SOURCE WATER ASSESSMENT AND PROTECTION REPORT
Havre de Grace

Prepared by:
Susquehanna River Basin Commission
Watershed Assessment and Protection Program

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

I. EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (USEPA) established a new requirement under Section 1453 of the 1996 Safe Drinking Water Act. The Act requires each state to develop a Source Water Assessment Program (SWAP) to evaluate the drinking water sources that serve public water systems. The city of Havre de Grace operates drinking water intakes on the Susquehanna River. This SWAP report: (1) delineates the entire watershed area for the surface-water source; (2) identifies the significant potential sources of contamination; and (3) determines the susceptibility of the public water source to contamination. The goal of the SWAP report is to guide local, state, and federal agencies, and private landowners to develop partnerships for the protection of source water supplies.

The methods used for the assessment are outlined in Maryland Department of the Environment's (MDE) approved SWAP Plan, submitted for the USEPA in February 1999. The SWAP reports utilize pre-existing data for determination of raw water source susceptibility. The data used for this report includes data sources from local, state, and federal agencies.

Contaminants of concern to the water supply include turbidity and sediment, microbial, disinfection byproducts, inorganic compounds, organic compounds, and radionuclides. The sources for these contaminants are largely associated with agricultural land use within the Lower Susquehanna Subbasin, and to a lesser degree urban/residential development. Runoff from agricultural land contributes significant amounts of sediment, microbial contaminants, and nutrients to the raw water source through overland runoff. Sediment in particular can contribute other harmful constituents as well, such as pesticides and other organic contaminants that commonly attach to sediment particles. With an increase in concentrated animal operations and sewage effluent, microbial contaminants pose an increased threat as well. Additionally, increased amounts of organic material from all these sources can lead to the formation of harmful disinfection byproducts during the treatment process. With regards to development, the proximity of urban/residential/boating activities, as well several major transportation corridors, poses an increased threat of organic contamination. Although radioactive constituents are generally well below harmful levels, the existence of several nuclear power generating plants with outfalls along the Susquehanna River, upstream of Havre de Grace's intakes, indicates a significant potential for radionuclide contamination.

Source water protection efforts can be improved by increasing communication, and utilizing partnerships between local, state, and federal agencies, as well as the emergency response community. Partnerships can provide the mechanism to affect significant changes through a collective voice. Regular monitoring for turbidity and bacteria should be continued, and additional monitoring should be considered based on the potential threats to the raw water source outlined in this report.

II. INTRODUCTION

A. Surface Water Source

1. Description

The Havre de Grace Water Supply System treats water received from the Susquehanna River. The Susquehanna River Basin spans three states (New York, Pennsylvania, and Maryland), draining approximately 27,500 square miles, or 43 percent of the Chesapeake Bay's drainage area. The population within the basin is approximately 4.1 million people.

The Susquehanna River flows 444 miles from its headwaters at Otsego Lake near Cooperstown, N.Y. to Havre de Grace, Md. where it meets the Chesapeake Bay. The river flows approximately 20 miles per day on average during summer. The average flow of the Susquehanna River is 34,450 cubic feet per second (cfs). The highest recorded flow was during June of 1972, when flows reached 1,020,000 cfs at Harrisburg, Pennsylvania. The lowest recorded flow was during the 1930 drought, when flows dropped to 1,700 cfs. Table 1 shows annual water discharge for 2001, as well as long-term annual mean flows, for selected sites located on the Susquehanna River.

Table 1. Annual Water Discharge, Calendar Year 2001

Site Short Name	Years of Record	Long-term Annual Mean cfs[1]	2001 Mean cfs	2001 Percent of Long-Term Mean
Towanda	88	10,617	7,727	72.8
Danville	97	15,224	11,067	72.7
Lewisburg	62	10,809	6,749	62.4
Newport	102	4,305	2,499	58.0
Marietta	70	37,038	24,378	65.8
Conestoga	17	634	367	57.9

[1] Cubic feet per second

2. Political jurisdictions

All three states in the Susquehanna River Basin have county level governments. In New York and Pennsylvania, political boundaries are further subdivided into urban and township units. Unlike the Maryland county system, most of the land use control is delegated down to the township and municipal levels.

Nineteen major population centers are located throughout the basin (Figure 1). At the headwaters in N.Y., Cortland, Norwich, Oneonta, and Corning represent the more populated areas. South of these cities, Elmira and Binghamton also are heavily populated areas in the Upper Susquehanna Subbasin.

Figure 1. Location Map for the Susquehanna River Basin

In northern Pennsylvania, Towanda, Scranton, and Wilkes-Barre are population centers located in the Middle Susquehanna Subbasin. The West Branch of the Susquehanna River represents the most sparsely populated area of the basin and is comprised of a significant amount of state-owned lands. Clearfield, Renovo, and Williamsport are the largest population centers. Sunbury, Pa., is located at the confluence of the West Branch Susquehanna River and the mainstem of the Susquehanna River. It also hosts the uppermost dam on the mainstem of the Susquehanna River in Pennsylvania. The portion of the basin downstream of Sunbury comprises the Lower Susquehanna Subbasin, which is the primary focus of this assessment.

The last major subbasin contributing to the lower Susquehanna is the Juniata Subbasin. The cities of Altoona and Lewistown are located within this subbasin. Raystown Lake, one of the largest impoundments in the Susquehanna basin, is located within the Juniata Subbasin.

Representing the most densely populated region in the Susquehanna River Basin, the metropolitan areas of Harrisburg, York, and Lancaster are located in southcentral Pennsylvania, within the Lower Susquehanna Subbasin. The Lower Susquehanna Subbasin empties into the Chesapeake Bay at Havre de Grace, Md.

3. Topography and climate

The Susquehanna River Basin is very diverse with respect to topography and climatic conditions. Within the basin, there are three predominant physiographic provinces (Figure 2). The characteristics of each of these provinces largely control factors such as weather patterns and ambient water quality conditions. The physiographic provinces in downstream order include the Appalachian Plateau, Valley and Ridge, and Piedmont. A small portion of the Blue Ridge Province extends into the southern extent of the basin. The highest elevations lie in New York and northern Pennsylvania. Elevations significantly decrease towards Sunbury, Pa., and then continue to decrease more gradually towards the mouth of the river at Havre de Grace, Md.

The predominant physiographic province in the basin is the Appalachian Plateaus Province, which comprises about 40 percent of the Susquehanna River Basin. The province boundary trends southwest to northeast across the upper portions of the Susquehanna River Basin. Most of the province is characterized by flat-lying bedrock geology, primarily sedimentary rock. The western portion of the province in Pennsylvania contains bituminous coal reserves that have been mined extensively in the past and continue to be mined today. Weather patterns are primarily influenced by systems moving from the Midwest United States, and "lake-effect" systems moving across northwestern Pennsylvania from Canada.

Figure 2. Physiographic Provinces in the Susquehanna River Basin

The Valley and Ridge Province, which also trends northwest to southeast across the basin, is characterized by steeply folded and faulted geology. The geologic materials are predominantly interbedded sedimentary sandstones, shale, and limestone. The eastern portion of the province has significant anthracite coal reserves, which was mined extensively in the past, and continues to be mined today. Surface water quality in the higher elevations is influenced more by precipitation quality than local environmental factors, although degraded water quality and erosion is common in the abandoned-mine areas. The topography of the ridges and slopes creates rapid, direct runoff to streams, with short contact time with materials. Another portion of the province of significant influence is the Great Valley Section, composed primarily of limestone. Within this area, local environmental factors have a greater influence on the water quality. Commonly referred to as karst terrain, this section of the province extends across Franklin, Cumberland, Dauphin, and Lebanon Counties in the Lower Susquehanna Subbasin. The Great Valley Section bounds some of the most productive agricultural areas within the river basin, as well as some of the most densely populated areas. Erosion in the Great Valley Section tends to occur at higher rates compared to anywhere else in the Valley and Ridge Province. Climatic conditions for the Valley and Ridge Province are generally transitional between the Appalachian and Piedmont Provinces and are largely controlled by the northwest to southeast trending Appalachian Mountains of the Valley and Ridge Province.

The Piedmont Physiographic Province is the southernmost province in the Susquehanna River Basin. It represents a significant change in the geology of the basin, characterized predominantly by metamorphic and igneous rock. The topography of the Piedmont Province is generally low rolling hills and broad valleys. Based on the friable nature of the geologic material, the derived soils are subject to a significant amount of erosion. The increase in erosion is typically associated with the Uplands Section of the Piedmont Province, located in the southern portions of York and Lancaster Counties. Climatic conditions tend to be fairly mild and are largely controlled by weather systems moving into the region from the southern and coastal areas. The typical air temperature ranges from about 46 to 55 degrees.

As mentioned before, climatic conditions vary somewhat throughout the Susquehanna basin. Mean annual precipitation ranges from about 38 inches to 48 inches. Most of the precipitation is in the form of rain, although the northern portions of the basin can receive significant amounts of snowfall. Table 2 shows a summary of precipitation for selected areas of the basin.

Table 2. **Summary for Annual Precipitation for Selected Areas in the Susquehanna River Basin, Calendar Year 2001**

Area	Season	Average Long-Term Precipitation inches	Calendar Year 2001 Precipitation inches
Susquehanna River above Towanda, Pa. (Chemung and Upper Susquehanna Subbasins)	January-March	7.96	6.95
	April-June	9.98	8.82
	July-September	10.22	10.48
	October-December	8.70	6.15
	Yearly Total	**36.86**	**32.41**
Susquehanna River above Danville, Pa. (Middle Susquehanna Subbasin)	January-March	7.90	6.78
	April-June	10.07	8.68
	July-September	10.36	10.36
	October-December	8.72	6.03
	Yearly Total	**37.05**	**31.85**
West Branch Susquehanna River above Lewisburg, Pa. (West Branch Susquehanna Subbasin)	January-March	8.90	5.75
	April-June	11.38	9.08
	July-September	11.53	10.19
	October-December	9.38	5.6
	Yearly Total	**41.19**	**30.62**
Juniata River above Newport, Pa. (Juniata Subbasin)	January-March	8.84	4.67
	April-June	10.95	7.12
	July-September	10.83	4.73
	October-December	9.07	3.42
	Yearly Total	**39.70**	**19.93**
Susquehanna River above Marietta, Pa. (Within Lower Susquehanna Subbasin)	January-March	8.51	6.94
	April-June	10.66	8.92
	July-September	10.75	9.40
	October-December	9.01	5.37
	Yearly Total	**38.93**	**30.63**
Conestoga River above Conestoga, Pa. (Within Lower Susquehanna Subbasin)	January-March	8.58	7.08
	April-June	10.80	6.52
	July-September	11.78	6.59
	October-December	9.35	2.49
	Yearly Total	**40.51**	**22.68**

B. Development of the Water Supply

The Havre de Grace Water Treatment Plant serves approximately 11,500 customers in Havre de Grace, Md. Havre de Grace uses an average of about 2.6 million gallons per day (mgd). The design capacity of the plant is 4.0 mgd and their permit limits their withdrawal to not exceed 4 mgd on average for the year, or 10 million gallons on any one day.

The Susquehanna River is the most plentiful source of freshwater near Havre de Grace. Water from the Susquehanna River is pumped to the Havre de Grace Water Filtration Plant. Liquid coagulant and activated carbon is added to the raw water. Following chemical addition, the water passes through a screened structure to collect any remaining debris. Chlorine and alum are added to the water prior to flocculation. Following flocculation, water enters a sedimentation basin. Finally, water passes through a filtration system and additional chlorine is added as needed. The water is stored in clearwells, where additional chemical treatment is used as necessary.

III. RESULT OF SITE VISITS

A. Intake Description

Havre de Grace operates three intakes on the Susquehanna River. The primary intakes are located approximately 300 yards off the west shore of the river and are immersed into approximately 17 feet of water. An alternate intake is located near shore at the surface of the river. This intake is used when salinity values are high, particularly during drought conditions.

The primary intake consists of 12- and 10-inch cast iron intake lines. Both lines contain perforated metal plates over the intake openings. There is also an alternate 12-inch intake that is used during periods of high salinity. Four vertical, centrifugal, raw water pumps are used. Raw water from the Susquehanna River enters the intake lines through perforated plates on the ends of the pipes. The water is directed to the intake manifold for the raw water pumps. The raw water pumps take the water from the intake manifold and pump it to the rapid mixer. Normally, both river intake lines will be in service to supply water to the intake header, and the alternate intake line will be closed.

B. Operator Concerns

High salinity in the river water is a concern of the water supplier. This occurs typically during drought conditions. When high salinity occurs, the operator may need to switch to the shallower intake. Elevated turbidity levels are another concern of the operator, particularly during high-flow conditions. According to the water supplier, factory discharges, as well as releases from an upstream quarry, are possibly linked to increases in turbidity. Such increases can cause the water supplier to change their treatment processes. Figure 3 shows the turbidity at Havre de Grace during 1996.

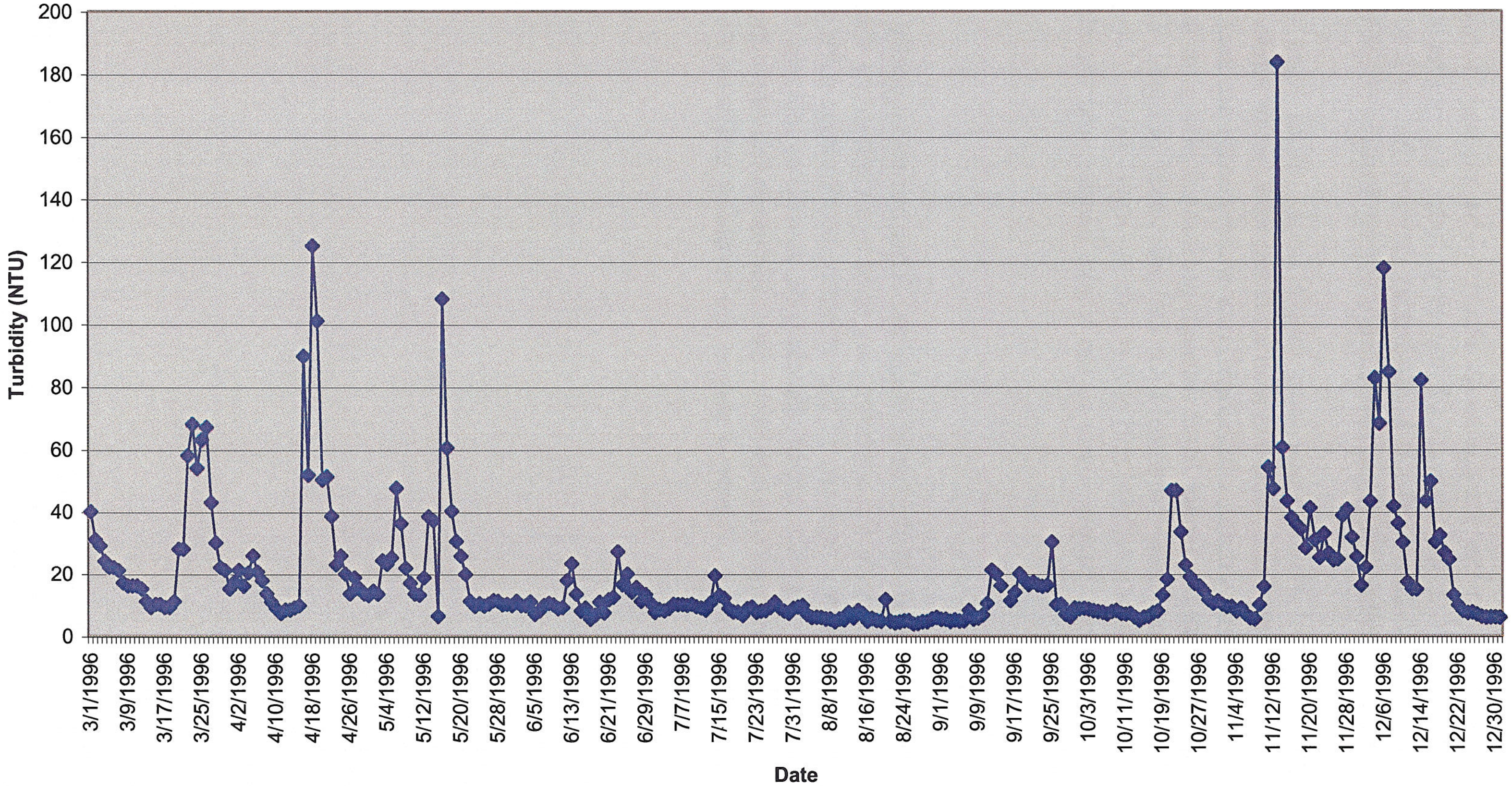


Figure 3. Daily Turbidity Values at the Havre de Grace Water Treatment Plant During 1996.

IV. WATERSHED CHARACTERIZATION

A. Source Water Assessment Area

Delineation of the watershed for the purposes of this assessment included the area contributing water to Havre de Grace's Susquehanna intake. For the purposes of this assessment, a general contaminant review was developed for the entire Susquehanna River Basin. Given the vast size of the basin, the assessment focused with greater detail on the Lower Susquehanna Subbasin. The Lower Susquehanna Subbasin extends from the confluence of the West Branch and Susquehanna River at Sunbury, Pa., to the mouth of the river at Havre De Grace, Md. Havre de Grace's water supply intake is located just upstream of the mouth of the river. The delineation area is shown in Figure 4.

1. Breakdown of subbasins

The Susquehanna River Basin can be broken down into six major subbasins: Upper Susquehanna; Chemung; West Branch Susquehanna; Middle Susquehanna; Juniata; and Lower Susquehanna (Figure 5). These subbasins can be further divided into major watersheds within each major subbasin. A listing of these watersheds can be reviewed in Appendix 1.

The watershed delineations were included from several sources. The source of the watershed delineations in New York was based on the Department of Environmental Conservation's 11-digit hydrologic unit codes (HUC). The watersheds in Pennsylvania were delineated using a combination of the state's 11-digit HUC codes, as well as delineations from the State Water Plan. The watersheds in Maryland are similar to the state's 11-digit HUC codes.

There are 19 subwatersheds within the Lower Susquehanna Subbasin. Primary focus was given to this subbasin, since it is the greatest influence to Havre de Grace's water supply.

B. General Subbasin Characteristics

The northernmost subbasin is the Upper Susquehanna Subbasin. This subbasin encompasses 4,944 square miles in New York. The Susquehanna River begins at Ostego Lake in Cooperstown, N.Y. and flows south into Pennsylvania and back into New York at Great Bend, Pa. The river flows west and joins the Chemung River in Sayre, Pa. Most of this subbasin is forested and steeply sloped with some agricultural areas. Agricultural runoff is the major source of stream impairment.

The Chemung Subbasin comprises 2,604 square miles of the Susquehanna River Basin. The subbasin begins at the confluence of the Tioga River, which flows north from Pennsylvania to meet the Coshocton River in New York. The terrain is typical of a glaciated watershed. The subbasin is composed of rolling to flat-topped uplands with steep valleys where the main rivers flow. Acid mine drainage (AMD) is the major source of impairment in this subbasin.

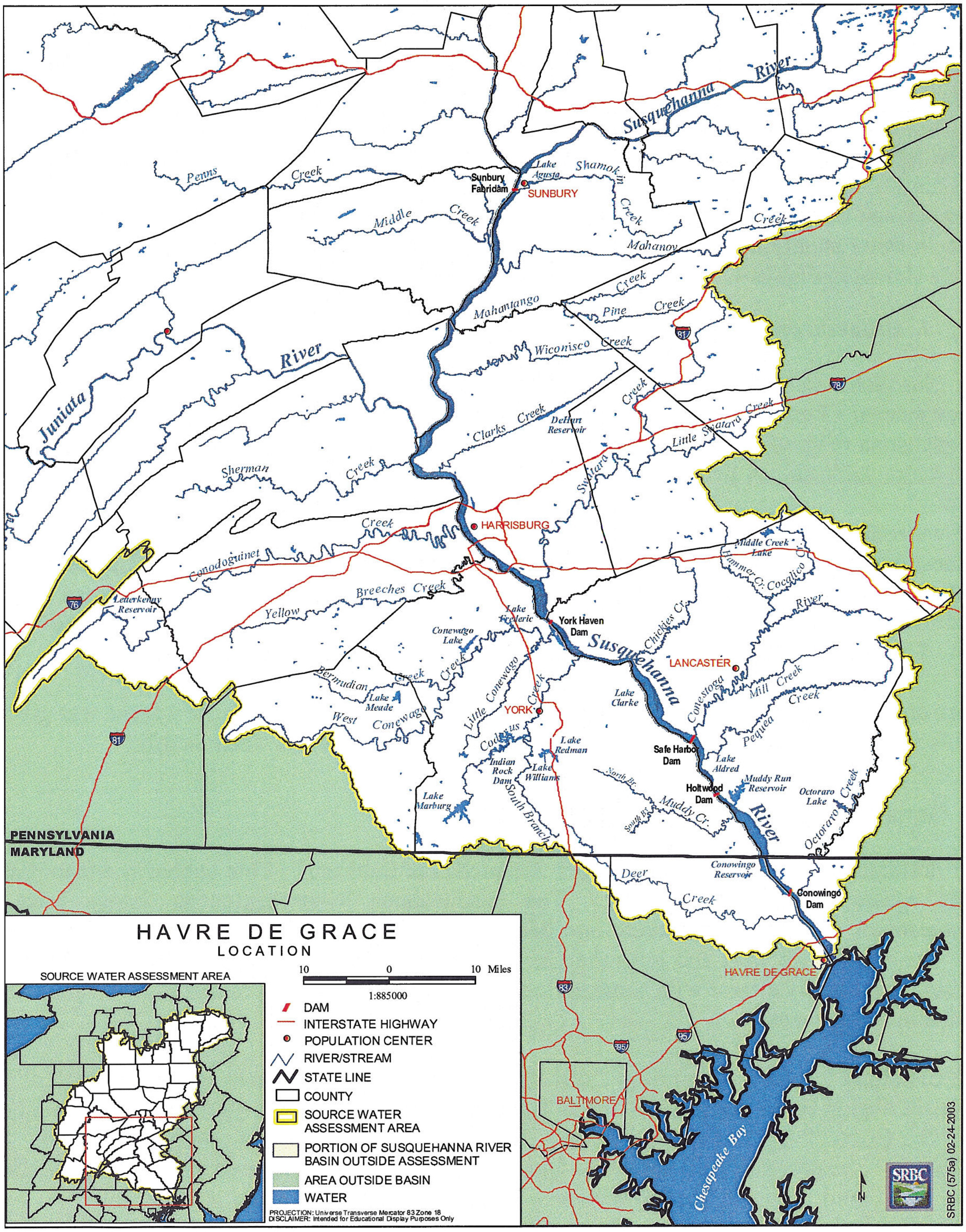


Figure 4. Source Assessment Delineation Area

Figure 5. Major Subbasins in the Susquehanna River Basin

The Middle Susquehanna Subbasin flows southeast through high plateaus separated by steep valleys. It comprises 3,755 square miles of the entire basin. The Susquehanna River joins the Lackawanna River before turning to flow southwest towards Sunbury. Much of this area is known as Wyoming Valley and extends from Carbondale to Nanticoke, Pa. This is a coal-mining region that has become urbanized, and as a result, AMD is the major source of stream impairment in this region.

The West Branch Susquehanna Subbasin originates in the rolling hills of the Allegheny Mountains and is 6,992 square miles. The West Branch flows northeast passing the Allegheny High Plateaus section. At Renovo, Pa., the West Branch flows southeast and then turns south to meet its confluence with the Susquehanna River. This area is predominantly forested, although extensive coal mining has occurred in the western parts of the subbasin. As a result, AMD is the major source of stream impairment in this region.

The Juniata River is a major tributary to the Susquehanna River in the Juniata Subbasin, which is 3,406 square miles. This subbasin is contained entirely within the Ridge and Valley Province, which has parallel mountains with long, narrow valleys. The dominant land use is forested, although agriculture maintains a significant presence in the subbasin, as well. Hence, agricultural runoff is a major source of stream impairment in the subbasin.

The Lower Susquehanna Subbasin is the most developed subbasin comprising 5,809 square miles, of which 275 square miles lie in Maryland. The northern part of the subbasin contains ridges that follow southwest to northeast. The river flows through these ridges and widens as it flows through the central portion of the basin. The southern portion of the subbasin is comprised of metamorphosed sediments that are folded and faulted. The steep river slope and narrow valley of the Lower Susquehanna Gorge creates a suitable environment for hydroelectric power generation. Agriculture is very prominent, and as a result, is a major source of stream impairment. In addition, some of the largest urban centers are located in this subbasin. Three basins in Lancaster County, Pa. are ranked as the most susceptible to agricultural contamination in the state of Pennsylvania. The Lower Susquehanna Subbasin empties into the Chesapeake Bay in Havre de Grace, Md., providing greater than 50 percent of the freshwater inflow.

1. *Travel time information from subbasins to intake*

Time-of-travel information is important when considering impacts of contamination on a drinking water source. For the Susquehanna River in New York and Pennsylvania, no dye studies for estimating time-of-travel information have been conducted since the 1960s. For the purpose of this assessment, a U.S. Geological Survey (USGS) estimation method was used to summarize time-of-travel information above Conowingo Dam. In 2001 and 2002, the Susquehanna River Basin Commission (SRBC) performed a series of dye studies in the lower Susquehanna River below Conowingo Dam. The information from this dye study was used to help characterize travel times for the Susquehanna River below the dam. Both sets of information are presented in the following section.

The USGS recently developed regression equations for determining time-of-travel estimates in Pennsylvania (Reed and Stuckey, 2002). Streamflow data obtained from USGS gauges were used to calculate the time-of-travel estimates from selected points within the Susquehanna River

Basin to the Conowingo Dam at Md. State Route 1 (Table 3). The flows used in the equations were the 80th, 50th, and 20th percentile exceedance flows for each gauge. Figure 6 shows the locations used to calculate the time-of-travel information.

Table 3. Time-of-Travel Information from Selected Locations in the Susquehanna River Basin

USGS Gauge	Flow (percentile exceedance) Low = 80th Medium = 50th High = 20th	Velocity (ft/sec)	Reach Length (mi)	Time-of-Travel (days)	Time –of-Travel (hrs)
Chemung, NY	Low	0.74	284.5	18.85	452.50
	Medium	1.18		12.60	302.22
	High	2.20		6.75	162.10
Waverly, NY	Low	1.08	277.0	17.86	428.64
	Medium	1.91		11.85	284.54
	High	2.59		6.47	155.39
Towanda, PA	Low	0.83	259.0	16.76	402.24
	Medium	1.27		11.28	270.72
	High	2.52		6.05	145.20
Danville, PA	Low	0.98	122.0	6.66	159.84
	Medium	1.40		4.68	112.32
	High	2.42		2.72	65.28
Lewisburg, PA	Low	0.87	117.5	6.48	155.52
	Medium	1.27		4.55	109.20
	High	2.43		2.61	62.64
Sunbury, PA	Low	1.08	108.0	5.80	139.20
	Medium	1.53		4.08	97.92
	High	2.69		2.37	56.88
Newport, PA	Low	0.88	83.0	4.73	113.52
	Medium	1.09		3.52	84.48
	High	1.90		2.06	49.44
Harrisburg, PA	Low	1.17	55.5	2.83	67.92
	Medium	1.73		1.98	47.52
	High	3.17		1.18	28.32
Marietta, PA	Low	1.22	30.0	1.50	36.00
	Medium	1.69		1.08	25.92
	High	2.65		0.69	16.56

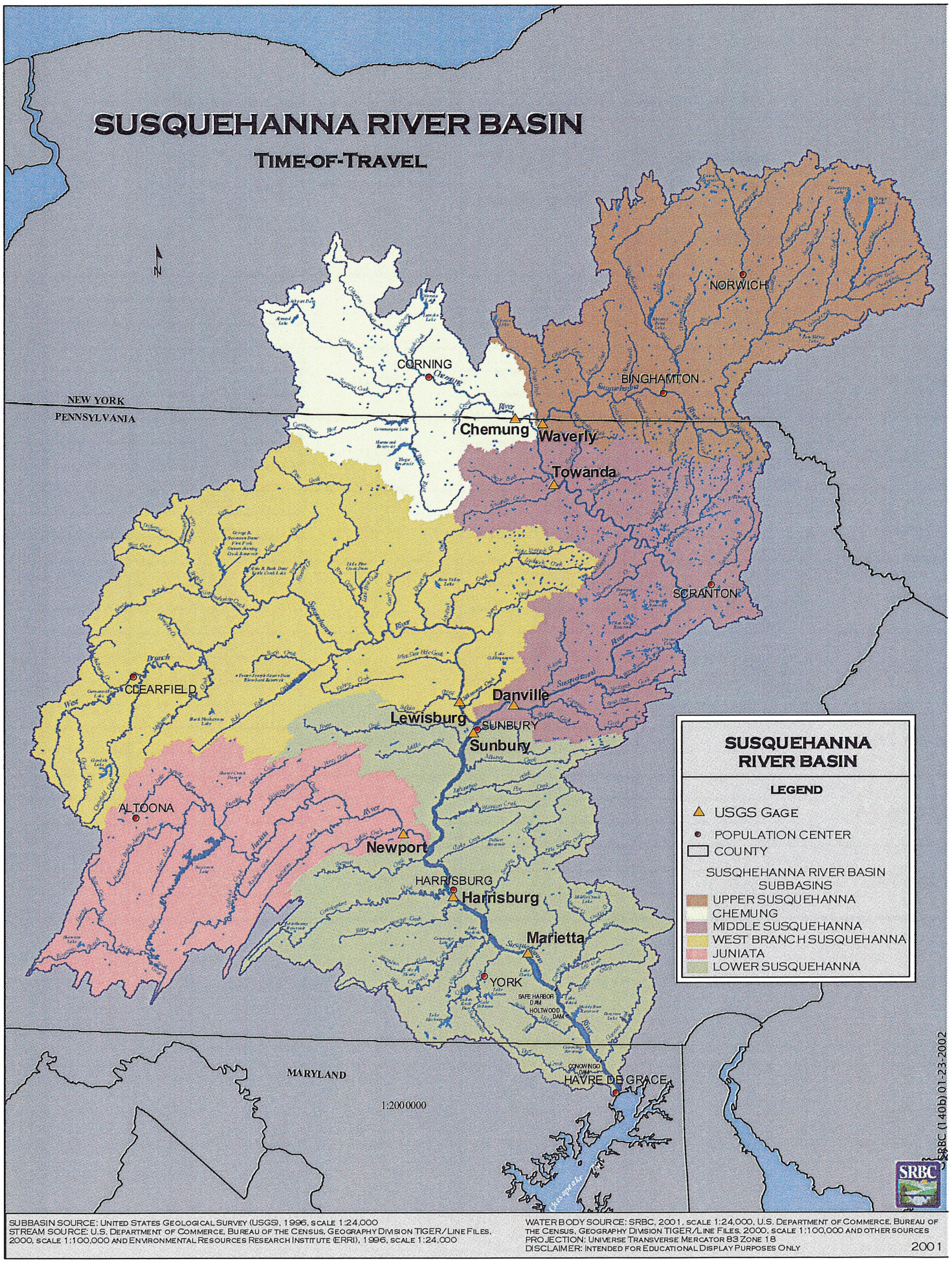


Figure 6. Locations Used for Time-of-Travel Estimates

In 2001 and 2002, the SRBC conducted a series of dye releases in Deer and Octoraro Creeks, tributaries that enter the Susquehanna River below Conowingo Dam. In addition, dye was released in the vicinity of Arundel Quarry, located on the west bank of the river upstream of Havre de Grace's intakes. The purpose of the study was to determine possible travel times and upstream influences on source water during selected flow conditions. It is important to note that the discussion of the dye study results in this assessment report represents data collected during a very limited set of hydrologic conditions. However, the dye releases from Deer Creek and Arundel Quarry yielded useful information when considering impacts of a spill on Havre de Grace's intakes.

The Deer Creek dye releases were performed during both high- and low-flow conditions. The release point was approximately eight miles upstream of the intakes. The study indicated that at an average river flow of 5,000 cfs, the travel time from Deer Creek to the intakes at Havre de Grace was 72 hours. The dye was present in the vicinity of the intakes for a period of over eight hours. With an average river flow of 42,000 cfs, the travel time for the same distance was 27 hours. Elevated dye concentrations in the vicinity of the intakes persisted for about four hours. Based on the results from both studies, fluctuations in river flows had a significant influence on both travel time and persistence of the dye, with respect to the location of the intakes.

A high-flow dye release also was performed at a holding pond of Arundel Quarry. The pond is located approximately 3.5 miles upstream of the intakes. A primary concern of the water supplier is discharges from the quarry upstream of the intakes during precipitation events. Since the discharge from the quarry is overflow from holding ponds, there are no "typical" discharge flows. Holding ponds at the quarry may overflow into the Susquehanna River only during high-flow conditions brought about by significant rainfall.

The dye was released along one of the holding ponds at Arundel Quarry at a river flow averaging around 30,000 cfs. The approximate travel time from Arundel Quarry to the intakes in Havre de Grace was 10 hours. Elevated dye concentrations were detected for approximately three hours at the sampling point near the intakes.

In general, when river flows are higher, the influence of the tides seems to be much less in the vicinity of Havre de Grace's intakes. Additionally, flow along the west side of the river is generally less inhibited due to releases from the Conowingo Dam occurring on that side. During low flows, it was observed that dye lingered for longer periods of time in the vicinity of the intakes, based on the oscillatory influence of the incoming/outgoing tides. The tidal influences typically dispersed dye laterally across the channel near the mouth, based on results obtained from carbon samplers placed on bridge piers across the river. Dye was detected in the carbon samplers during high flow as well, although the highest concentrations occurred on the west side of the river. Table 4 provides a summary of the dye study results.

Table 4. Summary of Dye Trace Study Results at the Havre de Grace Intakes

Release Date	Release Site	Miles Upstream of Intakes	Average Flow (cfs)	Time-of-Travel (hours)
June 7, 2001	Arundel Quarry	3.5	25,000	11
October 19, 2001	Deer Creek	8	5,000	73
June 7, 2002	Deer Creek	8	42,000	26

Overall, the flow controlled by the Conowingo Dam's generation station appeared to be the single most dominant influence. The flows of the two major tributaries downstream of the dam, Octoraro and Deer Creeks, typically represent less than one percent of the flow generated by the dam, even at high flows. Dye concentrations also were typically 5-8 orders of magnitude less at the downstream intake than at the release sites. This dilution was an obvious effect of flows from the dam, as well.

C. Land Use Characteristics

1. Analysis of land use types for the assessment area

As stated in previous sections, each of the major subbasins has unique characteristics with regard to land use. Table 5 shows in detail the breakdown of land use types for each of the subbasins in the assessment area. The information was derived from USEPA Multi-Resolution Land Cover (MRLC) 1993 Landsat Thematic Mapper data, developed by the USGS Earth Resources Observation Systems Data Center (Vogelmann, 1993). The MRLC data was reclassified to improve data quality and released again in 1997.

The basin as a whole is predominantly forested. This is true for all the major subbasins, with the exception of the Lower Susquehanna Subbasin. The lower Susquehanna is predominantly agricultural, and also has the highest percentage of developed lands in the basin. Figure 7 is a pie chart of land use in the basin.

Table 5. Land Use for Major Subbasins in the Susquehanna River Basin

Land Use	Upper	Chemung	Middle	West Branch	Juniata	Lower	Entire River Basin
Water	1%	1%	2%	< 1%	1%	2%	1%
Low Intensity Developed	1%	1%	2%	1%	1%	3%	1%
High Intensity Residential	< 1%	< 1%	1%	< 1%	< 1%	1%	< 1%
High Intensity Commercial/Industrial	< 1%	< 1%	1%	< 1%	< 1%	1%	< 1%
Hay/Pasture	14%	9%	7%	4%	7%	18%	10%
Row Crops	12%	22%	20%	12%	20%	32%	19%
Other Grass (lawns, city parks, golf courses)	< 1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
Evergreen Forest	5%	3%	7%	7%	4%	3%	5%
Mixed Forest	28%	17%	9%	11%	6%	3%	12%
Deciduous Forest	37%	47%	50%	63%	59%	36%	49%
Woody Wetland	1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Emergent Herbaceous Wetland	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Bare; quarries, strip mines, and pits	< 1%	< 1%	1%	1%	< 1%	1%	1%
Bare; transitional	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%

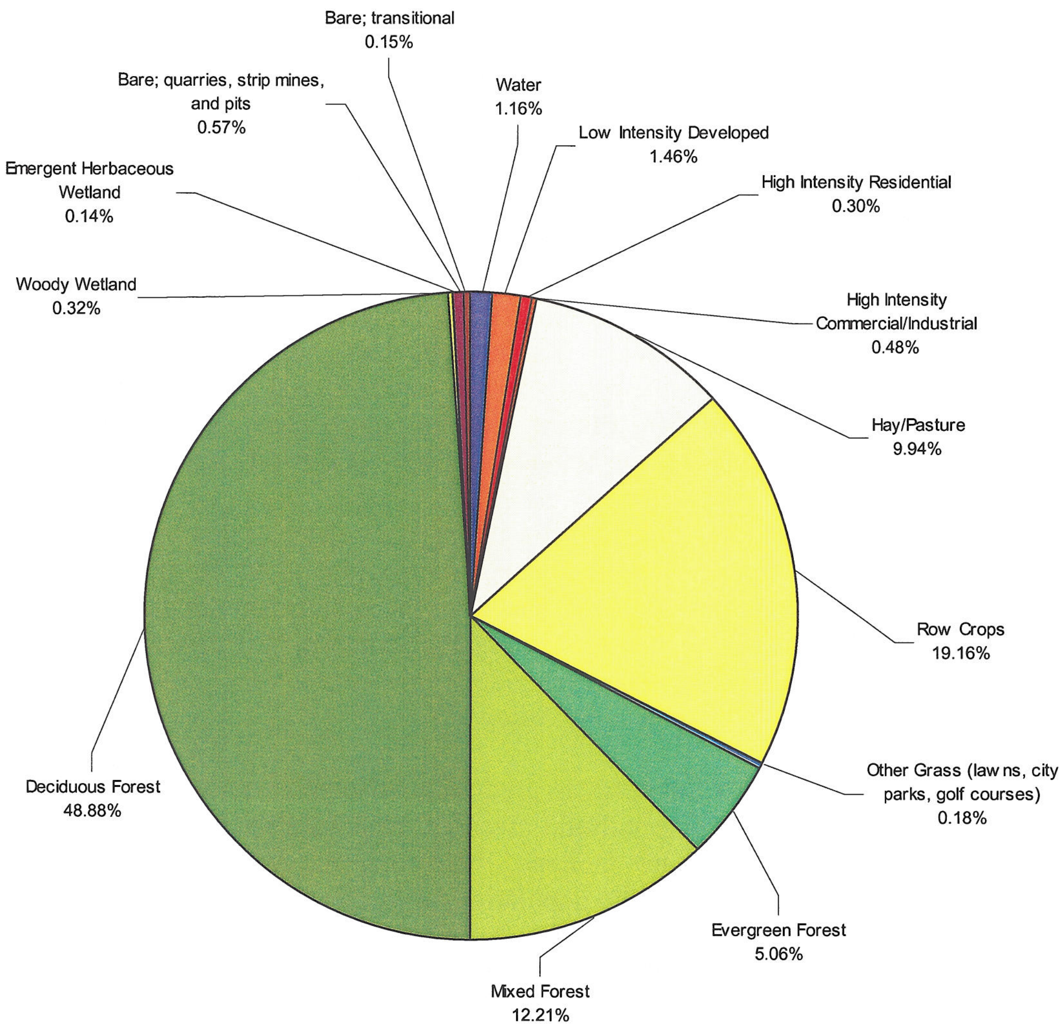


Figure 7. Land Use in the Susquehanna River Basin

2. Subbasin characteristics and trends

The following section discusses general land use characteristics and trends for each subbasin. As seen in both Table 5 and the land cover map (Appendix 4), land use varies between the major subbasins in the assessment area. Land cover data for the entire Susquehanna Basin only covers data collected in the early 1990s. The 2000 MRLC land cover update has not been released as of the date of this assessment report. However, U.S. Census Bureau data collected on populations surveyed in 1990 and 2000 were used to assist with the general trends observed in each of the subbasins.

In the Upper Susquehanna Subbasin, much of the land is steeply sloped with hills and ridges dominated by forested land. Agricultural land occupies the lower lying areas possessing more productive soil types. The major population centers in the subbasin are Binghamton, Johnson City, Endicott, Cortland, and Oneonta, N.Y. Small villages exist throughout the subbasin. Census data indicates that the population in the subbasin has decreased slightly during 1990 to 2000.

The Chemung Subbasin is composed of terrain that is typical of glaciated watersheds. Forested land occupies the steep hillsides, while flat hilltops and valleys are used for agriculture. Agricultural activity is almost evenly split between cropland and pasture grazing. The major population centers in the subbasin are Elmira, Corning, and Hornell, N.Y. Populations within the subbasin did not significantly change between the 1990 and 2000 census.

The Middle Susquehanna Subbasin terrain has many high plateaus that are separated by steep valleys. This subbasin is a highly urbanized coal-mining region. Much of the mining region is abandoned lands; however, remining activity has been increasing with technological advances in extraction methods. The major population centers are Scranton, Wilkes-Barre, Carbondale, and Sunbury, Pa. The Scranton/Wilkes-Barre corridor represents a very intensely urbanized area, extending over 20 miles in the Lackawanna Valley.

The West Branch Susquehanna Subbasin is predominantly covered by forested land with low rolling hills. Mining, urban, and agricultural areas are dispersed throughout the subbasin. The major population centers are State College, Lock Haven, Williamsport, Clearfield, and Lewisburg, Pa. Census data indicates the population has increased by approximately 5 percent in the subbasin over the last decade. Most of this increase is focused in the Nittany Valley, surrounding the State College area. Development has increased rapidly in the area with the addition of housing at the expense of traditionally agricultural areas.

The Juniata Subbasin is composed of terrain with mountains and long, narrow valleys. Agriculture is common in the valley portions of the subbasin where soils are more productive, while the steep mountains are primarily forested. The subbasin is predominantly rural. The major population centers in the subbasin are Altoona, Hollidaysburg, Bedford, Lewistown, Huntingdon, and Mount Union, Pa. The subbasin is facing increasing development pressure with the addition and improvement of several travel corridors. Interstate 99 is currently being built to connect Interstate Routes 76/70 and 80, which run parallel to each other in an east-west direction across Pennsylvania. State Route 322, which travels northwest into the subbasin from Harrisburg was recently expanded to accommodate four lanes of traffic. With this expansion, the increased accessibility to the Harrisburg Metropolitan Area has spurred development in the eastern portions of the basin.

With respect to land use distribution, the Lower Susquehanna Subbasin contrasts greatly in comparison to the other subbasins. Fifty percent of the subbasin is dedicated to agricultural activities. Several counties in the subbasin possess some of the most productive soils in the state of Pennsylvania, with a significant amount of effort being placed on preserving current agricultural activities. Urban and residential development accounts for almost 5 percent. Although the percent development does not seem significantly different than some of the other subbasins, the 2000 update for land cover for this region is expected to show dramatic increases. Census data indicates that population growth in the metropolitan areas within the subbasin has increased over 10 percent. Additionally, there is a significant amount of growth occurring in Pennsylvania, along the southern portions of Adams and York Counties, as a result of expansion around the city of Baltimore, Md. The predominant trend in land use within the subbasin is the conversion of cropland and pastures to residential and commercial development

D. Localized Characteristics

1. Land ownership

Immediately above the water supply intakes are boating docks and residential lands. A quarry is located further above the intake. This quarry occasionally discharges into the Susquehanna River, typically during higher flow conditions. The Susquehanna State Park is located even further north of the intake.

2. Land use

Havre de Grace, in Harford County, Md., is a town with a population of 11,000 that borders the Susquehanna River where it meets the Chesapeake Bay. There are many boating docks in this area, as boating is very popular. Further north is the Lapidum boat launch and the Susquehanna State Park. Four bridges cross the river in Maryland (Route 40, Interstate 95, Route 1, and a railroad bridge).

Cecil County, Md. is not as populated as Harford County, Md. North of the Perry Point VA Hospital are the towns of Perryville and Port Deposit. Some boat launch sites exist in this area. Port Deposit borders the river before Conowingo Dam. The Town of Rising Sun is even further northeast of the intake, within the Octoraro drainage basin.

Over 18 percent of the land in Harford and Cecil Counties, Md. is protected lands. These lands are a combination of parks, fisheries, and agricultural easements. The designation of such lands can affect water quality. Several state parks in Maryland are located in the Susquehanna River Basin. Susquehanna State Park is a large protected area in Harford County, covering over 3,300 acres within the assessment area. Rocks State Park also falls within the basin in Harford County, occupying approximately 855 acres west of Susquehanna State Park. The Broad Creek Memorial Scout Reservation occupies 2,000 acres in Maryland. Additionally, other campsites and small parks fall within the boundaries of the basin.

In addition to state parks, agricultural easements are located within Harford and Cecil Counties. Harford County has numerous agricultural easements, especially in the western portion of the county. The Agricultural Land Preservation Program protects productive agricultural land and woodlands providing for the continued production of food. To enter this program a farmer must have at least 50 acres of land. The Rural Legacy Program is an approach to land conservation created to protect Maryland's best remaining landscapes and natural areas. Through this program, greenbelts and greenways dominated by farms and forests are conserved by the voluntary purchase of conservation easements or fee estate interests in land preservation. There are many incentives to protect farms and to allow farms to pass to future generations. The combination of estate and income tax planning with land preservation funds, and property tax credits, allows the farm owner to maintain income, without having to give up land for development. Over 2,000 acres of such easements are located within the assessment area.

3. *Analysis of land use types*

Maryland land use in the Susquehanna River Basin is primarily cropland, agriculture, developed land, and forested land. Agricultural lands, particularly row crops, make up over 40 percent of the watershed in Maryland. Agriculture is spread throughout both Cecil and Harford Counties, and some agricultural lands border the Susquehanna River. Developed land exists throughout both counties; however, the Havre de Grace area has the greatest development and commercial land. Perry Point also is highly developed. Table 6 depicts the breakdown of the land use within the basin in Maryland. Figure 8 is a pie chart of the local land use in the assessment area. Figure 9 shows the land use in the Lower Susquehanna Subbasin. The 2000 land use dataset was acquired from the Maryland Department of Planning.

Table 6. Land Use in the Susquehanna River Basin in Maryland

Land Use	Percent	Square Miles
Low Density Residential	10.62	28.12
Medium Density Residential	1.17	3.1
High Density Residential	0.11	0.30
Commercial	0.58	1.54
Industrial	0.06	0.17
Institutional	1.12	2.98
Extractive	0.09	0.25
Open Urban Land	0.31	0.82
Cropland	42.33	112.10
Pasture	5.23	13.84
Orchards	0.45	1.18
Row Crops	0.01	0.03
Deciduous Forest	30.51	80.80
Evergreen Forest	0.37	0.97
Mixed Forest	1.02	2.69
Brush	1.09	2.90
Water	4.17	11.05
Wetlands	0.02	0.06
Bare Ground	0.08	0.20
Feeding Operations	0.05	0.14
Agricultural Building	0.60	1.58
Total	**100**	**264.83**

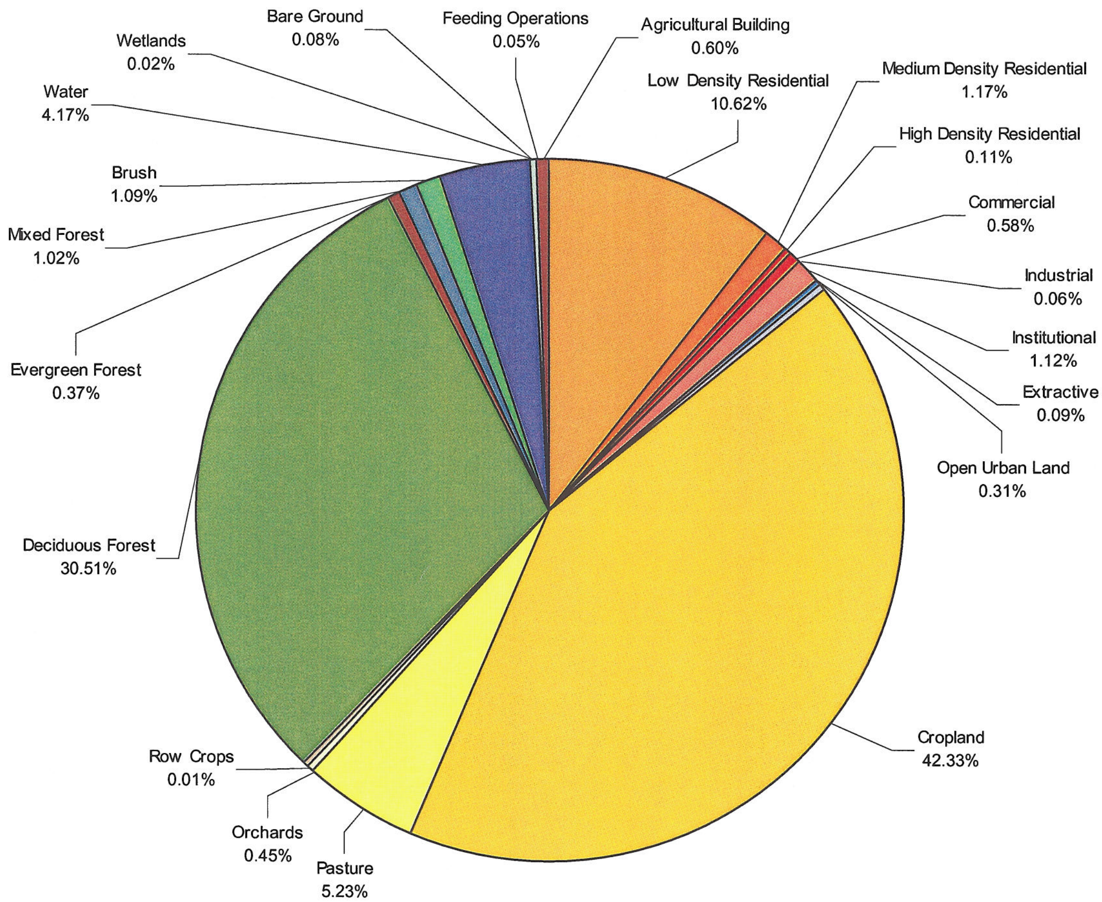


Figure 8. Localized Land Use Pie Chart

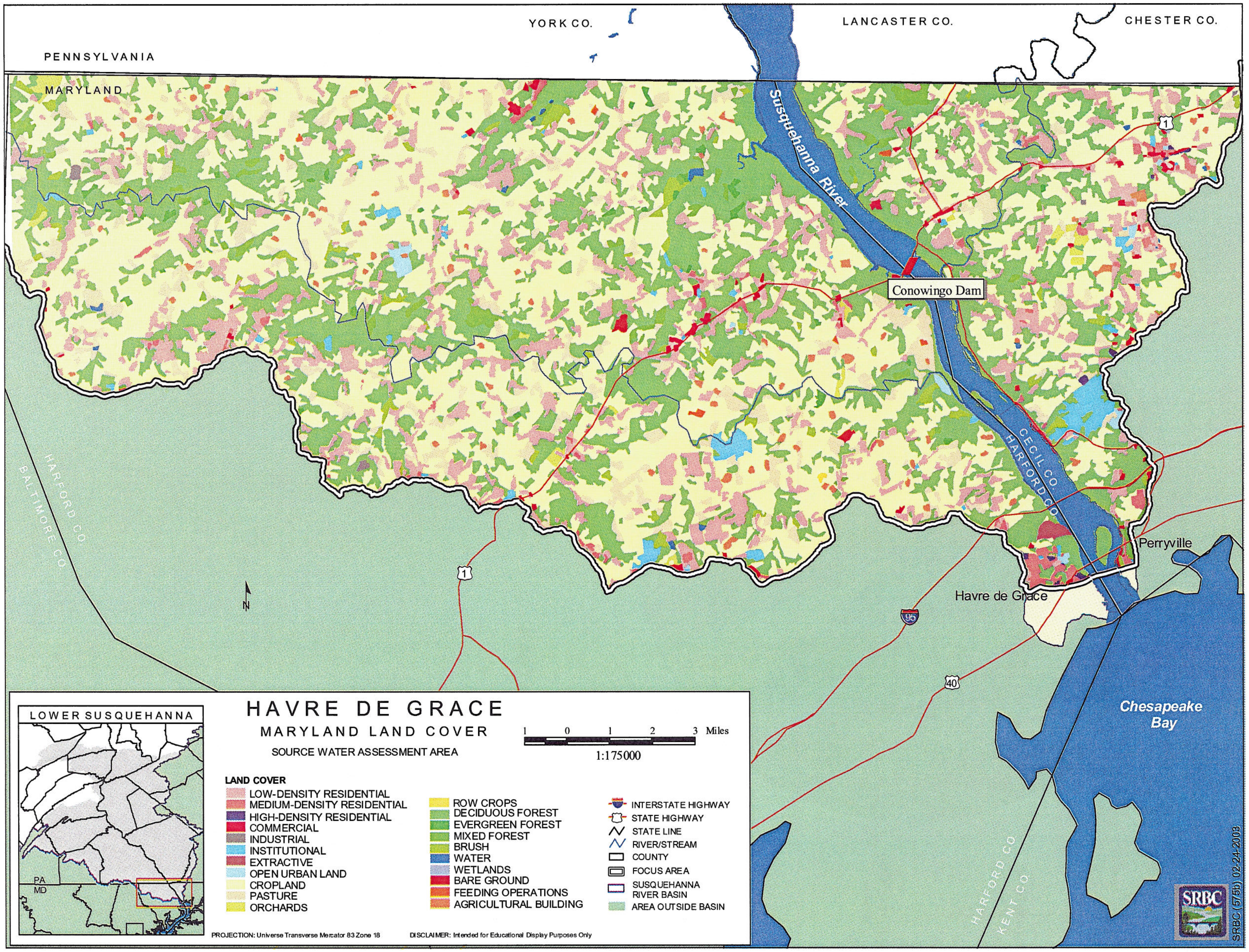


Figure 9. Map of Land Use in the Lower Susquehanna Subbasin in Maryland

E. Subwatersheds of Concern

Water quality varies between the major subbasins due to a number of characteristics associated with land use, soils, and geology. Under the federal Clean Water Act, states are required to assess streams and lakes within their jurisdiction and list waterbodies that do not meet water quality standards. The lists are called the Section 303(d) List, and are published every two years on even numbered years. The following section summarizes major influences on water quality within each of the major subbasins and identifies watersheds of concern, based on SRBC subbasin surveys and state 303(d) lists (Appendix 2).

Overall, the Upper Susquehanna Subbasin has excellent water quality conditions. Most sample sites were found to be supporting healthy water quality, biological conditions, and habitat. Some areas for concern include Tioughnioga River Watershed, Salt Lick Creek, and Nanticoke Creek, which all had slightly impaired sample sites. The water quality impairments that do exist tend to be associated with atmospheric deposition, particularly acid rain and mercury from air pollution.

The Chemung Subbasin has five major watersheds. Much of the Tioga River Watershed is severely impacted by AMD. Biological conditions are greatly impaired on most of the mainstem. The Cowanesque River Watershed has slight impairments due to excessive nutrients from wastewater discharges and agricultural runoff. Overall, the Canisteo River Watershed is fairly healthy. There is a small area with urban influences. The Cohocton River Watershed has poor water quality due to the agricultural activities throughout the watershed.

A subbasin survey was completed for the Middle Susquehanna Subbasin in 2001. The survey found the watersheds of the upper half of the basin, such as Towanda Creek, Tunkhannock Creek, and Meshoppen Creek to be fairly healthy. None of the watersheds are considered to be extremely degraded in water quality, biology, or habitat. The watersheds in the lower half of the basin, which include the Lackawanna River, Nescopeck Creek, and Catawissa Creek, are greatly affected by AMD and urban influences. Smaller tributaries such as Solomons, Nanticoke, and Newport Creeks are strongly impacted by urban influences and AMD and provide very poor quality water to the Susquehanna River. Most of the sample sites on the mainstem in the middle Susquehanna either had water quality of low or nonexistent acidity and high organic carbon concentrations; or had high levels of nutrients and AMD inputs. The AMD and nutrient effected sites were generally located between Wilkes-Barre and Sunbury. Few sites had an increase in ammonia and decrease in sulfate due to major point-source inputs.

The West Branch Susquehanna Subbasin is largely affected by AMD. Over 100 miles of the West Branch Susquehanna River between the towns of Clearfield and Lock Haven have no aquatic life due to AMD. The pH in this section of river is as low as 3.2 at the town of Karthaus. Another 100 miles of the river varies in degree of degradation due to AMD. Water quality ranges from fair to good, and some life is found in the biological communities. The lower 50 miles of the West Branch is the only section of the river that is free from the effects of AMD. The tributaries to the West Branch Susquehanna River have a tremendous impact on its water quality. Clearfield Creek negatively impacts the West Branch due to its large flow and its degraded water quality. Alder Run is another tributary with a negative impact on the West Branch. Water quality is poor and the biological conditions are stressed. Moshannon Creek contributes highly acidic water and the greatest acid load of all of the tributaries to the West

Branch. The Sinnemahoning Creek is the largest tributary to the West Branch. One of its branches is severely degraded by AMD. Chest Creek discharges beneficial water into the upper West Branch; however, the West Branch does not receive a major contribution of beneficial water quality until Bald Eagle Creek at Lock Haven. From Lock Haven down, the river begins to show signs of improving water quality.

Water quality conditions in the Juniata Subbasin are fairly good. However, there are some watersheds such as the Frankstown Branch, Beaverdam Branch and Kishacoquillas Creek that contribute poor water quality to the Juniata River. A section of the Frankstown Branch is impaired by a point-source discharger. The Beaverdam Branch has poor water quality due to AMD, point sources, and runoff from the Altoona/Hollidaysburg area. Several sections of the Kishacoquillas Creek are impaired due to agricultural impacts. The lower section of the Kishacoquillas Creek is moderately impaired due to urban runoff during storm events or point-source discharges.

In the lower Susquehanna River Basin, the major sources of contamination are agricultural runoff, AMD, urban runoff, municipal and industrial waste discharges, atmospheric deposition, and septic discharges. Nutrients and siltation from agricultural runoff and streambank erosion have been identified as pollutants causing designated use impairments throughout the subbasin. In many places, little to no riparian buffer zone exists along pastures and croplands. Livestock also have unlimited access to streambanks in many parts of the subbasin. Fertilizer and animal manure contribute to agricultural related contamination. The Chickies Creek and Conestoga River, both in Lancaster County, have the highest and second highest animal-loading indices, respectively, in Pennsylvania. AMD contributes sediment and metals to surface waters, particularly in the northern portions of the subbasin. Urban runoff and municipal and industrial discharges contribute high concentrations of nutrients, heavy metals, organic contaminants, and other materials to surface waters. On-lot septic systems contribute nutrients to the basin. Degradation of surface water also is caused by atmospheric deposition and natural conditions. Precipitation in Pennsylvania has low pH, which can affect poorly buffered headwater streams. Emissions of sulfur and nitrogen oxides have resulted in some of the most acidic precipitation in the nation.

V. WATER QUALITY DATA

Different sources of water quality data were reviewed for the Susquehanna River Basin. Data were collected and reviewed from water suppliers' monthly operating reports, SRBC data, MDE data, Maryland Department of Natural Resources (MD DNR) data, and USGS data.

Water quality data from the Susquehanna River will be compared with maximum contaminant levels (MCLs) set by the USEPA to ensure safe drinking water.

A. Review and Discussion of Existing Plant Data

The city of Havre de Grace performs water quality tests on both finished and raw water. In 2001, Havre de Grace had no drinking water standards violations for finished water.

Raw Water Data
Raw water turbidity, alkalinity, and pH are parameters that are tested daily. Turbidity in the river is occasionally high, especially following a heavy rain event. The average turbidity was about 7 Neophelometric Turbidity Units (NTU) in 2000. From August through October 2002, turbidity ranged from about 3 to 7 NTU. The average pH and alkalinity were approximately 7 and 60 mg/l, respectively in 2000.

Havre de Grace also monitors their raw water supply daily for iron, and weekly for bacteria. The highest iron level in 2001 was 0.268 mg/l, which is below the USEPA Secondary Drinking Water Regulation of 0.3 mg/l. Bacteria data varied greatly. Weekly total coliforms and fecal coliform data were reviewed for in 2001. Total coliforms ranged from below detection limits to over 4,000 coliforms per 100 milliliters (ml) of raw water. In 2001, there were several occasions when the fecal coliform concentrations in the source water samples exceeded MDE's water quality criteria. The water quality criteria require fecal coliform densities not to exceed a geometric mean of 200 per 100 ml, based on a minimum of not less than five samples taken over any 30-day period. In addition, there were several violations of the additional criteria requiring fecal coliform densities not to exceed 400 per 100 ml for 10 percent of the total number of samples taken during a 30-day period. Most of the criteria violations occurred during the January through June timeframe.

Total organic carbon (TOC) data, collected monthly during 2001, indicated that source TOC ranged from 2.0 to 2.8 mg/l, with an annual average of 2.4 mg/l. Treated TOC ranged from 1.4 to 2.3 mg/l, with an annual average of 1.8 mg/l. Havre de Grace typically did not meet their removal objectives. The average annual removal rate was 24.5 percent, while most months required TOC removal rates between 25 and 35 percent.

As mentioned within the *Operator Concerns* section, salinity levels are a concern for Havre de Grace's intakes, especially during drought conditions. Havre de Grace regularly monitors its sodium levels. During 2000-2001, sodium levels were mostly below concentrations of 30 mg/l. If sodium levels reach 50-60 mg/l, it requires the water supplier to switch to using the surface intake. During drought conditions in 2002, sodium levels exceeded 200 mg/l. Conditions were not improved through the use of the surface intake, causing significant hardship for the water supplier

Finished Water Data
Disinfection byproducts (DBPs) are sampled within the distribution system by Havre de Grace personnel, and the analyses are submitted to MDE. Data collected during 2001 and 2002 indicated that total trihalomethanes (THMs) ranged from 0.010 to 0.139 mg/l. Total haloacetic acids (HAAs) ranged from 0.022 to 0.080 mg/l. The MCLs for THMs and HAAs is 0.08 mg/l and 0.06 mg/l, respectively, with compliance determined from the running annual average. DBPs information from 2002 for Havre de Grace is shown in Table 7. The data represents samples taken from the distribution system. The data shows that there were no MCL exceedances based on the annual average concentrations for either THMs or HAAs. However, both annual average concentrations did exceed the 50 percent level of the MCL.

Table 7. Detected in the Distribution System during 2002

Contaminant	2002 Peak Concentration (mg/l)	2002 Average concentration (mg/l)
Bromodichloromethane	0.019	0.009
Chloroform	0.117	0.043
Bromoform	<0.001	<0.001
Dibromochloromethane	0.004	0.001
Monochloroacetic Acid	0.003	<0.001
Monobromoacetic Acid	<0.001	<0.001
Dichloroacetic Acid	0.043	0.020
Trichloroacetic Acid	0.043	0.023
Bromochloroacetic Acid	0.004	0.003
Total Trihalomethanes	**0.139**	**0.054**
Total Haloacetic Acids	**0.080**	**0.044**

Additionally, certain inorganic contaminants were detected in Havre de Grace's finished water data. Data provided by MDE indicated that the highest nitrate value detected in 2002 was 1.5 mg/l. The MCL for nitrate is 10 mg/l. The highest fluoride value was 0.8 mg/l. The secondary standard for fluoride is 2 mg/l. Barium was detected in 2002 at 0.028 mg/l. Its MCL is 2 mg/l.

Pesticides and herbicides, such as atrazine, were tested periodically in finished water from 2000 through 2002. The organic contaminant Dalapon was detected in 2002, although the concentration was well below its MCL.

MDE also conducted testing for radioactive contaminants, with no detections. Radioactive particle testing will be conducted again in 2004.

B. Review and Discussion of Current or Completed Studies in Watershed

Nutrients and Sediment
The SRBC Publication No. 225 *Nutrients and Suspended Sediment Transported in the Susquehanna River Basin, 2001 and Trends 1985 Through 2001* collected nutrient data at three

sites on the Susquehanna River and three sites on major tributaries. The locations include the Susquehanna River at Towanda, Danville, and Marietta; the West Branch Susquehanna at Lewisburg; the Juniata River at Newport; and the Conestoga River at Conestoga. The study tracked seasonal variations for total nitrogen, total phosphorus and suspended sediment (Table 8) Total nitrogen had the highest loads in the spring followed by winter, fall, and summer. Suspended sediment loads and total phosphorus loads show similar seasonal variation at the sites on the Susquehanna River. The Conestoga River Watershed had the greatest yields in pounds per acre per year of total nitrogen, total phosphorus, and suspended sediment for all seasons. The long-term yields of total nitrogen increased in the Susquehanna River in a downstream order from Towanda to Marietta. The increase is possibly due to a larger amount of agricultural lands and sewage treatment plants in the lower Susquehanna. Overall, the Susquehanna River system is phosphorus limited. Long-term yields for total phosphorus at the sites on the Susquehanna River do not show a uniform seasonal pattern. Suspended sediment long-term yields decreased in downstream order except during the summer at Marietta. Overall, there were significant improving trends at all six stations for total nitrogen, total phosphorus and suspended sediment.

The USGS Lower Susquehanna National Water Quality Assessment (NAWQA) Study (1992-1995) found that nitrate concentrations exceeded the USEPA MCL (10 mg/l) in streams located in agricultural areas that are underlain by limestone. These areas have a strong correlation between the manure applications rate and nitrate concentrations. The study also found that streams located in agricultural areas that are underlain by sandstone, shale, and crystalline bedrock contribute large amounts of nitrate. Animal manure used as fertilizer for agriculture was determined to be the main source of nitrogen to the Susquehanna River. Manure application had a strong correlation with nitrate levels in the streams. The study found that there were higher concentrations in streams than in ground water in limestone urban areas. Tributaries like Mill Creek, Lancaster Co., that are in limestone areas had nitrate levels around 10 mg/l. There were some seasonal fluctuations in these concentrations. Nitrate concentrations were less than 2 mg/l in the Susquehanna River at Harrisburg. Nitrate concentrations in limestone areas are generally higher during the spring. Overall, nitrate was found in 98 percent of the samples. Ninety-two percent of the samples detected nitrate in concentrations above 0.3 mg/l. Streams with these levels of nitrates encourage excessive algae growth.

The Susquehanna River transports about 25 percent of the sediment, 40 percent of the phosphorus, and nearly 66 percent of the nutrient load to the Chesapeake Bay. Three hydroelectric dams on the lower Susquehanna River form the reservoir system, which consists of Lake Clarke, Lake Aldred, and the Conowingo Reservoir. Since their construction in the early 1900s these reservoirs have been filling with sediment and nutrients. Lake Clarke and Lake Aldred, the two upper reservoirs, have reached their capacity to store sediment and no longer trap sediments and nutrients. The Conowingo Reservoir currently traps 2 percent of the total nitrogen load, 40 percent of the total phosphorus load, and 70 percent of the suspended-sediment load. Concentrations of total nitrogen collected from bottom sediments averaged about 3,600 milligram/kilogram (mg/kg) in the area of the reservoir within 1-mile upstream of the Conowingo Dam. The average concentration for total phosphorus in this same area was about 850 mg/kg.

There is about 29,000 acre-ft of sediment storage capacity left in the reservoir. There is no storage capacity left in the Conowingo Reservoir from its upper end to about 28,000 feet upstream of the Conowingo Dam. Once the reservoir system reaches capacity, and if conditions remain constant, there will be a 2 percent average yearly increase in total nitrogen, a 70 percent average yearly increase in total phosphorus, and a 250 percent average yearly increase in suspended sediment entering the Chesapeake Bay. With Conowingo Dam no longer mitigating the effects of nutrient and sediment loads, downstream water suppliers such as Havre de Grace could potentially see significant changes in water quality conditions at the intake. Such conditions could result in elevated turbidity levels, an increase in algal-related problems, or increased risk of microbial contamination.

Volatile Organic Compounds
The NAWQA study found that VOCs were more frequently detected in ground water of urban areas than in agricultural areas. This is likely due to the numerous sources of VOCs found in urban areas. These sources include spills, improper disposal, runoff from pavement, leaks from underground storage tanks, atmospheric deposition, and leaking sewer lines. This study indicated that contaminated ground-water flows from springs into streams. The detection levels of VOCs in wells ranged from 0.2 to 1.0 ug/l. These levels were detected in 23 of the 60 compounds sampled. However, there were no significant concentrations detected in surface waters within the lower Susquehanna.

Synthetic Organic Compounds
Pesticide concentrations in the lower Susquehanna rarely exceeded the drinking water standards. Overall, the concentrations of individual pesticides were quite low. Forty-seven insecticides and herbicides were tested for. Only 22 of over 500 samples detected pesticides at levels greater than 0.002 mg/l. Herbicides that are widely used on corn were the most commonly detected pesticides. These herbicides include atrazine, metolachlor, simazine, prometon, alachlor, and cyanazine. The two most commonly used agricultural pesticides in the lower Susquehanna River Basin are metolachlor and atrazine. Generally, the detection of pesticides was related to bedrock type, pesticide leaching potential, and pesticide use. Storm runoff in the spring during the major application period was found to be a major contributor of high concentrations of pesticides to streams. During the major application period, concentrations of atrazine detected in Mill Creek ranged from 0.1 mg/l to 0.2 mg/l. The pesticides detected in the Susquehanna River at Harrisburg were similar to those found in streams in agricultural areas throughout the lower Susquehanna River Basin. Pesticide concentrations found at this site were usually less than 1 ug/l. Atrazine concentrations ranged from 0.00001 to 0.001 mg/l. Metolachlor concentrations ranged from 0.000007 to 0.002 mg/l. The MCL for atrazine is 0.003 mg/l, for simazine is 0.004 mg/l, and for alachlor is 0.002 mg/l.

A more recent NAWQA study took place nationwide during 1999 and 2000. This study looked for the occurrence of pharmaceuticals, hormones, and other organic wastewater contaminants in streams. Five of the sampling sites were located in the lower Susquehanna River Basin. These sites were located in the East Mahantango Creek at Klingerstown, Schuylkill County; Conodoguinet Creek at Hogestown, Cumberland County; Bachman Run at Annville, Lebanon County; Chickies Creek at Marietta, Lancaster County; and Mill Creek at Lyndon, Lancaster County.

Table 8. Seasonal Mean Water Discharges and Loads of Nutrients and Suspended Sediment, Calendar Year 2001

Station	Season	Mean Water Discharge	Total Ammonia as N	Total-Organic Nitrogen as N	Total Nitrite Plus Nitrate as N	Total Nitrogen as N	Dissolved Ortho-phosphate as P	Dissolved Phosphorus as P	Total Phosphorus as P	Dissolved Ammonia as N	Suspended Sediment	Dissolve Nitrogen as N	Dissolved Nitrite Plus Nitrate as N	Dissolved Organic Nitrogen as N	Total Organic Carbon
		cfs	thousands of pounds												
Towanda	Winter	9,929	259.1	2,045	3,901	6,211	255.9	228.2	402.5	327.5	170,359	6,112	3,959	1,807	13,865
	Spring	15,781	384.6	4,415	4,642	9,297	358.7	348.8	1,099.0	410.2	1,102,616	8,193	4,660	3,299	26,876
	Summer	1,978	22.3	573	428	953	92.4	67.2	108.9	26.0	13,055	839	429	427	3,598
	Fall	3,356	79.8	777	1,148	1,999	244.6	152.5	189.0	122.4	21,195	1,980	1,155	694	5,173
Danville	Winter	14,781	406.3	3,054	6,997	10,301	361.8	277.2	585.3	561.4	208,795	10,180	7,107	2,616	18,629
	Spring	20,990	433.0	5,719	7,417	13,212	407.1	366.7	1,289.3	525.1	877,762	11,899	7,459	4,175	32,927
	Summer	3,462	28.5	1,100	800	1,738	74.0	66.4	155.8	36.4	22,120	1,454	803	752	6,161
	Fall	5,223	110.2	1,404	2,096	3,474	226.6	162.8	276.2	167.9	38,226	3,361	2,122	1,173	7,775
Lewisburg	Winter	9,062	332.0	1,635	2,810	4,578	107.7	115.2	277.9	271.3	86,194	4,300	2,812	1,258	8,285
	Spring	10,014	241.0	1,827	2,569	4,462	106.9	104.3	298.3	192.3	107,395	3,993	2,555	1,324	9,992
	Summer	2,476	30.1	539	659	1,183	44.6	39.9	80.0	31.2	13,270	1,048	649	389	3,111
	Fall	5,529	103.0	1,205	1,685	2,973	122.4	120.7	245.2	147.8	46,311	2,676	1,672	880	6,368
Newport	Winter	4,054	46.9	920	2,494	3,524	154.6	132.7	221.4	61.8	80,589	3,352	2,515	755	5,676
	Spring	4,202	49.1	1105	2,283	3,432	184.8	152.7	305.6	71.1	149,541	3,140	2,294	812	6,501
	Summer	883	8.0	283	364	588	46.1	45.1	71.4	12.4	9,730	531	365	211	1,640
	Fall	912	7.8	255	462	695	47.5	49.4	65.5	12.3	5,873	662	467	214	1,539
Marietta	Winter	33,127	829.7	8,599	18,225	27,089	1,452.3	966.3	1,813.1	935.4	786,776	24,951	18,280	5,914	43,722
	Spring	42,905	780.7	13,965	18,856	30,894	2,329.9	1,374.4	3,402.7	850.3	1,948,548	27,395	18,800	8,729	67,466
	Summer	8,382	82.4	3,396	2,742	5,248	463.9	311.9	552.0	106.2	150,945	4,697	2,777	2,273	16,153
	Fall	13,490	312.0	5,081	6,776	11,315	1,136.6	625.8	1,006.3	362.4	285,069	10,364	6,865	3,439	22,488
Conestoga	Winter	635	30.2	487	2,104	2,587	49.7	52.6	122.6	31.5	42,775	2,438	2,092	295	1,456
	Spring	521	19.0	342	1,715	2,003	53.5	46.3	111.8	19.5	35,897	1,896	1,706	193	1,170
	Summer	200	4.4	116	635	737	38.9	30.6	50.2	4.5	6,754	696	636	68	488
	Fall	120	1.7	78	410	502	18.7	18.4	20.8	2.1	630	478	412	54	264

In the lower Susquehanna River Basin, 18 antibiotic compounds were sampled for at the five sites. Each site had concentrations of the antibiotics that were generally below the detectable limits. Erythromycin (sampled at Chickies Creek) was the only compound found in the lower Susquehanna at a detectable limit (0.00005 mg/l). Lincomycin and erythromycin were the only antibiotics found in the basin that were frequently detected nationwide. Steroid and hormone compound data were only collected in Chickies Creek. Cholesterol, used as a plant/animal steroid, was found at a level of 0.0023 mg/l. Coprostanol, a fecal steroid, had a concentration of 0.00014 mg/l. Estriol, a reproductive hormone, was the only other compound with a concentration (0.000019 mg/l) above the detectable limit. Forty-five compounds considered as wastewater-related were sampled for at the Chickies Creek site. Twenty of these compounds were frequently detected in streams nationwide. Four of the compounds sampled at Chickies Creek had concentrations at a detectable limit. Ethanol, used as a blending component in gasoline, had a concentration of 0.0002 mg/l. Naphthalene, a polycyclic aromatic hydrocarbon (PAH), was detected at 0.00005 mg/l. The health advisory level for this contaminant is 0.02 mg/l. Triclosan, an antimicrobial disinfectant, had a concentration of 0.00006 mg/l. Tri (chloroethyl) phosphate, a fire retardant was found at a level of 0.00006 mg/l.

The USGS and George Mason University (Koplin and others, 2002) studied organic contaminants sampled at the Conowingo Dam between March 4 and December 12, 1994. Some common contaminants that were detected included pesticides (atrazine, metolachlor, cyanazine, and malathion), insecticides (chlordane), total PCBs, and total PAHs. Both point and nonpoint sources are associated with contributing these contaminants to the environment.

Sample concentrations were measured in filtered water and filtered particles. The samples were filtered with Whatman glass fiber filters. For a list of common filtered water concentrations see Table 9. Although there were detections for many of the compounds sampled, all were well below any established MCLs.

Table 9. Organic Contaminants Detected at Conowingo Dam, 1994

Contaminant	Mean Concentration (nanograms per liter	Concentration Range (nanograms per liter)	MCL (nanograms per liter)
Pesticides			
Malathion	105	<2.9-279	NA
Cyanazine	84.5	<0.9-184	NA
Atrazine	81.5	26-241	3,000
Metolachlor	61.2	16-195	NA
Insecticides			
Chlordane	0.19	<0.0009-0.65	2,000
Total PCB	1.7	0.5-5.3	500
Total PAH	99.6	25-240	NA

Malathion was found in the river water in high concentrations, but was infrequently detected. There was a peak in the discharge between March and May due to combined runoff from snowmelt and rainfall. Concentrations of organo nutrient/phosphorus pesticides showed a seasonal link to agriculture activities. PCBs and chlordanes concentrations were linked to seasonal runoff. PBC concentrations were greatest during the spring due to increased runoff from precipitation and snowmelt. Chlordane concentrations showed an increase during the spring and the month of August when river flows were high.

Radionuclides

Present both naturally and as a result of human activity, low concentrations of radionuclides are typically found when sampling air, soil, or water. However, potential contamination of drinking water sources by increased levels of radionuclides exists due to human activities such as the mining of radioactive substances, production of nuclear power, use and/or production of nuclear weapons, and practice of nuclear medicine. The most significant sources of radionuclides in the lower Susquehanna are nuclear power plants and residual piles of surfaced elements from mining operations.

In order to ensure public safety from exposure to radioactive particles, the USEPA has set MCLs for radium (5 picocuries per liter - pCi/l), gross alpha particles (15 pCi/l), beta particles (50 pCi/l), tritium (20,000 pCi/l), and uranium (30 ug/l). Public water systems are required to test annually for radioactive contaminants.

Upstream surface water data supplied by AmerGen-Three Mile Island (TMI) and MDE was reviewed. TMI data incorporates several locations (upstream control sites and downstream indicator sites) sampled monthly from January to December of 2001. MDE data represents weekly sampling from the Susquehanna River at Conowingo from January 2000 through September 2002. Concentrations of tritium (H-3), iodine-131 (I-131), and gross beta particles were reviewed for both datasets. MDE samples additionally for xenon-133 (Xe-133), and TMI for numerous gamma-emitting isotopes.

TMI samples along the Susquehanna River near Steelton for control measurements. Downstream indicator measurements of outfalls are taken along the Susquehanna River near TMI (west shore), Columbia, and Wrightsville. Tritium levels at the upstream control location ranged from <143-<183 pCi/l, averaging over the 12 month collection period at approximately 168 pCi/l. Levels at the indicator location (downstream of the outfall) typically ranged from <159 to approximately 3,300 pCi/l, spiking once in January 2001 at 30,129 $\pm$ 495 pCi/l. The median for this period was 1,657 pCi/l. Not including the January event, the yearly average over the remaining 11 months was approximately 1,300 pCi/l. It should be noted, that some of the samples from this location were grab samples, due to freezing temperatures and/or sampler malfunction. Columbia data indicated only one instance of slightly elevated tritium levels (437 pCi/l). Wrightsville data stayed within control levels for tritium.

Both Columbia and Wrightsville sites sampled for gross beta particle levels and I-131. I-131 levels oscillated infrequently and very slightly, deviating from control values (<0.4 pCi/l) by no more than 0.2 pCi/l. Gross beta results were similar. Control values (1.5-2.4 pCi/l) were seldom exceeded at Columbia, and although exceeded frequently at Wrightsville, the variation in concentration was small (max. record 3.7 pCi/l).

MDE data from the Susquehanna River at Conowingo also indicates stable levels of I-131 and gross beta particles. However, gross beta particle values for MDE data exceeded those of TMI, the low value being 1.0 pCi/l in January of 2000, and the high value in August and September of 2002 at 6.0 pCi/l. Tritium concentrations remained <300 pCi/l throughout the study period.

C. Review and Discussion of Outside Sources of Data and Findings

USEPA STORrage and RETrieval DATABASE (STORET) DATA

STORET data has been collected at many sites on the Susquehanna River. Lower Susquehanna River data collected by the Pennsylvania Department of Environmental Protection (Pa. DEP), SRBC, and MD DNR were reviewed. Pa. DEP monthly data were reviewed for 1997 and 1998. These data were collected from the Susquehanna River at Columbia and Wrightsville, Pa. SRBC monthly data from 1987 to 1990 also were reviewed. These data were collected from the Susquehanna River in Cecil County, Md., near Lapidum. MD DNR monthly data were reviewed from 1978 to 1995. These data were collected near the Conowingo Dam Pool.

Low DO in a stream can be indicative of poor water quality. The measured DO values typically ranged from 4 to 14 mg/l, with the lowest values typically measured during the summer months. DO values near the Conowingo Pool typically ranged from 4 to 12 mg/l. Nitrate and nitrite measured as nitrogen in stream water may result from fertilizer runoff use, leaching from septic tanks and natural erosion. USEPA sets the MCL for nitrate at 10 mg/l and for nitrite at 1 mg/l. Nitrate values at ranged from approximately 0.53-2.79 mg/l. Nitrite values ranged from 0.003-0.154 mg/l. All the data exhibited a general trend where nitrate/nitrite levels increased during the winter months.

Copper and lead found in streams may result from plumbing corrosion and natural erosion. USEPA sets action levels for copper and lead at 1.3 mg/l and 0.015 mg/l, respectively. Pa. DEP data indicated that the concentrations of both metals were typically below detection limits.

The National Secondary Drinking Water Regulations provide guidelines for regulating nontoxic contaminants. Total aluminum, chloride, iron, manganese, and sulfate in drinking water have recommended maximum values under these guidelines. The recommended maximum concentrations for each compound are shown in Table 10. In addition, Table 10 provides a summary of the reviewed STORET data.

Table 10. Summary of STORET Data

Contaminant	Pa. DEP Data	SRBC Data	MD DNR	US EPA Limits
				Recommended Maximum Values
Total Aluminum	0.0264-2.235 mg/l	0.150-1.350 mg/l	N/A	0.05-0.2 mg/l
Chloride	8-30 mg/l	10-92 mg/l	N/A	250 mg/l
Iron	0.0264-2.235 mg/l	0.00298-3.060 mg/l	N/A	0.3 mg/l
Manganese	<0.001-0.405 mg/l	0.010-0.420 mg/l	N/A	0.05mg/l
Sulfate	19-92 mg/l	23-61 mg/l	N/A	250 mg/l
				MCL
Copper	<0.001-0.0093 mg/l	N/A	N/A	1.3 mg/l
Lead	<0.001-0.00252 mg/l	N/A	N/A	0.015 mg/l
Nitrite	<0.02 mg/l	0.01-0.03 mg/l	0.003-0.154 mg/l	1 mg/l
Nitrate	0.56-1.93 mg/l	0.81-2.99 mg/l	0.53-2.79 mg/l	10 mg/l

Data from Fish Tissue

The Pa. DEP and Pennsylvania Fish and Boat Commission (PFBC) regularly sample fish tissue for contaminants. Levels of a specific PCB compounds were detected in fish tissue at all sites sampled north of Sunbury, Pa., with the exception of one site at Sayre, Pa. Of the six PCB compounds analyzed, only one compound was typically above detectable limits. Pesticides and trace elements also were detected at varying levels in fish tissues. The metals detected include arsenic, mercury, copper, lead, chromium, and cadmium.

VI. SIGNIFICANT SOURCES OF CONTAMINATION

A. Nonpoint Source Concerns

Unlike point sources, nonpoint sources are unable to be isolated to a specific discharge point. Runoff from agricultural activities and roads, improper stormwater drainage, erosion along streambanks or from uncontrolled construction, and on-lot septic systems are all examples of nonpoint sources. Nonpoint sources in this assessment were identified using several geographic information system (GIS) datasets. These data sets included land use, animal indices, stream assessment information, and field observations.

Although difficult to quantify, nonpoint sources are significant contributors to water quality degradation in the Susquehanna River Basin. Several hundred miles of streams are listed on Maryland, New York, and Pennsylvania's 303(d) List of Impaired Waters (Appendix 2). The sources and causes range significantly. In the Susquehanna River Basin, the leading sources of contamination in order of significance are agricultural runoff, AMD, and runoff associated with urban/residential areas and storm sewers (Table 11). The leading cause of water quality impairment from nonpoint sources is sediment, coming from all three major sources. Additionally, agricultural runoff contributes to a majority of the problems associated with excessive nutrients and organic enrichment. AMD is the primary source for metals and low pH, although urban runoff is believed to contribute some metals as well. Urban runoff is a source for numerous contaminants, based on the range of activities present. Appendix 3 indicates which watersheds have approved Total Maximum Daily Loads established, and lists the pollutants addressed.

Table 11. Summary of Stream Assessments in the Susquehanna Basin

Category	Entire Susquehanna Basin (in stream miles)	Lower Susquehanna Subbasin (in stream miles)
Stream Assessment Status		
Assessed	27,000	7,500
Impaired	4,100	2,000
Unassessed	9,200	1,900
Three Leading Impairment Sources		
Agriculture	1,900	1,200
Acid Mine Drainage	1,300	200
Urban/Residential	60	50

The Susquehanna River Basin north of Sunbury, Pa. is predominantly forested with some agricultural land use and a few urban centers. Water quality conditions in the Upper Susquehanna Subbasin are fairly good, with little agriculture and development. The only potential for significant contamination exists from urban/stormwater runoff in the Elmira and Binghamton, N.Y. areas. Agricultural practices in the Chemung Subbasin have caused an increase in nutrients and sediments, and to a lesser extent, AMD has caused problems with metals and sediment. The single most problematic area in the northern portion of the assessment area is the large urban area located in the Wyoming Valley, within the Middle Susquehanna

Subbasin (Wilkes Barre/Scranton, Pa.). The tributaries in the Wyoming Valley contribute a large amount of sewage, trash, and urban runoff to the Susquehanna River. The Middle Susquehanna Subbasin also has severe problems associated with AMD. Combined with the West Branch Susquehanna Subbasin, these two subbasins contribute the majority of the problems associated with AMD in the Susquehanna basin. AMD causes low pH, high levels of metals, and acidity. However, the effects of AMD are largely mitigated by dilution downstream of the subbasin.

As stated in previous sections, the Lower Susquehanna Subbasin is the southernmost subbasin and most influential regarding Maryland's source water quality. Unlike all the other subbasins, it is dominantly agricultural land, with most of the activity occurring within Lancaster and York Counties, Pa. (Appendix 4, Land Cover Map). It represents the most productive area in the Susquehanna River Basin. Hence, the leading cause for water quality problems is associated with agricultural runoff, specifically siltation and nutrients.

Siltation is fairly severe in portions of the lower Susquehanna, degrading to source water quality, as well as recreational use and fish habitat. The small particles clog waterways and decrease water clarity. Sediment also can carry contaminants such as pesticides into streams. The major contributors of siltation in the lower Susquehanna are predominantly unmanaged crop and pasture fields, and to a lesser extent urban/stormwater runoff, and unmanaged construction.

The problems associated with excessive nutrients are also prevalent in the lower Susquehanna. Sources of phosphorus include human sewage, urban/residential runoff, agricultural run-off from crops, sewage from animal feedlots, pulp and paper industry, vegetable and fruit processing, chemical and fertilizer manufacturing, and detergents. Aside from the negative health effects from elevated nutrients such as nitrate, elevated nutrient loads (nitrogen and phosphorus) can lead to increased algal productivity (Novotny and Olem, 1994). The addition of large quantities of phosphorus to waterways accelerates algae and plant growth by enhancing eutrophication and depleting the water body of oxygen. Increases in algal productivity also can have adverse effects on water supplies, such as potentially clogging a filter or affecting taste and odor. Any increase in TOC also increases the excretion of toxins and the probability for the formation of harmful DBPs during treatment.

Agricultural practices also can increase the loads of fecal coliforms, cryptosporidium, and giardia in waterways, particularly where the animal populations are high. These microbial contaminants can result in severe gastrointestinal illnesses. Increases in the number of industrial farms, or concentrated animal feeding operations, have increased the potential for contamination of source water in the Lower Susquehanna Subbasin. To determine relative inputs, animal biomass indices were calculated for the subbasin using 1998 zip code data with animal population numbers, and USEPA estimates for daily manure loadings by animal type. The calculations were then distributed on a per acre basis of animal biomass. The index map identifies high animal densities throughout Lancaster County (Figure 10). The highest densities are represented in the Chickies Creek watershed, followed in decreasing order by Pequea Creek, Conestoga River, and Octoraro Creek watersheds. Due to the proximity and concentration of livestock sources in the Lower Susquehanna to the intake, potential for source contamination is high. Contaminants of high concern include: nutrients, siltation/turbidity, and bacteria/protozoa (total coliforms, Giardia, Cryptosporidium, etc.).

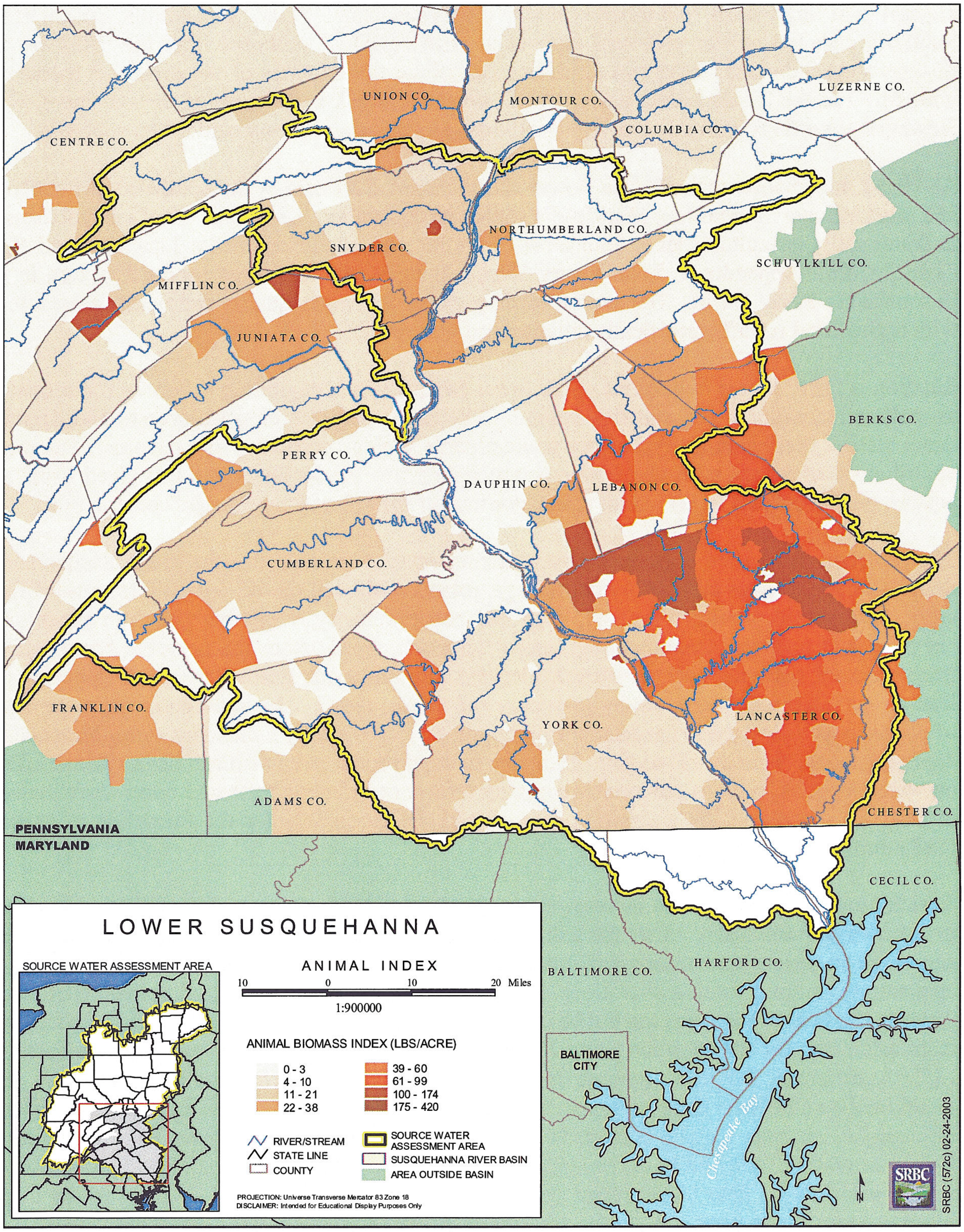


Figure 10. Animal Biomass Index for the Pennsylvania Portion of the Lower Susquehanna Subbasin

Although their occurrence is not as frequent as the previously mentioned contaminants, herbicide/pesticide usage also has been documented to contribute contaminants to waterways from runoff associated with agricultural activities. Aside from an agricultural source, residential use of lawn fertilizers/pesticides, as well as increases in the number of golf courses, is responsible for an increase in the contribution of these types of contaminants as development increases in the Lower Susquehanna Subbasin.

Within the Lower Susquehanna Subbasin, there are three major metropolitan areas (Harrisburg, Lancaster, and York). Development has been rapidly expanding for both residential and commercial areas. Runoff from these developed areas can lead to increased problems with VOCs, SOCs, metals, and turbidity. Runoff containing road de-icing chemicals is also becoming an increasing problem during the winter months. On such occasions, the presence of several bridges in the lower subbasin, with minimal drainage controls, has caused some water suppliers to experience problems with chlorine demand during treatment due to ammonia levels present in road de-icers.

B. Point Discharge Concerns

Point-source pollutants generally refer to instream discharges that have a discrete, identifiable outfall, regulated by the state and federal government. Point sources are commonly called "end of pipe" discharges. Examples of point sources include sewage treatment plants and industrial wastewater discharges. For this assessment, point sources were identified using GIS datasets provided by the USEPA, Pa. DEP, and MDE. For permits located within the Lower Susquehanna Subbasin, discharge monitoring reports were reviewed and water quality violations were noted.

There are approximately 1,152 permitted discharge sites in the entire Susquehanna River Basin covered under the USEPA's National Pollutant Discharge Elimination System (NPDES). Of that total, there are 115 sites located in New York, 1,024 in Pennsylvania, and 13 in Maryland. Within the Lower Susquehanna River Basin there are about 381 NPDES discharges upstream of Havre de Grace's intakes. Of these dischargers, 252 (66 percent) are municipal and 113 (29 percent) are industrial. Sixteen sites (5 percent) are a combination municipal/industrial. Within the Maryland portion of the assessment area, there are 9 municipal and 4 industrial discharges. The NPDES map (Appendix 4) shows the sites within Havre de Grace's assessment area for the Lower Susquehanna Subbasin. A majority of the municipal sources discharge contaminants such as nutrients, while the industrial sources discharge a full range of contaminants (metals, VOCs, SOCs, etc.). It is important to note that mine and quarry operations do not always have NPDES permits for discharges, based on differences in the way the sites are managed and regulated.

The USGS NAWQA Program summarized nutrient levels in the Lower Susquehanna River Basin between 1975 and 1990. Based on volume, the two primary contaminants of concern associated with point-source discharges in the Lower Susquehanna Subbasin are nitrogen and phosphorus. With respect to point source contribution, about 60 percent of the nitrogen comes from municipal discharges, while almost 90 percent of the phosphorus load comes from industrial sources such as food processing facilities and pharmaceutical laboratories (Risser and

Siwiec, 1996). Overall, point-source nitrogen loads exceed phosphorus loads in the Susquehanna River and its tributaries. The study determined that Codorus Creek, the Juniata, and Conestoga Rivers receive the majority of the nitrogen and phosphorus loads from municipal dischargers, with nitrogen loads significantly higher than phosphorus loads.

Overall, estimated nutrient loads from point sources are significantly lower than loads emanating from nonpoint sources. Another USGS study (Sprague and others, 2000) found that approximately 10 percent and 27 percent of the total load for nitrogen and phosphorus, respectively, originate from point sources within the Susquehanna Basin.

Based on permits reviewed for this assessment, flows from municipal and industrial discharges in the Lower Susquehanna Subbasin are estimated to comprise less than 5 percent of the mean annual flow for the Susquehanna River as measured at Marietta, Pa. Average flows from municipal and industrial discharges are estimated to be 110 mgd and 50 mgd, respectively. These estimates did not include flows associated with non-contact cooling water.

Several power plants comprise the majority of the flow contribution to the Susquehanna from point-source discharges in the Lower Susquehanna Subbasin. Table 12 shows the facilities and their associated flows. Water used for non-contact cooling processes in 2001 comprised almost 20 percent of the flow in the lower Susquehanna River as measured at Marietta, Pa., during the same time period (approximately 15,000 mgd).

Table 12 Power Facilities Located in the Lower Susquehanna Subbasin

Permit Number	Permit Name	Design Flow (mgd)	Average Flow (mgd)	Average Flow for Non-contact Cooling (mgd)
		Non-contact Cooling		
PA0008281	PP&L Brunner Island	744.5	580	580
PA0009733	Exelon Energy Company – Peach Bottom	2,199.8	1,960	1,960
PA0009920	AmerGen Energy Company - TMI	83.4	20	20
PA0008451	Sunbury Generation LLC	330.0	260	260
		Power Generation		
PA0009741	Exelon Energy Company – Muddy Run	N/A	6.40	--
PA0008435	PP&L Holtwood	N/A	0.17	--
PA0044628	York Haven Power Company	N/A	0.28	--
PA0032379	Safe Harbor Water Power Corporation	N/A	0.03	--
MD0002518	Susquehanna Energy Company (SEC)	N/A	5,000	--
Total Flows		**3,357.7**	**7,826.88**	**2,820**

C. Transportation Related Concerns

Transportation crossings on the Susquehanna River mainstem are another concern due to the possibility of spills. There are numerous road and railroad crossings over the Susquehanna River in Pennsylvania. Most of these crossings are U.S. routes or state routes that are classified as primary highways. Fifteen crossings are by rail. The majority of pipeline and utility crossings are found within the Lower Susquehanna Subbasin. Below Sunbury, Pa. there are 19 road/train crossings, 10 pipeline crossings, and 35 utility crossings.

Four heavily traveled bridges cross the Susquehanna River in Maryland. Three of these bridges transport cars and trucks, and one bridge is a railroad bridge. A high volume of traffic crosses the river daily by means of these bridges. The greatest transportation threat would be a potential spill from one of these bridges or a train derailment.

Route 222 runs through Port Deposit to Perry Point, Md. At times, this road is very close to the river and to Octoraro Creek, which empties into the river. Road runoff, as well as de-icing materials may contribute contaminants to the river.

Table 13 shows pipeline crossings in the Susquehanna basin in order of closest proximity to Havre de Grace's intakes. Colonial Pipelines, the major petroleum pipeline that connects the northeast United States with Texas, crosses the Susquehanna River just below the Conowingo Dam.

Table 13. Pipeline Crossings in the Susquehanna Subbasin

Pipeline Name/Company	River Crossing	Commodity
Colonial Pipeline	Cecil/Harford Co., Md.	Refined Petroleum Product
Williams Gas Co. Pipeline - Transco	Lower Lanc./York Co., Pa.	Natural gas
Texas Eastern Transmission Corp.	Wrightsville/Columbia, Pa.	Natural gas
Sun Pipeline Co.	Highspire/New Cumberland, Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Buckeye Pipeline	Highspire/New Cumberland, Pa.	Refined Petroleum Product
Texas Eastern Products Pipeline Co.	Highspire/New Cumberland, Pa.	Liquefied Petroleum Gas
Buckeye Pipeline	Marysville/Harrisburg, Pa.	Refined Petroleum Product
Texas Eastern Transmission Corp.	Speeceville/Perry Co. , Pa.	Natural gas
Buckeye Pipeline	Duncannon, Pa.	Refined Petroleum Product
Sun Pipeline Co.	Northumberland Co., Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Sun Pipeline Co.	Berwick, Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Williams Gas Co. Pipeline - Transco	Berwick, Pa.	Natural gas
Williams Gas Co. Pipeline - Transco	Wyoming, Pa.	Natural gas
Exxon Pipeline Co.	Pittston, Pa.	Refined Petroleum Product
Sun Pipeline Co.	Ransom, Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Tennessee Gas Pipeline Co.	Wyalusing, Pa.	Natural gas

D. Land Use Planning Concerns

Maryland

The populations in Cecil and Harford Counties, Md. have increased over the past decade. From 1990 to 2000, the population in both counties increased by about twenty percent. As mentioned in the previous discussions on land use, little more than 12 percent of the assessment area in Maryland is significantly developed. So a majority of the county's planning efforts are focused on agricultural activities. Land use changes in the county over the past ten years has been predominantly through the conversion of agricultural lands to developed lands, although forested to developed land use conversion is common as well in some areas.

As of 1999, Harford County had 27,500 acres of permanent agricultural easements. Harford County's agricultural land preservation program allows landowners to preserve farmland for future generations. Cecil County also has some agricultural easements. With respect to conservation practices, the County Soil Conservation Districts have assisted farmers with the installation of riparian buffers on crop and pasturelands, through programs such as the Conservation Reserve Enhancement Program. Additionally, the retirement of steep croplands within 1,000 feet of waterbodies is being promoted, as is the construction of wetlands in croplands. Conservation district activities have focused on areas within the Broad and Deer Creek Watersheds, as well as some other tributaries draining directly into the Susquehanna River.

The Environmental Quality Incentive Program supports a wide range of conservation practices including grassed waterways, nutrient management, manure storage, and other practices. This program has active participation in both Broad and Deer Creeks, as does the Maryland Cost Share Program that assists with stream crossings for livestock, watering troughs, and riparian buffers.

Pennsylvania

Several of the heavily agricultural counties in the Pennsylvania portion of the assessment area also employ many of the same types of conservation programs as Maryland. Many watershed groups and county conservation districts are planning and implementing restoration projects for various watersheds with both state and federal grant assistance. With agricultural land use exceeding 60 percent, both Lancaster and York Counties have very active farm preservation programs. Last year, close to 60 farms, encompassing 60,000 acres of farmland, were preserved in the two counties under the conservation easement program.

In addition to the conservation easement program, there are numerous other efforts working towards the goal of reducing nonpoint agricultural runoff. Within the lower counties, there are over 30 active USEPA 319 Nonpoint Source Control projects active in York and Lancaster Counties. Pennsylvania's Growing Greener Grant Program has funded dozens more. A sample list of activities ongoing in the two counties includes streambank restoration, fencing, wetland construction, installation of manure treatment systems, Best Management Practices (BMPs) effectiveness studies, and numerous educational activities. In recent years, there also has been special focus on such tributaries of concern as Codorus Creek, Pequea Creek, Chickies Creek, Octoraro Creek, and the Conestoga River. River conservation plans are underway or completed for several of these waterbodies. One of the largest contributors of nutrients to the Susquehanna

River, the Conestoga, is currently the focus of a pilot nutrient trading project. It is hoped that this project will determine the best way to manage and reduce nutrient inputs from both nonpoint and point sources.

Aside from agricultural issues, the Lower Susquehanna Subbasin in Pennsylvania is experiencing an increase in water quality problems associated with development. The second biggest source of contamination in the southernmost counties is related to development issues. Specific examples of sources include urban runoff, storm sewers, construction, runoff from residential areas, and road runoff. Development pressure is growing due to growth in both the southcentral Pennsylvania corridor (York, Lancaster, and Harrisburg), as well as the expansion of the Baltimore commuter communities to southern Adams and York Counties.

Currently, there are only a handful of stormwater management plans developed for watersheds in the Lower Susquehanna Subbasin. These plans were developed under Pennsylvania's Act 167 Stormwater Management Program. The development of an Act 167 plan is voluntary, so few are approved and operational at present. With the implementation of USEPA's NPDES Phase II Program, stormwater and urban runoff controls should improve with mandatory BMP construction. However, there are still several communities in the lower subbasin that will not be covered under the program. Full implementation of the program also will not take effect for several years, and program effectiveness will not be measurable until a numbers of years beyond.

VII. SUSCEPTIBILITY ANALYSIS (FOR EACH CONTAMINANT CLASS)

Each class of contaminants that were detected in the water will be analyzed based on the potential for contaminating the water supply. The analysis will identify suspected sources of contaminants, evaluate the natural conditions in the watershed that may decrease or increase the likelihood of a contaminant entering the river, and evaluate the impacts that future changes may have on the susceptibility of the river.

A. Turbidity and Sediment

The average turbidity at the Havre de Grace intake is approximately 7. However, turbidity may range from less than 3 NTU to greater than 25 NTU. Excessively high turbidity can interfere with water treatment and can carry harmful microorganisms into drinking water supplies. The highest recorded turbidity during 2001 was 48 NTU and occurred in April. High levels of turbidity in the river can result from storm events (rainfall) and snowmelt, or both. Heavy rains into Deer Creek also can result in turbidity on the west side of the river. Additionally, according to the water supplier, discharges from quarries and point sources can increase turbidity in the water. Spring turbidity levels generally tend to be more sensitive to rainfall events, where runoff from agricultural fields and urban areas is prevalent.

Sedimentation is the leading cause of impairment within the Susquehanna River Basin and contributes to elevated turbidity levels. The predominance of agriculture within the critical portion of the assessment area indicates it will continue to be a high priority issue. Springtime sediments loads in Marietta, Pa. reached almost two billion pounds in 2001. In addition to degrading fish habitat and decreasing water clarity, sediments can serve as the transport media for microbial contaminants, pesticides, and other organic contaminants. The sediment load also has been attributed to filling in the Conowingo Reservoir. After the reservoir reaches capacity in an estimated 20 to 25 years, the likelihood of contamination from sediments will increase significantly.

The Lower Susquehanna Subbasin has experienced a significant increase in developed lands in recent years. Although a majority of the sediment load is from agricultural practices, sediment loads emanating from developed areas may increase if proper stormwater controls are not implemented in the future.

B. Microbial Contaminants

Since turbidity and sediment are considered priority issues, it is logical that microbial contamination also would be considered a priority contaminant of concern, as well. Under certain conditions, both parameters can give some indication as to the presence/absence of microbial contamination, based on similar sources and transport mechanisms.

The agricultural activities in the Lower Susquehanna Subbasin are the most likely source for microbial concentrations in the river. Agricultural manure application, concentrated feeding operations, and general management practices may contribute significantly to the amount of fecal material that enters surface waters through runoff. Such runoff also is likely to increase the amount of coliforms moving down the river. Coliform data collected by MDE from 2000 to 2002, indicated that higher levels of coliforms were more likely to be found during the winter months, due to improper manure storage and increased runoff from frozen agricultural lands. The high animal loading indices in Lancaster County suggests that those areas might be the most significant source for microbial contamination.

Human waste is also a feasible source of contamination through permitted point source discharges of wastewater The Lower Susquehanna Subbasin has experienced a significant increase in developed lands in recent years. Although a majority of the sediment load is from agricultural practices, sediment loads emanating from developed areas may increase if proper stormwater controls are not implemented in the future.

The possibilities for microbiological contamination grow as human activities increase in the basin. As noted in previous sections, the growth trends in the Lower Susquehanna Subbasin indicate that microbial contamination will continue to be a concern.

C. Disinfection Byproducts

Disinfection of drinking water is one of the major public health advances in the 20th century. In the past, typhoid and cholera epidemics were common throughout the United States. Disinfection was the major reason for the reduction in these epidemics, and it is an essential part of drinking water treatment today. However, while disinfectants are effective in controlling many microorganisms, they react with natural organic and inorganic matter in source water and distribution systems to form potentially harmful DBPs.

Many of these DBPs have been shown to cause cancer and reproductive and developmental effects in laboratory animals. Chlorine can combine with organic materials in the raw water to create the THMs discussed in previous sections. THMs are known to cause liver, kidney, or central nervous system problems. Repeated exposure to elevated levels of THMs or haloacetic acids over a long period of time could increase a person's risk of cancer.

The formation of DBPs is a concern for Havre de Grace, based on the nature of the source. Surface water sources are more likely to contain organic materials that combine with chlorine to form DBPs. Organic matter introduced under such common events as leaf fall can increase the likelihood of DBP formation. In addition, the Conowingo Pool has some similarities to a lake under certain flow conditions, which can increase the effects of eutrophication downstream of the dam. Nutrients such as phosphorus increase the rates of production of aquatic biomass, while organic matter attached to sediment can increase TOC. As discussed in previous sections, DBPs could become an increasing concern as the Conowingo Reservoir becomes a less effective trap for sediment and nutrients. Low-flow conditions in the river, particularly in the summer months, also can increase the effects of any of the aforementioned processes.

Other factors controlling the formation of DBPs include source water pH, temperature, and the presence of certain inorganic constituents. Biological activity discussed in the previous paragraph can cause small changes in pH. Temperatures can fluctuate significantly not only with the change of seasons, but with changing tides as well. Some studies also have indicated links between DBP formation and the presence of bromide and other saltwater constituents.

D. Inorganic Compounds

Phosphorus

Natural waters have a phosphorus concentration of approximately 0.02 ppm, which is a limiting factor for plant growth. Large concentrations of this nutrient can accelerate plant growth. When the concentration of phosphorus rises above 100 mg/l the coagulation processes in drinking water treatment plants may be adversely affected. Manmade sources of phosphorus include human sewage, agricultural runoff from crops, sewage from animal feedlots, pulp and paper industry, vegetable and fruit processing, chemical and fertilizer manufacturing, and detergents, all of which occur in the lower Susquehanna River Basin.

Phosphorus is a pollution concern in the lower Susquehanna River. Regarding the sources mentioned in the previous paragraph, agricultural practices are the greatest source of phosphorus. Excess phosphorus in the river may result in the growth of algae and aquatic plants. This condition is known as eutrophication, or over-fertilization of receiving waters. The rapid growth of algae and aquatic vegetation depletes DO levels, contributing to further biological impairment and die-off. In addition, the resulting rises in TOC levels can contribute to the formation of DBPs.

It is important to prevent erosion of soils, as it can be a contributor of phosphorus in runoff water. Riparian buffers and streambank fencing can help reduce this runoff in agricultural areas. Similarly to sediment, as the trapping capacity of the Conowingo Reservoir decreases, phosphorus will become more of a problem downstream of the dam.

Nitrates

Nitrates can enter the water supply from fertilizer runoff, leaching from septic tanks, wastewater effluent, atmospheric deposition, and erosion of natural deposits. Although nitrates have been detected in the finished water supply, no samples have been close to the 50 percent MCL trigger.

Since so much land use within the basin is agricultural, nitrate will continue to enter the water supply. It is unlikely that nitrates will increase in the future based on long-term decreasing trends in loads observed in the more heavily agricultural watersheds in the lower Susquehanna basin. With regards to point-source discharges, it is believed that any increase in the numbers of facilities will be offset by improvements in removal technologies. Presently, only 2 percent of the nitrogen load is trapped by the Conowingo Reservoir, so any change in storage capacity associated with the dam is probably insignificant from the water system's perspective.

E. Volatile Organic Compounds and Synthetic Organic Compounds

VOCs are more commonly found in urban areas. The greatest sources of VOCs are spills, improper disposal, runoff from pavement, leaks from underground storage tanks, atmospheric deposition, and leaking sewer lines. The highway and railway bridges that cross the Susquehanna River north of the intake are the most likely source of potential VOC contamination. A spill from one of these bridges could release significant quantities of VOCs into the river. Stormwater runoff from these bridges and other nearby roads also may introduce VOCs into the raw water source.

Boating is a popular activity in and around the Chesapeake Bay. An American Legion boating dock exists immediately above the intake. North of these boating docks, in Harford County, are several petroleum storage tanks. These storage tanks are near shore north of the Havre de Grace intakes. Some of these storage tanks contain oil that is used for home heating. Other tanks store gasoline for use by boaters and barges. Leakages from these boats, gas tanks, or other boats in the water or at nearby docks, could contribute VOCs to the water supply. The level of boat traffic during certain times of the year also cannot be ignored as a possible source. The likelihood of contamination increases, based on the proximity of several docks and the main navigational channel.

Although VOCs can pose a threat to drinking water supplies, the tendency for these groups of contaminants to float on the water's surface would likely prevent such spills and leakages from posing a major threat to the intake, which is well below the surface of the river.

USGS studies have indicated herbicides such as atrazine, cyanazine, alachlor, and simazine have been detected above MCLs in tributaries; however, the dilution occurring in the mainstem of the Susquehanna appears to mitigate the impact of SOC contamination. The same can be said for the other organic contaminants. However, increasing use of such compounds in the environment has the potential to cause future problems.

Overall, VOC/SOC contamination is expected to increase with development. Within the Lower Susquehanna Subbasin, there are three major metropolitan areas (Harrisburg, Lancaster, and York) experiencing rapid expansion of residential and commercial areas. Runoff from these urban areas has been linked to elevated levels of VOCs, SOCs, and turbidity in streams within the subbasin.

F. Radionuclides

Radionuclides were not detected in the Havre de Grace water supply in 2000. Gross alpha and beta are tested once every four years in the Havre de Grace water supply. Without the presence of any natural sources, radionuclides are not expected to be present. The next testing at the water supply will be in 2004. Radioactivity sampled from 2000 to 2002, in the Susquehanna River at Conowingo Dam, indicated that gross beta was detected at times up to four.

Although radioactive monitoring values remain quite constant and low concentrations are the norm, the existence of several nuclear power generating plants with outfalls along the Susquehanna River upstream of Havre de Grace's intakes indicates a significant potential for radionuclide contamination. Based solely on close proximity to the intake, Peach Bottom should be considered a potential source of contamination. The accident at TMI in 1979 is an example that the possibility does exist.

Contaminants used to clean water intake and cooling tower structures can also pose a unique problem for water supply intakes downstream of nuclear facilities. Pesticides are often used to control organisms, such as zebra mussels, from attaching to the structures. Regular cleaning of the same structures can also introduce halogenated disinfectants, commonly chlorine based, which can lead to DBP formation.

VIII. RECOMMENDATIONS FOR SOURCE WATER PROTECTION PLAN

The assessment report for Havre de Grace's Susquehanna intake was developed to provide the city with the information it needs to best protect its raw source. Although the vast size of the assessment area creates a daunting task in terms of source protection, there are feasible steps that can be taken to improve the use of the source. With the information contained in this report, the water supplier is in a position to better understand the water supply area, track potential contaminant sources, identify critical protection areas, and evaluate the potential for future problems. It is hoped that the information will assist the management of resources associated with source water protection activities. Some recommendations are presented in the following sections.

A. Increase Partnerships

Many comprehensive planning, restoration, and protection efforts are currently underway in the Lower Susquehanna Subbasin. Source water protection efforts could be improved with minimal resources by increasing the level of communication and partnerships with other water suppliers, local/state/federal agencies, and the emergency response community. Efforts could be focused on priority issues identified within this assessment report. When considering the size of the assessment area, joining a collective body with similar goals for source water protection could increase the opportunities for implementing actions and influencing measures to improve water quality conditions in the Susquehanna River.

The SRBC and Pa. DEP are currently developing the framework for an early warning communication network for the Susquehanna River and major tributaries. The goal of the system is to provide water suppliers and the emergency response community the means for exchanging water quality information for the purpose of protecting the public health and improving treatment strategies. Havre de Grace is encouraged to participate in activities related to this project.

In addition, the U.S. Army Corp of Engineers (USACE) Section 22 Lower Susquehanna Comprehensive Water Resources Study is currently underway. The USACE has partnered with Pa. DEP, SRBC, and the Capital Region Water Board (CRWB), to develop a management plan for the water resources in southcentral Pennsylvania. The study may provide additional information for the understanding of the assessment area.

B. Planning and Regulatory Activities

Emergency response plans should be in place in case of an accidental spill into the river from a bridge, nearby road, or pipeline. In addition, an action plan in response to a train derailment should also be in place based on the proximity of an active railway, and response plans should be implemented in case of an accidental leak from one of the petroleum storage tanks north of the intakes.

Havre de Grace should periodically conduct its own detailed field survey in the vicinity of their intake to ensure there are no new potential sources of contamination, and provide updates on potential changes in land use that may affect raw water quality. In regards to planning information, Havre de Grace could establish a protocol for regularly obtaining updates on state and county planning initiatives relating to source water quality issues such as:

- Stormwater management planning;
- Agricultural runoff prevention programs; and
- Land use planning initiatives.

Increasing development within the vicinity of the intake can potentially lead to an increase in permitted discharges. Strict compliance to permitted discharge regulations should be enforced to reduce point source pollution.

C. Public Education and Outreach

Public education is an important aspect of watershed protection. The public should be made aware of their watershed through signs and Consumer Confidence Reports. Educating the general public about protecting their waterways is an important step in achieving a successful protection plan. Increased education about protecting drinking water sources also could enhance public support for source water protection activities.

Based on the aforementioned concept, the SRBC conducted a workshop in 1999 focusing on the formation of community partnerships to foster or enhance source protection efforts (SRBC, 1999). The goal was to bring together a diverse group of representatives from government, industry, academia, and citizen groups for the purpose of developing a source protection plan for Swatara Creek Watershed. The groups were asked to present ideas for developing and implementing the steps needed for source water protection, with the emphasis on utilizing effective partnerships. The basic steps identified were: (1) establish a steering committee; (2) delineate the protection area; (3) identify the sources of contamination; (4) determine the methods to be utilized; and (5) implement the plan of action.

The model outlined at the workshop has proven to be an effective catalyst for source water protection efforts. Results that can be linked to the success of the workshop include:

- The establishment of the Swatara Creek Watershed Association as an example of the importance of citizen involvement in source protection efforts;
- The Swatara becoming a pilot watershed for Pa. DEP's new Environmental Futures Planning Initiative; and
- The development of the U.S. Army Corps of Engineers Lower Susquehanna Comprehensive Water Resources Study, working in partnership with the SRBC, Pa. DEP, and a regional water suppliers board.

A similar model could be followed by potential stakeholders in the Maryland portion of the basin, as well. The formation of community partnerships can facilitate reaching a consensus on the steps needed to solve complex water quality issues. It also provides the necessary support needed to acquire funds to perform the necessary work.

D. Monitoring

Regular monitoring for turbidity and fecal coliforms should be continued. Additional monitoring activities could include more frequent collection of upstream raw water coliform data, thus increasing the understanding of microbial susceptibility for the Susquehanna intake. Also, sampling for total suspended solids could be used as an indicator of other potential pollutants, such as metals and bacteria. These constituents commonly attach to particles as a transport mechanism in surface waters. Monitoring for suspended solids measures an actual weight of material per volume of water, and is valuable for determining the total quantities of materials.

Based on difficulties posed to the treatment process, sodium monitoring should be continued to determine the salinity levels at the intakes.

Monitoring and studying which source areas have the potential to affect water quality conditions through the formation of DBPs should be conducted. Since organic matter in surface water sources can increase the formation of DBPs, recognizing and monitoring parameters related to organic content could help water suppliers to control the formation of DBPs. Additionally, bromide sampling also should be conducted, considering its role with the production of DBPs.

E. Availability of the Assessment

A public meeting presenting the results of this source water assessment was held on March 5, 2003, in Havre de Grace. Over 15 people attended the meeting, including 3 individuals from the city and 8 individuals representing local, state, and federal agencies. Several local citizens were also in attendance.

A summary of this assessment should be included in future Consumer Confidence Reports. Full reports will be available at public libraries, town/city offices, or by contacting the Water Supply Program of MDE.

REFERENCES

Commonwealth of Pennsylvania. 2001. Pennsylvania Code. Title 25 Environmental Protection. Department of Environmental Protection. Chapter 93. Water Quality Standards. Harrisburg, PA.

Foster, G.D., K.A. Lippa and C.V. Miller. 2000. Seasonal Concentrations of Organic Contaminants at the Fall Line of the Susquehanna River Basin and the Estimated Fluxes to northern Chesapeake Bay, USA. Environmental Toxicology and Chemistry, Vol. 19.

Frey, Robert. 2002. Fish Tissue data. Unpublished. Pennsylvania Department of Environmental Protection, Bureau of Water Supply and Wastewater Management, Division of Water Quality Assessment and Standards.

Hainly, Robert A. and Connie A. Loper. 1997. Water Quality Assessment of the Lower Susquehanna River Basin, Pennsylvania and Maryland: Sources, Characteristics, Analysis, and Limitations of Nutrient and Suspended Sediment Data, 1975-90.

Hoffman, J.L.R. 2002. The 2002 Susquehanna River Basin Water Quality Assessment 305 (b) Report. Susquehanna River Basin Commission (Publication No. 220).

Kauffman, C.D., J.T. Armbruster, and A. Voytik. 1976. Time-of-Travel; Susquehanna River; Binghamton, New York to Clarks Ferry, Pennsylvania. U.S. Department of the Interior Geological Survey. Open-File Report 76-247

Koplin, D.W., E.T. Furlong, M.T. Meyer, E.M. Thurman, S.D. Zaugg, L.B. Barber, H.T. Buxton. 2002. Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in the U.S. Streams, 1999-2000: A National Reconnaissance. U.S. Geological Survey. Environmental Science and Technology. Vol. 6.

LeFevre, Susan R. 2002. Middle Susquehanna Subbasin: A Water Quality and Biological Assessment. Susquehanna River Basin Commission (Publication No. 222).

Lindsey, B.D., K.J. Breen, M.D. Bilger, and R.A. Brightbill. 1998. Water Quality in the Lower Susquehanna River Basin, Pennsylvania and Maryland 1992-1995. U.S. Geological Survey. National Water-Quality Assessment Program. Circular 1168.

Maryland Department of the Environment. 1993. Water Quality Regulations for Designated Uses, COMAR. 26.08.02.03-3 Annapolis, Maryland (488-3)

McGarrell, Charles A. 1997. Water Quality and Biological Assessment of the Juniata Subbasin. Susquehanna River Basin Commission (Publication No. 178).

McGonigal, Kevin and Robert E. Edwards. 2002. Nutrients and Suspended Sediment Transported in the Susquehanna River Basin, 2001, and Trends, January 1985 Through December 2001. Susquehanna River Basin Commission.

Millard, C.J., P.F. Kazyak, and D. M. Boward. 1999. Lower Susquehanna Basin, Environmental Assessment of Stream Conditions. Maryland Department of Natural Resources. Resource Assessment Service. Monitoring and Non-Tidal Assessment Division.

Novotny, V., and H. Olem, 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

Originator: James Vogelmann. U.S.G.S. EROS Data Center, Sioux Falls, SD Publication_Date: 1993 Title: Multi-Resolution Land Characteristic (MRLC) Grid of Pennsylvania, Maryland, Delaware, Virginia, and West Virginia

Reed, Lloyd A., and Marla H. Stuckey. 2002. Prediction of Velocities for a Range of Streamflow Conditions in Pennsylvania. U.S. Geological Survey, New Cumberland, PA.

Risser, D.W., and S.F. Siwiec. 1996. Water Quality Assessment of the Lower Susquehanna River Basin, Pennsylvania and Maryland: Environmental Setting. U.S. Geological Survey. Water-Resources Investigations Report 94-4245.

Sprague, L. A., M.J. Langland, S. E. Yochum, R.E. Edwards, J.D. Blomquist, S.W. Phillips, G. W. Shenk, and S.D. Preston. 2000. Factors Affecting Nutrient Trends in Major Rivers of the Chesapeake Bay Watershed. United States Department of the Interior Geological Survey. Water-Resources Investigations Report 00-4218.

Stoe, Travis W. 1999. Water Quality and Biological Assessment of the Upper Susquehanna Subbasin. Susquehanna River Basin Commission (Publication No. 203).

Susquehanna River Basin Commission. 1999. Source Water Protection Community Partnership Workshop - Proceedings.

Susquehanna River Basin Commission. 1985. Water Quality and Biological Survey of the West Branch Susquehanna River. Resource Quality Management and Protection Division.

——. 1997. Water Quality and Biological Assessment of the Middle Susquehanna Subbasin, 1993. Water Quality and Monitoring Programs Division.

Takita, Charles S. and Robert E. Edwards. 2001. Nutrients and Suspended Sediment Transported in the Susquehanna River Basin, 2000, and Trends, January 1985 Through December 2000. Susquehanna River Basin Commission (Publication No. 218).

Traver, Carrie L. 1998. Water Quality and Biological Assessment of the Chemung Subbasin. Susquehanna River Basin Commission (Publication No. 198).

U. S. Geological Survey. Real-Time Data for Pennsylvania. http://waterdata.usgs.gov/pa/nwis/rt

——. National Water-Quality Assessment Program. Water Resources Investigations Report 97-4209.

Appendix 1. Major Watersheds within the Six Susquehanna Subbasins

Major watersheds in the Upper Susquehanna Basin

Cayuta Creek Watershed	Oaks Creek Watershed
Catatonk Creek Watershed	Otego Creek Watershed
Owego Creek Watershed	Cherry Valley Creek Watershed
Nanticoke Creek Watershed	Schenevus Creek Watershed
Wappasening Creek Watershed	Charlotte Creek Watershed
Apalachin Creek Watershed	Ouleout Creek Watershed
Choconut Creek Watershed	Snake Creek Watershed
Tioughnioga River Watershed	Saltlick Creek Watershed
Otselic River Watershed	Starrucca Creek Watershed
Chenango River Watershed	Susquehanna River
Unadilla River Watershed	

Major Watersheds in Chemung Basin

Canisteo River Watershed	Tioga River Watershed
Cowanesque River Watershed	Seeley Creek Watershed
Cohocton River Watershed	Chemung River Watershed

Major Watersheds in the West Branch Susquehanna Basin

Sinnemahoning Creek Watershed	Anderson Creek Watershed
Kettle Creek Watershed	Chest Creek Watershed
Young Woman's Creek Watershed	Clearfield Creek Watershed
Pine Creek Watershed	Moshannon Creek Watershed
Larry's Creek Watershed	Beech Creek Watershed
Lycoming Creek Watershed	Bald Eagle Creek Watershed
Loyalsock Creek Watershed	Fishing Creek Watershed
Muncy Creek Watershed	Buffalo Creek Watershed
Mosquito Creek Watershed	White Deer Hole Creek Watershed
West Branch Susquehanna River Watershed	Chillisquaque Creek Watershed

Major Watersheds in the Middle Susquehanna Basin

Sugar Creek Watershed	Bowman Creek Watershed
Towanda Creek Watershed	Lackawanna River Watershed
Wysox Creek Watershed	Susquehanna River Watershed
Wyalusing Creek Watershed	Fishing Creek Watershed
Meshoppen Creek Watershed	Nescopeck Creek Watershed
Tunkhannock Creek Watershed	Catawissa Creek Watershed
Mehoopany Creek Watershed	Roaring Creek Watershed

Major Watersheds in the Juniata River Basin

Raystown Branch Juniata River Watershed	Kishacoquillas Creek Watershed
Frankstown Branch Juniata River Watershed	Tuscarora Creek Watershed
Little Juniata River Watershed	Juniata River Watershed
Shaver Creek Watershed	Buffalo Creek Watershed
Standing Stone Creek Watershed	

Major Watersheds in the Lower Susquehanna Basin

Penns Creek Watershed	Yellow Breeches Watershed
Middle Creek Watershed	West Conewago Creek Watershed
Shamokin Creek Watershed	Chickies Creek Watershed
Mahanoy Creek Watershed	Conestoga River Watershed
Mahantango Creek Watershed	Codorus Creek Watershed
Wiconisco Creek Watershed	Muddy Creek Watershed
Susquehanna River Watershed	Pequea Creek Watershed
Sherman Creek Watershed	Octoraro Creek Watershed
Swatara Creek Watershed	Deer Creek Watershed
Conodoguinet Creek Watershed	

Appendix 2. Impairments of Major Streams in the Susquehanna River Basin

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
Lower Susquehanna			
MD(02120202)	Deer Creek	Unknown	Biological
MD(02120203)	Octoraro Creek	Unknown	Biological
MD(02120205)	Muddy Creek (Broad Creek)	Unknown	Biological
MD(02120201)	Susquehanna River	Unknown	Biological
		Non-point, Natural	Metals
		Non-point, Natural	Nutrients
		Non-point, Natural	Sediments
		Undefined	Toxics
MD(02120204)	Susquehanna River	Undefined	Bacteria
	(Conowingo Dam)	Unknown	Biological
		Atmospheric Deposition	Metals
		Non-point, Natural	Nutrients
		Non-point, Natural	Sediments
PA(7I)	Deer Creek	Agriculture	Nutrients
		Agriculture	Suspended Solids
PA(7K)	Octoraro Creek	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
PA	Susquehanna River	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Urban Runoff/Storm Sewers	Siltation
		Road Runoff	Water/Flow Variability
		Road Runoff	Siltation
		Channelization	Water/Flow Variability
		Other	Cause Unknown
		Habitat Modification	Other Habitat Alterations
PA(7I)	Muddy Creek	On Site Wastewater	Taste and Odor
		On Site Wastewater	Organic Enrichment/Low DO
		Petroleum Activities	Oil and Grease
PA(7K)	Pequea Creek	Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Crop Related Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
PA(7J)	Conestoga River	Agricultural	Nutrients
		Agricultural	Siltation
		Crop Related Agriculture	Nutrients
		Crop Related Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Urban Runoff/Storm Sewers	Cause Unknown
		Urban Runoff/Storm Sewers	Nutrients
		Urban Runoff/Storm Sewers	Siltation
		Urban Runoff/Storm Sewers	Suspended Solids
		Small Residential Runoff	Nutrients
		Small Residential Runoff	Siltation
		Road Runoff	Siltation
		Golf Courses	Nutrients
		Municipal Point Source	Chlorine
		Surface Mining	Siltation
		Upstream Impoundment	Siltation
		Channelization	Siltation

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Channelization Removal of Vegetation Other Land Development Erosion from Derelict Land Erosion from Derelict Land	Flow Alterations Siltation Organic Enrichment/Low DO Siltation Cause Unknown Siltation
PA(7G)	Chickies Creek	Agriculture Agriculture Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Other	Siltation Nutrients Flow Alterations Metals Cause Unknown Other Habitat Alterations
PA(7H)	Codorus Creek	Agriculture Agriculture Agriculture Agriculture Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Channelization Industrial Point Source Industrial Point Source Industrial Point Source Industrial Point Source Habitat Modification Municipal Point Source	Siltation Nutrients Flow Alterations Suspended Solids Flow Alterations Siltation Other Habitat Alterations Suspended Solids Organic Enrichment/Low DO Thermal Modifications Color Other Habitat Alterations Nutrients
PA(7F)	West Conewago Creek	Agriculture Other	Suspended Solids Suspended Solids
PA(7D)	Swatara Creek	Agriculture Agriculture Agriculture Crop Related Agriculture Crop Related Agriculture Abandoned Mine Drainage Abandoned Mine Drainage Abandoned Mine Drainage Construction Road Runoff Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Municipal Point Source On Site Wastewater Natural Sources Other	Nutrients Siltation Organic Enrichment/Low DO Nutrients Siltation Metals Suspended Solids pH Siltation Siltation Siltation Suspended Solids Nutrients Organic Enrichment/Low DO Water/Flow Variability Siltation
PA(7E)	Yellow Breeches Creek	Agriculture Agriculture Agriculture Agriculture Construction Construction Construction Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Hydromodification Habitat Modification Source Unknown Source Unknown Atmospheric Deposition	Nutrients Siltation Organic Enrichment/Low DO Other Habitat Alterations Siltation Organic Enrichment/Low DO Other Habitat Alterations Siltation Cause Unknown Water/Flow Variability Other Habitat Alterations Siltation Flow Alterations pH
PA(7B)	Conodoguinet Creek	Agriculture	Pesticides

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Agriculture	Nutrients
		Agriculture	Suspended Solids
		Habitat Modification	Flow Alterations
		Construction	Siltation
		Land Disposal	Cause Unknown
		Land Disposal	Priority Organics
		Other	Organic Enrichment/Low DO
		Other	Siltation
		Other	Nutrients
		Source Unknown	Cause Unknown
PA(7A)	Sherman Creek	Removal of Vegetation	Siltation
		Crop Related Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Atmospheric Deposition	Metals
PA(6C)	Wiconisco Creek	Agriculture	Siltation
		Agriculture	Nutrients
		Crop Related Agriculture	Siltation
		Grazing Related Agriculture	Siltation
		Removal of Vegetation	Siltation
		Small Residential Runoff	Nutrients
		Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	Siltation
PA(6C)	Mahantango Creek	Agriculture	Siltation
		Silvaculture	Siltation
		Road Runoff	Siltation
		Removal of Vegetation	Siltation
PA(6B)	Mahanoy Creek	Grazing Related Agriculture	Organic Enrichment/Low DO
		Grazing Related Agriculture	Siltation
		Crop Related Agriculture	Siltation
		Agriculture	Siltation
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Water/Flow Variability
		Abandoned Mine Drainage	Siltation
		Atmospheric Deposition	pH
PA(6A)	Middle Creek	Atmospheric Deposition	pH
		Grazing Related Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
PA(6A)	Penns Creek	Grazing Related Agriculture	Siltation
		Crop Related Agriculture	Siltation
		Animal Feeding Agriculture	Nutrients
		Animal Feeding Agriculture	Siltation
PA(6B)	Shamokin Creek	Grazing Related Agriculture	Organic Enrichment/Low DO
		Grazing Related Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
		Agriculture	Siltation
Juniata			
PA	Juniata River	Crop Related Agriculture	Siltation
PA(12B)	Buffalo Creek	Crop Related Agriculture	Siltation
PA(12B)	Tuscarora Creek	Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
PA(12A)	Kishacoquillas Creek	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Water/Flow Variability
		Agriculture	Flow Alterations
		Urban Runoff/Storm Sewers	Siltation

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Hydromodification Hydromodification	Flow Alterations Other Habitat Alterations Siltation Water/Flow Variability
PA(12C)	Aughwick Creek	Crop Related Agriculture Crop Related Agriculture Grazing Related Agriculture	Nutrients Nutrients Siltation
PA(11D)	Raystown Branch	Abandoned Mine Drainage Abandoned Mine Drainage	Metals pH
PA(11B)	Standing Stone Creek	No Listings	
PA(11B)	Shaver Creek	No Listings	
PA(11A)	Frankstown Branch	Industrial Point Source Industrial Point Source Industrial Point Source Road Runoff Urban Runoff/Storm Sewers Abandoned Mine Drainage Abandoned Mine Drainage Abandoned Mine Drainage Combined Sewer Overflow	Suspended Solids Priority Organics Cause Unknown Siltation Cause Unknown Metals pH Siltation Organic Enrichment/Low DO
PA(11A)	Little Juniata River	Urban Runoff/Storm Sewers Municipal Point Source	Cause Unknown Organic Enrichment/Low DO
West Branch Susquehanna			
PA	West Branch Susquehanna River	Abandoned Mine Drainage Abandoned Mine Drainage Road Runoff Upstream Impoundment Upstream Impoundment Industrial Point Source Industrial Point Source Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Urban Runoff/Storm Sewers Agriculture Flow Regulation/Modification Small Residential Runoff Other	Metals pH Siltation Siltation Nutrients Organic Enrichment/Low DO Thermal Modification Filling and Draining Siltation Cause Unknown Siltation Water/Flow Variability Cause Unknown Siltation
PA(10D)	Chillisquaque Creek	Industrial Point Source Agriculture Agriculture On Site Wastewater On Site Wastewater Hydromodification Hydromodification	Other Habitat Alterations Siltation Organic Enrichment/Low DO Nutrients Organic Enrichment/Low DO Other Habitat Alterations Flow Alterations
PA(10C)	Buffalo Creek	Atmospheric Deposition Small Residential Runoff Grazing Related Agriculture Grazing Related Agriculture	pH Nutrients Nutrients Siltation
PA(10C)	White Deer Hole Creek	No Listings	
PA(10D)	Muncy Creek	Source Unknown	Cause Unknown
PA(10B)	Loyalsock Creek	Abandoned Mine Drainage Abandoned Mine Drainage	Metals pH
PA(10A)	Lycoming Creek	No Listings	
PA(10A)	Larry's Creek	No Listings	
PA(9A)	Pine Creek	Abandoned Mine Drainage Abandoned Mine Drainage Urban Runoff/Storm Sewers	pH Metals Siltation

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Urban Runoff/Storm Sewers Upstream Impoundment Channelization	Water/Flow Variability Organic Enrichment/Low DO Flow Alterations
PA(9C)	Fishing Creek	Urban Runoff/Storm Sewers Crop Related Agriculture On Site Wastewater Source Unknown Grazing Related Agriculture	Siltation Siltation Nutrients Unknown Toxicity Siltation
PA(9C)	Bald Eagle Creek	Grazing Related Agriculture Grazing Related Agriculture Removal of Vegetation Industrial Point Source	Siltation Organic Enrichment/Low DO Siltation Metals
PA(9C)	Beech Creek	Abandoned Mine Drainage Abandoned Mine Drainage	pH Metals
PA(9B)	Young Woman's Creek	No Listings	
PA(9B)	Kettle Creek	Abandoned Mine Drainage Abandoned Mine Drainage Abandoned Mine Drainage	pH Metals Siltation
PA(8A)	Sinnemahoning Creek	Abandoned Mine Drainage Abandoned Mine Drainage Abandoned Mine Drainage Road Runoff Draining or Filling	pH Metals Other Habitat Alterations Siltation Siltation
PA(8A)	Mosquito Creek	Abandoned Mine Drainage	Metals
PA(8D)	Moshannon Creek	Abandoned Mine Drainage Abandoned Mine Drainage Abandoned Mine Drainage On Site Wastewater Small Residential Runoff	Metals pH Siltation Nutrients Siltation
PA(8C)	Clearfield Creek	Abandoned Mine Drainage Abandoned Mine Drainage Golf Courses	pH Metals Water/Flow Variability
PA(8B)	Anderson Creek	Abandoned Mine Drainage Abandoned Mine Drainage Grazing Related Agriculture	Metals pH Siltation
PA(8B)	Chest Creek	Agriculture Removal of Vegetation	Siltation Other Habitat Alterations
Middle Susquehanna			
PA	Susquehanna River	No Listings	
PA(5E)	Roaring Creek	No Listings	
PA(5E)	Catawissa Creek	Abandoned Mine Drainage Abandoned Mine Drainage	Metals pH
PA (5C)	Fishing Creek	Atmospheric Deposition Atmospheric Deposition Road Runoff Removal of Vegetation Agriculture	Metals pH Siltation Siltation Siltation
PA(5D)	Nescopeck Creek	Abandoned Mine Drainage Abandoned Mine Drainage	Metals pH
PA(5A)	Lackawanna River	Abandoned Mine Drainage Abandoned Mine Drainage Abandoned Mine Drainage Abandoned Mine Drainage Hydromodification Hydromodifcation Urban Runoff/Storm Sewers Channelization Land Development	Flow Alterations pH Metals Siltation Flow Alterations Other Habitat Alterations Siltation Other Habitat Alterations Water/Flow Variability

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Upstream Impoundment Source Unknown	Cause Unknown Cause Unknown
PA(4G)	Bowman Creek	No Listings	
PA(4F)	Tunkhannock Creek	No Listings	
PA(4G)	Mehoopany Creek	No Listings	
PA(4F)	Meshoppen Creek	No Listings	
PA(4D)	Wyalusing Creek	No Listings	
PA(4D)	Wysox Creek	No Listings	
PA(4C)	Towanda Creek	Abandoned Mine Drainage Abandoned Mine Drainage	Metals pH
PA(4C)	Sugar Creek	No Listings	
Upper Susquehanna			
PA(4E)	Susquehanna River	No Listings	
PA(4B)	Cayuta Creek	No Listings	
NY	Susquehanna River	Atmospheric Deposition	Mercury
NY	Cayuta Creek	No Listings	
NY	Wappasening Creek	No Listings	
PA(4B)	Wappasening Creek	Animal Feeding Agriculture	Nutrients
NY	Catatonk Creek	No Listings	
NY	Owego Creek	No Listings	
NY	Apalachin Creek	No Listings	
PA(4B)	Apalachin Creek	No Listings	
NY	Nanticoke Creek	No Listings	
NY	Choconut Creek	No Listings	
PA(4E)	Choconut Creek	No Listings	
NY	Chenango River	Atmospheric Deposition	Mercury
NY	Otselic River	No Listings	
NY	Tioughnioga River	No Listings	
NY	Snake Creek	No Listings	
PA(4E)	Snake Creek	No Listings	
PA(4E)	Starucca Creek	No Listings	
NY	Unadilla River	Atmospheric Deposition	Mercury
NY	Ouleout Creek	No Listings	
NY	Otego Creek	No Listings	
NY	Shenevus Creek	No Listings	
NY	Cherry Valley Creek	No Listings	
NY	Oaks Creek	No Listings	
NY	Salt Lick Creek	No Listings	
Chemung			
PA	Chemung River	No Listings	
NY	Chemung River	No Listings	
NY	Seeley Creek	No Listings	
PA(4B)	Seeley Creek	No Listings	
NY	Cohocton River	No Listings	
NY	Canisteo River	No Listings	
NY	Tioga River	No Listings	
PA(4A)	Tioga River	Road Runoff Small Residential Runoff Atmospheric Deposition Upstream Impoundment Abandoned Mine Drainage Abandoned Mine Drainage	Siltation Siltation pH Siltation pH Metals
NY	Cowanesque River	No Listings	
PA(4A)	Cowanesque River	Agriculture Agriculture Municipal Point Source Upstream Impoundment	Nutrients Siltation Nutrients Organic Enrichment/Low DO

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Industrial Point Source Industrial Point Source Removal of Vegetation	Thermal Modifications Cause Unknown Siltation

Lower Susquehanna: Major and Minor Contributing Tributary 303(d) listings within each major watershed
5 other Subbasins: Major Contributing Tributary 303(d) listings within each major watershed.

Appendix 3. Pa TMDL List

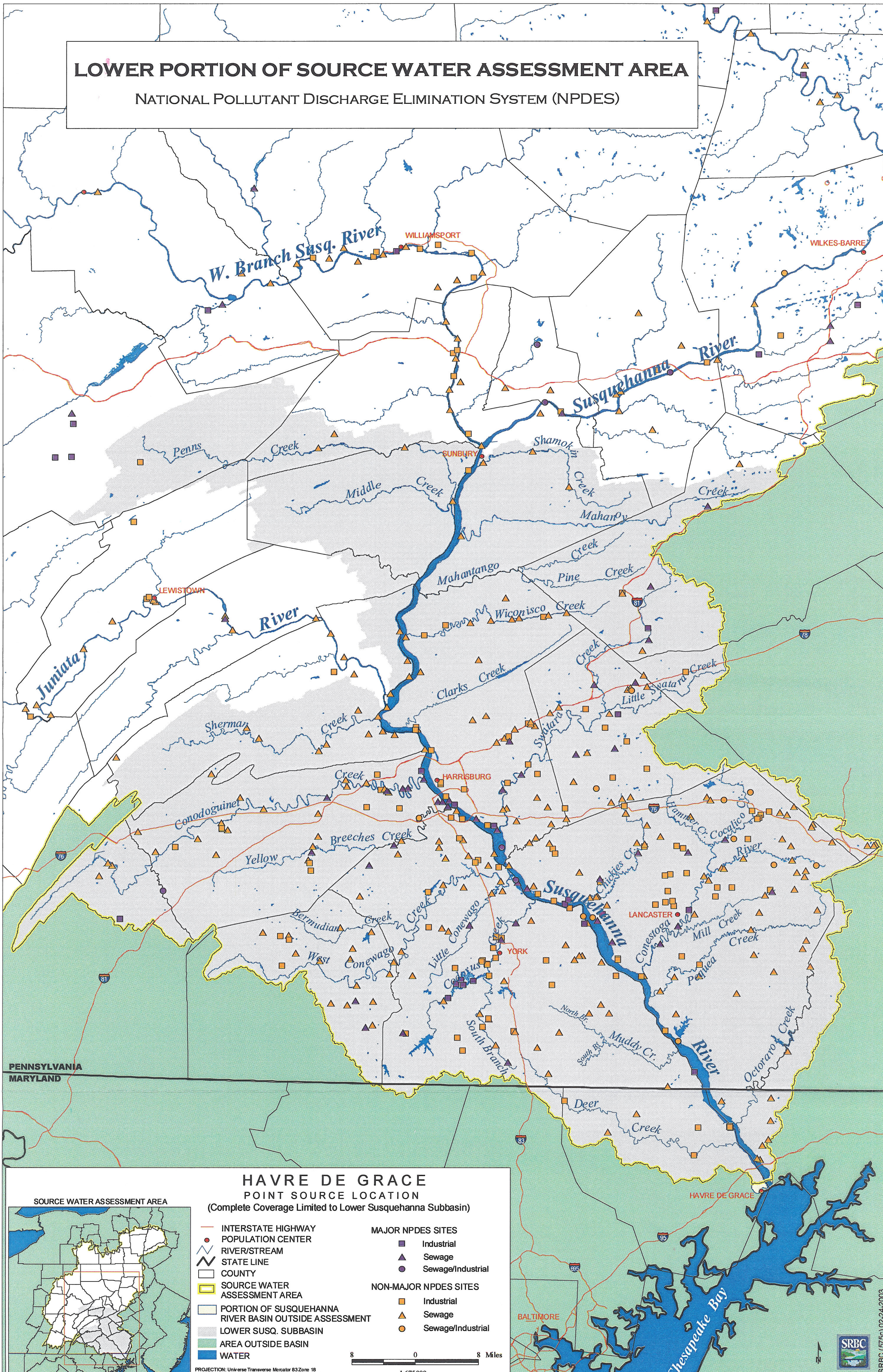
County Name	TMDL Name	Cause	Pollutant(s)	Other Counties
Lancaster	Conowingo Creek	NPS (ag runoff)	Phosphorus, sediments	
	Muddy Run Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Pequea Creek	NPS (ag runoff)	Phosphorus, sediments	
	Chickies Creek Watershed	NPS (ag runoff)	Nitrogen, Phosphorus, sediments	
	Donegal Creek Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Conewago Creek Watershed	Primarily agriculture	N, P, Sediments	Lebanon, Dauphin
Dauphin	Conewago Creek Watershed	Primarily agriculture	N, P, Sediments	Lebanon, Lancaster
	Bear Creek	AMD	AL, FE, MN, pH	
Lebanon	Conewago Creek Watershed	Primarily agriculture	Nitrogen, Phosphorus, sediments	Lancaster, Dauphin
Cumberland	Conodoguinet Creek Watershed	Point and NPS (runoff)	Phosphorus, sediments	Franklin
Lebanon	Quittapahilla Creek Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Deep Run Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Earlakill Run Watershed	NPS (ag runoff)	Phosphorus, sediments	
Franklin	Conodoguinet Creek Watershed	Point and NPS (runoff)	Phosphorus, sediments	Cumberland
Schuylkill	Hans Yost Creek	AMD	AL, FE, MN, pH	
Northumberland	Shamokin Creek Watershed	AMD	AL, FE, MN, pH	Columbia, Montour
Montour	Shamokin Creek Watershed	AMD	AL, FE, MN, pH	Columbia, Northumberland
Columbia	Shamokin Creek Watershed	AMD	AL, FE, MN, pH	Montour, Northumberland
Huntingdon	Shoup Run Watershed	AMD	AL, FE, MN, pH	
Blair	Kittaning Run Watershed	AMD	AL, FE, MN	Cambria
Cambria	Kittaning Run Watershed	AMD	AL, FE, MN	Blair
Clinton	Tangascootack Watershed	AMD	AL, FE, MN, pH	
	Two Mile Run	AMD	AL, FE, MN, pH	
	Drury Run Watershed	AMD	AL, FE, MN, pH	
Bradford	Stephen Foster Lake	Overland Runoff	Phosphorus, TSS	
Potter	North fork Cowanesque River Watershed	NPS (ag runoff)	Phosphorus, sediments	Tioga
Clearfield	Little Muddy Run, and East Branch	AMD	AL, FE, MN, pH	Blair
Cambria	Little Muddy Run, and East Branch	AMD	AL, FE, MN, pH	Clearfield
Jefferson	Whites Run Watershed	AMD	AL, FE, MN, pH	

Appendix 4. Large Format Map Attachments

Map 1. Susquehanna River Basin Land Cover

Map 2. NPDES Discharge Sites for the Lower Susquehanna. Subbasin


SUSQUEHANNA RIVER BASIN
LAND COVER
LANDSAT THEMATIC MAPPER (TM) IMAGE
N
NEW YORK
PENNSYLVANIA
MARYLAND
CORTLAND
NORWICH
ONEONTA
CORNING
ELMIRA
BINGHAMTON
TOWANDA
SCRANTON
RENOVO
WILLIAMSPORT
WILKES-BARRE
CLEARFIELD
SUNBURY
LEWISTOWN
ALTOONA
HARRISBURG
LANCASTER
YORK
HAVRE DE GRACE
Chesapeake Bay
SRBC (140h) 02-25-2003
WATER
DEVELOPED
CULTIVATED
NATURAL VEGETATED AREA
BARREN AREA
NO DATA
20 0 20 Miles
1:1410000
DISCLAIMER: INTENDED FOR EDUCATIONAL DISPLAY PURPOSES ONLY
SOURCE: UNITED STATES GEOLOGICAL SURVEY EROS DATA CENTER, 1997, VERSION 3B
30 METER RESOLUTION
PROJECTION: UTM 83 ZONE 18
2001
SRBC



LOWER PORTION OF SOURCE WATER ASSESSMENT AREA
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
W. Branch Susq. River
WILLIAMSPORT
WILKES-BARRE
Susquehanna River
SUNBURY
Penns Creek
Middle Creek
Shamokin Creek
Mahanoy Creek
Mahantango Creek
Pine Creek
Wiconisco Creek
LEWISTOWN
Juniata River
Clarks Creek
Swatara Creek
Little Swatara Creek
Sherman Creek
HARRISBURG
Conodoguinet Creek
Yellow Breeches Creek
Bermudian Creek
West Conewago Creek
Little Conewago Creek
Codorus Creek
South Branch
YORK
Susquehanna
Chickies Cr.
Hammer Cr.
Cocalico Cr.
Conestoga River
LANCASTER
Mill Creek
Pequea Creek
North Br.
South Br.
Muddy Cr.
River
Octoraro Creek
PENNSYLVANIA
MARYLAND
Deer Creek
HAVRE DE GRACE
BALTIMORE
Chesapeake Bay
HAVRE DE GRACE
POINT SOURCE LOCATION
(Complete Coverage Limited to Lower Susquehanna Subbasin)
SOURCE WATER ASSESSMENT AREA
INTERSTATE HIGHWAY
POPULATION CENTER
RIVER/STREAM
STATE LINE
COUNTY
SOURCE WATER ASSESSMENT AREA
PORTION OF SUSQUEHANNA RIVER BASIN OUTSIDE ASSESSMENT
LOWER SUSQ. SUBBASIN
AREA OUTSIDE BASIN
WATER
MAJOR NPDES SITES
Industrial
Sewage
Sewage/Industrial
NON-MAJOR NPDES SITES
Industrial
Sewage
Sewage/Industrial
8 0 8 Miles
1:675000
PROJECTION: Universe Transverse Mercator 83 Zone 18
DISCLAIMER: Intended for Educational Display Purposes Only
SRBC
SRBC (575c) 02-24-2003