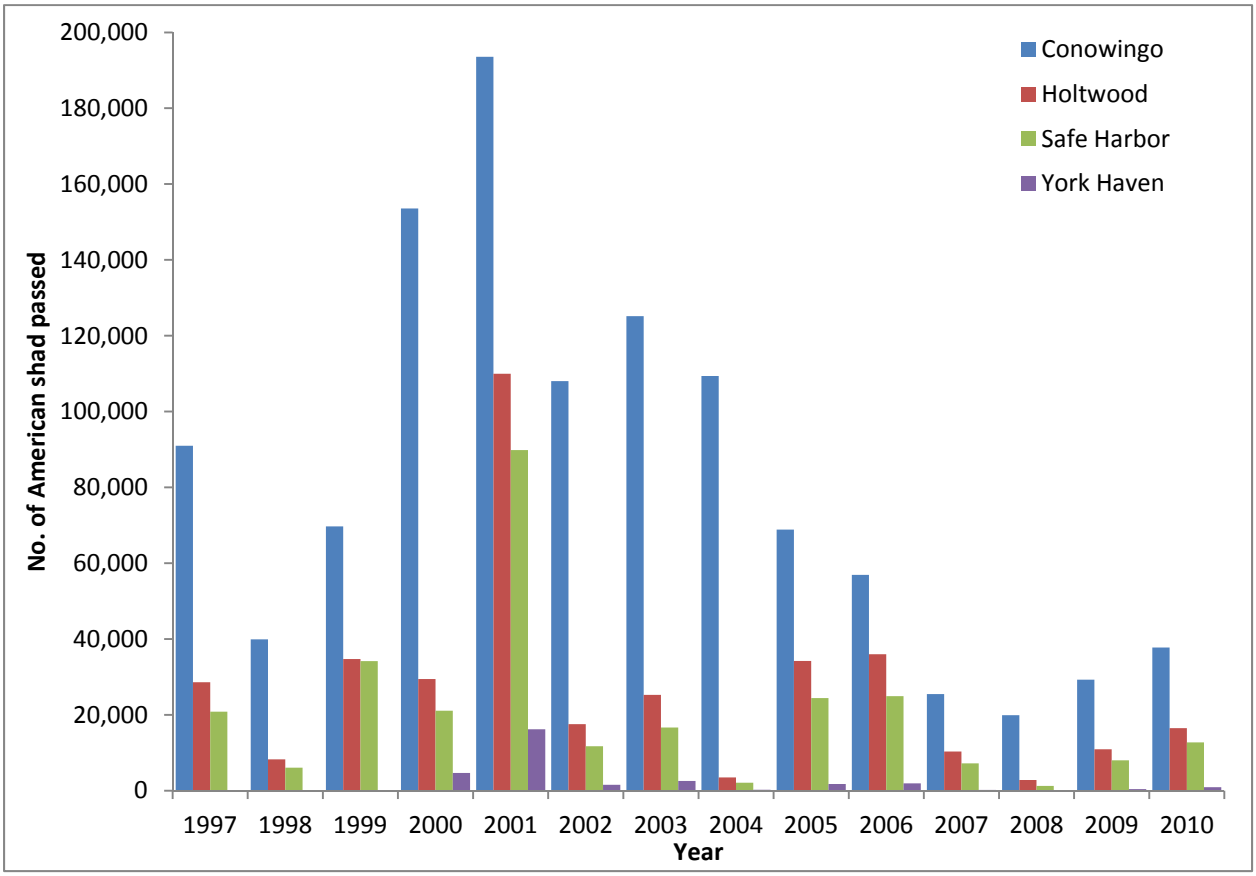

Figure 8.4.1. Number of American shad *Alosa sapidissima* passed at each of the four Susquehanna River hydropower dams annually for the period 1997 through 2010.

As mentioned previously, the complex factors associated with fisheries restoration of large river systems require diverse partnerships to effectively carry out these activities. The Atlantic States Marine Fisheries Commission (ASMFC) is a stake-holder group comprised of representatives from all the Atlantic Coastal States, of which the PFBC is a voting member. The ASMFC regulates shared marine and migratory fish populations. The ASMFC is one of the lead organizations in diadromous fish restoration efforts in the Chesapeake Bay and Susquehanna River. The USEPA Chesapeake Bay Program also plays an active role in water quality and living resource issues in the Susquehanna River. More locally, the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC), composed of technical and policy committees, manages migratory fish populations in the Susquehanna River basin. It is comprised members of the USFWS, SRBC, and the three basin states: New York, Pennsylvania, and Maryland. SRAFRC recently released a *Migratory Fish Management and Restoration Plan for the Susquehanna River* (2010) which will serve as the guidance document

for management of the migratory species in the Susquehanna River Basin. This document details adaptive management options to tackle a number of the local factors limiting successful restoration of migratory fish stock including restoring access to historic habitats (i.e., increasing passage efficiency), maintaining and improving existing habitat, enhancing spawning stock biomass and recruitment, evaluating restoration efforts and adjusting programs as needed, and ensuring cooperation between project partners (SRAFRC 2010). In addition, other federal agencies like the Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), United State Department of Defense, Army Corps of Engineers (USACE), and Federal Energy Regulatory Commission (FERC) each work on issues crucial to fisheries restoration in the Susquehanna River. On the state level, PADEP and Pennsylvania Department of Conservation and Natural Resources (DCNR) are partners in fish passage restoration through dam removals and maintenance of fishways. Additionally, NGO advocacy groups such as American Rivers, the Alliance for the Chesapeake Bay, the Chesapeake Bay Foundation, The Nature Conservancy, Western Pennsylvania Conservancy, ClearWater Conservancy of Central Pennsylvania, Inc., Trout Unlimited, and various watershed organizations play key roles in restoration efforts.

Fish Passage

One of the factors limiting diadromous fish populations in the West Brach Susquehanna and Susquehanna rivers is access to suitable spawning habitat above dams. Since the colonization of North America by European settlers, construction of dams, for various reasons, has limited the movement of fish populations throughout the Susquehanna River Basin. Dams isolated migratory fishes from vital spawning habitat and as a result, population numbers dwindled. More recently, large hydroelectric power dams in the downstream reaches of the Susquehanna River preclude free movements of both migratory and resident fishes. Further description of hydroelectric power dams is detailed in Section 5.2.1. Early efforts to provide passage around dams via fish ladders were not successful as little consideration was given to species specific requirements of targeted fishes. As a result, generation facilities simply paid royalties to the PFBC in lieu of construction and maintenance of fish passage facilities. In 1972, construction of the West Fish Lift at Exelon Power Corporation's Conowingo Dam provided adult shad for biomonitoring and transport to upstream habitat. Since that time, Conowingo Dam East Fish Lift was constructed and became operation in 1991 in addition to fishways at York Haven, Safe Harbor, and Holtwood dams. In the 1990s, attraction flow modifications were employed at the Conowingo East Fish Lift in an effort to optimize American shad passage by deterring passage by non-target species (e.g., gizzard shad); however the efficacy of this effort was never evaluated (SRAFRC 2010). Fish elevators, each with a design capacity of 2 million American shad, were constructed as Safe Harbor and Holtwood dams in time for the 1997 migration. In spring 2000, a vertical slot fishway with a design capacity of 500,000 American shad began operation at York Haven Dam (SRAFRC 2010). A recent agreement with York Haven Dam has allowed the fishway to remain open for most of the year to allow volitional passage of resident fish species outside of the normal spring migratory period. The addition of these fishways opened a total of 122 river miles for upstream migration (SRAFRC 2010). American shad passage on the Susquehanna River has not met expectations. While large numbers of shad have passed the Conowingo Dam fishways, the efficacy has not been adequately assessed.

Similarly, the passage at upstream dams have had mixed results. American shad passage efficiencies at Holtwood, Safe Harbor, and York Haven dams have average 32%, 71%, and 11%, respectively during the period 1997-2009 (SRAFRC 2010). Downstream passage of emigrating fish through the hydropower dams is also a topic of concern. Studies found that juvenile American shad turbine survival to be 97 percent at Safe Harbor Dam and 93 percent at Conowingo Dam (SRAFRC 2010). Studies at Holtwood and York Haven dams estimated juvenile American shad turbine passage survival at 67 to 80 percent and 77 to 93 percent, respectively (SRAFRC 2010). These values result in a cumulative juvenile American shad turbine survival estimate of 33 to 53 percent for fish passing through all four dams (SRAFRC 2010). Recent FERC license amendment negotiations with PPL's Holtwood Dam allowed expanded generating capacity and fishway improvements that would increase passage efficiency at their existing fishway. As part of the negotiation, fishway efficiency targets were set at 75 percent of American shad must past within five days of their passage at Conowingo Dam inorder to meet the license requirements. Current and future passage efficiency studies as part of FERC relicensing will provide valuable information about the issues limiting fish passage at each of the hydropower dams.

In addition to passage of anadromous fishes, there is increased interest in passage of catadromous American eels. The physiological and behavioral differences of American eels in comparison to other fishes prevent adequate passage of this species using existing fishway technology. As such, consideration for passage will be required under new FERC license agreements. Similar to targets set for American shad passage, targets will also be set for both upstream and downstream passage of the different life stages of American eels.

The PFBC, Bureau of Fisheries, divisions of Fish Production Services and Fisheries Management, in cooperation with partner agencies, provides commentary through the FERC relicensing and other management processes with respect to fish passage and other restoration measures of migratory fish stocks in the West Branch Susquehanna and Susquehanna rivers. These fishways provide volitional fish passage to the Susquehanna River upstream to the inflatable dam at Sunbury and the Juniata River upstream to Raystown and Warrior Ridge dams. Further upstream, a nature-like bypass fishway is planned for the inflatable dam in Sunbury, Northumberland County, Pennsylvania. A low-head dam in Williamsport, Lycoming County, Pennsylvania presently has a vertical slot fishway in place. Additionally, fish passage improvement projects are being considered at Sunbury, Pennsylvania; Williamsport, Pennsylvania; and at the City of Lock Haven's, Grant Street Dam in Lock Haven, Pennsylvania. The PFBC's Division of Habitat Management is the agency lead on acquisition, creation, and maintenance of fish passage opportunities. By the end of 2008, eleven fishways and 76 dam removals have been completed and another 40 on-going fishway and dam removal projects are in various levels of completion in Susquehanna River Basin (D. Kristine, PFBC, personal communication).

*Habita*t

World-wide, habitat degradation is a primary factor leading to declines of fish populations. Many historic anthropogenic activities have caused changes to instream habitat, resulting in changes in the density and diversity of fish populations. These include sedimentation, dredging, and

flooding via impoundment of flowing water with the construction of dams, among others. At the time of publication, one habitat enhancement project has been conducted on the Susquehanna River, at Lake Augusta, the pool formed by the inflatable dam at Sunbury, Pennsylvania by the PFBC, Bureau of Fisheries, Division of Habitat Management. This enhancement project placed a series of rock mounds in the pool to serve as cover objects for several species of fish. Opportunities for habitat restoration for large river systems will improve and increase in frequency as the PFBC, Bureau of Fisheries, Division of Habitat Management expands. Beginning in March 2009, The Nature Conservancy in cooperation with the SRBC and USACE began the "Susquehanna River Ecosystem Flow Study" to address and quantify habitat types at various discharge levels for ecologically-based decision making concerning water resource management for protection of populations of fish, unionid mussels, and other aquatic organisms. Further description of this program is detailed in *Section 5.2.5 Hydrologic Monitoring and Modeling*.

Restorative stocking

In addition to fish passage and habitat issues, the PFBC rears and plants migratory fishes in an effort to restore their populations. The Division of Fish Production Services, Anadromous Fish Restoration Unit operates the Van Dyke Research Station for Anadromous Fishes, near Thompsontown, Juniata County, as part of an effort to restore diadromous fishes in the Susquehanna River Basin (Hendricks and Tryninewski 2008). The Unit spawns and rears hickory shad and American shad for reintroduction as fry into the Susquehanna River and its tributaries, with a goal of producing 10 – 20 million American shad fry for release, annually. The goal of the program is to rear individuals that are imprinted to the Susquehanna River drainage for return and natural spawning as a way to restore viable populations.

The ratio of naturally reproduced versus hatchery-origin American shad returning each year to Conowingo Dam as adults varies as well. The proportion of returning American shad adults that are naturally produced has been increasing steadily since 2003 (Figure 8.4.2). In addition to returning adults, the number of emigrating juveniles is also tracked through seine hauls and lift nets in the autumn. In recent years, there has been a decline in the catch rates of emigrating juvenile American shad in the Susquehanna River drainage (Figure 8.4.3), indicating that there is some local impact that has been limiting survival of larval and fingerling American shad while still in the Susquehanna River system.

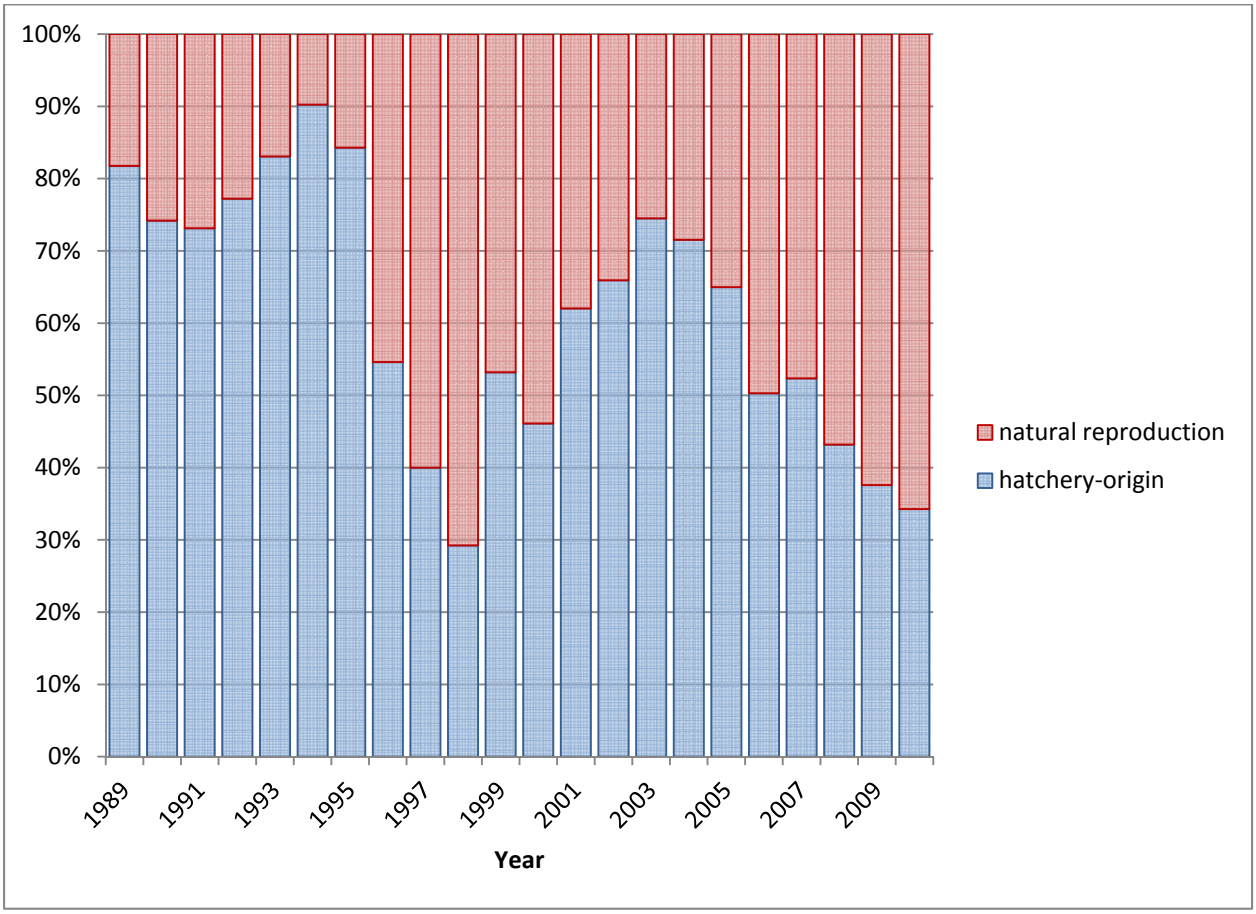

Figure 8.4.2. Proportions of hatchery-origin versus naturally spawned American shad *Alosa sapidissima* adults returning annually to Conowingo Dam from 1989 through 2010.

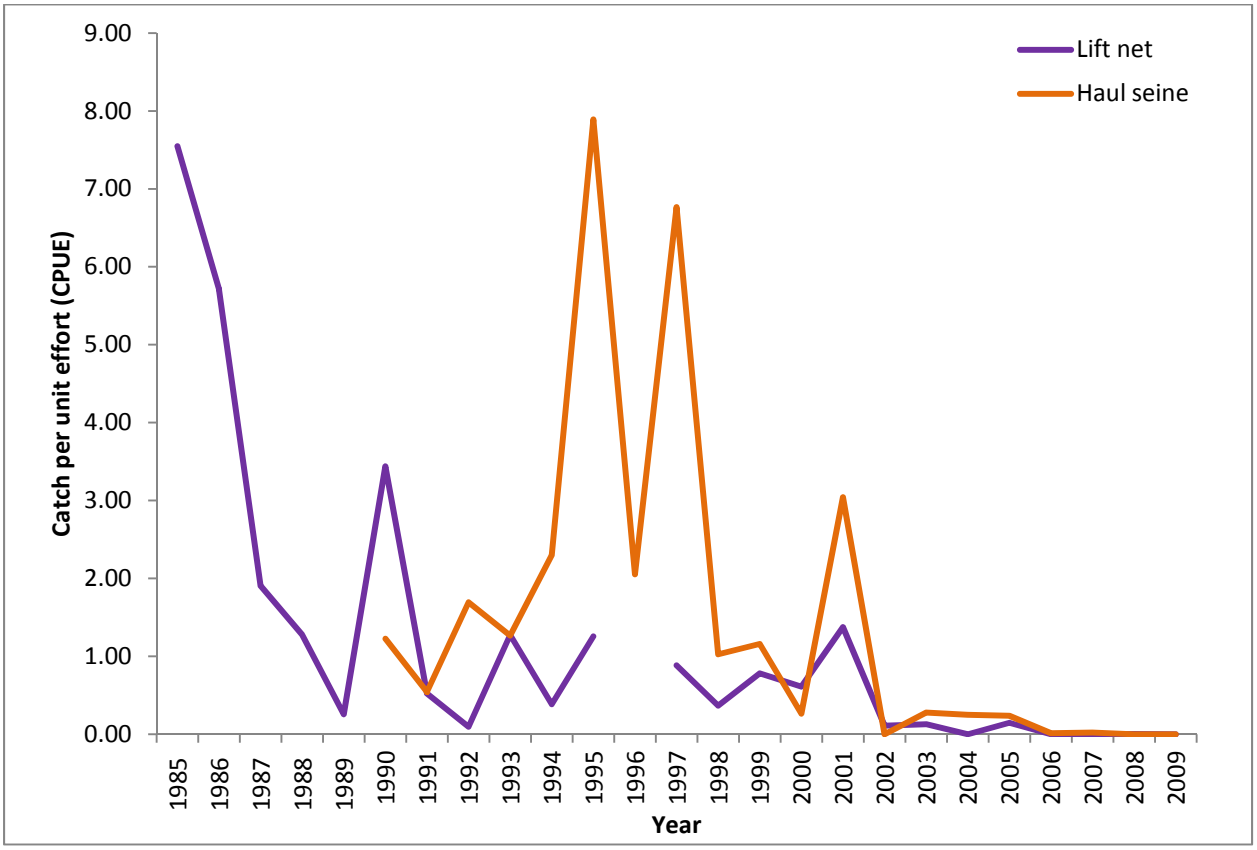

Figure 8.4.3. Catch per unit effort (CPUE) of emigrating, juvenile American shad Alosa sapidissima from seine hauls and lift nest at the Susquehanna River, 1985 through 2010.

Recently, efforts conducted by USFWS have focused on restoring American eels by capturing returning elvers from below Conowingo Dam and transporting individuals upstream to Conestoga and Conowingo creeks. In 2008, approximately 17,000 elvers were relocated to Conestoga Creek. Approximately the same number was relocated to Conowingo Creek in 2009.

8.5 Management Options

Priority 1: (*on-going activities or recommendations to be implemented in first year of management plan*).

- Continue annual, directed sampling of YOY and adult smallmouth bass and YOY walleye to track trends in West Branch Susquehanna and Susquehanna River populations of both species and expand efforts as needed.

Priority 2: (*recommendations with implementation date in years 2-3 of management plan*).

- Evaluate affects of catch-and-immediate-release regulation change on Susquehanna River smallmouth bass populations and develop population thresholds to trigger future management action.
- Develop a study to determine the effects that tournament angling has on Susquehanna River smallmouth bass populations.
- Begin evaluation of natural walleye reproduction in the West Branch Susquehanna and Susquehanna rivers as per recommendation in the PFBC, Division of Fisheries Management, Walleye Management Plan.
- Work with Division of Fisheries Management, Warmwater Unit to evaluate the feasibility of periodic, smaller-scale angler use and harvest surveys at the West Branch Susquehanna and Susquehanna rivers to identify trends in angler behavior to aid in determination of regulatory and management practices.

~Return to Table of Contents~

9.0 Human Dimensions

9.1 River Boating Activities

Commercial Vessels

Commercial vessels operating on the West Branch Susquehanna and Susquehanna rivers are limited to daily use or passenger transportation. Navigability limitations associated with the hydropower dams in the downstream portion of the rivers and caused by unique geomorphological characteristics of the basin (i.e., expansive shallows and numerous bedrock ridges) prevent traditional commercial freight operations in the Pennsylvania portion of these rivers. Canal systems were used historically for commercial transport of freight but have since been abandoned. Charter or commercial operations are required to register their vessels with the PFBC and United States Coast Guard (USCG). Presently, three vessels are registered with the PFBC as operating commercial operations on the West Branch Susquehanna and Susquehanna rivers (Appendix A, Table 9.1.1).

Recreational vessels

Recreational boating is a primary activity that occurs at the West Branch Susquehanna and Susquehanna rivers. Recreational boating pools are maintained at Curwensville Lake, Lock Haven, Williamsport at the West Branch Susquehanna River and at Lake Augusta located near the confluence of the Susquehanna River and West Branch Susquehanna River. Impoundments created by York Haven Dam, Safe Harbor Dam, Holtwod Dam and Conowingo Dam hydroelectric generation facilities also provide recreational boating opportunities.

All powered boats are required to be registered semi-annually with the PFBC Bureau of Administration, Division of Licensing and Registration if they are launched from a PFBC access area or property, a Department of Conservation and Natural Resources (DCNR), Bureau of State Parks property or a property where the owner requires such documentation. Unpowered vessels not covered by the previously described criteria are not required to be registered but must display a launch permit to use PFBC accesses and properties and DCNR state parks. However, unpowered vessels may be voluntarily registered. Further information regarding registration of recreational vessels is detailed at http://www.fish.state.pa.us/registration.htm.

All recreational vessels operated in the waters of the Commonwealth are subject to the requirements of the Pennsylvania Fish and Boat Code and the regulations published in Title 58 of the Pennsylvania Code (http://www.fish.state.pa.us/bookboat.htm).

Military vessels

The West Branch Susquehanna and Susquehanna rivers are currently covered by the Department of Homeland Security, United States Coast Guard, Fifth Coast Guard District based in Portsmouth, Virginia. This District serves the mid-Atlantic Region.

Marinas (public and private)

Eleven marinas or other similar facilities are located at the West Branch Susquehanna and the Susquehanna rivers (Appendix A, Table 9.1.2). The only public marinas are located at Shikellamy State Park at the city of Sunbury, Pennsylvania and City Island at the city of Harrisburg, Pennsylvania and are owned by the, DCNR, Bureau of State Parks and the City of Harrisburg, respectively.

Launch ramps (public and private)

A total of 157 boating access points are available for boaters at the West Branch Susquehanna and Susquehanna rivers (Appendix A, Table 9.1.3). Of these, 112 are public, 43 are private, and three have unknown status. The PFBC currently owns and maintains 35 boating access points on the West Branch Susquehanna and Susquehanna rivers and serves as a cooperator with local government at two others. Funding for acquisition, construction, and maintenance of all PFBC access is directed by the Bureau of Boating and Access through the PFBC "boat fund", DCNR cost sharing matches, and federal sportfishing support dollars.

Boat liveries/rental companies

A limited number of boat liveries and rental companies provide rental equipment and shuttle services for use at the West Branch Susquehanna and Susquehanna rivers (Appendix A, Table 9.1.4). A list of these providers is periodically updated by the PFBC (http://www.fishandboat.com/livery.htm).

9.2 Tourism/Recreation Use

Tourism and recreational use are major contributors to not only the appreciation of these rivers as resources but also to the economies of the local communities. Fishing, hunting, power boating, paddling, and swimming are available in the West Branch Susquehanna and Susquehanna rivers along with hiking and biking opportunities on nearby trail systems.

Recreation facilities

Numerous recreation facilities are associated with the West Branch Susquehanna River and Susquehanna River. These include DCNR Parks and Forests, Pennsylvania Game Commission Game Lands, and a multitude of private and public parks and recreation facilities. Due to the large number of such facilities, this plan will only focus on the Commonwealth-owned facilities or other significant facilities. For a more comprehensive list of private and public recreational facilities, contact the Susquehanna Greenway Partnership (http://www.susquehannagreenway.org/greenway/site/default.asp) or any of their regional contacts (http://www.susquehannagreenway.org/greenway/cwp/view.asp?a=3&Q=413297&greenwayNav=|).

Curwensville Lake

Clearfield County operates and maintains the recreation area associated with Curwensville Lake which includes a beach, boat launch, picnic areas, athletic fields, playgrounds, picnic pavilions

and a 52-site campground. Recreational attendance during fiscal year 2006 was 228,583 visitor hours. Further information regarding the park is available from the park website, http://www.curwensvillelake.com (http://www.nab.usace.army.mil/EOC/Stats/curwensville.html 2009).

State Forests

Portions of the West Branch Susquehanna and Susquehanna rivers are bordered by or fall within portions of Sproul and Tiadaghton State Forests. More information regarding state forests is available from DCNR, Bureau of Forestry (http://www.dcnr.state.pa.us/forestry/).

State Parks

Portions of the West Branch Susquehanna and Susquehanna rivers are bordered by or fall within portions of Bucktail State Park Natural Area, and Hyner View, Susquehanna, Milton, Shikellamy and Susquehannock State parks. More information regarding state parks is available from DCNR, Bureau of State Parks (http://www.dcnr.state.pa.us/stateparks/index.aspx).

Game Lands

Portions of the West Branch Susquehanna and Susquehanna rivers are bordered by or fall within portions of PGC State Game Lands (SGL) 89, 100, 126, 194, 233, 237, 254, 258 and 290. More information regarding SGL is available from the PGC (http://www.pgc.state.pa.us/pgc/cwp/browse.asp?a=480&bc=0&c=69913&pgcNav=|).

City Island

City of Harrisburg, Department of Parks and Recreation operates City Island in the Susquehanna River near Harrisburg, Pennsylvania. This facility includes numerous recreational opportunities including a beach, marina, sports complex, fitness area, arcade, batting cages, miniature golf course and is home to the Harrisburg Senators minor league baseball team. More information regarding City Island is available from the City of Harrisburg, Department of Parks and Recreation (http://www.harrisburgevents.com/Common/City_Island_Map.html).

Guide Industry

The guide industry operating at the West Branch Susquehanna and Susquehanna rivers has grown in recent years. The most popular guided activity is recreational angling; however, some liveries offer guide service for canoe and kayak excursions. A comprehensive list of angler guides is detailed in Appendix A, Table 8.2.1. At the time of printing, the PFBC does not maintain a list of all canoe/kayak guiding services operating on the West Branch Susquehanna and Susquehanna rivers.

Nature programming and activities

There are numerous opportunities for nature programming and other nature related activities associated with the West Branch Susquehanna and Susquehanna rivers. Government

agencies, non-profit organizations, scout groups, watershed associations and other similar organizations could provide nature programming and activities associated with these rivers. Programs listed below include some of the more popular public programs; however, it is not a comprehensive list of all nature programs and activities that occur in the basin. The Susquehanna Greenway Partnership is currently developing an Interpretive Master Plan for the Susquehanna River Water Trail and Susquehanna Greenway. This project will include an inventory of existing educational and interpretive programs in the region (http://www.susquehannagreenway.org).

The Chesapeake Bay Foundation (CBF), Susquehanna Watershed Education Program, offered through the Pennsylvania office of the CBF, introduces teachers and students to aquatic ecosystems through daily, hands-on experience on waterways throughout the Susquehanna River watershed (http://www.cbf.org/Page.aspx?pid=871).

Harrisburg Area Riverboat Society, Susquehanna River School provides educational programming for area youth and adults about the history, ecology, environment, and conservation of the Susquehanna River. Activities are conducted on the "Pride of the Susquehanna" paddle wheel river boat which serves as a floating classroom (http://www.harrisburgriverboat.com/index.php?option=com_content&task=view&id=20&Itemid=23).

Water trails/bicycle paths

Water trails are boat routes suitable for canoes, kayaks and small motorized watercraft. Paddling is increasing in popularity making water trails more popular as well. The river trail network associated with the West Branch Susquehanna and Susquehanna rivers covers nearly the entire length of both rivers placing these rivers in a good position to accept this increase in popularity.

Susquehanna River Water Trail – West Branch

The West Branch Susquehanna River portion of the Susquehanna River Water Trail is a 240-mile trail extending downstream from the town of Cherry Tree, Pennsylvania to the confluence with the Susquehanna River at the city of Sunbury, Pennsylvania. The trail is sponsored by the Pennsylvania Lumber Heritage Region and approved by the American Canoe Association. More information is available via the Pennsylvania Lumber Heritage Region (http://www.lumberheritage.org/).

Susquehanna River Water Trail – North Branch

The North Branch portion of the Susquehanna River Water Trail extends from the New York-Pennsylvania border downstream to the confluence with the West Branch Susquehanna River at the city of Sunbury, Pennsylvania. This portion of the water trail is sponsored by the Endless Mountains Heritage Region and the Pennsylvania Environmental Council and is approved by

the American Canoe Association. More information is available via the Endless Mountains Heritage Region (http://www.endlessmountainsheritage.org/waterTrail.php).

Susquehanna River Water Trail – Middle

The Susquehanna River Water Trail is a 51-mile trail extending from Sunbury, Pennsylvania to Harrisburg, Pennsylvania, incorporating 25 access sites and 20 islands designated for day use and primitive camping. The Susquehanna River Trail is managed in partnership by the DCNR, Bureau of Forestry, the PFBC, the City of Harrisburg and the nonprofit Susquehanna River Trail Association, Inc. Volunteer individuals or groups can adopt islands where they serve as stewards for maintenance, monitoring resource impacts and tracking public use. Management techniques and use levels are continually evaluated to insure resource protection and a positive experience for the visitor. This water trail is approved by the American Canoe Association **(**http://www.susquehannarivertrail.org/**).**

Susquehanna River Water Trail – Lower Section

The lower section of the Susquehanna River Water trail is a 53-mile trail extending from the New Market Access downstream of Harrisburg, Pennsylvania to the Pennsylvania-Maryland border. This trail is sponsored by the Susquehanna Gateway Heritage Region and is approved by the American Canoe Association. More information is available via the Susquehanna Gateway Heritage Region (**http://www.lyhr.org/maps&guides.asp#**).

William J. Clinger Walkway

The William J. Clinger Walkway is a macadam walking path located on top of the levee system in the city of Lock Haven, Pennsylvania on the south shore of the West Branch Susquehanna River (Northcentral Pennsylvania Conservancy 2003).

Williamsport Riverwalk

The Williamsport Riverwalk is a three-mile loop trail along north shore of the West Branch Susquehanna River on the top of the levee system in the city of Williamsport, Pennsylvania and connects to South Williamsport, Pennsylvania via the Maynard and Market Street Bridges. The Riverwalk also provides access to other local trail systems (Susquehanna Greenway Partnership 2009).

Capital Area Greenbelt

The Capital Area Greenbelt is a 20-mile trail around the urbanized portions of Harrisburg, Pennsylvania. A large portion of the trail follows the eastern shore of the Susquehanna River in Harrisburg, Pennsylvania. The trail provides recreational opportunities such as hiking, biking, birding, walking, jogging and cross-country skiing for area residents. More information is available via the Capital Area Greenbelt Association (http://www.caga.org).

Wildlife viewing

Wildlife viewing opportunities are available throughout the West Branch Susquehanna River and Susquehanna River basins. Audubon Pennsylvania has developed the Susquehanna River Birding and Wildlife Trail comprised of 218 locations in 39 counties (http://web1.audubon.org/trailMaps/). Wildlife viewing opportunities are also available at any of the DCNR State Forests or State Parks or at PGC State Game Lands (SGL) and propagation areas associated with the rivers.

Economic value

No comprehensive estimate of the recreational value of the West Branch Susquehanna or Susquehanna rivers has been published to date. Several studies have presented some components of recreational value that could be extrapolated to give some importance to recreation value of the West Branch Susquehanna and Susquehanna rivers. The USFWS (2007) estimated that nearly $4 billion of expenditures were made associated with fishing, hunting and wildlife viewing in Pennsylvania during 2006. Considering the large portion of the Commonwealth encompassed by the Susquehanna River drainage, it is conceivable that a substantial portion of this value is associated with the Susquehanna River basin.

Hansen and colleagues (2008) estimated that recreational loss related to angling alone in the West Branch Susquehanna River watershed due to AMD pollution was $22.3 million, annually, based on 2006 values. The recreational angling opportunities lost at the West Branch Susquehanna River specifically was in excess of $2 million. The PFBC (Shields 2009) estimated that recreational angling associated with the Susquehanna River between Sunbury, Pennsylvania and Holtwood Dam had an annual estimated economic contribution of more than $2.4 million in 2007. Recreational angling in this section of the Susquehanna River also generated an economic impact of more than $975,000 annually, including creation of 16 full-time jobs created specifically by this use.

9.3 Public Comments

Upon completion of the draft of the West Branch Susquehanna and Susquehanna Rivers Management Plan, a period for public review and comment was available through April 30, 2011.

Meetings

Two public meetings were held to introduce the Susquehanna River Management Plan. These meetings will be held in Harrisburg and Lewisburg, Pennsylvania to ensure that the plan is presented to a comprehensive audience. These meetings served as an opportunity to provide recorded public comment regarding the plan and its adoption.

Written and electronic comments

Both written and electronic comments were taken through April 30, 2011. All comments were compiled and addressed in the final version of the Susquehanna River Management Plan.

9.4 Funding Opportunities

In order to implement many of the recommendations outlined in this plan, significant funding from outside sources will be necessary. Existing funding sources for this work include both public and private funding and cover a number of different disciplines. Appendix A, Table 9.4.1 lists available funding sources applicable for research directed toward the West Branch Susquehanna and Susquehanna rivers.

9.5 Education/ Research

Kindergarten through grade-12 programming

The PFBC, Bureau of Policy, Planning, and Communication, Division of Communication, Education and Outreach Section currently works with schools throughout the Commonwealth to coordinate and provide curriculum, including schools within the Susquehanna River Basin. In addition, both the PFBC and the PGC are contributors to Project WILD; a network of wildlife agencies that provides a wildlife-focused conservation education program for kindergarten through grade-12 educators and students (http://www.projectwild.org/). The PFBC is the state sponsor for WILD Aquatic. The Project WILD Aquatic K-12 Curriculum and Activity Guide emphasize aquatic wildlife and aquatic ecosystems. PFBC Project Aquatic WILD workshops are a minimum of eight hours, and participants receive the activity guide and PFBC publications and educational resources. Training includes the use of the guide and aquatic ecology background information. Aquatic WILD workshops may also be offered on specific topics such as American shad and Pennsylvania fishes.

College and University undergraduate programs

A number of private and Pennsylvania State System of Higher Education colleges and universities currently offer programs and courses that have environmental or aquatic components that focus on the West Branch Susquehanna and Susquehanna rivers due in large part to their proximity to the systems. A list of colleges and universities that have programs or courses that address the West Branch Susquehanna and Susquehanna rivers is detailed in Appendix A, Table 9.5.1.

A consortium of colleges and universities, in cooperation with the Geisinger Foundation, has initiated the Susquehanna River Heartland Coalition for Environmental Studies (SRHCES) to focus on the areas around the confluence of the West Brach Susquehanna and Susquehanna rivers. This group conducts research in this vicinity on topics ranging from water quality to social aspects of the river communities. The SRHCES has recently purchased the marina facility from the DCNR Bureau of Forestry, Shikellamy State Park and is in the process of remodeling to accommodate suitable area for laboratory analysis and class room space for the various member institutions. The SRHCES plans to conduct a number of cooperative research projects from this facility.

Scientific research activities (state, federal, private)

Research activities are conducted throughout the West Branch Susquehanna and Susquehanna rivers by a number of different agencies and organizations. Federal agencies

include the US EPA, USGS PA Water Science Center, USGS Leetown Science Center, USGS PA Cooperative Fisheries and Wildlife Research Unit, USFWS and the NWS. State agencies include PA DEP, DCNR, PGC and PFBC. The sole interstate agency is the Susquehanna River Basin Commission. Other organizations include Academy of Natural Science of Philadelphia Ruth Patrick Center for Environmental Studies, Chesapeake Bay Foundation, Stroud Water Research Center, The Nature Conservancy, Trout Unlimited and Western Pennsylvania Conservancy.

Opportunities for partnership

A primary focus of the PFBC Large River Program is to foster partnerships between the PFBC and other agencies and organizations to address an ecosystem-wide framework for managing Pennsylvania's large river systems including the Susquehanna, Delaware, Monongahela, Allegheny and Ohio rivers and their major tributaries. The immense scope and diversity of disciplines necessary to address the complexity of issues associated with the West Branch Susquehanna and Susquehanna rivers requires a strong network of partnerships. Presently, the PFBC Susquehanna River Biologist or other PFBC staff take part in the following cooperative efforts related to the West Branch Susquehanna and Susquehanna rivers: Susquehanna River smallmouth bass workgroup, Susquehanna River Anadromous Fish Restoration Cooperative, Technical Committee (SRAFRC); Susquehanna River Anadromous Fish Restoration Cooperative, Policy Committee (SRAFRC); Susquehanna River Heartland Coalition for Environmental Studies (SRHCES); West Branch Susquehanna River Restoration Coalition; Susquehanna River Basin Commission Water Quality Advisory Committee; and the Atlantic States Marine Fisheries Council (ASMFC).

9.6 River Stewardship

Several stewardship and advocacy groups exist though out the watershed that promote recreational and conservation uses of the West Branch Susquehanna and Susquehanna rivers. These groups include angler organizations and environmental advocacy groups, many of which having dual roles.

Angler organizations

The prevalence of angler organizations, primarily competitive fishing organizations, has increased in number in recent years. These groups, as they have grown, have brought large amounts of attention to the West Branch Susquehanna and Susquehanna rivers and often serve as 'watchdog' groups regarding game fish populations and water quality conditions. Through their activities, these groups promote the resources of these rivers. Table 9.6.1 lists angler organizations associated with the West Branch Susquehanna and Susquehanna rivers. More information regarding tournament angling is detailed in *Section 8, Recreational Fisheries*.

Environmental organizations

Similar to angler organizations, stewardship and environmental advocacy groups have also increased in numbers in recent years. Many of these groups have a specific focus (e.g. Susquehanna River Waterfowlers Association or Canoe Club of Greater Harrisburg), but all operate in the spirit of conservation and protection of the resources of the West Branch Susquehanna and Susquehanna rivers. These groups also vary broadly in scope and scale; including regional, national, and international organizations and vary in membership size. Appendix A, Table 9.6.2 lists environmental advocacy organizations associated with the West Branch Susquehanna and Susquehanna rivers.

9.7 Management Options

Priority 1: (*on-going activities or recommendations to be implemented in first year of management plan*).

- Actively pursue innovative and traditional funding sources for the completion of priority projects identified in the Susquehanna River Management Plan consistent with Issue 1, Goal 1 of the PFBC Strategic Plan.

~Return to Table of Contents~

10.0 Management Options

This following is a compendium of all management options recommended for action through out the management plan. The following management options are copied *verbatim* from previous sections of this plan.

Priority 1: (*on-going activities or recommendations to be implemented in first year of management plan*).

- Continue annual, directed sampling of YOY and adult smallmouth bass and YOY walleye to track trends in West Branch Susquehanna and Susquehanna River populations of both species and expand efforts as needed.
- Continue investigation into disease and intersex within the Susquehanna River smallmouth bass population and determine their impacts on the population.
- Develop a monitoring scheme to gather baseline community fisheries data to identify trends in species status over time and help to track and identify ecosystem-wide problems, should they arise.
- Actively pursue innovative and traditional funding sources for the completion of priority projects identified in the Susquehanna River Management Plan consistent with Issue 1, Goal 1 of the PFBC Strategic Plan.
- Continue to work with owners of FERC-licensed hydropower dams to promote timely, safe and effective migratory and resident fish passage to restore and maintain fisheries under existing licenses and negotiate terms and conditions of renewed licenses.
- Continue to work with SRBC and other agency partners to ensure that river flows are adequate to sustain quality, aquatic communities.
- Continue to coordinate with partner agencies to determine feasibility of installation of real-time water quality monitoring stations (temperature, dissolved oxygen, pH, and specific conductance) in association with at least a subset of existing stream gages at the West Branch Susquehanna and Susquehanna rivers.

Priority 2: (*recommendations with implementation date in years 2-3 of management plan*).

- Evaluate affects of catch-and-immediate-release regulation change on Susquehanna River smallmouth bass populations and develop population thresholds to trigger future management action.
- Develop a study to determine the effects that tournament angling has on Susquehanna River smallmouth bass populations.
- Begin evaluation of natural walleye reproduction in the West Branch Susquehanna and Susquehanna rivers as per recommendation in the PFBC, Division of Fisheries Management, Walleye Management Plan.
- Develop a study through the state wildlife grants program to determine the current status of the white fly *Ephoron leukon* in the West Branch Susquehanna and Susquehanna rivers

- Determine the impacts of the invasive rusty crayfish *Orconectes rusticus* and implications of future range expansion.
- Develop study to determine the role that gastropods may be having in parasite infections of fish species such as smallmouth bass.
- Work with PADEP to identify fisheries-based criteria to create a high-quality warm-water fisheries designation for inclusion in their existing criteria.
- Work with Division of Fisheries Management, Warmwater Unit to evaluate the feasibility of periodic, smaller-scale angler use and harvest surveys at the West Branch Susquehanna and Susquehanna rivers to identify trends in angler behavior to aid in determination of regulatory and management practices.

Priority 3: (*recommendations with implementation date in years 4-5 of management plan*).

- Develop a study through the state wildlife grants program to determine the status and distribution of riverine herptile species the eastern hellbender *Cryptobranchus allegeniensis* and redbelly turtle *Psuedemys rubriventris.*
- Facilitate or complete studies to identify habitat preferences of eastern hellbender *Cryptobranchus alleganiensis alleganiensis,* Chesapeake logperch *Percina bimaculata,* yellow lampmussel *Lampsilis cariosa* and rayed lampmussel *Lampsilis radiata*.
- Work with key cooperators to further define the scope of largemouth bass virus (LMBv) within the Susquehanna River Basin, determine role it has, if any, in the health of other centrarchid species, and potential ramifications of the presence of the virus.

~Return to Table of Contents~

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~Return to Table of Contents~

Appendix A

Table 5.3.2. Physicochemical water quality standards identified by SRBC for the Large River Assessment Program (from Hoffman 2006)

Parameter	Standard value
temperature	25 ^{o}C
dissolved oxygen (DO)*	4 mg/L
conductivity	800 mmhos/cm
pH$^{\$}$	6.0 -9.0 SU
alkalinity*	20 mg/L
total nitrogen	1.0 mg/L
nitrite	0.06 mg/L
nitrate	1.0 mg/L
total phosphorus	0.1 mg/L
orthophosphate	0.05 mg/L
total organic carbon (TOC)	10 mg/L
hardness	300 mg/L
magnesium	35 mg/L
calcium	100 mg/L
total suspended solids (TSS)	25 mg/L
sodium	20 mg/L
chloride	150 mg/L
sulfate	250 mg/L
iron	1,500 mg/L
maganese	1,000 mg/L
aluminum	200 mg/L
turbidity	150 NTU

** violation of standard for this parameter is reached by falling below indicated value*

$ violation of standad for this parameter is reached by falling outside of indicated range

Table 5.3.3.1. Locations in the West Branch Susquehanna and Susquehanna Rivers attaining at least 1 designated use (Category 2).

Water body	HUC Name	Miles	Use	Source	Pollutant
Susquehanna River	Upper Susquehanna	4.10	Potable Water Supply		14337
Susquehanna River	Upper Susquehanna River - Tunkhannock Creek	1.00	Aquatic Life		13328
Susquehanna River	Upper Susquehanna River - Tunkhannock Creek	1.00	Potable Water Supply		14325
Susquehanna River	Upper Susquehanna River - Tunkhannock Creek	1.00	Potable Water Supply		14325
Susquehanna River	Upper Susquehanna River- Lackawanna River	7.20	Potable Water Supply		14427
Susquehanna River	Upper Susquehanna River- Lackawanna River	7.20	Potable Water Supply		11868
West Branch Susquehanna River	Upper West Branch Susquehanna River	0.40	Aquatic Life		5972
West Branch Susquehanna River	Upper West Branch Susquehanna River	0.40	Potable Water Supply		14431
West Branch Susquehanna River	Upper West Branch Susquehanna River	0.40	Aquatic Life		11288
West Branch Susquehanna River	Upper West Branch Susquehanna River	0.40	Potable Water Supply		14349
West Branch Susquehanna River	Upper West Branch Susquehanna River	0.40	Fish Consumption		3261
West Branch Susquehanna River	Upper West Branch Susquehanna River	0.40	Aquatic Life		9934
West Branch Susquehanna River	Lower West Branch Susquehanna River	3.40	Potable Water Supply		14348
West Branch Susquehanna River	Lower West Branch Susquehanna River	3.40	Potable Water Supply		12071
West Branch Susquehanna River	Lower West Branch Susquehanna River	3.40	Aquatic Life		8299
Susquehanna River	Lower Susquehanna River - Penns Creek	5.60	Fish Consumption		3239

Table 5.3.3.1. Locations in the West Branch Susquehanna and Susquehanna Rivers attaining at least 1 designated use (Category 2) *(continued).*

Water body	HUC Name	Miles	Use	Source	Pollutant
Susquehanna River	Lower Susquehanna River - Penns Creek	5.60	Potable Water Supply		14328
Susquehanna River	Lower Susquehanna River - Swatara Creek	3.30	Fish Consumption		3240
Susquehanna River	Lower Susquehanna River - Swatara Creek	3.30	Fish Consumption		12742
Susquehanna River	Lower Susquehanna River - Swatara Creek	3.30	Aquatic Life		11427
Susquehanna River	Lower Susquehanna	1.80	Potable Water Supply		14417
Susquehanna River	Lower Susquehanna	1.80	Fish Consumption		3256
Susquehanna River	Lower Susquehanna	1.80	Aquatic Life		7844
Susquehanna River	Lower Susquehanna	1.80	Fish Consumption		3238
Susquehanna River	Lower Susquehanna	1.80	Fish Consumption		3255

Table 5.3.3.2. Locations in the West Branch Susquehanna and Susquehanna Rivers impaired for one or more uses, TMDL approved (Category 4a)

Water body	HUC Name	Miles	Use	Souce	Pollutant	List Date	TMDL Date
Susquehanna River	Upper Susquehanna River- Lackawanna River	73.57	Fish Consumption	Unknown	PCB	1996	
Susquehanna River	Owego-Wappasening	8.30	Fish Consumption	Unknown	PCB	2006	
Susquehanna River	Upper Susquehanna River - Tunkhannock Creek	84.44	Fish Consumption	Unknown	PCB	2006	03/12/1999

Table 5.3.3.3. Locations in the West Branch Susquehanna and Susquehanna Rivers impaired for one or more uses, not requiring TMDL (Category 4c).

Water body	HUC Name	Miles	Use	Souce	Pollutant	List Date	TMDL Date
Susquehanna River	Upper Susquehanna River - Lackawanna River	0.17	Aquatic Life	AMD	Flow alteration	2002	N/A

Table 5.3.3.4. Locations in the West Branch Susquehanna and Susquehanna Rivers impaired for one or more uses, requiring TMDL (Category 5).

Water body	HUC Name	Miles	Use	Souce	Pollutant	List Date	TMDL Date
Susquehanna River	Upper Susquehanna River	15.83	Fish Consumption	Unknown	Mercury	2002	2015
Susquehanna River	Upper Susquehanna River	2.47	Aquatic Life	Unknown	Metals	2006	2019
Susquehanna River	Owego-Wappasening	8.30	Fish Consumption	Unknown	Mercury	2002	2015
Susquehanna River	Upper Susquehanna River - Tunkhannock Creek	1.04	Aquatic Life	Unknown	Metals	2006	2019
Susquehanna River	Upper Susquehanna River - Tunkhannock Creek	84.44	Fish Consumption	Unknown	Mercury	2002	2015
Susquehanna River	Upper Susquehanna River- Lackawanna River	0.17	Aquatic Life	AMD	Metals	1996	2009
Susquehanna River	Upper Susquehanna River- Lackawanna River	0.17	Aquatic Life	AMD	pH	2002	2015
Susquehanna River	Upper Susquehanna River- Lackawanna River	0.17	Aquatic Life	AMD	Siltation	2002	2015
Susquehanna River	Upper Susquehanna River- Lackawanna River	37.19	Aquatic Life	AMD	Metals	1996	2009
Susquehanna River	Upper Susquehanna River- Lackawanna River	73.57	Fish Consumption	Unknown	Mercury	2002	2015

Table 5.3.3.4. Locations in the West Branch Susquehanna and Susquehanna Rivers impaired for one or more uses, requiring TMDL (Category 5) *(continued).*

Water body	HUC Name	Miles	Use	Souce	Pollutant	List Date	TMDL Date
West Branch Susquehanna River	Upper West Branch Susquehanna River	12.54	Aquatic Life	AMD	Siltation	2004	2017
West Branch Susquehanna River	Upper West Branch Susquehanna River	12.76	Aquatic Life	AMD	Metals	1996	2009
West Branch Susquehanna River	Upper West Branch Susquehanna River	2.69	Aquatic Life	road runoff	Siltation	2002	2015
West Branch Susquehanna River	Upper West Branch Susquehanna River	2.69	Aquatic Life	upstream impoundment	Nutrients	2002	2015
West Branch Susquehanna River	Upper West Branch Susquehanna River	2.69	Aquatic Life	upstream impoundment	Siltation	2002	2015
West Branch Susquehanna River	Upper West Branch Susquehanna River	8.37	Aquatic Life	AMD	Metals	2002	2015
West Branch Susquehanna River	Upper West Branch Susquehanna River	20.04	Aquatic Life	AMD	Metals	2002	2015
West Branch Susquehanna River	Upper West Branch Susquehanna River	20.04	Aquatic Life	Industrial Point Source	Thermal modification	2002	2015
West Branch Susquehanna River	Upper West Branch Susquehanna River	7.55	Aquatic Life	AMD	Metals	2002	2015

Table 5.3.3.4. Locations in the West Branch Susquehanna and Susquehanna Rivers impaired for one or more uses, requiring TMDL (Category 5) *(continued).*

Water body	HUC Name	Miles	Use	Souce	Pollutant	List Date	TMDL Date
West Branch Susquehanna River	Middle West Branch Susquehanna River	9.00	Fish Consumption	Unknown	PCB	2004	2017
West Branch Susquehanna River	Middle West Branch Susquehanna River	51.57	Aquatic Life	AMD	metals	1996	2009
West Branch Susquehanna River	Lower West Branch Susquehanna River	11.86	Fish Consumption	Unknown	PCB	2002	2015
West Branch Susquehanna River	Lower West Branch Susquehanna River	41.18	Fish Consumption	Unknown	PCB	2004	2017
West Branch Susquehanna River	Lower West Branch Susquehanna River	1.18	Aquatic Life	Unknown	metals	2006	2019
Susquehanna River	Lower Susquehanna River	1.23	Recreational	Unknown	Pathogens	2004	2017
Susquehanna River	Lower Susquehanna River	2.26	Aquatic Life	Unknown	Metals	2006	2019

Table 7.3.1. Insects and crustaceans documented from the West Branch Susquehanna River.

ARTHROPODA (arthropods)	
Insecta (insects)	
Ephemeroptera (mayflies)	
Ameletidae	
	Ameletus sp.
Baetidae	
	Acentrella sp.
	Acentrella turbida
	Acerpenna sp.
	Baetis sp.
	Baetis intercalaris
	Callibaetis sp.
	Centroptilum sp./ *Procloeon* sp.
	Heterocloeon sp.
	Plauditus sp.
	Plauditus cestus
	Pseudocloeon sp.
Isonychiidae	
	Isonychia sp.
Heptageniidae	
	Epeorus sp.
	Heptagenia sp.
	Leucrocuta sp.
	Rhithrogena sp.
	Stenacron sp.
	Stenacron interpunctatum
	Stenonema sp.
	Maccaffertium sp.
	Maccaffertium mediopunctatum
	Maccaffertium terminatum
Ephemerellidae	
	Ephemerella sp.
	Serratella sp.
	Dannella sp.
Tricorythidae	
	Tricorythodes sp.
Caenidae	
	Caenis sp.

Table 7.3.1. Insects and crustaceans documented from the West Branch Susquehanna River *(continued)*

Baetiscidae	
	Baetisca sp.
Leptophlebiidae	
	Paraleptophlebia sp.
Potamanthidae	
	Anthopotamus sp.
Ephemeridae	
	Ephemera sp.
	Ephemera guttulata
Odonata (dragonflies, damselflies)	
Ansioptera (dragonflies)	
Gomphidae	
	Dromogomphus sp.
	Gomphus sp.
	Lanthus sp.
	Ophiogomphus sp.
Zygoptera (damselflies)	
Calopterygidae	
Coenagrionidae	
	Argia sp.
Plecoptera (stoneflies)	
Peltoperlidae	
	Peltoperla sp.
	Tallaperla sp.
Taeniopterygidae	
	Taeniopteryx sp.
	Taenionema sp.
Nemouridae	
Capniidae	
Perlidae	
	Paragnetina sp.
	Acroneuria sp.
Chloroperlidae	
	Sweltsa sp.

Table 7.3.1. Insects and crustaceans documented from the West Branch Susquehanna River *(continued)*

Hemiptera (true bugs)	
Corixidae	
	Trichocorixa sp.
Coleoptera (beetles)	
Gyrinidae	
	Dineutus sp.
	Gyrinus sp.
Hydrophilidae	
	Berosus sp.
	Hydrobius sp.
Psephenidae	
	Psephenus sp.
Elmidae	
	Dubiraphia sp.
	Macronychus sp.
	Optioservus sp.
	Oulimnius sp.
	Promoresia sp.
	Stenelmis sp.
Megaloptera (alderflies, dobsonflies)	
Sialidae	
	Sialis sp.
Corydalidae	
	Corydalus cornutus
	Nigronia sp.
Diptera (true flies)	
Athericidae	
	Atherix sp.
Empididae	
	Hemerodromia sp.
Tipulidae	
	Tipula sp.
	Antocha sp.

	Dicranota sp.
	Hexatoma sp.

Table 7.3.1. Insects and crustaceans documented from the West Branch Susquehanna River *(continued)*

Simuliidae	
	Simulium sp.
Ceratopogonidae	
	Bezzia sp.
	Probezzia sp.
Chironomidae	
	Procladius sp.
	Ablabesmyia sp.
	Orthocladiinae
	Thienemanniella sp.
	Cardiocladius sp.
	Cricotopus sp.
	Cricotopus bicinctus group
	Cricotopus sp./*Orthocladius* sp.
	Chironominae
	Chironomus sp.
	Dicrotendipes sp.
	Phaenopsectra sp.
	Polypedilum sp.
	Stenochironomus sp.
	Rheotanytarsus sp.
	Tanytarsus sp.
Trichoptera (caddisflies)	
Philopotamidae	
	Chimarra sp.
Polycentropodidae	
	Neureclipsis sp.
	Polycentropus sp.
Hydropsychidae	
	Diplectrona sp.
	Ceratopsyche sp.
	Ceratopsyche morosa
	Cheumatopsyche sp.
	Hydropsyche sp.
	Hydropsyche dicantha

	Potamyia sp.
	Macrostemum sp.
	Macrostemum zebratum

Table 7.3.1. Insects and crustaceans documented from the West Branch Susquehanna River *(continued).*

Rhyacophilidae	
	Rhyacophila sp.
Glossosomatidae	
	Glossosoma sp.
Hydroptilidae	
	Dibusa sp.
	Hydroptila sp.
	Orthotrichia sp.
Brachycentridae	
	Brachycentrus sp.
	Brachycentrus lateralis
	Micrasema sp.
Uenoidae	
	Neophylax sp.
Leptoceridae	
	Oecetis sp.
Lepidoptera (moths)	
Crambidae	
	Petrophila sp.
CRUSTACEA (crustaceans)	
Ostracoda	
Cladocera	
Amphipoda	
Gammaridae	
	Gammarus sp.
Isopoda	
Asellidae	
	Caecidotea sp.
	Lirceus sp.
Decapoda	
Cambaridae	
	Orconectes sp.
	Orconectes obscurus

	Orconectes rusticus

data compiled from historic collections made by PADEP, SRBC, and USGS

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River.

ARTHROPODA (arthropods)	
Insecta (insects)	
Ephemeroptera (mayflies)	
Baetidae	
	Acentrella sp.
	Baetis sp.
	Baetis intercalaris
	Centroptilum sp.
	Heterocloeon sp.
	Heterocloeon curiosum
	Plauditus sp.
	Plauditus cestus
Isonychiidae	
	Isonychia sp.
	Isonychia rufa
Heptageniidae	
	Cinygmula sp.
Tricorythidae	*Epeorus* sp.
	Heptagenia sp.
	Heptagenia culacantha
	Heptagenia sp. nr. *flavescens*
	Leucrocuta sp.
	Leucrocuta sp. nr. *maculipennis*
	Maccaffertium sp.
	Maccaffertium mediopunctatum
	Maccaffertium meririvulanum
	Maccaffertium pulchellum
	Maccaffertium sp. nr. *meririvulanum*
	Rhithrogena sp.
	Stenacron sp.
	Stenacron interpunctatum
	Stenonema sp.
	Stenonema sp./ *Maccaffertium* sp.
Ephemerellidae	
	Ephemerella sp.
	Eurylophella sp.

	Serratella sp.
	Teloganopsis deficiens

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Tricorythidae	
	Tricorythodes sp.
Caenidae	
	Caenis sp.
Leptophlebiidae	
	Choroterpes sp.
	Habrophlebiodes sp.
	Leptophlebia sp.
	Paraleptophlebia sp.
Potamanthidae	
	Anthopotamus sp.
	Anthopotamus neglectus
Ephemeridae	
	Ephemera sp.
	Hexagenia sp.
	Hexagenia limbata
Polymitarcyidae	
	Ephoron sp.
	Ephoron leukon
Odonata (dragonflies, damselflies)	
Ansioptera	
Gomphidae	
	Dromogomphus sp.
	Gomphus sp.
	Gomphus lividus
	Gomphus vastus
	Lanthus sp.
	Ophiogomphus sp.
	Stylogomphus sp.
Aeshnidae	
	Anax sp.
	Anax junius
	Boyeria sp.
	Boyeria vinosa
Corduliidae	
	Macromia sp.
	Macromia illinoiensis

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Zygoptera	
Calopterygidae	
	Calopteryx sp.
	Hetaerina sp.
Coenagrionidae	
	Argia sp.
	Argia apicalis
	Argia moesta
	Enallagma sp.
	Enallagma civile
	Enallagma geminatum
	Enallagma signatum
	Ischnura sp.
Plecoptera (stoneflies)	
Pteronarcyidae	
	Pteronarcys sp.
Taeniopterygidae	
	Taeniopteryx sp.
	Taenionema sp.
Leuctridae	
	Leuctra sp.
Capniidae	
Perlidae	
	Agnetina sp.
	Agnetina capitata
	Neoperla sp.
	Paragnetina sp.
	Paragnetina media
	Acroneuria sp.
	Acroneuria carolinensis
	Acroneuria internata
	Attaneuria sp.
	Perlesta sp.
Perlodidae	

	Isoperla sp.
Chloroperlidae	
	Sweltsa sp.

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Hemiptera (true bugs)	
Belostomatidae	
	Belostoma sp.
Gerridae	
	Gerris sp.
	Metrobates sp.
	Rheumatobates sp.
	Trepobates sp.
Mesoveiidae	
	Mesovelia mulsanti
Coleoptera (beetles)	
Gyrinidae	
	Dineutus sp.
	Dineutus discolor
Haliplidae	
	Peltodytes sp.
Hydrochidae	
	Hydrochus sp.
Hydrophilidae	
	Berosus sp.
	Enochrus sp.
Hydraenidae	
Psephenidae	
	Psephenus sp.
	Psephenus herricki
	Ectopria sp.
Dryopidae	
	Helichus sp.
Scirtidae	
	Elodes sp.
Elmidae	
	Dubiraphia sp.
	Macronychus sp.
	Macronychus galbratus
	Optioservus sp.

	Oulimnius sp.
	Promoresia sp.
	Stenelmis sp.

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Megaloptera (alderflies, dobsonflies)	
Sialidae	
	Sialis sp.
Corydalidae	
	Corydalus cornutus
	Nigronia sp.
Diptera (true flies)	
Athericidae	
	Atherix sp.
	Atherix lantha
Empididae	
	Hemerodromia sp.
Tipulidae	
	Antocha sp.
	Hexatoma sp.
	Tipula sp.
Tabanidae	
	Tanbanus sp.
Simuliidae	
	Prosimulium sp.
	Simulium sp.
	Twinnia sp.
Ceratopogonidae	
	Bezzia sp.
	Probezzia sp.
Chironomidae	
	Tanypodinae
	Ablabesmyia auriensis
	Ablabesmyia mallochi
	Ablabesmyia sp.
	Anatopynia sp.
	Coelotanypus concinnus
	Coelotanypus sp.
	Labrundinia virescens

	Pentaneura sp.
	Procladius sp.
	Procladius riparius

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Chironomidae *(cont.)*	*Procladius rubellus*
	Thienemannimyia group
	Potthastia sp.
	Orthocladiinae
	Cardiocladius sp.
	Cricotopus sp.
	Cricotopus bicinctus
	Cricotopus bicinctus group
	Cricotopus nr *trifasciatus*
	Cricotopus sp./*Orthocladius* sp.
	Paracricotopus sp.
	Parametriocnemus sp.
	Psectrocladius sp.
	Tvetenia sp.
	Chironominae
	Chironomus sp.
	Chironomus attenuatus
	Chironomus decorus
	Cladopelma amachaerus
	Cryptochironomus sp.
	Cryptochironomus blarina
	Cryptochironomus fulvus
	Cryptochironomus nr *fulvus*
	Cryptochironomus nais
	Dicrotendipes sp.
	Glyptotendipes sp.
	Glyptotendipes lobiferus
	Microchironomus sp.
	Microtendipes sp.
	Paracladopelma sp.
	Parachironomus sp.
	Phaenopsectra sp.
	Phaenopsectra sp./*Tribelos* sp.
	Polypedilum sp.
	Polypedilum fallax

	Polypedilum halterale
	Polypedilum illinoense
	Stenochironomus sp.

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Chironomidae *(cont.)*	*Tribelos* sp.
	Pseudochironomus sp.
	Tanytarsini
	Micropsectra sp./*Tanytarsus* sp.
	Rheotanytarsus sp.
	Tanytarsus sp.
Culcidae	
	Chaoborus sp.
	Chaoborus punctipennis
Trichoptera (caddisflies)	
Philopotamidae	
	Chimarra sp.
	Chimarra obscura
	Dolophilodes sp.
Psychomyiidae	
	Psychomyia sp.
Polycentropodidae	
	Cyrnellus sp.
	Neureclipsis sp.
	Nyctiophylax sp.
	Polycentropus sp.
Hydropsychidae	
	Diplectrona sp.
	Ceratopsyche sp.
	Ceratopsyche morosa
	Cheumatopsyche sp.
	Hydropsyche sp.
	Hydropsyche hageni
	Hydropsyche leonardi
	Hydropsyche phalerata
	Hydropsyche sp. nr. *aerata*
	Potamyia sp.
	Macrostemum sp.
	Macrostemum zebratum

Rhyacophilidae	
	Rhyacophila sp.

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Glossosomatidae	
	Glossosoma sp.
	Agapetus sp.
	Protoptila sp.
Hydroptilidae	
	Agraylea sp.
	Dibusa sp.
	Hydroptila sp.
	Hydroptila perdita
	Hydroptila spatulata
	Oxyethira sp.
	Leucotrichia sp.
Brachycentridae	
	Brachycentrus sp.
	Micrasema sp.
Lepidostomatidae	
	Lepidostoma sp.
Limnephilidae	
	Pycnopsyche sp.
Uenoidae	
	Neophylax sp.
Helicopsychidae	
	Helicopsyche sp.
Leptoceridae	
	Ceraclea sp.
	Mystacides sp.
	Oecetis sp.
Lepidoptera (moths)	
Crambidae	
	Petrophila sp.
Pyralidae	
CRUSTACEA (crustaceans)	
Ostracoda	
Cladocera	

Amphipoda	
Crangonycidae	
	Crangonyx sp.

Table 7.3.2. Insects and crustaceans documented from the Susquehanna River *(continued).*

Gammaridae	
	Gammarus sp.
	Gammarus fasciatus
	Hyalella sp.
	Hyalella azteca
Isopoda	
Asellidae	
	Caecidotea sp.
	Caecidotea militaris
Decapoda	
Cambaridae	
	Orconectes sp.
	Orconectes obscurus
	Orconectes rusticus

Data compiled from historic collections made by PADEP, SRBC, USGS, RMC 1979, RMC 1980a, RMC 1980b, Robbins and Mathur 1977, Wurtz 1970a and Wurtz 1970b.

Table 7.5. Bird species associated with the West Branch Susquehanna and Susquehanna rivers

Species (common)	Species (scientific)
greater snow goose	*Chen caerulescens*
brant	*Branta bernicla*
Canada goose	*Branta canadensis*
mute swan	*Cygnus olor*
trumpeter swan	*Cygnus buccinator*
tundra swan	*Cygnus columbianus*
wood duck	*Aix sponsa*
gadwall	*Anas strepera*
Eurasian wigeon	*Anas penelope*
American wigeon	*Anas americana*
American black duck	*Anas rubripes*
mallard	*Anas platyrhynchos*
blue-winged teal	*Anas discors*
northern shoveler	*Anas clypeata*
northern pintail	*Anas acuta*
green-winged teal	*Anas crecca*
canvasback	*Aythya valisineria*
ring-necked duck	*Aythya collaris*
greater scaup	*Aythya marila*
lesser scaup	*Aythya affinis*
surf scoter	*Melanitta perspicillata*
white-winged scoter	*Melanitta fusca*
black scoter	*Melanitta nigra*
bufflehead	*Bucephala albeola*
common goldeneye	*Bucephala clangula*
hooded merganser	*Lophodytes cucullatus*
common merganser	*Mergus merganser*
red-breasted merganser	*Mergus serrator*
ruddy duck	*Oxyura jamaicensis*
wild turkey	*Meleagris gallopavo*
red-throated loon	*Gavia stellata*
common loon	*Gavia immer*
pied-billed grebe	*Podilymbus podiceps*
horned grebe	*Podiceps auritus*
red-necked grebe	*Podiceps grisegena*
double-crested cormorant	*Phalacrocorax auritus*

great cormorant	*Phalacrocorax carbo*

Table 7.5. Bird species associated with the West Branch Susquehanna and Susquehanna rivers *(continued).*

Species (common)	Species (scientific)
American bittern	*Botaurus lentiginosus*
least bittern	*Ixobrychus exilis*
great blue heron	*Ardea herodias*
great egret	*Casmerodius albus*
snowy egret	*Egretta thula*
little blue heron	*Egretta caerulea*
tricolored heron	*Egretta tricolor*
cattle egret	*Bubulcus ibis*
green heron	*Butorides virescens*
black-crowned night heron	*Nycticorax nycticorax*
yellow-crowned night heron	*Nyctanassa violacea*
glossy ibis	*Plegadis falcinellus*
plegadis ibis species	*Plegadis sp.*
black vulture	*Coragyps atratus*
turkey vulture	*Cathartes aura*
osprey	*Pandion haliaetus*
bald eagle	*Halieaeetus leucocephalus*
peregrine falcon	*Falco peregrinus*
king rail	*Rallus elegans*
Virginia rail	*Rallus limicola*
sora	*Porzana carolina*
common moorhen	*Gallinula chloropus*
American coot	*Fulica americana*
sandhill crane	*Grus canadensis*
black-bellied plover	*Pluvialis squatarola*
American golden-plover	*Pluvialis dominica*
semipalmated plover	*Charadrius semipalmatus*
piping plover	*Charadrius melodus*
killdeer	*Charadrius vociferus*
American avocet	*Recurvirostra americana*
spotted sandpiper	*Actitis macularia*
solitary sandpiper	*Tringa solitaria*
greater yellowlegs	*Tringa melanoleuca*
lesser yellowlegs	*Tringa flavipes*
willet	*Catoptrophorus semipalmatus*
whimbrel	*Numenius phaeopus*

Hudsonian godwit	*Limosa haemastica*
marbled godwit	*Limosa fedoa*

Table 7.5. Bird species associated with the West Branch Susquehanna and Susquehanna rivers *(continued)*

Species (common)	**Species (scientific)**
red knot	*Calidris canutus*
sanderling	*Calidris alba*
semipalmated sandpiper	*Calidris pusilla*
western sandpiper	*Calidris mauri*
little stint	*Calidris minuta*
least sandpiper	*Calidris minutilla*
white-rumped sandpiper	*Calidris fuscicollis*
Baird's sandpiper	*Calidris bairdii*
pectoral sandpiper	*Calidris melanotos*
dunlin	*Calidris alpina*
stilt sandpiper	*Calidris himantopus*
peep species	*Calidris sp.*
buff-breasted sandpiper	*Tryngites subruficollis*
short-billed dowitcher	*Limnodromus griseus*
long-billed dowitcher	*Limnodromus scolopaceus*
Wilson's (common) snipe	*Gallinago delicata*
American woodcock	*Scolopax minor*
Wilson's phalarope	*Phalaropus tricolor*
red-necked phalarope	*Phalaropus lobatus*
red phalarope	*Phalaropus fulicaria*
Bonaparte's gull	*Larus philadelphia*
black-headed gull	*Larus ridibundus*
little gull	*Larus minutus*
laughing gull	*Larus atricilla*
Franklin's gull	*Larus pipixcans*
ring-billed gull	*Larus delawarensis*
herring gull	*Larus argentatus*
lesser black-backed gull	*Larus fuscus*
glaucous gull	*Larus glaucescens*
great black-backed gull	*Larus marinus*
least tern	*Sterna antillarum*
gull-billed tern	*Sterna nilotica*
Caspian tern	*Sterna caspia*
black tern	*Chlidonias niger*
common tern	*Sterna hirundo*
Forster's tern	*Sterna forsteri*

belted kingfisher	*Ceryle alcyon*

Table 7.5. Bird species associated with the West Branch Susquehanna and Susquehanna rivers *(continued)*

Species (common)	Species (scientific)
eastern wood-peewee	*Contopus virens*
willow flycatcher	*Empidonax traillii*
yellow-throated vireo	*Vireo flavifrons*
blue-headed vireo	*Vireo solitarius*
warbling vireo	*Vireo gilvus*
red-eyed vireo	*Vireo olivaceus*
eastern tufted titmouse	*Baeolophus bicolor*
sedge wren	*Cistothorus platensis*
marsh wren	*Cistothorus palustris*
eastern bluebird	*Sialis sialis*
wood thrush	*Hylocichla mustelina*
cedar waxwing	*Bombycilla cedrorum*
northern parula	*Parula americana*
black-throated green warbler	*Dendroica virens*
pine warbler	*Dendroica pinus*
prairie warbler	*Dendroica discolor*
American redstart	*Setaphaga ruticilla*
prothonotary warbler	*Protonotaria citrea*
worm-eating warbler	*Helmitheros vermivorus*
ovenbird	*Seiurus aurocapilla*
common yellowthroat	*Geothlypis trichas*
field sparrow	*Spizella pusilla*
Nelson's sharp-tailed sparrow	*Ammodramus nelsoni*
seaside sparrow	*Ammodramus maritimus*
song sparrow	*Melospiza melodia*
swamp sparrow	*Melospiza georgiana*
scarlet tanager	*Piranga olivacea*
rose-breasted grosbeak	*Pheucticus ludovicianus*
indigo bunting	*Passerina cyanea*
red-winged blackbird	*Agelaius phoeniceus*
orchard oriole	*Icterus spurius*
Baltimore oriole	*Icterus galbula*

Data from Acres International (2003), Audubon Society of PA, county natural heritage inventories, and PGC

Table 8.1.1.1. Management sections of the West Branch Susquehanna River based on the recommendations of the PFBC sectioning strategy.

Section	Upper River Mile	Lower River Mile	Section Limit (upper)	Section Limit (lower)
1	240.89	207.30	Source	Chest Creek
2	207.30	175.91	Chest Creek	SR1001 Bridge near Hyde, PA
3	175.91	173.26	SR1001 Bridge near Hyde, PA	First RR Bridge downstream of Moose Creek
4	173.26	66.86	First RR Bridge downstream of Moose Creek	Bald Eagle Creek
5	66.86	35.79	Bald Eagle Creek	Loyalsock Creek
6	35.79	0.00	Loyalsock Creek	Mouth

Table 8.1.1.2. Management sections of the Susquehanna River based on the recommendations of the PFBC sectioning strategy.

Section	Upper River Mile	Lower River Mile	Section Limit (upper)	Section Limit (lower)
1	359.54	354.66	PA-NY state line	Oakland Dam
2	354.66	343.96	Oakland Dame	PA-NY state line
3	289.30	272.70	PA-NY state line	Sugar Creek
4	272.70	268.30	Sugar Creek	Towanda Creek
5	268.30	231.80	Towanda Creek	Meshoppen Creek
6	231.80	196.40	Meshoppen Creek	Lackawanna River
7	196.40	194.46	Lackawanna River	Border W. Pittston and Exeter
8	194.46	165.30	Border W. Pittston and Exeter	Wapwallopen Creek
9	165.30	145.90	Wapwallopen Creek	Fishing Creek
10	145.90	124.50	Fishing Creek	Mouth
11	124.50	121.20	West Branch Susquehanna River	PPL Dam
12	121.20	84.60	PPL Dam	Juniata River
13	84.60	60.00	Juniata River	Swatara Creek
14	60.00	56.20	Swatara Creek	York Haven Dam
15	56.20	42.40	York Haven Dam	PA Route 462 Bridge
16	42.40	31.90	PA Route 462 Bridge	Safe Harbor Dam
17	31.90	24.50	Safe Harbor Dam	Holtwood Dam
18	24.50	15.30	Holtwood Dam	PA-MD state line

Table 8.1.3.1. Historical stocking of the West Branch Susquehanna River by species.

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Restorative	1968	elvers	American eel	*Anguilla rostrata*	N/A	50,000	N/A
Restorative	1983	fry	American shad	*Alosa sapidissima*	06	323,000	N/A
Restorative	1996	fry	American shad	*Alosa sapidissima*	06	561,000	137.00
Restorative	1997	fry	American shad	*Alosa sapidissima*	06	622,000	152.00
Restorative	1998	fry	American shad	*Alosa sapidissima*	06	994,000	243.00
Restorative	1999	fry	American shad	*Alosa sapidissima*	06	994,000	243.00
Restorative	2000	fry	American shad	*Alosa sapidissima*	06	632,000	952.24
Restorative	2001	fry	American shad	*Alosa sapidissima*	06	23,000	34.65
Restorative	2002	fry	American shad	*Alosa sapidissima*	06	75,000	113.00
Restorative	2003	fry	American shad	*Alosa sapidissima*	06	591,557	891.30
Restorative	2004	fry	American shad	*Alosa sapidissima*	06	282,143	425.11
Restorative	2005	fry	American shad	*Alosa sapidissima*	05	335,083	730.30
Restorative	2006	fry	American shad	*Alosa sapidissima*	05	315,388	687.37
Restorative	2007	fry	American shad	*Alosa sapidissima*	06	67,673	101.96
Restorative	2008	fry	American shad	*Alosa sapidissima*	05	1,733,315	3,777.69
Restorative	1968	fingerling	northern pike^	*Esox lucius*	03	500	44.06
Restorative	1969	fingerling	northern pike^	*Esox lucius*	03	100,000	8,812.60
Maintenance	1983	fingerling	muskellunge	*Esox masquinongy*	06	1,500	2.26
Maintenance	1974	fry	tiger muskellunge	*Esox lucius x Esox masquinongy*	N/A	10,500	N/A
Maintenance	1975	fry	tiger muskellunge	*Esox lucius x Esox masquinongy*	N/A	15,000	N/A
Maintenance	1976	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	N/A	1,700	N/A
Maintenance	1977	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	N/A	1,010	N/A
Maintenance	1978	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	N/A	1,000	N/A
Maintenance	1979	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	N/A	1,650	N/A
Maintenance	1982	fingerling	tiger muskellunge^	*Esox lucius x Esox masquinongy*	03	550	48.47
Maintenance	1986	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	06	1,650	2.49
Maintenance	1988	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	06	1,650	2.49

Table 8.1.3.1. Historical stocking of the West Branch Susquehanna River by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1990	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	06	1,650	2.49
Maintenance	1992	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	06	4,850	7.31
Introduction	1955	fingerling	channel catfish^	*Ictalurus punctatus*	03	2,000	176.25
Introduction	1956	fingerling/ adult	channel catfish^	*Ictalurus punctatus*	03	1,000	88.13
Introduction	1974	fingerling	channel catfish	*Ictalurus punctatus*	06	29,000	N/A
Introduction	1986	adult	channel catfish#	*Ictalurus punctatus*	04	200	N/A
Introduction	1986	fingerling	channel catfish	*Ictalurus punctatus*	06	40,000	N/A
Introduction	1987	fingerling	channel catfish	*Ictalurus punctatus*	N/A	25,000	N/A
Maintenance	2003	adult	brown trout	*Salmo trutta*	03	2,000	176.21
Maintenance	2004	adult	brown trout	*Salmo trutta*	03	2,000	176.21
Maintenance	2005	adult	brown trout	*Salmo trutta*	03	1,800	158.59
Maintenance	2006	adult	brown trout	*Salmo trutta*	03	2,299	202.55
Maintenance	2007	adult	brown trout	*Salmo trutta*	03	960	84.58
Maintenance	2008	adult	brown trout	*Salmo trutta*	03	200	17.62
Maintenance	2009	adult	brown trout	*Salmo trutta*	03	900	79.30
Maintenance	2003	adult	rainbow trout	*Oncorhynchus mykiss*	03	1,000	88.11
Maintenance	2004	adult	rainbow trout	*Oncorhynchus mykiss*	03	1,100	96.92
Maintenance	2005	adult	rainbow trout	*Oncorhynchus mykiss*	03	2,795	246.26
Maintenance	2006	adult	rainbow trout	*Oncorhynchus mykiss*	03	2,296	202.29
Maintenance	2007	adult	rainbow trout	*Oncorhynchus mykiss*	03	2,735	240.97
Maintenance	2008	adult	rainbow trout	*Oncorhynchus mykiss*	03	3,495	307.93
Maintenance	2009	adult	rainbow trout	*Oncorhynchus mykiss*	03	2,600	229.07
Maintenance	2005	adult	rainbow trout (golden)	*Oncorhynchus mykiss*	03	5	0.44
Maintenance	2006	adult	rainbow trout (golden)	*Oncorhynchus mykiss*	03	2	0.18

Table 8.1.3.1. Historical stocking of the West Branch Susquehanna River by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	2007	adult	rainbow trout (golden)	*Oncorhynchus mykiss*	03	5	0.44
Maintenance	2008	adult	rainbow trout (golden)	*Oncorhynchus mykiss*	03	10	0.88
Maintenance	2009	adult	rainbow trout (golden)	*Oncorhynchus mykiss*	03	5	0.44
Introduction	1975	adult	black crappie^	*Poxomis nigromaculatis*	03	302	26.61
Introduction	1976	adult	black crappie^	*Poxomis nigromaculatis*	03	165	14.54
Introduction	1982	fingerling	smallmouth bass^	*Micropterus dolomieu*	03	5,400	475.88
Supplemental	1982	fingerling	smallmouth bass	*Micropterus dolomieu*	05	2,600	5.67
Supplemental	1982	fingerling	smallmouth bass	*Micropterus dolomieu*	06	2,000	3.01
Supplemental	1982	fingerling	smallmouth bass	*Micropterus dolomieu*	N/A	3,400	N/A
Introduction	1983	fingerling	smallmouth bass^	*Micropterus dolomieu*	03	6,700	590.44
Supplemental	1983	fingerling	smallmouth bass	*Micropterus dolomieu*	06	3,350	5.05
Supplemental	1983	fingerling	smallmouth bass	*Micropterus dolomieu*	N/A	7,700	N/A
Supplemental	1987	fingerling	smallmouth bass	*Micropterus dolomieu*	02	1,350	N/A
Supplemental	1987	fingerling	smallmouth bass^	*Micropterus dolomieu*	03	8,650	762.29
Introduction	1975	adult	bluegill^	*Lepomis macrochirus*	03	298	26.26
Introduction	1976	adult	bluegill^	*Lepomis macrochirus*	03	400	35.25
Introduction	1986	adult	bluegill#	*Lepomis macrochirus*	04	800	N/A
Introduction	1968	fingerling	walleye^	*Sander vitreus*	03	500	44.06
Introduction	1969	fry	walleye^	*Sander vitreus*	03	200,000	17,625.20
Introduction	1970	fingerling	walleye^	*Sander vitreus*	03	200,000	17,625.20
Supplemental	1980	fry	walleye	*Sander vitreus*	06	2,900,000	4,369.44
Supplemental	1984	fry	walleye	*Sander vitreus*	06	4,100,000	6,177.48
Supplemental	1987	fry	walleye	*Sander vitreus*	06	4,100,000	6,177.48
Supplemental	1990	fry	walleye	*Sander vitreus*	06	3,636,000	5,478.37
Supplemental	1991	fry	walleye	*Sander vitreus*	06	3,636,000	5,478.37
Supplemental	1992	fry	walleye	*Sander vitreus*	06	10,000,000	15,067.03

TABLE 8.1.3.1 Historical stocking of the West Branch Susquehanna River by species (*continued*)

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Supplemental	1993	fry	walleye	*Sander vitreus*	N/A	5,336,000	N/A
Supplemental	1994	fry	walleye	*Sander vitreus*	N/A	10,000,000	N/A
Supplemental	1995	fingerling	walleye	*Sander vitreus*	N/A	48,000	N/A
Restorative	1976	adult	yellow perch^	*Perca flavescens*	03	35	3.08

^ *reach designated for stocking extended beyond the bounds of current sectioning strategy*

records found of a private stocking conducted by the "Dam Fish Program" in Lock Haven, PA

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species.

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Restorative	1996	fry	American shad	*Alosa sapidissima*	09	682,500	1,643.11
Restorative	1997	fingerling	American shad	*Alosa sapidissima*	08	1,199,000	2,578.50
Restorative	1998	fry	American shad	*Alosa sapidissima*	09	1,126,000	2,710.84
Restorative	1999	fry	American shad	*Alosa sapidissima*	09	1,211,000	2,915.47
Restorative	2000	fry	American shad	*Alosa sapidissima*	06	974,000	1,879.72
Restorative	2001	fry	American shad	*Alosa sapidissima*	06	677,000	1,306.55
Restorative	2002	fry	American shad	*Alosa sapidissima*	10	21,000	40.02
Restorative	2003	fry	American shad	*Alosa sapidissima*	06	800,129	1,544.17
Restorative	2004	fry	American shad	*Alosa sapidissima*	06	479,805	925.98
Restorative	2006	fry	American shad	*Alosa sapidissima*	06	273,594	528.01
Restorative	2007	fry	American shad	*Alosa sapidissima*	06	28,949	55.87
Restorative	2008	fry	American shad	*Alosa sapidissima*	06	172,581	333.07
Supplemental	1960	fingerling	muskellunge~	*Esox masquinongy*	06	400	0.77
Maintenance	1961	fingerling	muskellunge~	*Esox masquinongy*	06	100	0.19
Maintenance	1962	fingerling	muskellunge~	*Esox masquinongy*	06	1,000	1.93
Maintenance	1963	fingerling	muskellunge~	*Esox masquinongy*	06	1,000	1.93
Maintenance	1964	fingerling	muskellunge~	*Esox masquinongy*	06	3,000	5.79
Maintenance	1965	fry	muskellunge~	*Esox masquinongy*	06	10,000	19.30
Maintenance	1966	fry	muskellunge~	*Esox masquinongy*	01	5,000	146.77
Maintenance	1966	fry	muskellunge~	*Esox masquinongy*	06	10,000	19.30
Maintenance	1967	fry	muskellunge~	*Esox masquinongy*	01	5,000	146.77
Maintenance	1967	fry	muskellunge~	*Esox masquinongy*	06	10,000	19.30
Maintenance	1967	fry	muskellunge	*Esox masquinongy*	09	10,000	24.07
Maintenance	1967	fingerling	muskellunge	*Esox masquinongy*	09	600	1.44
Maintenance	1967	fry	muskellunge	*Esox masquinongy*	10	10,000	19.06
Maintenance	1967	fingerling	muskellunge	*Esox masquinongy*	10	600	1.14

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1968	fry	muskellunge~	*Esox masquinongy*	01	5,000	146.77
Maintenance	1968	fingerling	muskellunge~	*Esox masquinongy*	01	600	17.62
Maintenance	1968	fry	muskellunge~	*Esox masquinongy*	06	10,000	19.30
Maintenance	1968	fingerling	muskellunge~	*Esox masquinongy*	06	600	1.16
Maintenance	1968	fingerling	muskellunge	*Esox masquinongy*	09	600	1.44
Maintenance	1968	fingerling	muskellunge	*Esox masquinongy*	10	600	1.14
Maintenance	1969	fingerling	muskellunge~	*Esox masquinongy*	01	600	17.62
Maintenance	1969	fingerling	muskellunge~	*Esox masquinongy*	06	600	1.16
Maintenance	1969	fry	muskellunge	*Esox masquinongy*	09	10,000	24.07
Maintenance	1969	fingerling	muskellunge	*Esox masquinongy*	09	975	2.35
Maintenance	1969	fry	muskellunge	*Esox masquinongy*	10	10,000	19.06
Maintenance	1969	fingerling	muskellunge	*Esox masquinongy*	10	975	1.86
Maintenance	1970	fingerling	muskellunge~	*Esox masquinongy*	01	1,100	32.29
Maintenance	1970	fry	muskellunge~	*Esox masquinongy*	06	10,000	19.30
Maintenance	1970	fingerling	muskellunge~	*Esox masquinongy*	06	600	1.16
Maintenance	1970	fingerling	muskellunge	*Esox masquinongy*	09	600	1.44
Maintenance	1970	fingerling	muskellunge	*Esox masquinongy*	10	600	1.14
Maintenance	1971	fingerling	muskellunge~	*Esox masquinongy*	01	1,100	32.29
Maintenance	1971	fingerling	muskellunge~	*Esox masquinongy*	06	1,100	2.12
Maintenance	1971	fry	muskellunge	*Esox masquinongy*	09	10,000	24.07
Maintenance	1971	fingerling	muskellunge	*Esox masquinongy*	09	600	1.44
Maintenance	1971	fry	muskellunge	*Esox masquinongy*	10	10,000	19.06
Maintenance	1971	fingerling	muskellunge	*Esox masquinongy*	10	975	1.86
Maintenance	1972	fry	muskellunge~	*Esox masquinongy*	01	10,000	293.54
Maintenance	1972	fingerling	muskellunge~	*Esox masquinongy*	01	1,100	32.29
Maintenance	1972	fry	muskellunge~	*Esox masquinongy*	06	10,000	19.30

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1972	fingerling	muskellunge~	*Esox masquinongy*	06	10,000	19.30
Maintenance	1972	fry	muskellunge	*Esox masquinongy*	09	10,000	24.07
Maintenance	1972	fingerling	muskellunge	*Esox masquinongy*	09	600	1.44
Maintenance	1972	fry	muskellunge	*Esox masquinongy*	10	10,000	19.06
Maintenance	1972	fingerling	muskellunge	*Esox masquinongy*	10	600	1.14
Maintenance	1973	fry	muskellunge~	*Esox masquinongy*	01	10,000	293.54
Maintenance	1973	fingerling	muskellunge~	*Esox masquinongy*	01	600	17.61
Maintenance	1973	fingerling	muskellunge~	*Esox masquinongy*	06	600	1.16
Maintenance	1973	fry	muskellunge	*Esox masquinongy*	09	10,000	24.07
Maintenance	1973	fingerling	muskellunge	*Esox masquinongy*	09	600	1.44
Maintenance	1973	fry	muskellunge	*Esox masquinongy*	10	10,000	19.06
Maintenance	1973	fingerling	muskellunge	*Esox masquinongy*	10	500	0.95
Maintenance	1974	fry	muskellunge~	*Esox masquinongy*	01	10,000	293.54
Maintenance	1974	fingerling	muskellunge~	*Esox masquinongy*	01	1,000	29.35
Maintenance	1974	fry	muskellunge~	*Esox masquinongy*	06	10,000	19.30
Maintenance	1974	fingerling	muskellunge~	*Esox masquinongy*	06	1,100	2.12
Maintenance	1974	fry	muskellunge	*Esox masquinongy*	07	10,000	277.93
Maintenance	1974	fry	muskellunge	*Esox masquinongy*	08	10,000	21.51
Maintenance	1974	fry	muskellunge	*Esox masquinongy*	09	10,000	24.07
Maintenance	1974	fingerling	muskellunge	*Esox masquinongy*	09	600	1.44
Maintenance	1974	fry	muskellunge	*Esox masquinongy*	10	12,000	22.87
Maintenance	1974	fingerling	muskellunge	*Esox masquinongy*	10	600	1.14
Maintenance	1975	fry	muskellunge~	*Esox masquinongy*	01	8,000	234.84
Maintenance	1975	fry	muskellunge~	*Esox masquinongy*	06	20,000	38.60
Maintenance	1975	fingerling	muskellunge~	*Esox masquinongy*	06	1,100	2.12
Maintenance	1976	fingerling	muskellunge~	*Esox masquinongy*	06	800	1.54

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1976	fingerling	muskellunge	*Esox masquinongy*	07	800	22.23
Maintenance	1976	fingerling	muskellunge	*Esox masquinongy*	08	800	1.72
Maintenance	1976	fingerling	muskellunge	*Esox masquinongy*	09	800	1.93
Maintenance	1976	fingerling	muskellunge	*Esox masquinongy*	10	600	1.14
Maintenance	1977	fingerling	muskellunge~	*Esox masquinongy*	06	1,600	3.09
Maintenance	1977	fingerling	muskellunge	*Esox masquinongy*	10	400	0.76
Maintenance	1978	fingerling	muskellunge~	*Esox masquinongy*	06	1,200	2.32
Maintenance	1978	fingerling	muskellunge	*Esox masquinongy*	07	900	25.01
Maintenance	1978	fingerling	muskellunge	*Esox masquinongy*	08	900	1.94
Maintenance	1978	fingerling	muskellunge	*Esox masquinongy*	09	1,000	2.41
Maintenance	1978	fingerling	muskellunge	*Esox masquinongy*	10	900	1.72
Maintenance	1980	fingerling	muskellunge	*Esox masquinongy*	05	2,000	4.05
Maintenance	1980	fingerling	muskellunge	*Esox masquinongy*	09	1,000	2.41
Maintenance	1980	fingerling	muskellunge	*Esox masquinongy*	10	400	0.76
Maintenance	1981	fingerling	muskellunge	*Esox masquinongy*	02	700	7.69
Maintenance	1981	fingerling	muskellunge	*Esox masquinongy*	05	2,000	4.05
Maintenance	1981	fingerling	muskellunge~	*Esox masquinongy*	06	2,000	3.86
Maintenance	1981	fingerling	muskellunge	*Esox masquinongy*	10	1,300	2.48
Maintenance	1982	fingerling	muskellunge~	*Esox masquinongy*	06	2,000	3.86
Maintenance	1982	fingerling	muskellunge	*Esox masquinongy*	10	600	1.14
Maintenance	1983	fingerling	muskellunge	*Esox masquinongy*	03	750	3.50
Maintenance	1983	fingerling	muskellunge	*Esox masquinongy*	05	1,600	3.24
Maintenance	1983	fingerling	muskellunge	*Esox masquinongy*	09	1,000	2.41
Maintenance	1984	fingerling	muskellunge	*Esox masquinongy*	02	700	7.69
Maintenance	1984	fingerling	muskellunge	*Esox masquinongy*	04	700	12.23
Maintenance	1984	fingerling	muskellunge	*Esox masquinongy*	06	1,602	3.09

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1984	fingerling	muskellunge	*Esox masquinongy*	10	1,200	2.29
Maintenance	1985	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	1985	fingerling	muskellunge	*Esox masquinongy*	02	500	5.50
Maintenance	1985	fingerling	muskellunge	*Esox masquinongy*	03	750	3.50
Maintenance	1985	fingerling	muskellunge	*Esox masquinongy*	05	1,600	3.24
Maintenance	1985	fingerling	muskellunge	*Esox masquinongy*	09	851	2.05
Maintenance	1986	fingerling	muskellunge	*Esox masquinongy*	04	200	3.51
Maintenance	1986	fingerling	muskellunge	*Esox masquinongy*	06	1,600	3.09
Maintenance	1986	fingerling	muskellunge	*Esox masquinongy*	10	2,000	3.81
Maintenance	1987	fingerling	muskellunge	*Esox masquinongy*	01	400	11.74
Maintenance	1987	fingerling	muskellunge	*Esox masquinongy*	02	400	4.40
Maintenance	1987	fingerling	muskellunge	*Esox masquinongy*	03	800	3.73
Maintenance	1987	fingerling	muskellunge	*Esox masquinongy*	05	1,600	3.24
Maintenance	1987	fingerling	muskellunge	*Esox masquinongy*	09	1,600	3.85
Maintenance	1988	fingerling	muskellunge	*Esox masquinongy*	04	200	3.51
Maintenance	1988	fingerling	muskellunge	*Esox masquinongy*	06	1,300	2.51
Maintenance	1988	fingerling	muskellunge	*Esox masquinongy*	10	2,600	4.96
Maintenance	1989	fingerling	muskellunge	*Esox masquinongy*	01	250	7.34
Maintenance	1989	fingerling	muskellunge	*Esox masquinongy*	02	550	6.04
Maintenance	1990	fingerling	muskellunge	*Esox masquinongy*	04	200	3.51
Maintenance	1990	fingerling	muskellunge	*Esox masquinongy*	06	1,600	3.09
Maintenance	1990	fingerling	muskellunge	*Esox masquinongy*	10	1,800	3.43
Maintenance	1991	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	1991	fingerling	muskellunge	*Esox masquinongy*	02	550	6.04
Maintenance	1991	fingerling	muskellunge	*Esox masquinongy*	03	650	3.03
Maintenance	1991	fingerling	muskellunge	*Esox masquinongy*	05	3,000	6.08

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1991	fingerling	muskellunge	*Esox masquinongy*	07	250	6.95
Maintenance	1991	fingerling	muskellunge	*Esox masquinongy*	09	900	2.17
Maintenance	1992	fingerling	muskellunge	*Esox masquinongy*	04	300	5.27
Maintenance	1992	fingerling	muskellunge	*Esox masquinongy*	06	2,200	4.25
Maintenance	1992	fingerling	muskellunge	*Esox masquinongy*	08	2,800	6.02
Maintenance	1992	fingerling	muskellunge	*Esox masquinongy*	10	700	1.33
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	02	600	6.59
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	03	1,300	6.06
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	05	2,700	5.47
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	07	300	8.34
Maintenance	1994	fingerling	muskellunge	*Esox masquinongy*	04	300	5.27
Maintenance	1994	fingerling	muskellunge	*Esox masquinongy*	06	2,202	4.25
Maintenance	1994	fingerling	muskellunge	*Esox masquinongy*	08	2,800	6.02
Maintenance	1994	fingerling	muskellunge	*Esox masquinongy*	10	3,451	6.58
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	02	600	6.59
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	03	1,300	6.06
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	05	3,100	6.28
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	07	300	8.34
Maintenance	1996	fingerling	muskellunge	*Esox masquinongy*	04	300	5.27
Maintenance	1996	fingerling	muskellunge	*Esox masquinongy*	06	2,200	4.25
Maintenance	1996	fingerling	muskellunge	*Esox masquinongy*	08	2,800	6.02
Maintenance	1996	fingerling	muskellunge	*Esox masquinongy*	10	3,451	6.58
Maintenance	1997	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	1997	fingerling	muskellunge	*Esox masquinongy*	02	600	6.59

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1997	fingerling	muskellunge	*Esox masquinongy*	03	1,300	6.06
Maintenance	1997	fingerling	muskellunge	*Esox masquinongy*	05	3,100	6.28
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	04	300	5.27
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	06	2,200	4.25
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	08	2,800	6.02
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	10	3,451	6.58
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	01	600	17.62
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	02	1,800	19.78
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	03	3,900	18.19
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	05	9,300	18.85
Maintenance	2000	fingerling	muskellunge	*Esox masquinongy*	04	300	5.27
Maintenance	2000	fingerling	muskellunge	*Esox masquinongy*	06	2,200	4.25
Maintenance	2000	fingerling	muskellunge	*Esox masquinongy*	08	2,800	6.02
Maintenance	2000	fingerling	muskellunge	*Esox masquinongy*	10	3,452	6.58
Maintenance	2001	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	2001	fingerling	muskellunge	*Esox masquinongy*	02	597	6.56
Maintenance	2001	fingerling	muskellunge	*Esox masquinongy*	03	1,300	6.06
Maintenance	2001	fingerling	muskellunge	*Esox masquinongy*	05	3,100	6.28
Maintenance	2002	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	2002	fingerling	muskellunge	*Esox masquinongy*	02	600	6.59
Maintenance	2002	fingerling	muskellunge	*Esox masquinongy*	03	1,300	6.06
Maintenance	2002	fingerling	muskellunge	*Esox masquinongy*	05	3,100	6.28
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	01	200	5.87
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	02	600	6.59
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	03	1,298	6.05
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	05	3,096	6.27

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	2004	fingerling	muskellunge	*Esox masquinongy*	04	300	5.27
Maintenance	2004	fingerling	muskellunge	*Esox masquinongy*	06	3,100	5.98
Maintenance	2004	fingerling	muskellunge	*Esox masquinongy*	08	2,800	6.02
Maintenance	2004	fingerling	muskellunge	*Esox masquinongy*	10	3,199	6.10
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	01	100	2.94
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	02	300	3.30
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	03	650	3.03
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	04	150	2.63
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	05	1,500	3.04
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	06	1,551	2.99
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	07	100	2.78
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	08	1,400	3.01
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	10	1,600	3.05
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	01	100	2.94
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	02	298	3.30
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	03	650	3.03
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	04	148	2.60
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	05	1,500	3.04
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	06	1,548	2.99
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	07	100	2.78
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	08	1,400	3.01
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	10	1,600	3.05
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	01	100	2.94
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	02	300	3.30
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	03	650	3.03
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	04	150	2.63

Table 8.1.3. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	05	1,500	3.04
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	06	1,551	2.99
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	07	100	2.78
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	08	1,400	3.01
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	10	1,600	3.05
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	01	100	2.94
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	02	300	3.30
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	03	650	3.03
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	04	150	2.63
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	05	1,500	3.04
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	06	1,551	2.99
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	07	100	2.78
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	08	1,400	3.01
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	10	1,600	3.05
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	01	100	2.94
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	02	300	3.30
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	03	650	3.03
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	04	150	2.63
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	05	1,500	3.04
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	06	1,550	2.99
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	07	100	2.78
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	08	1,400	3.01
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	10	1,600	3.05
Maintenance	1985	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	05	10,300	20.87
Supplemental	1992	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	03	1,300	6.06
Supplemental	1992	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	04	300	5.27

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Supplemental	1992	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	05	2,050	4.15
Supplemental	1992	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	10	9,620	18.33
Supplemental	1993	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	10	1,751	3.34
Supplemental	1994	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	04	300	5.27
Supplemental	1994	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	06	2,202	4.25
Supplemental	1994	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	08	2,800	6.02
Supplemental	1994	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	10	3,451	6.58
Maintenance	1983	fingerling	chain pickerel	*Esox niger*	02	400	4.40
Maintenance	1967	fingerling	smallmouth bass	*Micropterus dolomieu*	06	1,700	3.28
Maintenance	1967	fingerling	smallmouth bass	*Micropterus dolomieu*	07	1,700	47.25
Maintenance	1967	fingerling	smallmouth bass	*Micropterus dolomieu*	08	750	1.61
Maintenance	1968	fingerling	smallmouth bass	*Micropterus dolomieu*	06	3,500	6.75
Maintenance	1968	fingerling	smallmouth bass	*Micropterus dolomieu*	07	3,500	97.27
Maintenance	1968	fingerling	smallmouth bass	*Micropterus dolomieu*	08	3,000	6.45
Maintenance	1968	fingerling	smallmouth bass	*Micropterus dolomieu*	09	3,000	7.22
Maintenance	1968	fingerling	smallmouth bass	*Micropterus dolomieu*	10	2,000	3.81
Maintenance	1970	fingerling	smallmouth bass	*Micropterus dolomieu*	10	2,500	4.77
Supplemental	1963	fingerling	walleye~	*Sander vitreus*	01	6,000	176.13
Supplemental	1964	fry	walleye~	*Sander vitreus*	06	550,000	1,061.45
Supplemental	1964	fry	walleye	*Sander vitreus*	07	250,000	6,948.19
Supplemental	1964	fry	walleye	*Sander vitreus*	08	250,000	537.64
Supplemental	1965	fingerling	walleye~	*Sander vitreus*	06	24,000	46.32
Supplemental	1965	fingerling	walleye	*Sander vitreus*	07	24,000	667.03
Supplemental	1965	fingerling	walleye	*Sander vitreus*	08	24,000	51.61
Supplemental	1965	fingerling	walleye	*Sander vitreus*	10	27,000	51.46
Supplemental	1966	fry	walleye~	*Sander vitreus*	06	250,000	482.48

Table 8.1.3.2. Historical stocking of the Susquehanna River upstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Supplemental	1966	fry	walleye	*Sander vitreus*	07	250,000	6,948.19
Supplemental	1966	fry	walleye	*Sander vitreus*	08	200,000	430.11
Supplemental	1966	fry	walleye	*Sander vitreus*	10	400,000	762.34
Supplemental	1967	fry	walleye~	*Sander vitreus*	06	500,000	964.95
Supplemental	1967	fry	walleye	*Sander vitreus*	07	500,000	13,896.38
Supplemental	1967	fry	walleye	*Sander vitreus*	08	500,000	1,075.28
Supplemental	1969	fry	walleye	*Sander vitreus*	10	100,000	190.58
Supplemental	1988	fry	walleye	*Sander vitreus*	10	800,000	1,524.68
Supplemental	1989	fry	walleye	*Sander vitreus*	10	708,000	1,349.34
Supplemental	1990	fry	walleye	*Sander vitreus*	10	2,610,253	4,974.75

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species.

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Restorative	1978	fingerling	American eel	*Anguilla rostrata*	13	20,000	12.84
Restorative	1979	fingerling	American eel	*Anguilla rostrata*	13	300,000	192.56
Restorative	1980	fingerling	American eel	*Anguilla rostrata*	13	108,000	69.32
Restorative	2003	fry	hickory shad	*Alosa mediocris*	18	1,000,000	1,848.36
Restorative	2004	fry	hickory shad	*Alosa mediocris*	18	3,366,574	6,222.64
Restorative	2005	fry	hickory shad	*Alosa mediocris*	18	5,355,380	9,898.67
Restorative	2006	fry	hickory shad	*Alosa mediocris*	18	2,593,164	4,793.10
Restorative	2007	fry	hickory shad	*Alosa mediocris*	18	3,323,742	6,143.47
Restorative	1989	fry	American shad	*Alosa sapidissima*	12	11,544,450	4,920.89
Restorative	1990	fingerling	American shad	*Alosa sapidissima*	12	1,000	0.43
Restorative	1990	fry	American shad	*Alosa sapidissima*	12	2,973,900	1,267.64
Restorative	1991	fry	American shad	*Alosa sapidissima*	12	3,835,400	1,634.86
Restorative	1992	fry	American shad	*Alosa sapidissima*	12	1,249,900	532.78
Restorative	1995	fry	American shad	*Alosa sapidissima*	12	961,000	409.63
Restorative	1996	fry	American shad	*Alosa sapidissima*	12	943,300	402.09
Restorative	1997	fry	American shad	*Alosa sapidissima*	12	2,801,000	1,193.94
Restorative	1998	fry	American shad	*Alosa sapidissima*	12	1,787,000	761.72
Restorative	2000	fry	American shad	*Alosa sapidissima*	12	1,122,000	478.26
Restorative	2001	fry	American shad	*Alosa sapidissima*	12	2,818,000	1,201.19
Restorative	2003	fry	American shad	*Alosa sapidissima*	12	4,021,511	1,714.19
Restorative	2004	fry	American shad	*Alosa sapidissima*	12	284,266	121.17
Restorative	2005	fry	American shad	*Alosa sapidissima*	12	981,842	418.52
Restorative	2006	fry	American shad	*Alosa sapidissima*	12	28,607	12.19
Restorative	2007	fry	American shad	*Alosa sapidissima*	12	80,384	34.26
Restorative	2008	fry	American shad	*Alosa sapidissima*	12	175,000	74.60
Maintenance	1975	fingerling	muskellunge	*Esox masquinongy*	12	1,100	0.47

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1975	fingerling	muskellunge	*Esox masquinongy*	13	3,800	2.44
Maintenance	1975	fry	muskellunge	*Esox masquinongy*	13	59,000	37.87
Maintenance	1976	fingerling	muskellunge	*Esox masquinongy*	13	300	0.19
Maintenance	1977	fingerling	muskellunge	*Esox masquinongy*	13	1,100	0.71
Maintenance	1978	fingerling	muskellunge	*Esox masquinongy*	13	5,504	3.53
Maintenance	1980	fingerling	muskellunge	*Esox masquinongy*	13	4,338	2.78
Maintenance	1982	fingerling	muskellunge	*Esox masquinongy*	12	3,000	1.28
Maintenance	1982	fingerling	muskellunge	*Esox masquinongy*	13	2,353	1.51
Maintenance	1983	fingerling	muskellunge	*Esox masquinongy*	13	1,300	0.83
Maintenance	1984	fingerling	muskellunge	*Esox masquinongy*	13	5,253	3.37
Maintenance	1986	fingerling	muskellunge	*Esox masquinongy*	11	100	2.04
Maintenance	1986	fingerling	muskellunge	*Esox masquinongy*	12	1,702	0.73
Maintenance	1986	fingerling	muskellunge	*Esox masquinongy*	13	400	0.26
Maintenance	1986	fingerling	muskellunge	*Esox masquinongy*	14	372	3.18
Maintenance	1987	fingerling	muskellunge	*Esox masquinongy*	13	31	0.02
Maintenance	1988	fingerling	muskellunge	*Esox masquinongy*	11	250	5.10
Maintenance	1988	fingerling	muskellunge	*Esox masquinongy*	12	1,900	0.81
Maintenance	1988	fingerling	muskellunge	*Esox masquinongy*	13	1,200	0.77
Maintenance	1988	fingerling	muskellunge	*Esox masquinongy*	14	1,300	11.10
Maintenance	1990	fingerling	muskellunge	*Esox masquinongy*	11	250	5.10
Maintenance	1990	fingerling	muskellunge	*Esox masquinongy*	12	5,500	2.34
Maintenance	1990	fingerling	muskellunge	*Esox masquinongy*	13	1,200	0.77
Maintenance	1990	fingerling	muskellunge	*Esox masquinongy*	14	950	8.12
Maintenance	1991	fingerling	muskellunge	*Esox masquinongy*	12	1,226	0.52
Maintenance	1992	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1992	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1992	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	13	6,551	4.21
Maintenance	1993	fingerling	muskellunge	*Esox masquinongy*	15	1,100	1.63
Maintenance	1994	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1994	fingerling	muskellunge	*Esox masquinongy*	12	2,000	0.85
Maintenance	1994	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	1995	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	1996	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1996	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	1996	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	1997	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1997	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	1997	fingerling	muskellunge	*Esox masquinongy*	13	4,326	2.78
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	1998	fingerling	muskellunge	*Esox masquinongy*	15	1,100	1.63
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	1999	fingerling	muskellunge	*Esox masquinongy*	15	1,100	1.63
Maintenance	2000	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	2000	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	2000	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	2001	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	2001	fingerling	muskellunge	*Esox masquinongy*	12	3,692	1.57
Maintenance	2001	fingerling	muskellunge	*Esox masquinongy*	13	5,498	3.53
Maintenance	2002	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	2002	fingerling	muskellunge	*Esox masquinongy*	12	3,700	1.58
Maintenance	2002	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	11	499	10.17
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	12	3,696	1.58
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	2003	fingerling	muskellunge	*Esox masquinongy*	15	1,100	1.63
Maintenance	2004	fingerling	muskellunge	*Esox masquinongy*	11	4,200	85.64
Maintenance	2004	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	11	495	10.09
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	12	3,676	1.57
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	13	5,488	3.52
Maintenance	2005	fingerling	muskellunge	*Esox masquinongy*	15	1,994	2.96
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	11	500	10.20
Maintenance	2006	fingerling	muskellunge	*Esox masquinongy*	13	5,494	3.53
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	11	1,000	20.39
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	2007	fingerling	muskellunge	*Esox masquinongy*	15	2,050	3.04
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	11	2,000	40.78
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	13	6,500	4.17
Maintenance	2008	fingerling	muskellunge	*Esox masquinongy*	15	1,000	1.48

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	11	1,000	20.39
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	13	5,500	3.53
Maintenance	2009	fingerling	muskellunge	*Esox masquinongy*	15	2,050	3.04
Maintenance	1981	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	16	14,800	12.66
Maintenance	1981	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	17	6,050	12.20
Maintenance	1987	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	1,400	2.08
Maintenance	1987	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	17	400	0.81
Maintenance	1989	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	4,100	6.08
Maintenance	1989	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	17	400	0.81
Maintenance	1991	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	4,100	6.08
Maintenance	1991	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	17	400	0.81
Maintenance	1992	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1993	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1993	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	3,000	4.45
Maintenance	1994	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1995	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1995	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	2,000	2.96
Maintenance	1996	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1997	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1997	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	2,000	2.96
Maintenance	1998	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1999	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	1999	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	2,000	2.96
Maintenance	2000	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	2001	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	2001	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	2,000	2.96

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	2002	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,396	20.47
Maintenance	2002	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	1,998	2.96
Maintenance	2003	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	3,900	33.31
Maintenance	2003	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	1,100	1.63
Maintenance	2004	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,398	20.48
Maintenance	2005	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,396	20.47
Maintenance	2005	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	2,100	3.11
Maintenance	2006	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	2006	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	1,200	1.78
Maintenance	2007	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	3,550	30.32
Maintenance	2007	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	3,000	4.45
Maintenance	2008	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	430	3.67
Maintenance	2009	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	14	2,400	20.50
Maintenance	2009	fingerling	tiger muskellunge	*Esox lucius x Esox masquinongy*	15	3,000	4.45
Restorative	1986	fingerling	striped bass	*Morone saxatilis*	18	54,000	99.81
Restorative	1987	fingerling	striped bass	*Morone saxatilis*	18	26,000	48.06
Restorative	1987	fry	striped bass	*Morone saxatilis*	18	200,000	369.67
Restorative	1988	fingerling	striped bass	*Morone saxatilis*	18	21,400	39.56
Restorative	1988	fry	striped bass	*Morone saxatilis*	18	200,000	369.67
Restorative	1989	fingerling	striped bass	*Morone saxatilis*	18	10,026	18.53
Restorative	1989	fry	striped bass	*Morone saxatilis*	18	200,000	369.67
Restorative	1990	fingerling	striped bass	*Morone saxatilis*	18	55,400	102.40
Restorative	1990	fry	striped bass	*Morone saxatilis*	18	100,000	184.84
Restorative	1991	fingerling	striped bass	*Morone saxatilis*	18	54,000	99.81
Restorative	1991	fry	striped bass	*Morone saxatilis*	18	100,000	184.84
Restorative	2003	fingerling	striped bass	*Morone saxatilis*	15	10,300	15.26

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Restorative	2003	fingerling	striped bass	*Morone saxatilis*	16	14,750	12.62
Restorative	2003	fingerling	striped bass	*Morone saxatilis*	17	7,550	15.23
Restorative	2004	fry	striped bass	*Morone saxatilis*	15	2,500,000	3,704.75
Restorative	2004	fry	striped bass	*Morone saxatilis*	16	1,800,000	1,540.02
Restorative	2005	fingerling	striped bass	*Morone saxatilis*	15	10,580	15.68
Restorative	2005	fingerling	striped bass	*Morone saxatilis*	16	14,786	12.65
Restorative	2005	fingerling	striped bass	*Morone saxatilis*	17	7,612	15.35
Restorative	2006	fingerling	striped bass	*Morone saxatilis*	15	7,000	10.37
Restorative	2006	fingerling	striped bass	*Morone saxatilis*	16	14,750	12.62
Restorative	2006	fingerling	striped bass	*Morone saxatilis*	17	7,550	15.23
Maintenance	1977	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	40,910	75.62
Maintenance	1977	fry	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	50,000	92.42
Maintenance	1978	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	48,700	90.02
Maintenance	1979	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	41,170	76.10
Maintenance	1981	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	16	12,326	10.55
Maintenance	1982	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	20,180	37.30
Maintenance	1983	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	16	44,000	37.65
Maintenance	1983	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	17	18,150	36.61
Maintenance	1983	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	54,000	99.81
Maintenance	1984	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	16	44,000	37.65
Maintenance	1984	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	17	18,218	36.74
Maintenance	1984	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	54,000	99.81
Maintenance	1986	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	16	14,000	11.98
Maintenance	1986	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	17	14,000	28.24
Maintenance	1986	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	18	15,000	27.73
Maintenance	1988	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	15	14,950	22.15

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Maintenance	1990	fingerling	hybrid striped bass	*Morone chrysops x Morone saxatilis*	15	12,500	18.52
Supplemental	1958	adult	smallmouth bass	*Micropterus dolomieu*	14	156	1.33
Supplemental	1983	fingerling	bluegill	*Lepomis macrochirus*	18	143,000	264.32
Supplemental	1986	fingerling	walleye	*Sander vitreus*	11	5,000	101.95
Supplemental	1986	fry	walleye	*Sander vitreus*	12	3,000,000	1,278.77
Supplemental	1986	fry	walleye	*Sander vitreus*	13	2,000,000	1,283.72
Supplemental	1986	fingerling	walleye	*Sander vitreus*	14	10,000	85.42
Supplemental	1987	fry	walleye	*Sander vitreus*	12	3,000,000	1,278.77
Supplemental	1987	fry	walleye	*Sander vitreus*	13	3,300,000	2,118.14
Supplemental	1988	fingerling	walleye	*Sander vitreus*	11	5,000	101.95
Supplemental	1988	fry	walleye	*Sander vitreus*	12	6,000,000	2,557.53
Supplemental	1988	fry	walleye	*Sander vitreus*	13	4,000,000	2,567.44
Supplemental	1988	fingerling	walleye	*Sander vitreus*	14	20,000	170.84
Supplemental	1989	fry	walleye	*Sander vitreus*	12	6,000,000	2,557.53
Supplemental	1989	fry	walleye	*Sander vitreus*	13	4,000,000	2,567.44
Supplemental	1990	fry	walleye	*Sander vitreus*	11	369,750	7,539.00
Supplemental	1990	fry	walleye	*Sander vitreus*	12	12,087,001	5,152.15
Supplemental	1990	fry	walleye	*Sander vitreus*	13	8,464,500	5,433.03
Supplemental	1990	fry	walleye	*Sander vitreus*	14	1,812,750	15,484.33
Supplemental	1991	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	1991	fry	walleye	*Sander vitreus*	12	17,645,001	7,521.28
Supplemental	1991	fry	walleye	*Sander vitreus*	13	14,107,500	9,055.05
Supplemental	1991	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	1992	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	1992	fry	walleye	*Sander vitreus*	12	19,605,501	8,356.96
Supplemental	1992	fry	walleye	*Sander vitreus*	13	12,147,000	7,796.68

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Supplemental	1992	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	1993	fry	walleye	*Sander vitreus*	11	369,750	7,539.00
Supplemental	1993	fry	walleye	*Sander vitreus*	12	8,813,251	3,756.70
Supplemental	1993	fry	walleye	*Sander vitreus*	13	10,195,751	6,544.25
Supplemental	1993	fry	walleye	*Sander vitreus*	14	1,812,750	15,484.33
Supplemental	1994	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	1994	fry	walleye	*Sander vitreus*	12	6,463,251	2,755.00
Supplemental	1994	fry	walleye	*Sander vitreus*	13	9,852,000	6,323.61
Supplemental	1994	fry	walleye	*Sander vitreus*	14	1,812,750	15,484.33
Supplemental	1995	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	1995	fry	walleye	*Sander vitreus*	12	8,438,301	3,596.87
Supplemental	1995	fry	walleye	*Sander vitreus*	13	13,915,753	8,931.98
Supplemental	1995	fry	walleye	*Sander vitreus*	14	1,812,750	15,484.33
Supplemental	1996	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	1996	fry	walleye	*Sander vitreus*	12	8,438,300	3,596.87
Supplemental	1996	fry	walleye	*Sander vitreus*	13	14,467,500	9,286.12
Supplemental	1996	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	1997	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	1997	fry	walleye	*Sander vitreus*	12	8,438,301	3,596.87
Supplemental	1997	fry	walleye	*Sander vitreus*	13	14,107,500	9,055.05
Supplemental	1997	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	1998	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	1998	fry	walleye	*Sander vitreus*	12	13,813,750	5,888.19
Supplemental	1998	fry	walleye	*Sander vitreus*	13	15,707,500	10,082.03
Supplemental	1998	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	1999	fry	walleye	*Sander vitreus*	11	616,250	12,564.99

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Supplemental	1999	fry	walleye	*Sander vitreus*	12	5,586,750	2,381.38
Supplemental	1999	fry	walleye	*Sander vitreus*	13	12,507,500	8,028.08
Supplemental	1999	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	2000	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	2000	fry	walleye	*Sander vitreus*	12	9,800,000	4,177.31
Supplemental	2000	fry	walleye	*Sander vitreus*	13	14,100,000	9,050.24
Supplemental	2000	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	2001	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	2001	fry	walleye	*Sander vitreus*	12	8,813,750	3,756.91
Supplemental	2001	fry	walleye	*Sander vitreus*	13	14,200,000	9,114.43
Supplemental	2001	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	2002	fry	walleye	*Sander vitreus*	11	614,250	12,524.21
Supplemental	2002	fry	walleye	*Sander vitreus*	12	8,813,750	3,756.91
Supplemental	2002	fry	walleye	*Sander vitreus*	13	14,107,500	9,055.05
Supplemental	2002	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	2003	fry	walleye	*Sander vitreus*	11	713,750	14,552.96
Supplemental	2003	fry	walleye	*Sander vitreus*	12	8,813,751	3,756.91
Supplemental	2003	fry	walleye	*Sander vitreus*	13	14,107,500	9,055.05
Supplemental	2003	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	2004	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	2004	fry	walleye	*Sander vitreus*	12	8,813,751	3,756.91
Supplemental	2004	fry	walleye	*Sander vitreus*	13	9,464,500	6,074.89
Supplemental	2004	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	2005	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	2005	fry	walleye	*Sander vitreus*	12	7,063,251	3,010.75
Supplemental	2005	fry	walleye	*Sander vitreus*	13	14,107,500	9,055.05

Table 8.1.3.3. Historical stocking of the Susquehanna River downstream of the confluence of the West Branch Susquehanna River, by species (*continued*).

Stock type	Date	Lifestage	Species (common)	Species (scientific)	Management section	Number stocked	Density (# per acre)
Supplemental	2005	fry	walleye	*Sander vitreus*	14	3,021,250	25,807.21
Supplemental	2006	fry	walleye	*Sander vitreus*	11	616,250	12,564.99
Supplemental	2006	fry	walleye	*Sander vitreus*	12	8,813,250	3,756.70
Supplemental	2006	fry	walleye	*Sander vitreus*	13	9,654,500	6,196.85
Supplemental	2006	fry	walleye	*Sander vitreus*	14	1,812,750	15,484.33
Supplemental	2007	fry	walleye	*Sander vitreus*	11	369,750	7,539.00
Supplemental	2007	fry	walleye	*Sander vitreus*	12	5,063,250	2,158.24
Supplemental	2007	fry	walleye	*Sander vitreus*	13	4,800,000	3,080.93
Supplemental	2007	fry	walleye	*Sander vitreus*	14	1,812,750	15,484.33

Table 8.2.1. Permitted guides listing West Branch Susquehanna and Susquehanna rivers as waters used to service clientele.

Business Name	Guide Name		County
A A Outfitters	Gene	Ercolani	Monroe
A A Outfitters	Eric	Girardi	Monroe
AA Outfitters	Walter	Plasson	Monroe
Backwoods Angler	Blaine	Mengel, Jr	Northampton
Barrys Reel Bassin	Barry	Vuolo	Bucks
Bass Chasers	Karl	Hoelper, Jr	Bucks
Big D River Guide	Dieter	Scheel	Bucks
Brian R. Kessel	Brian	Kessel	Adams
Bronzeback Guide Service	James	Kindler	Luzerne
Bronzeback Guide Service	James	Kindler	Luzerne
Chad M. Boyer	Chad	Boyer	Lancaster
Chuck Swartzs Angling Adventures	Charles	Swartz	Pike
Chuck Swartzs Angling Adventures	Charles	Swartz	Pike
Coveted Waters	Eric	Richard	Perry
Coveted Waters	John	Conrad III	Perry
Dick Ackourey and Son Inc	Joseph	Ackourey	Luzerne
Dons River Bass Adventures Inc	Donald	Haskins, Jr	Nonresident
Dusk To Dawn Bowfishing	Marc	Spagnola	York
East Coast Outdoors, Inc.	David	Kerrigan, Sr	Nonresident
FishinFools	Jesse	Stoner, Sr	Dauphin
Fly Guide Services	John	Yankanich, Jr	Chester
Goin 4 Smallies Guide Service	David	Bruchey	Nonresident
Hershey Outfitters	Kurt	Segerberg	Dauphin
J and J Outfitters	Jamie	Brown	Snyder
Jack O Donnell	John	O Donnell	Luzerne
Jerry Haddens Guide Service	Gerald	Hadden	Susquehanna
John S Stanton IV Guide Service	John	Stanton IV	Allegheny
Karl Gebhart	Karl	Gebhart	Snyder
Ken Penrod Life Outdoors Unlimited	Ken	Penrod, Jr	Nonresident
Ken Penrods Life Outdoors Unlimited	Jonathan	Drever	Nonresident
Ken Penrods Life Outdoors Unlimited	Eugene	Renner	Nonresident
Kettle Creek Adventures	David	Cardellino	Potter
Keystone Anglers	Charles	Rosamilia III	Clinton
Kickin Bass Baits Guide Service	William	Showers	Northumberland
Koinonia Guide Service	Rodney	Bates	Cumberland
LD Guide Service	Daniel	Dunham	Bradford
Life Outdoors Unlimited	Tracey	Peyton	Nonresident
Live to Fish Guide Service	John	Pfleckl	Lackawanna

Table 8.2.1. Permitted guides listing West Branch Susquehanna and Susquehanna rivers as waters used to service clientele (*continued*).

Business Name	Guide Name		County
Lone Goose Guide Service	Jonathan	Else	Northumberland
Max E McAllister	Max	McAllister	Cumberland
Mega Bass Guide Service	Michael	Gurreri	York
Mikes Guide Service	Michael	Lionetti	Bradford
Night Ventures Bow Fishing	John	Ridings, Jr	Lancaster
North Branch Outfitters	Gregory	Smith	Wyoming
On The Hook Guide Service	Thomas	Houseman	Monroe
Patrick A Appignani	Patrick	Appignani	Chester
Paul L. Davidson	Paul	Davidson	Carbon
Paul M. Antolosky	Paul	Antolosky	Centre
Richard E Brown	Richard	Brown	Dauphin
RipEm Fishing Guide Services	Craig	Shilling	Adams
River Watch	Julie	Shannon	Lycoming
River Watch	Nancy	Whisenhunt	Lycoming
River Watch	Julie	Shannon	Lycoming
Rivers M Grove	Rivers	Grove	Adams
Rivers Outdoor Adventures LLC	Joseph	Demarkis	Schuylkill
Rivers Outdoor Adventures LLC	Brent	Faust	Schuylkill
Rivers Outdoor Adventures LLC	Timothy	Skoraszewski	Schuylkill
Slate Drake Guide Service, Inc.	William	Whitebread	Columbia
Smallmouth Magic	Jeffrey	Rock	Franklin
Southside Sports	Kenneth	Maurer	Northumberland
Spachts Custom Flies	William	Spacht	Cumberland
Susquehanna Fishing Tackle	George	Acord, Jr	Lancaster
Susquehanna Fishing Tackle	Michael	Acord	Lancaster
Susquehanna Fly & Spin Guide Service LLC	Steven	Hancock	Dauphin
The Evening Rise Fly Fishing Outfitters	William	Gebhard	Lancaster
Toms Fly - Fishing Service	Thomas	Brtalik	York
Trout Getter Files & Guide Service	Craig	Hull	Cumberland
Yellow Breeches Outfitters	Emily	Zeiders	Cumberland
Youth Fishing Foundation Inc	Duane	Smith	York

Table 9.1.1. Commercial passenger-for-hire vessels operating on the West Branch Susquehanna and Susquehanna rivers.

Vessel	Owner	Waterbody
Hiawatha	Hiawatha, Inc.	West Branch Susquehanna River
Millersburg Ferry	Millersburg Ferry Boat Association	Susquehanna River
Pride of the Susquehanna	Harrisburg Area Riverboat Society	Susquehanna River

Table 9.1.2. Boating clubs and marinas located at the West Branch Susquehanna and Susquehanna rivers.

Club/ marina name	Owner	Access	Water body
West Branch Motor Club	West Branch Motor Club	private	West Branch Susquehanna River
Montgomery Boat Club	Montgomery Boat Club	private	West Branch Susquehanna River
Shikellamy State Park South	Bureau of State Parks	public	Susquehanna River (Lake Augusta)
New Cumberland Boating & Fishing Club	New Cumberland Boating & Fishing Club	private	Susquehanna River
City Island	City of Harrisburg	public	Susquehanna River
Tri-County	Tri-County Boat Club	private	Susquehanna River
Long Level Marina	Long Level Marine	private	Susquehanna River
Lake View Yacht Club	Lake View Yacht Club	private	Susquehanna River
Susquehanna Yacht Club	Susquehanna Yacht Club	private	Susquehanna River
Lake Clarke Marina	Lake Clarke Marina, Inc.	private	Susquehanna River
Arrowhead Marina	Private	private	Susquehanna River

Table 9.1.3 Boating accesses located on or near the West Branch Susquehanna and Susquehanna rivers

Access Name	Owner	Owner Type	Waterbody
Mahaffey	Unknown	private	West Branch Susquehanna River
Cherry Tree Borough	Cherry Tree Borough	public	West Branch Susquehanna River
McGees Mills	Unknown	private	West Branch Susquehanna River
Curwensville Lake	US Army Corps of Engineers	public	West Branch Susquehanna River
Irvin Park Borough	Curwensville Borough	public	West Branch Susquehanna River
Lower Witmer Park Borough Access	Clearfield Borough	public	West Branch Susquehanna River
Chest Falls Campground	Unknown	private	West Branch Susquehanna River
Shawville Grocery	Pennsylvania Electric Co.	private	West Branch Susquehanna River
Deer Creek	Private	private	West Branch Susquehanna River
Rolling Stone	Private	private	West Branch Susquehanna River
Ring Rock	Private	private	West Branch Susquehanna River
Karthaus	Bureau of Forestry	public	West Branch Susquehanna River
Pa State Flaming Foliage Canoe Access	Pa State Flaming Foliage Associacion	private	West Branch Susquehanna River
North Bend	PFBC	public	West Branch Susquehanna River
Hyner	PFBC	public	West Branch Susquehanna River
Lock Haven	Unknown	public	West Branch Susquehanna River
Pine Access	PFBC	public	West Branch Susquehanna River
Jersey Shore Boat Club	Jersey Shore Borough	public	West Branch Susquehanna River
Linden Access	PFBC	public	West Branch Susquehanna River
West Branch Motor Club	West Branch Motor Club	private	West Branch Susquehanna River

Table 9.1.3 Boating accesses located on or near the West Branch Susquehanna and Susquehanna rivers (continued)

Access Name	Owner	Owner Type	Waterbody
Susquehanna State Park	Bureau of State Parks	public	West Branch Susquehanna River
Greevy	PFBC	public	West Branch Susquehanna River
Montoursville	Montoursville	public	West Branch Susquehanna River
Muncy	PFBC	public	West Branch Susquehanna River
Montgomery	PFBC	public	West Branch Susquehanna River
Montgomery Boat Club	Montgomery Boat Club	private	West Branch Susquehanna River
Unnamed	Unknown	public	West Branch Susquehanna River
Great Stream Commons	Union Co Industrial Development Corp	public	West Branch Susquehanna River
Unnamed	Lewis Township	public	West Branch Susquehanna River
Watsontown	PFBC	public	West Branch Susquehanna River
Watsontown Borough	Watsontown Borough	public	West Branch Susquehanna River
Milton State Park	Bureau of State Parks	public	West Branch Susquehanna River
St. George St.	Lewisburg Borough	public	West Branch Susquehanna River
Chillisquaque	PFBC	public	West Branch Susquehanna River
Riverside Campground	Unknown	private	West Branch Susquehanna River
Fort Boone Campground	Unknown	private	West Branch Susquehanna River
Rivers Edge RV Campground	Unknown	private	West Branch Susquehanna River
Millstone Run	PFBC	public	West Branch Susquehanna River
Susquehanna Campground	Unknown	private	West Branch Susquehanna River
Oakland	PFBC	public	Susquehanna River (North Branch)

Table 9.1.3 Boating accesses located on or near the West Branch Susquehanna and Susquehanna rivers (*continued*)

Access Name	Owner	Owner Type	Waterbody
P.J.O'Hare's	Unknown	private	Susquehanna River (North Branch)
Susquehanna Depot	Unknown	public	Susquehanna River (North Branch)
Susquehanna Depot Dam Portage	Unknown	private	Susquehanna River (North Branch)
Great Bend Boro Access	Unknown	public	Susquehanna River (North Branch)
Great Bend	PFBC	public	Susquehanna River (North Branch)
Interstate 81 Bridge	Unknown	public	Susquehanna River (North Branch)
Great Bend Twp/Hallstead	PFBC	public	Susquehanna River (North Branch)
Sayre	PFBC	public	Susquehanna River (North Branch)
Riverfront	Sayre Borough	public	Susquehanna River (North Branch)
Susquehanna St Bridge	Unknown	public	Susquehanna River (North Branch)
Ulster	Ulster Borough	public	Susquehanna River (North Branch)
Larnard Hornbrook Park	Unknown	public	Susquehanna River (North Branch)
SR 6 Bridge	Towanda Borough	public	Susquehanna River (North Branch)
Towanda Riverside Park W	Unknown	public	Susquehanna River (North Branch)
Wysox	PFBC	public	Susquehanna River (North Branch)
Wysox Township Access	Wysox Township	public	Susquehanna River (North Branch)
Homet’s Ferry Left	Unknown	public	Susquehanna River (North Branch)
Homet’s Ferry Right	Unknown	public	Susquehanna River (North Branch)
Terrytown	PFBC	public	Susquehanna River (North Branch)
PA Game Commission	Unknown	public	Susquehanna River (North Branch)

Table 9.1.3 Boating accesses located on or near the West Branch Susquehanna and Susquehanna rivers (*continued*)

Access Name	Owner	Owner Type	Waterbody
Ingham's Mill	Unknown	private	Susquehanna River (North Branch)
Laceyville	Laceyville Borough	public	Susquehanna River (North Branch)
Meshoppen	Meshoppen Borough	public	Susquehanna River (North Branch)
Mehoopany	Unknown	private	Susquehanna River (North Branch)
Tunkhannock Park	Tunkhannock Borough	public	Susquehanna River (North Branch)
Tunkhannock	PFBC	public	Susquehanna River (North Branch)
Whites Ferry - Undeveloped	PFBC	public	Susquehanna River (North Branch)
West Falls	PFBC	public	Susquehanna River (North Branch)
Apple Tree Road	PFBC	public	Susquehanna River (North Branch)
Pittston Riverfront Park	Unknown	public	Susquehanna River (North Branch)
Nesbitt Park	City of Wilkes Barre	public	Susquehanna River (North Branch)
Hanover Township Access	Local	public	Susquehanna River (North Branch)
Canal Park	Unknown	public	Susquehanna River (North Branch)
Hunlock Township	Unknown	public	Susquehanna River (North Branch)
Union Township	PFBC	public	Susquehanna River (North Branch)
Shickshinny	Unknown	public	Susquehanna River (North Branch)
Wetlands Nature Area	PPL Riverlands	public	Susquehanna River (North Branch)
Test Track Park	Berwick Borough	public	Susquehanna River (North Branch)
Mifflinville	Unknown	public	Susquehanna River (North Branch)
Columbia Park	Unknown	public	Susquehanna River (North Branch)

Table 9.1.3 Boating accesses located on or near the West Branch Susquehanna and Susquehanna rivers (*continued*)

Access Name	Owner	Owner Type	Waterbody
Espy Park	Unknown	public	Susquehanna River (North Branch)
Bloomsburg	PFBC	public	Susquehanna River (North Branch)
Bloomsburg Town Park	Unknown	public	Susquehanna River (North Branch)
Indianhead Campground	Unknown	private	Susquehanna River (North Branch)
Danville	PFBC	public	Susquehanna River (North Branch)
Montgomery Park	Unknown	public	Susquehanna River (North Branch)
Wray's Riverfront Campground	Riverfront Campground	private	Susquehanna River (North Branch)
Northumberland Municipal Access	Unknown	public	Susquehanna River (North Branch)
Shikellamy State Park North	Bureau of State Parks	public	Susquehanna River (Lake Augusta)
Shikellamy State Park South	Bureau of State Parks	public	Susquehanna River (Lake Augusta)
Sunbury Boro	Sunbury Borough	public	Susquehanna River (Lake Augusta)
Northumberland Point	Northumberland Borough	public	Susquehanna River (Lake Augusta)
Pineknotter Point	Northumberland Borough	public	Susquehanna River (Lake Augusta)
Sunbury	PFBC	public	Susquehanna River
Shady Nook	PPL	public	Susquehanna River
Stiely's Rivershore Campground	Stiely's Rivershore Campground	private	Susquehanna River
Isle of Que	Unknown	unknown	Susquehanna River
PFBC Isle of Que	PFBC	public	Susquehanna River
Hoovers Island	PGC	public	Susquehanna River
Port Treverton	Unknown	public	Susquehanna River
Mahantango	PFBC	public	Susquehanna River
Sweigarts Island	PGC	public	Susquehanna River
PFBC Liverpool Access	PFBC	public	Susquehanna River
Liverpool Access	Unknown	unknown	Susquehanna River
Millersburg	Millersburg Borough	public	Susquehanna River
Millersburg Ferry	Unknown	private	Susquehanna River
Montgomery Ferry	PFBC	public	Susquehanna River

Table 9.1.3 Boating accesses located on or near the West Branch Susquehanna and Susquehanna rivers (*continued*)

Access Name	Owner	Owner Type	Waterbody
Halifax	PFBC	public	Susquehanna River
Halifax Boro	Halifax Borough	public	Susquehanna River
Clemson Island	PGC	public	Susquehanna River
Riverfront Campground and Rent-a-Boat	Private	private	Susquehanna River
Haldeman Island	PGC	public	Susquehanna River
Dauphin Boro	Dauphin Borough	public	Susquehanna River
Fort Hunter Access	PFBC	public	Susquehanna River
Marysville Boro	Marysville Borough	public	Susquehanna River
Marysville Boro Schrauder Park	Marysville Borough	public	Susquehanna River
West Fairview	West Fairview Borough	public	Susquehanna River
Wormleysburg	Unknown	unknown	Susquehanna River
Locust Street	Wormleysburg Borough	public	Susquehanna River
City Island	City of Harrisburg	public	Susquehanna River
City Island New	City of Harrisburg	public	Susquehanna River
New Cumberland Boating and Fishing Club	New Cumberland Boating and Fishing Club	private	Susquehanna River
New Market	Fairview Township	public	Susquehanna River
Canal Lock	Med-Ed Power Co.	private	Susquehanna River
Tri-County	Tri-County Boat Club	private	Susquehanna River
Middletown	PFBC	public	Susquehanna River (*via* Swatara Creek)
Goldsboro	PFBC	public	Susquehanna River
Falmouth	PFBC	public	Susquehanna River
York Haven Hydro Station	Unknown	private	Susquehanna River
Conewago	PPL	public	Susquehanna River (via Conewago Creek)
Kings Road Campground	PFBC	private	Susquehanna River
Brunner Island	Unknown	private	Susquehanna River
Conoy Picnic Area	PFBC	public	Susquehanna River
Bainbridge	American Legion	private	Susquehanna River
Riverview Park	East Donegal Township	public	Susquehanna River
Hellam Township	Hellam Township	public	Susquehanna River
Chestnut Street	PFBC/Marietta Parks	public	Susquehanna River
Marietta	PFBC/Marietta Parks	public	Susquehanna River

Table 9.1.3 Boating accesses located on or near the West Branch Susquehanna and Susquehanna rivers (*continued*)

Access Name	Owner	Owner Type	Waterbody
Commons Park	Wrightsville Borough	public	Susquehanna River
Columbia	PFBC/Columbia Borough	public	Susquehanna River
Wrightsville	PFBC	public	Susquehanna River
Lake Clarke Marina	Lake Clarke Marina, Inc.	private	Susquehanna River
Kines Run Park	Safe Harbor Water Power	private	Susquehanna River
Susquehanna Yacht Club	Susquehanna Yacht Club	private	Susquehanna River
Lake View Yacht Club	Lake View Yacht Club	private	Susquehanna River
Long Level Marina	Long Level Marine	private	Susquehanna River
Lock #2 Recreation Area	Safe Harbor Water Power Co.	private	Susquehanna River
Lock #2 Recreation Area	Safe Harbor Water Power Co.	private	Susquehanna River
Safe Harbor Park	Private	private	Susquehanna River
Pequea	Private	private	Susquehanna River
Arrowhead Marina	Private	private	Susquehanna River
Otter Creek Campground	PPL	public	Susquehanna River
York Furnace	PPL	public	Susquehanna River
Gamblers Boatyard and Campground	Private	private	Susquehanna River
Indian Steps	Unknown	private	Susquehanna River
Holtwood Recreation Area	PPL	public	Susquehanna River
Lock 12 Historic Area	PPL	public	Susquehanna River
Lock 15 Historic Area	Unknown	private	Susquehanna River
Muddy Creek	PFBC	public	Susquehanna River
Cold Cabin Park	Peach Bottom Township	public	Susquehanna River
Dorsey Park	Philadelphia Electric Co.	private	Susquehanna River
Peach Bottom Marina	Private	private	Susquehanna River
Broad Creek	Philadelphia Electric Co.	public	Susquehanna River

Table 9.1.4 Boat liveries and rental locations servicing the West Branch Susquehanna and Susquehanna Rivers

Livery/ Rental Name	Location	Waterbody
McCracken's Canoe Rental	Clearfield	West Branch Susquehanna River
Rock, River, and Trail Outfitters, Inc.	Lock Haven	West Branch Susquehanna River
Country Ski and Sports	Montoursville	West Branch Susquehanna River
Endless Mountain Outfitters	Sugar Run	Susquehanna River
Susquehanna Canoe Rentals	Falls	Susquehanna River
Canoe Susquehanna	Lewisburg	Susquehanna River
Riverfront Campground/ Rent-a-boat	Duncannon	Susquehanna River
Blue Mountain Outitters	Marysville	Susquehanna River
Susquehanna Outfitters	Harrisburg	Susquehanna River
Shank's Mare Outfitters	Wrightsville	Susquehanna River
Starrk Moon	Delta	Susquehanna River

Table 9.4.1. Existing funding sources for research and other associated activities related to the West Branch Susquehanna and Susquehanna rivers.

Funding source	Funding Type	Comment
Sport Fish Restoration Act	Federal	Restoration of sport fish populations
State wildlife grants program	Federal/ State	Protection and management of non-game animal populations
Cora L. Brooks Foundation	Private	Environmental conservation, restoration or education within the watersheds of the Delaware and Susquehanna Rivers, with particular emphasis on environmental protection issues relating to clean water and water related ecologies
PA DEP Growing Green	State	
PA DEP Environmental Education Grant Track Program	State	
PA DEP 205 Program	Federal/ State	Federal water quality act
League of Women Voters Water Resources Education Network (WREN)	Private	Projects sponsored by community based partnerships that educate, build awareness, and promote water-sustaining public policies and/or behavior change
R.K Mellon Foundation	Private	Regional economic development, the quality of life in southwestern Pennsylvania, land preservation, and watershed restoration and protection with an emphasis on western Pennsylvania
Geisinger Foundation	Private	
Foundation for Pennsylvania Watersheds	Private	Local efforts to protect healthy, natural streams, to clean up pollution and to restore degraded wildlife habitat
The Chesapeake Bay Trust, Fisheries and Headwaters grants program	Federal/ Private	Headwaters track available to entire watershed (primarily fish passage and stream restoration)

Table 9.4.1. Existing funding sources for research and other associated activities related to the West Branch Susquehanna and Susquehanna rivers *(continued).*

Funding source	Funding Type	Comment
Pew Charitable Trust	Private	Improve public policy, inform the public and stimulate civic life
The FishAmerican Foundation	Private	Enhance fish populations, restore fish habitat, improve water quality, and advance fisheries research in North America and Canada, thereby increasing the opportunity for sportfishing success.
NOAA Restoration Center	Federal	Financial and technical assistance to communities for the restoration of fisheries habitat nationwide
Stormwater Management Act 167 Program	State	Aid counties in development and implementation of stormwater management plans
PA Dept. of Agriculture Growing Greener Grants	State	Farmland preservation grants to purchase conservation easements
PennVEST Growing Greener Grants	State	Funding for sewer, stormwater, and drinking water projects
Small Business Pollution Prevention Assistance Account	State	Low interest loans to small businesses to implement energy efficiency and pollution prevention projects.
National Fish and Wildlife Foundation	Public/ Federal	Sustain, restore, and enhance our Nation's fish, wildlife, and plants and their habitats
Henry Luce Foundation	Private	

Table 9.5.1. Colleges and universities having programs or courses associated with the West Branch Susquehanna and Susquehanna rivers.

Institution	Funding	Program	Comment
Lock Haven University	Public	Biology, Geology	
Pennsylvania State University~	Public	Agricultural Sciences, Earth and Mineral Sciences	USGS Fisheries and Wildlife Co-op location
Lycoming College	Private	Biology	Clean Water Institute
Bucknell University	Private	Biology, Environmental Geology, Environmental Studies	Susquehanna River Initiative, Bucknell University Environmental Center
King's College	Private	Biology	Susquehanna River Institute
Wilkes Univeristy	Private	Biology, Environmental Engineering & Earth Sciences	The Institute for Environmental Science and Sustainability
Bloomsburg University	Public	Biology, Geoscience	
East Stroudsburg University~	Public	Biology, Environmental Studies	
Mansfield University	Public	Biology (Environmental Science, Fisheries)	
Susquehanna University	Public	Biology, Earth and Environmental Science, Ecology	
Shippensburg University~	Public	Biology, Earth Science, Geoenvironmental Studies	
Millersville University~	Public	Biology, Chemistry, Earth Sciences, Industry & Technology, Geography	MU Center for Environmental Science

~ institution provides undergraduate and graduate programs

Table 9.6.1. Angler organizations associated with the West Branch Susquehanna and Susquehanna rivers.

Organization name
Capital City Bass Masters
Columbia County Bassmasters
Columbia Outdoors
Cumberland Valley Bass Anglers
Curwensville Anglers Restocking Program
E Penn-Jersey Deaf Anglers Association
Keystone Walleye Club
Mountain Valley Bassmasters
N.A.S.S. Bassmasters
North Branch Smallmouth Alliance
Pennsylvania Angler Sportsmen Association, Inc.
Pennsylvania BASS Federation, Inc.
South Central, PA Bass Casters
Suskie Bassmasters
Susquehanna Smallmouth Alliance
Unified Sportsmen of Pennsylvania
Western Clinton Sportsman Association
Williamsport Bassmasters

Table 9.6.2. Environmental advocacy organizations associated with the West Branch Susquehanna and Susquehanna rivers.

Organization name
Abandoned Mine Reclamation Clearinghouse
Alliance for the Chesapeake Bay
American Canoe Association
American Farmland Trust, Northeast Region
American Rivers
American Water Resources Association
Audubon Society of Pennsylvania
Canoe Club of Greater Harrisburg
Chesapeake Bay Foundation
ClearWater Conservancy of Central Pennsylvania, Inc.
Foundation for Pennsylvania Watersheds
Friends of Shikellamy State Park
Izaak Walkton League of America
Lower Susquehanna Riverkeeper
National Audubon Society
Northcentral Pennsylvania Conservancy
Northeast-Midwest Institute
PA CleanWays
PA Parks and Forest Foundation
PennFuture
Pennsylvania Federation of Sportsmen's Clubs
Pennsylvania Organization of Watersheds and Rivers
Sierra Club (Pennsylvania Chapter)
Sierra Club Moshannon Group
Stroud Water Research Center
Susquehanna River Greenway Partnership
Susquehanna River Trail Association
Susquehanna River Waterfowlers Association
Susquehanna River Wetlands Trust
The Nature Conservancy
Trout Unlimited
Upper Susquehanna Coalition
West Branch Susquehanna Restoration Coalition
West Branch Susquehanna River Task Force
Western Pennsylvania Conservancy