PHILADELPHIA WATER DEPARTMENT – BELMONT & QUEEN LANE TREATMENT PLANTS (PWSID #1510001)
SECTION 1: GENERAL SCHUYLKILL RIVER WATERSHED SOURCE WATER ASSESSMENT REPORT

This report was produced for the Pennsylvania Department of Environmental Protection in accordance with the Source Water Assessment and Protection Plan.

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Executive Summary – Schuylkill River Watershed Assessment

The 1996 Safe Drinking Water Act Amendments required the assessment of all source water supplies across the country to identify potential sources of contamination, the vulnerability and susceptibility of water supplies to that contamination, and public availability of the information. In response to this charge, the Schuylkill River Source Water Assessment Partnership, comprised of the Pennsylvania Department of Environmental Protection, the Philadelphia Water Department, the Philadelphia Suburban Water Company, and the Pennsylvania American Water Company, conducted an assessment with stakeholders to identify water supply protection priorities in the Schuylkill River watershed. The following summary includes two main sections. One section discusses the various characteristics and observations made through collection of watershed wide information. The remaining section provides a brief listing of the main recommendations based on the observations and analysis of watershed data.

Observations & Characterization

- The Schuylkill River has been an important source of drinking water in the region for over two centuries. Philadelphia began using the Schuylkill River as a water supply in 1801.

- The Schuylkill River has been historically impacted by mining activities. Many of the dams along the river were originally built to support the canal system for mining or to trap mining wastes.

- During the late 1800s, untreated sanitary and industrial wastewater was discharged directly into the River. This combined with pollution from mining forced many communities away from the river as a water supply or caused significant investments in additional treatment capabilities.

- The Schuylkill River Watershed is approximately 1900 square miles encompassing portions of 11 counties with almost 3 million residents

- Approximately 1.75 million people in the watershed receive drinking water from the Schuylkill River and its tributaries. About 80 percent of those persons receive drinking water from surface water supplies withdrawing water from the river below Pottstown.

- Between 700 and 900 million gallons of water are withdrawn every day from ground and surface water within the Schuylkill River watershed. Between 570 to 600 million gallons are withdrawn every day from surface water (streams and rivers) for a variety of purposes.

- Approximately 40 percent of the surface water withdrawn from the Schuylkill River and its tributaries is used for drinking water. Another 30 percent is used for

thermoelectric power generation. The remaining amounts of surface water are used for agriculture, commercial and mining.

- Over 75 percent of the total stream length within the Schuylkill River watershed is comprised of first and second order streams.

- Studies indicate that the amount of developed land within the Schuylkill River watershed ranges between 14 and 30 percent.

- Recent land use studies have concluded that the amount of developed land within the watershed is increasing as agricultural and forested lands decrease. The developed land areas are found mainly in the lower watershed, near major cities, or transportation corridors.

- The Perkiomen Creek Watershed and the area along the river from Phoenixville to Reading have seen the greatest population increases between 1990 and 2000. The area along the Schuylkill River from Philadelphia to Conshohocken has seen a significant decrease in population over the past decade. This data suggests more persons are moving upriver and contributing to sprawl.

- The areas along the Schuylkill River from Conshohocken to Reading have seen the greatest increases in developed lands (up to 8%) between 1990 and 2000. The Wissahickon Creek, Valley Creek, and Perkiomen Creek subwatersheds have also seen significant increases (up to 8%) in developed lands the past decade. Depending on the area, more than half the developed land was originally agricultural or forested lands.

- Over 3,000 potential point sources were identified within the Schuylkill River watershed. Most of these potential sources do not and will never discharge into the Schuylkill River, but may store, generate, or transport hazardous chemicals.

- Sewer systems, dry cleaners, and machine/metal working shops were among the most frequently identified potential point sources.

- The highest concentrations of potential point sources were located in the most highly developed sub-watersheds.

- Monocacy Creek, Wissahickon Creek, and Valley Creek had the greatest number of dischargers per acre of drainage area. Based upon drainage area and flow, the Wissahickon Creek had the highest discharger density.

- A total of 543 million gallons of petroleum, gasoline, and crude oil are stored in above ground storage tanks in the watershed. The tanks range in size from 250 gallons to 13 million gallons and range in age from 1 to 98 years old. The storage tanks were determined to hold 159 different substances or chemicals.

- Schuylkill River water quality has significantly improved over the past twenty years. As the impacts of point sources have been reduced over the years, the importance of non-point sources such as stormwater runoff from developed areas within the watershed has become evident.

- While dissolved solute and metal levels have increased over the past few decades, dissolved oxygen and nutrients have significantly improved, due to reductions in agricultural runoff and improved wastewater treatment.

- Over the past decade, levels of alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, total organic carbon, and turbidity have increased in the mainstem river and throughout portions of the watershed.

- Increases in levels of solids, salts, and metals are believed to result from contaminated runoff resulting from increased development, increased use of deicing chemicals, and from acid mine drainage. If current trends continue, there will be impacts on drinking water supplies that require additional treatment and costs to make the water potable for drinking.

- Analysis of water quality trends suggests that conductivity trends may provide a good indicator of trends in other water quality parameters.

- Of the 53 percent of the 2522 miles of streams and creeks within the watershed that have been assessed, nearly 73% of the streams have attained their applicable water quality standards and designated uses.

- Watersheds within the more highly developed downstream areas of the watershed have the highest percentage of stream length that are impaired.

- Flow variability and nutrients were listed as the two most frequent primary causes of impairment in the watershed.

- Stormwater runoff from urban and suburban areas was identified as the cause of over half of the impaired stream lengths within the watershed.

- Federal, state, and private grants have provided almost $20 million for environmental projects within the Schuylkill River watershed over the past seven years. Almost 50 percent of the grants awarded were used for restoration projects.

- Grants were awarded to 76 recipients, with county and municipal groups receiving the majority of funds.

- On a per capita basis, the Valley Creek subwatershed received the greatest amount of funding (> $55 per person) out of 18 subwatersheds. The most challenged and impaired watersheds tended to be located in developed areas.

Watershed Recommendations

- Grant funding should be directed towards restoration projects and the formation of watershed organizations along the main stem of the Schuylkill River between Philadelphia and Reading. This will benefit the water supply for communities from Philadelphia to Pottstown or 1.75 million people. Special legislation, zoning, ordinances, and regulations should also be developed for this water supply protection area.

- Both sewer system capacity and integrity as well as treatment plant capacity during wet weather periods represent the greatest and most difficult sewage related issue in the watershed. Infrastructure improvements for adequate wastewater collection and treatment systems are needed to address infiltration and inflow or system capacity issues. These improvements will eliminate events such as overflowing manholes of raw sewage into downstream water supplies.

- Raw sewage discharges by communities such as New Philadelphia and Middleport need to be eliminated and treated with proper wastewater treatment. This is not consistent with national and statewide sanitary practices.

- Discharges from Combined Sewer Overflow Systems such as Bridgeport and Norristown upstream of drinking water intakes need to be reduced and controlled. These discharges can significantly impact pathogen concentrations in downstream water supplies.

- Wastewater dischargers should be encouraged and given incentives to switch to ultraviolet light disinfection and/or filtration of effluents to reduce *Cryptosporidium* pathogen levels and viability from discharges.

- It is recommended that the DRBC and three PADEP regions covering the Schuylkill River Watershed develop a watershed wide approach to addressing permit requirements. One suggestion would be a uniform fecal coliform discharge limit for any wastewater discharge upstream of a drinking water intake in the watershed.

- Incentives for townships and communities along the mainstem Schuylkill River from Reading to Philadelphia are needed to mitigate stormwater impacts on water supplies.

- Strict enforcement of the Phase II stormwater regulations is recommended for communities discharging into protection priority areas for drinking water supplies.

- Acid Mine Drainage needs to be addressed and mitigated to reduce significant loadings of metals into downstream water supplies. The Pine Knot/Oak Hill acid mine drainage site in Schuylkill County is potentially the greatest single known

source of metals discharging into the Schuylkill River. Efforts should be focused towards the remediation of this site.

- Interaction and communication with petroleum pipeline owners and operators, railroads, and road or bridge construction crews needs to be developed and improved. It is important for these stakeholders to understand water supply issues and impacts from catastrophic accidents and right of way spraying of herbicides. Therefore a series of emergency response workshops needs to be held to raise awareness of the issue.

- Given the catastrophic impacts from spills and accidents, an early warning system similar to that on the Ohio River should be installed along the mainstem Schuylkill River to provide water suppliers warning and accurate real time data when spills and accidents occur. It is recommended that the USGS should be involved in the implementation of the early warning system.

- An accurate time of travel study needs to be conducted on the Schuylkill River to determine the time various spills will take to arrive at various water supply intakes and the amount of dilution under various flow scenarios. This should be incorporated into a computer model for emergency planning simulations using various chemicals and scenarios. This is also an important component necessary to make information from the early warning system more useful. The USGS should be involved in the implementation of this effort.

- Signage should be developed in sensitive water supply areas along roadways and bridges that include phone numbers to contact water suppliers during emergencies and spills. The signs should include a unique identification number corresponding to a known location for the water supplier.

- A special workshop with street departments and PennDot should be held to develop a strategy to reduce salt impacts from road salt application. This may include strategies to acquire special funding for salt misting trucks to reduce salt application in sensitive areas.

- Agricultural land that is preserved should have specific riparian buffer and streambank fencing requirements included in its preservation status.

- Additional incentives and efforts should be allocated to develop, monitor, and implement nutrient management and conservation plans for farms in sensitive water supply areas.

- Active agricultural lands adjacent to streams in sensitive water supply areas should be required to have riparian buffers or streambank fencing to reduce impacts from livestock activity, pasture runoff, and crop runoff.

- Agricultural protection activities should be focused in Berks County and along the mainstem Schuylkill River between Philadelphia and Reading. Efforts should build on the successes of the Berks County Conservancy in this area.

- USDA funding such as EQUP and CRP, that remove agricultural lands from production in sensitive water supply areas should be increased, more easily available, and discussed more aggressively with farmers. Water suppliers should also be included in EQUP and CRP funding decisions in order to maximize water supply protection.

- Areas of intense or concentrated agricultural activity should also be prioritized for protection and mitigation efforts.

- Special erosion controls and ordinances to reduce stormwater impacts from future development and erosion are needed in protection priority areas for water supplies.

- Conservation Districts need more assistance in addressing erosion control and stormwater runoff issues from development.

- The sediment impounded behind dams should be removed prior to removal of the dam. Future dam removal projects funded by PADEP or DCNR must have this component to reduce washdown impacts of impounded sediment from rain events after the dam is removed.

- The U.S. Fish and Wildlife, PA Game Commission, park managers, golf course managers, and water suppliers should develop and implement a regional management plan to address the exploding population of non-migratory Canada Geese

- Township officials along the protection priority corridor should be educated about stormwater impacts on water supplies through meetings, workshops, or mailings.

- The results of the local source water assessments need to be presented directly to local township officials. The common issues from multiple water supplies should also be provided to show how everybody lives downstream and feels the impact from pollution.

- There are significant needs for improved GIS information in order to conduct improved assessments for the watershed. This includes up to date land use, pipeline, preservation, and agricultural information.

- Water quality monitoring in the watershed needs improved coordination. Sentinel monitoring locations for tracking long term trends in water quality need to be established.

Contents

Section 1 – General Schuylkill River Watershed

1.1 Introduction 1-1

1.1.1 New Requirements Under SDWA 1-2

1.2 Background and History 1-4

1.2.1 Description of the Schuylkill River Watershed 1-4

1.2.2 History of the Schuylkill River Watershed 1-6

1.2.2.1 Colonial Settlement 1-6
1.2.2.2 Industrialization 1-7
1.2.2.3 Transportation 1-10
1.2.2.4 Dams 1-11
1.2.2.5 Water Supply 1-13
1.2.2.6 Historical Improvements in Source Water Quality 1-15

1.2.3 Physiography and Soils 1-16

1.2.3.1 Regional Physiography 1-16
1.2.3.2 Sub-Watershed Physical Settings 1-18
1.2.3.3 Geology and Soils 1-21

1.2.4 Hydrology 1-27

1.2.4.1 Surface Water 1-30
1.2.4.2 Flooding 1-34
1.2.4.3 Groundwater 1-35
1.2.4.3.1 Stressed Groundwater Areas 1-35
1.2.4.4 Water Usage 1-37

1.2.5 Land Use in the Schuylkill River Watershed 1-40

1.3 Summary of Past Studies 1-50

1.3.1 Introduction 1-50

1.3.2 Schuylkill River Studies 1-50

1.3.3 Schuylkill River Tributary Studies 1-51

1.3.3.1 Hay Creek 1-52

1.3.3.2 Lake Ontelaunee 1-52
1.3.3.3 Little Lehigh Creek 1-52
1.3.3.4 Maiden Creek 1-52
1.3.3.5 Perkiomen Creek 1-52
1.3.3.6 Sandy Run Creek 1-52
1.3.3.7 Saucony Creek 1-52
1.3.3.8 Tulpehocken Creek 1-53
1.3.3.9 Wissahickon Creek 1-54
1.3.3.10 Wyomissing Creek 1-54
1.3.3.11 Watershed Assessments 1-54

1.4 Identification of Universal Water Quality Issues 1-55

1.4.1 Introduction to Water Quality 1-55

1.4.2 Long-Term Water Quality, Historical Trends, and Comparison to Other Rivers 1-59

1.4.3 Changes in River Water Quality over the Past Decade 1-62

1.4.4 Differences in Water Quality Throughout the Watershed 1-71

1.4.5 Analysis of Stream Impairments and Sources in the Schuylkill River 1-73

1.4.6 Universal Water Quality Issues 1-78

1.4.6.1 Acid Mine Drainage 1-79
1.4.6.2 Discharges from Septic Systems, Sewerage Systems, and Wastewater Treatment Plants 1-81
1.4.6.3 Dumping, Tire Piles, Salvage Yards, and Abandoned Industry Near the Floodplain 1-86
1.4.6.4 Agricultural Runoff 1-87
1.4.6.5 Development, Construction, and Erosion Runoff 1-88
1.4.6.6 Dam Removal and Sediment Releases 1-90
1.4.6.7 Catastrophic Accidents and Spills 1-91
1.4.6.8 Road Runoff 1-96
1.4.6.9 Algae Impacts 1-97
1.4.6.10 Wildlife Management 1-98

1.4.7 Watershed Monitoring: Current and Future Needs 1-100

1.5 Inventory of Potential Point Sources of Contamination 1-105

1.5.1 Point Source Contaminant Inventory 1-106

1.5.2 Inventory Characterization 1-108
1.5.2.1 Entire Watershed Inventory Summary 1-108
1.5.2.2 PCS Dischargers ..... 11 ... 1-1
1.5.2.3 RCRA/AST Facilities 1-116
1.5.2.4 TRI Facilities 1-117
1.5.2.5 CERCLA Facilities 1-119

1.6 Identification of Restoration Efforts 1-120

1.7 Public Participation Process 1-125

1.7.1 Advisory Groups 1-127

1.7.2 Public Meetings 1-140

1.7.3 Website 1-142

1.8 General Recommendations for the Schuylkill River Watershed 1-143

1.8.1 Grant Funding and Watershed Organizations 1-143

1.8.2 Protection and Preservation 1-143

1.8.3 Sewage Discharge and Regulatory Enforcement 1-144

1.8.4 Stormwater Runoff Impacts 1-145

1.8.5 Acid Mine Drainage Impacts 1-146

1.8.6 Spills and Accidents/Emergency Response 1-146

1.8.7 Agricultural Impacts 1-147

1.8.8 Erosion and Sedimentation Issues 1-147

1.8.9 Wildlife Impacts 1-148

1.8.10 Public Education 1-148

1.8.11 Data and Informational Needs for Protection & Assessment Efforts 1-148

1.8.12 Water Quality Monitoring and Data Recommendations 1-149

List of Works Cited

List of Acronyms

Appendix

Figures

Figure 1.2.1-1 Schuylkill River Drainage Basin 1-5
Figure 1.2.2-1 Cumulative Coal Production in the Schuylkill River Basin 1-7
Figure 1.2.2-2 Locations of Water Supply Intakes in the Schuylkill River Basin 1-14
Figure 1.2.3-1 Physiographic Provinces of the Lower Schuylkill River Watershed 1-17
Figure 1.2.3-2 General Distribution of Soils and Parent Rocks in the Lower Schuylkill River Basin 1-22
Figure 1.2.3-3 Soil Types in the Lower Schuylkill River Watershed 1-24
Figure 1.2.3-4 Digital Elevation Model of the Lower Schuylkill River Watershed 1-26
Figure 1.2.4-1 Long Term Average Annual Temperature at Philadelphia 1-28
Figure 1.2.4-2 Long-Term Average Annual Temperature at Philadelphia 1-28
Figure 1.2.4-3 Precipitation trends in Southeastern Pennsylvania through the 1990's 1-29
Figure 1.2.4-4 Daily Average Schuylkill River Flow through the 1990's 1-30
Figure 1.2.4-5 Amount of Water Withdrawal from the Schuylkill River Watershed by Use 1-38
Figure 1.2.4-6 Percentage of Surface Water Withdrawn from the Schuylkill River Watershed by Water Suppliers 1-39
Figure 1.2.4-7 Percentage of Population Supplied from the Schuylkill River Watershed by Water Suppliers 1-39
Figure 1.2.5-1 Percentage of Land Area in the Schuylkill River Watershed within Each County 1-40
Figure 1.2.5-2 Percentage of Total County Land Area within the Schuylkill River Watershed 1-41
Figure 1.2.5-3 Overview of Schuylkill River Watershed Land Use (%) 1-42
Figure 1.2.5-4 Change in Land Use in the Schuylkill Watershed 1-42
Figure 1.2.5-5 Percent of Developed Land Use by County in 1995 1-43
Figure 1.2.5-6 Percentage of Developed Land Area by County 1-44
Figure 1.2.5-7 Changes in Developed Land Area by County (in sq. miles) 1-44
Figure 1.2.5-8 Percent Change in Developed Land and Population per Decade by County in the Philadelphia Region 1-45
Figure 1.2.5-9 Population Change from 1990 to 2000 by Major Watershed 1-46
Figure 1.2.5-10 Change in Developed Areas by Major Subwatershed 1-47
Figure 1.2.5-11 Change in Agricultural and Forested Areas by Major Subwatershed 1-47
Figure 1.2.5-12 Updated Land Use in the Schuylkill River Watershed 1-49
Figure 1.4.1-1 Changes in Water Quality Indicators in the Schuylkill River at Philadelphia 1-57
Figure 1.4.2-1 Historical Nitrate, Chloride and Total Residue in Eastern US Rivers From Jaworski et al., 1990 1-61

Figure 1.4.3-1 Percent Change per Decade in Schuylkill River Quality Parameters at Philadelphia, PA between 1990 and 1999 1-63
Figure 1.4.3-2 Bulk Mass Transport of Sodium and Chloride in the Schuylkill River in the 1990's 1-66
Figure 1.4.3-3 Watershed-wide Trends in Percent Increase per Decade in Conductivity in the mainstem of the Schuylkill River from 1990-1999 1-67
Figure 1.4.3-4 Watershed-wide Trends in Percent Increase per Decade in Conductivity in the Tributaries of the Schuylkill River from 1990-1999 1-69
Figure 1.4.3-5 Increased Conductivity Trends in the Maiden Creek Watershed 1990-1994 1-69
Figure 1.4.3-6 Increased Conductivity Trends in the Valley Creek Watershed 1990-1998 1-70
Figure 1.4.5-1 Impaired Miles vs. Miles Assessed in Each Watershed 1-74
Figure 1.4.5–2 Causes of Impairment Within the Schuylkill River Watershed 1-75
Figure 1.4.5-3 Miles of Impairment with in the Schuylkill River Watershed vs. Their Primary Sources of Impairment 1-76
Figure 1.4.5-4 Stream Assessment within the Schuylkill River Watershed 1-77
Figure 1.4.6-1 Mining Locations in the Schuylkill River Watershed 1-80
Figure 1.4.6-2 Comparison of Average Concentrations of Iron and Manganese Estimated in the Schuylkill River at Philadelphia by Acid Mine Discharge to Actual Concentrations Measured at Philadelphia 1-81
Figure 1.4.6-3 Comparison of Sources of Violation Information for the PADEP Southeast Region: PADEP staff and records vs. PADEP E-facts Electronic Database 1-84
Figure 1.4.6-4 Overflowing Manhole Nearby a Stream 1-85
Figure 1.4.6-5 Exeter Wastewater Treatment Plant 1-86
Figure 1.4.6-6 Tire Piles and Trash Dumping along the Schuylkill River 1-87
Figure 1.4.6-7 Cows in the Stream and Farming Tillage Impacts on Sediment and Nutrients 1-87
Figure 1.4.6-8 Farmers Installing Cattle Crossings (left) and Streambank Fencing with Riparian Buffers (right) to Limit the Impacts of Livestock on Streambanks and Filter Runoff from Pastures in Berks County. 1-88
Figure 1.4.6-9 Photographs of the Impacts of Runoff from Construction: Lake Ontelaunee 1-89
Figure 1.4.6-10 Aerial View of Green Lane Reservoir Before and After a Storm Event 1-90
Figure 1.4.6-11 Sediments Remaining behind Felix Dam after Breaching from Hurricane Floyd 1-91
Figure 1.4.6-12 Local Television and Newspaper Coverage of the Bridgeport Fire 1-92
Figure 1.4.6-13 Tanker Car Derailment in Philadelphia 1-93
Figure 1.4.6-14 Cleanup of an Oil Spill at Green Lane Reservoir from an Automotive Repair Facility 1-93

Figure 1.4.6-15 Petroleum and Natural Gas Pipelines in the Schuylkill River Watershed 1-95
Figure 1.4.6-16 Road Salt Application During the Winter 1-97
Figure 1.4.6-17 Picture of a Duckweed Bloom on the Schuylkill River (8/16/99) that Turned the River Green for Several Miles and Made the National News 1-98
Figure 1.4.6-18 Geese Damaging Land Near a Water Supply Intake 1-99
Figure 1.4.7-1 Number of Monitoring Sites in Schuylkill Subwatersheds 1-102
Figure 1.4.7-2 Routine Monitoring Locations by Organizations in the Schuylkill River Watershed 1-103
Figure 1.5.1-1 Point Source Contaminant Inventory for the Manatawny Watershed 1-107
Figure 1.6-1 Distribution of Grant Dollars within Schuylkill River Subwatersheds 1-121
Figure 1.6-2 Grant Money per Capita Awarded within each Schuylkill River Subwatershed 1-122
Figure 1.6-3 Distribution of Schuylkill River Watershed Grants by Recipient Type ..... 123 ... 1-
Figure 1.6-4 Distribution of Schuylkill River Watershed Grants by Project Type ..... 124 ... 1-
Figure 1.7-1 Ranking of Water Quality Issues by Stakeholders 1-126
Figure 1.7.1-1 Technical Advisory Group Breakdown 1-128
Figure 1.7.1-2 Summary of Criteria Types for Contaminant Categories 1-138
Figure 1.7.1-3 Summary of Criteria Types for Individual Contaminant Categories 1-139
Figure 1.7.3-1 Schuylkill River SWAP Website (www.schuylkillswa.org) 1-142

Tables

Table 1.2.2-1 Population by County within the Schuylkill River Watershed 1-10
Table 1.2.2-2 Dams along the Schuylkill River 1-12
Table 1.2.2-3 Dam and Pool Characteristics 1-12
Table 1.2.3-1 Prevalence of Various Soil Types in the Lower Half of the Schuylkill River Watershed (Pottstown to Philadelphia) 1-25
Table 1.2.4-1 Stream Gauging Data in the Schuylkill River Basin 1-31
Table 1.2.4-2 Characteristics of Tributaries in the Schuylkill River Watershed (from Bottom of Watershed to Top of Watershed by River Mile Location) .....3....1-3
Table 1.2.4-3 Reservoir Characteristics in the Schuylkill River Watershed.....1-33
Table 1.2.4-4 Summary Length by Stream Order for the Schuylkill River Watershed 1-34
Table 1.2.4-5 Water Withdrawn per Day in the Schuylkill River Watershed 1985-1995 (source USGS) 1-37
Table 1.2.5-1 Land Use Changes in the Schuylkill River Watershed: 1982-1997 1-42
Table 1.2.5-2 Updated Land Use Categories 1-48
Table 1.4.2-1 Summary of Historical and Current Water Quality Concentrations and Rates of Change For Northeastern Watersheds.....1-60
Table 1.4.3-1 Parameters that May Have Water Treatment Operation, Distribution System, or Finished Water Quality Impacts over the Past Decade or by 2020 Given Current Trends 1-64
Table 1.4.3-2 Summary of Water Quality Changes in the Schuylkill River During the 1990's that May Impact Water Treatment and Possible Sources .....64.....1-
Table 1.4.3-3 Reference Pollutant Concentrations (mg/l) in Roadway Runoff 1-65
Table 1.4.3-4 Spatial Comparison of Water Quality Parameters in the Schuylkill River Watershed.....1-68
Table 1.4.4-1 Spearman Rank Order Correlations of Mean Conductivity and Mean Water Quality Parameters in the Schuylkill River Watershed.....1-71
Table 1.4.4-2 Universal Water Quality Issues 1-72
Table 1.4.5-1 Breakdown of Total Miles of Impairment by Primary Causes 1-75
Table 1.4.5-2 Breakdown of Miles of Impairment by Sources 1-76
Table 1.4.7-1 Summary of Routine Watershed Monitoring 1-101
Table 1.5.2-1 Summary of Point Source Types by Major Watershed 1-109
Table 1.5.2-2 Major Subwatershed Source Type Occurrence 1-110
Table 1.5.2-3 Schuylkill Watershed Top Point Sources by Industrial Classification 1-110
Table 1.5.2-4 Watershed Clustering of Dischargers on a Drainage Area Basis.....1-111
Table 1.5.2-5 Watershed Clustering of Dischargers on a DA/Flow Basis 1-112
Table 1.5.2-6 PCS Discharger Summary 1-113
Table 1.5.2-7 Summary of Available DMR Data 1-114

Section 1
General Schuylkill River Watershed

1.1 Introduction

Key Points

- **The Schuylkill River Source Water Assessment Partnership, comprised of the Pennsylvania Department of Environmental Protection, the Philadelphia Water Department, the Philadelphia Suburban Water Company, and the Pennsylvania American Water Company, is collecting and evaluating the data necessary to identify water supply protection priorities in the Schuylkill River Watershed.**

The ability to obtain safe and potable drinking water has always been a key component in the location and development of communities. The quantity and quality of the drinking water supply has often defined a community's ability to grow and succeed. Therefore, protecting, maintaining, and improving the quality of a community's water supply is vital in ensuring its future.

The importance of water supply integrity has been recognized throughout the United States by municipalities and water suppliers who have implemented efforts to protect the drinking water supplies of their communities. From rural wells, to the rivers supplying potable water to big cities, everyone is getting involved in protecting the source of their drinking water.

In addition to local efforts, federal regulations, resources, and initiatives have been implemented to protect drinking water sources. These include the Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Safe Drinking Water Act (SDWA).

Most recently, the Safe Drinking Water Act Reauthorization in 1996 included a specific component for source water protection called the Source Water Assessments (SWAs). The SWAs are a process involving water suppliers, watershed organizations and other stakeholders, which identify the protection priorities of the water supply. Water suppliers will be required to make this information available to the public in their Consumer Confidence Reports in order to help the public understand the source of their drinking water and the challenges that must be met to protect it. It is important to note that these assessments are of the raw water sources prior to drinking water treatment, not assessments of the performance or compliance of public water systems.

As part of its federal requirement to conduct the SWAs, the Pennsylvania Department of Environmental Protection (PADEP) sought to involve water suppliers and the

community in the SWA process. It is believed that the partnership approach will increase the potential for public, community, and water supplier involvement to address source water issues after the assessments have been completed.

Using this partnership approach, the Schuylkill River Source Water Assessment Partnership was formed. The partnership includes water suppliers working with the state to conduct the assessments. The state contractor, the Philadelphia Water Department, has partnered with the Philadelphia Suburban Water Company and the Pennsylvania American Water Company to lead the Schuylkill River Source Water Assessment Partnership, and conduct source water assessments for 42 surface water supplies within the Schuylkill River Watershed.

1.1.1 New Requirements Under SDWA

Key Points

- **The 1996 amendments to the Safe Drinking Water Act require States to implement Source Water Assessment Programs.**

The EPA has supported efforts by States and communities to protect their water sources from contamination since 1986, with the establishment of the Wellhead Protection (WHP) Program and other federal initiatives. Encouraged by the WHP program's success, the EPA has set new goals for source water protection. By 2005, the EPA's goal is to have either Source Water Protection, Wellhead Protection, or Watershed Protection Programs in place for 60% of the country's population served by community water (source: EPA State Source Water Assessment and Protection Programs Guidance, August 1997, EPA 816-R-97-009, Office of Water 4606).

The amendments to the 1996 Safe Drinking Water Act include requirements for states to establish and implement Source Water Assessment Programs (SWAPs) that accomplish the following:

1. Set forth the state's strategic approach to conducting the assessments

2. Delineate the boundaries of the areas providing source waters for public water supply (PWS)

3. Identify, to the extent practical, the origins of regulated and certain unregulated contaminants in the delineated area in order to determine the susceptibility of PWSs to such contaminants

4. Complete the assessments within two years after EPA approval, with an opportunity to extend this period up to 18 months

5. Make the results of the source water assessments available to the public.

The intent of Congress by requiring the SWAs was to show water suppliers, municipalities, and the public the potential challenges facing their sources of drinking water and to develop local voluntary support for source water protection programs.

The PADEP has already been working hard to meet these requirements by developing an approved SWA Program and Plan and by hiring contractors to help assess a portion of its 14,000 water sources. In addition, the PADEP has set aside resources and monies in the forms of grants for communities that apply to develop local source water protection plans after assessments are finished. These plans were designed to be linked to the Growing Green Grant application process. Additional preference would be given to grant applications that can show that the proposed activities are linked to an approved Source Water Protection Plan or River Conservation Plan for that community. Therefore, local organizations seeking funds to conduct protection efforts would eventually be better coordinated to conduct efforts that can protect local water supplies.

1.2 Background and History

1.2.1 Description of the Schuylkill River Watershed

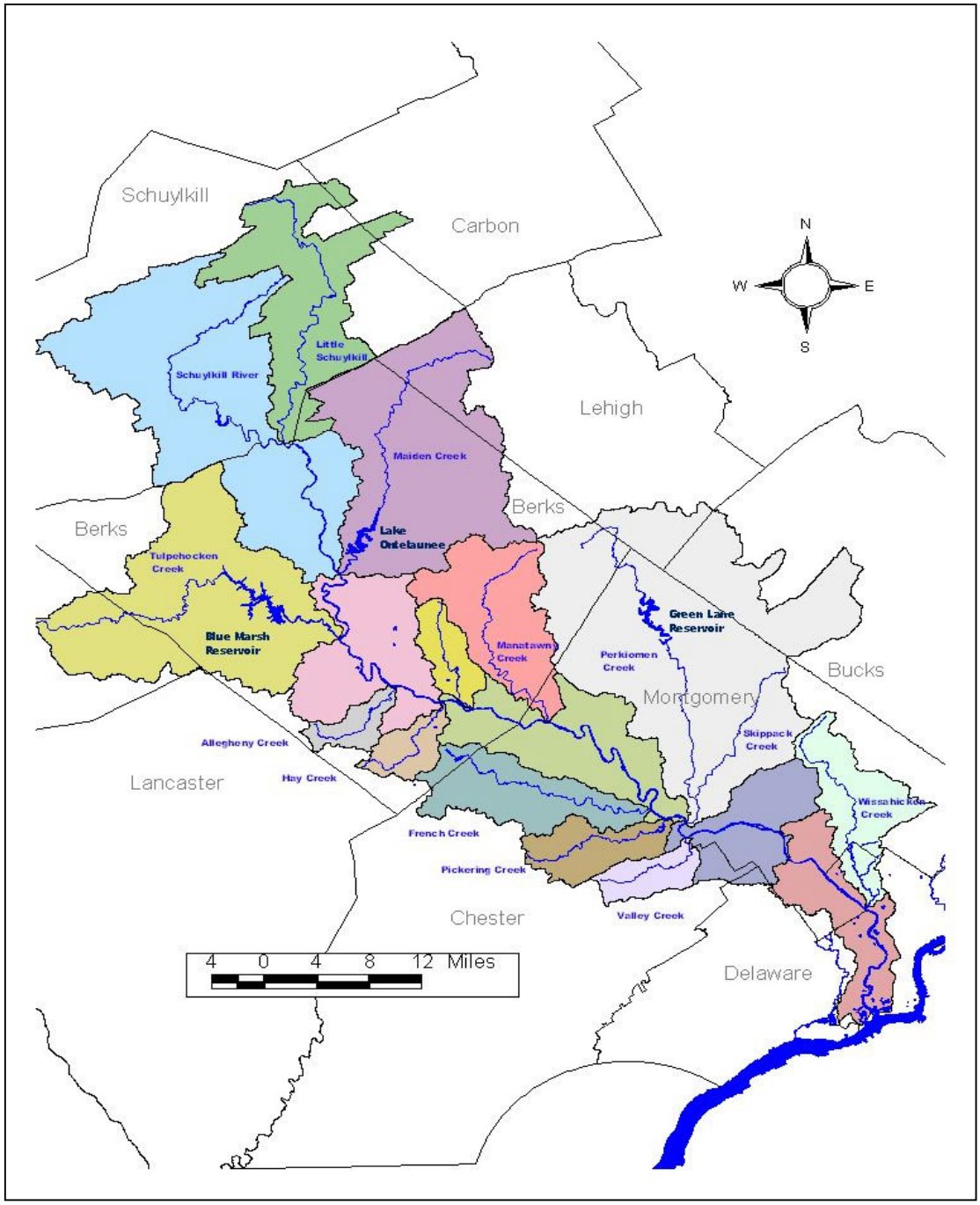
Key Points

- **Early colonial settlements along the Schuylkill River in the 1600s were established at the river's mouth and confluence with the Delaware River.**
- **Today, over 3,000,000 people live within the 2,000 square-mile watershed.**

The Schuylkill River Watershed is over 130 miles long, includes over 180 tributaries, and drains an area of 2,000 square miles. The watershed is located in southeastern Pennsylvania and is comprised of eleven counties and over three million residents. The headwaters of the Schuylkill River drain approximately 270 square miles of Schuylkill County and flow in a southeasterly direction into the tidal waters at the river's confluence with the Delaware Estuary. The basin includes large parts of Schuylkill, Berks, Montgomery, Chester and Philadelphia counties and smaller parts of Carbon, Lehigh, Lebanon, Lancaster, Bucks and Delaware counties. The major towns and cities along the river are Pottsville, Reading, Pottstown, Phoenixville, Norristown, Conshohocken and Philadelphia.

Figure 1.2.1-1 presents a map of the entire Schuylkill River Drainage Basin, its subwatersheds, and its tributaries.

Figure 1.2.1-1 Schuylkill River Drainage Basin



1.2.2 History of the Schuylkill River Watershed

Key Points

- The effects of historical coal mining in the headwaters of the Schuylkill River Watershed can still be observed today.
- Through the late 1800s, untreated sanitary and industrial wastewater was discharged directly into the river.
- Population growth in the Schuylkill River Basin increased the amount of wastewater discharged into the river, and changed the quantity and quality of stormwater runoff.
- In response to the accumulation of coal culm in the river, the Commonwealth of Pennsylvania prohibited the pollution of state waters, including the discharge of mining wastes into the river.
- Philadelphia began using the Schuylkill River as a potable water supply in 1801.
- Today, the Schuylkill River Watershed is the source of potable water for 1.8 million people.

1.2.2.1 Colonial Settlement

The initial settlement along the Schuylkill River began at the river's mouth and confluence with the Delaware River. Prior to colonial settlement by the British, the lower Schuylkill River Basin was the home of the Lenape Indians. In the early 1600s, Dutch and Swedish settlers also made the lower Schuylkill River Basin their home. It was not until the arrival of the British that settlement within the basin rapidly expanded.

William Penn chose the mouth of the Schuylkill River to establish the colonial city of Philadelphia, based on the region's physical features. The site was comprised of high dry land, the Atlantic Coastal Plain, and was flanked by the Delaware and Schuylkill rivers, which Penn envisioned would lead to rapid commercial and residential development along both rivers. During colonial times, both rivers also served as vital food sources (shad, herring, salmon and sturgeon) and provided cultural and recreational resources. The region still maintains vestiges of its Indian heritage; e.g. Wissahickon, an area within the watershed, is an Indian name for catfish. Similarly, many of the current town names were Indian words describing the local environmental conditions; Passyunk means "a level place below hills" and Cohocksink means "pinelands" (Toffey, 1982).

Since the city's founding by William Penn in 1682, significant alterations to the land and riverfront occurred to accommodate industrial and residential development. Along the Schuylkill riverfront, nearly all of the woodlands were cleared to make room for industrial development. During the 1700s and early 1800s, land development along both sides of the Schuylkill River south of central Philadelphia was mostly agricultural and recreational, except for elite residential development near the present-day Fairmount Dam. The original mouth of the Schuylkill was comprised of a small stream,

tidal flats, and several marshy islands. These lands were filled and drained by man-made canals, and tidal waters were diked to create thousands of acres of agricultural lands. The city estimates that approximately 7,000 acres of shallow water habitats existed at the time of Penn. Today only 500 acres remain (Philadelphia City Planning Commission, 1982).

1.2.2.2 Industrialization

Coal was discovered in the headwaters of the watershed as early as the 1770s. Commercial mining began in the 1820s and rapidly expanded with the completion of the Schuylkill River canal system in 1824. Initial mining efforts were limited to shallow mines above the water table. By 1835, several mines were excavating below the water table and pumping the mine water into the Schuylkill River. Coal production reached its peak in the 1920s, declined during the depression, rose again during World War II, and then declined to the present low rate. Figure 1.2.2-1 summarizes the cumulative production of coal in the Schuylkill River Basin.

Figure 1.2.2-1 Cumulative Coal Production in the Schuylkill River Basin

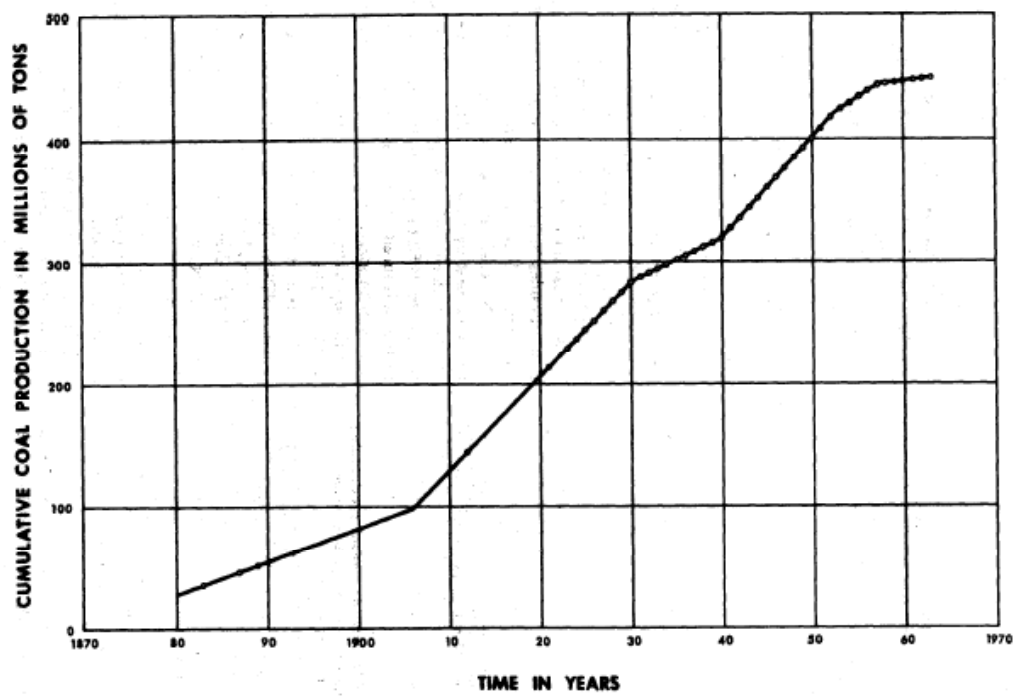


Figure 1.2.2-1 Cumulative Coal Production in the Schuylkill River Basin

Source: Water Resources of the Schuylkill River Basin, Water Resources Bulletin, Bulletin No. 3, United States Department of the Interior, Geological Survey, 1968.

The coalbeds in the Schuylkill Basin are part of Pennsylvania's southern anthracite coalfield. In areas of historic mining, land was stripped away to expose the coal vein. This soil was discarded and placed into piles next to the mining operation. These spoil piles are a source of coal fines, or culm, that if not properly contained, can run off into nearby streams. As the culm settles, it can cover the streambeds that serve as habitats for macroinvertebrates. Culm often contains iron pyrite, which is known for causing impacts to the stream bottom, but it also negatively impacts the water column by producing acid mine drainage. During industrialization, large discharges of culm into the river destroyed fish habitats and choked the flow of the river, increasing the frequency and magnitude of flood events.

As mining production increased, the impact on the Schuylkill River became more serious. Waters were acidic from the headwaters to Reading. In addition to acid mine drainage, coal processing introduced large amounts of sediment into the waterway. The accumulation of acid discharges and particulate waste from coal mining in the headwaters resulted in a lifeless Schuylkill River by the turn of the 20th Century.

Besides the adverse impacts of coal mining, the corresponding growth of industrialization also impacted the waters of the Schuylkill River. By the mid-1800s, the full force of industrialization had reshaped the development along the river's banks: industries, utilities and rail facilities replaced residential and recreational development along the riverfront below the Fairmount Dam in Philadelphia. Between the 1690s and 1860s, a series of dams within the Wissahickon Creek provided hydropower to run 24 mills (corn, wool, paper, etc). The advent of coal, steam, rail, and highway systems also impacted the waters of the Wissahickon, resulting in the clear cutting of woodlands for fuel and development and rock blasting along the shorelines to create space for transportation networks (West, 1985). Similar occurrences took place in booming industrial towns such as Manayunk, Conshohocken, Norristown and Phoenixville, all of which discharged their wastes directly into the Schuylkill River and its tributaries.

A sanitary survey conducted by the Philadelphia Water Department in 1884 provided an overview of the variety and magnitude of the contaminant sources to the Schuylkill River at that time. Beginning in Reading, the sources of pollution included two gasworks, five tanneries, one soap mill, several slaughterhouses, two paper mills, one woolen mill, nine hat factories, five breweries and two malt houses, rolling mills and hardware mills, as well as several others. To provide some insight to the amount of pollution discharged into the Schuylkill at that time, discharges from two of these sources, the Reading Gas-orks and one of the tanneries, are described here. The Reading Gasworks discharged, on average during the winter months, 150 gallons per day (GPD) to 250 GPD of a thick, pulpy, black matter, directly into the river. One out of the five tanneries on the river discharged up to 4,000 gallons of wastewater per day. Soaking animal skins in water for two or three days created this wastewater containing animal wastes, as well as lime, salt, alum, aniline dyes, and eggs.

The borough of Pottstown produced the greatest amount of pollution. Pottstown is located on the West Bank of the Schuylkill River just below the mouth of Manatawny Creek, and about 40 miles above the Fairmount Dam. The population of the town was 5,000; the population of the area including the suburbs was 9,000. The sources of the pollution included three natural watercourses that ran through the town and drained washwater from about two-fifths of the population, mostly through the street gutters, as well as water closet drainage from over one hundred houses that drained into the river. The Philadelphia and Reading Railroad Station water closets also drained into the river. After it was determined that drinking water should not be taken from the river, the Pottstown intake was moved upstream.

Between Pottstown and Reading (about 20 miles) agriculture was the main source of pollution entering the river. The largest polluter was at Birdsboro, located almost half way between the two towns, where about 20 houses had indirect washwater drainage into Hay Creek, a tributary of the Schuylkill River. The Phoenixville District extended from the pumping station to the upper boundary of Norristown. The source of the greatest pollution at the time of the 1884 watershed survey was in the borough of Phoenixville, on the east bank of the Schuylkill, 28 miles above Fairmount Dam. The population of about 7,500 resided primarily along both sides of the French Creek. The creek received washwater from about 800 people, and also received a large amount of human waste from the Phoenix Iron Company. Besides human wastes, a few slaughterhouses also discharged to the creek.

The borough of Norristown, on the left bank of the Schuylkill, had a population of 14,500 in 1884. Most of the pollution from Norristown was drainage of foul water matter into the river or its tributaries. The sources of this foul water included an oil factory, oil refineries, slaughterhouses, woolen and cotton mills, iron factories, breweries, etc. Stony Creek was the most grossly polluted tributary of the Schuylkill River in the whole valley; it received hospital drainage and the wastewater from Norristown sources.

Population in the basin was initially concentrated in Philadelphia. By the time of the revolution, the population had increased to 35,000. By the mid-1850s, the population of Philadelphia/Philadelphia County reached 460,000. Table 1.2.2-1 presents the historical population growth for the county areas within the watershed.

Table 1.2.2-1 Population by County within the Schuylkill River Watershed

County	1900	1910	1920	1930	1940	1950	1960	1990	2000
Berks	151,000	175,000	191,733	221,503	230,584	243,360	260,645	336,523	373,638
Bucks	10,000	12,100	11,319	12,905	14,597	16,210	18,996	541,174	597,635
Carbon	6,400	10,500	15,167	15,242	14,164	12,454	10,388	56,838	58,802
Chester	27,200	30,000	30,890	35,233	37,778	45,290	65,585	376,396	433,501
Delaware	1,400	1,800	1,636	2,453	2,402	2,942	4,339	547,651	550,864
Lebanon	7,300	8,000	8,320	8,654	9,013	10,097	11,334	113,744	120,327
Lehigh	4,900	4,100	4,015	3,910	4,166	4,543	5,307	291,130	312,090
Montgomery	115,400	137,800	156,997	200,083	216,117	257,496	356,512	678,111	750,097
Philadelphia	387,900	519,700	638,000	669,100	658,700	694,400	627,500	1,585,577	1,517,550
Schuylkill	76,100	95,100	104,265	115,860	113,404	103,590	94,571	152,585	150,336
Total	788,000	994,000	1,162,000	1,285,000	1,301,000	1,390,000	1,453,000	4,001,618	4,864,840

The early impacts of population growth on the watershed stemmed from the use of the river as a common disposal site for residential sewage and refuse. During colonial times, residential waste was disposed of in pits in backyards until it was declared a health problem. Thereafter, canals were built to drain the sewage directly to the rivers. By 1867, Philadelphia had constructed 67 miles of sewers; by 1900 there were 848 miles, and by 1944, more than 1,800 miles (Barber, 1885). As population grew with the development of industry in the upstream reaches of the Schuylkill River, domestic and industrial pollution posed a threat to Philadelphia's water supply.

Population growth also impacted water quality through land use changes. Wooded areas are not easily eroded and therefore do not release significant amounts of sediment during rainfall events. However, as the population grew, wooded areas were stripped and converted into agricultural lands or urban areas. Agricultural stormwater runoff included sediment and high concentrations of nutrients as well as herbicides and pesticides. Urban development reduced the percentage of permeable surface resulting in increased stormwater runoff, stream flows and velocities. Powerful stormwater flows eroded stream banks, causing sediment transfer that disrupted aquatic habitats and resulted in silt buildup behind dams. Today, urban stormwater is often contaminated with pollutants such as nutrients from lawn fertilizers as well as pollutants that have settled on paved surfaces.

1.2.2.3 Transportation

The Schuylkill River also served as an important transportation waterway. The Schuylkill Navigation Company constructed a 108-mile canal between 1817 and 1824. The canal connected Philadelphia and Carbon County and was comprised of 116 locks and 38 dams. Operation of the canal was slowly abandoned in the upper reaches due to high maintenance requirements, which were due in part to the silting of the river and canal with fine coal particles, or culm.

During the coal-mining era, chunks of coal and rock were separated using a hydraulic device. During this separation process, a byproduct of fine coal and rock particles in a water matrix was created. This byproduct was eventually disposed of in the nearby waterway. These wastes soon became a nuisance, and began to choke the river and

canals with sediment, creating both navigation and flooding problems. This compelled the Commonwealth of Pennsylvania to pass legislation that prohibited the pollution of state waters, and later abandoned all discharge of mining wastes into those waters. This legislation enabled the creation of a unique project which was completed in 1954, the Schuylkill River Desilting Project. The project combined dredging of the clogged river with planning and construction of desilting basins to abate the impacts of coal mining upstream of the Fairmount Dam. In short, this project removed the sand, gravel, and coal culm mixture from the bottom of the river and placed it into impounding basins to dewater. Once the dredged material was sufficiently dry, it was carried to a processing plant, where the coal culm was separated from the denser sand and gravel. The coal culm was sold. Today, there is much less culm that makes its way into the Schuylkill River, so the need for desilting appears to be decreasing.

Extensive railroad networks were built during the early 1800s with numerous terminals along both the Schuylkill and Delaware riverfronts. In 1928 the river was totally abandoned, as railroads succeeded as a faster and cheaper mode of transportation (Biesecker, 1968a).

1.2.2.4 Dams

There are three dams on the major tributaries of the Schuylkill River and ten dams on the main stem. Dams on the tributaries include Blue Marsh Reservoir on Tulpehocken Creek, Ontelaunee Reservoir on Maiden Creek, and Green Lane Reservoir on Perkiomen Creek. Blue Marsh has an estimated sediment trap efficiency of 83%. Ontelaunee and Green Lane Reservoirs are water supply facilities with theoretical trap efficiencies of 73 and 86%, respectively (Brune, 1953).

There are three dams within the upper portion of the Schuylkill River Basin that are downstream from the coal fields and were designed to trap the coal fines and other sediments discharged from mining and coal preparation operations. The Tamaqua Dam, which is on the Little Schuylkill River, Auburn Dam, which is on the main stem upstream from the Little Schuylkill River, and Kernsville Dam, which is on the main stem just downstream from the confluence with the Little Schuylkill River, are dredged periodically by the state. About 10.7 million cubic yards of material have been removed from behind the three dams since they were completed in 1951 (USGS, 1985b). The trap efficiency of the three desilting basins is estimated to be about 93%.

The remaining seven dams within the basin are remnants of a navigation system for barge traffic on the Schuylkill River. This system existed as the Schuylkill Navigation Company from 1825 until 1904. The original system was comprised of 38 dams, 32 canal segments, one tunnel, and 116 locks. This system enabled barges to navigate between Pottstown and Philadelphia, a distance of approximately 108 miles. Many of the remnants remained until the desilting project began in 1950. The Felix Dam, the uppermost of the seven dams located between Maiden Creek and Reading, was recently breached by Hurricane Floyd in September 1999. This suggests that many of the other dams of similar age and disrepair could be breached. The sediments in the pool behind the dam could contain remnants of contaminants from decades past. Therefore

sediment removal must be performed carefully so there is no possible impact on downstream water supplies.

The Black Rock, Vincent, Norristown, and Plymouth dams, on the lower part of the river, are remnants of the original structures build in the first half of the 19th century. These dams are rock-filled, timber-crib structures that are anchored to bedrock with iron dowels. Plymouth and Vincent dams are owned and maintained by the Commonwealth of Pennsylvania. The Philadelphia Electric Co. owns and maintains Black Rock and Norristown dams; both provide the necessary water depth at the cooling-water intakes of electric generating plants near the dams. The Flat Rock Dam, owned by the state, is a concrete gravity spillway, built in 1977 at the site of the old navigation dam. The Fairmount Dam, which is the lowermost dam located on the river, is also a concrete gravity spillway owned and maintained by the City of Philadelphia. All of the dams are low-level structures, ranging in height from 8 to 12 ft. Tables 1.2.2-2 and 1.2.2-3 summarize dam locations and characteristics, respectively.

Table 1.2.2-2 Dams along the Schuylkill River

Dam	River Mile
Vincent	44.8
Black Rock	36.7
Norristown	24.1
Plymouth	20.8
Flat Rock	15.7
Fairmount	8.4

Table 1.2.2-3 Dam and Pool Characteristics

Name of Dam	Drainage Area Above Dam (sq. mi.)	Approximate Height (ft)	Approximate Length (ft)	Approximate Pool Length(mile)	Approximate Pool Area (acres)	Approximate Pool Volume (MGD)
Plymouth	1,777	9	530	1	40	192
Norristown	1,765	12	900	3.5	180	670
Black Rock	1,296	11	370	2.9	95	274
Vincent	1,150	12	350	2.1	70	220
Felix	647	24	450	3.5	110	480
Kernville	340	17	600	1.25	54	190
Auburn	157	16	500	2.28	3	620

From: USGS, 1985

1.2.2.5 Water Supply

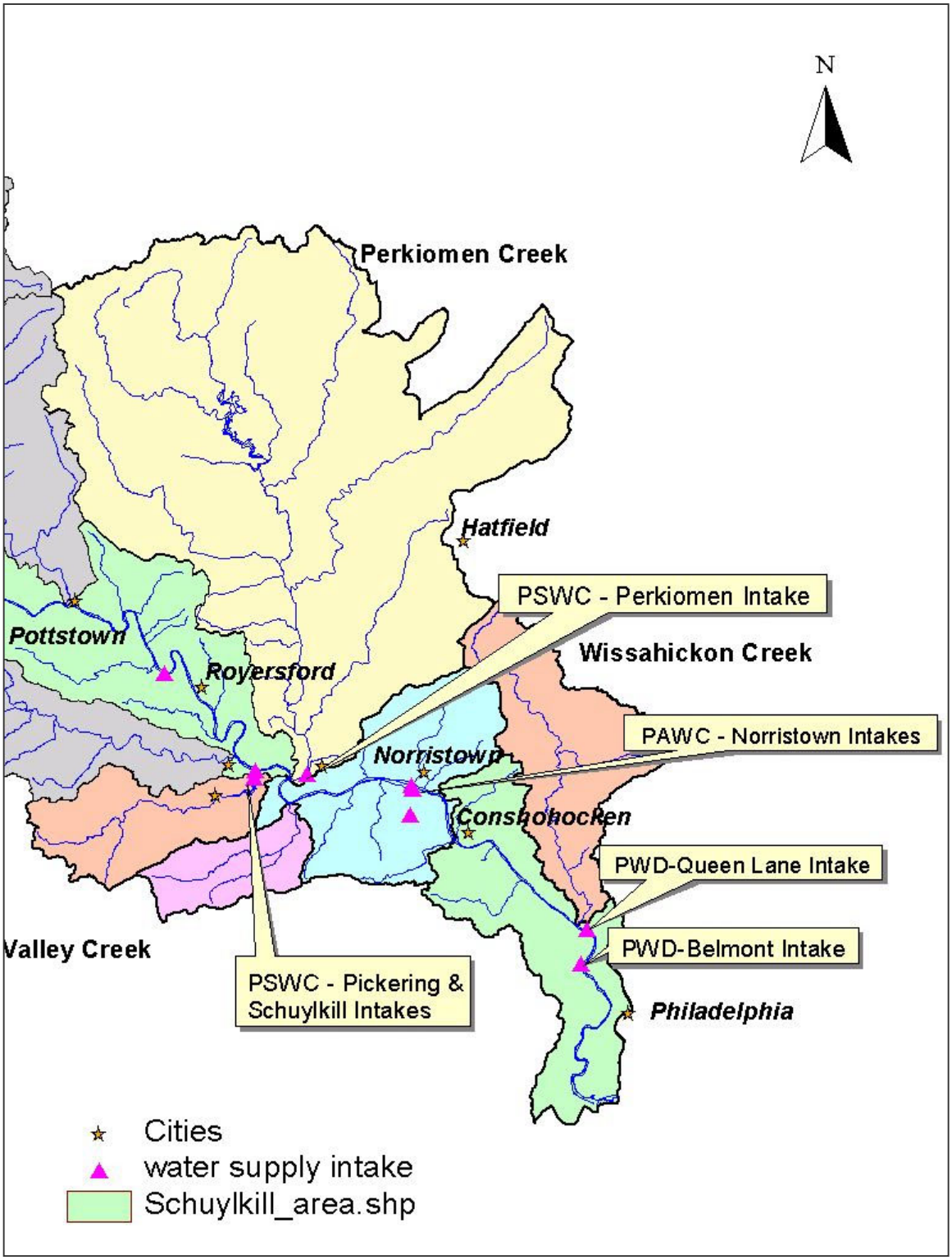
Philadelphia began using the Schuylkill River as a source of potable water supply in 1801. Today, a total of 265 million gallons of water is withdrawn from 57 surface water intakes located within the Schuylkill River Watershed each day to supply the needs of over 1.8 million people.

In colonial Philadelphia, the city's water supply was largely derived from wells. However, in 1793, a major yellow-fever epidemic and lack of water to cleanse streets or fight fires raised the awareness of the safeness of the city's water supply. In 1798, the city created the Joint Committee on Supplying the City with Water, also known as The Watering Committee. Philadelphia hired Benjamin Henry Latrobe to study the water supply and quality problem and to design a solution. He found that the city wells were contaminated by cesspools located too close to the public pumps and hydrants. Latrobe recommended the construction of a water supply and distribution system that would extract water from the Schuylkill River and distribute it throughout the city through mains constructed from bored logs and propelled by a combination of steam powered pump stations and gravity feed. In 1801, the first phase of the system and a pump house at Chestnut Street went into operation.

After several years of operation, continued improvements, and increased demand for water, the Watering Committee began to look for an alternative method to supply water to the city. The new facility included an intake from the fast flowing waters of the Schuylkill River, at what is currently the location of Fairmount Dam, a steam powered pump house, and a reservoir to store pumped water. The city began operation of these new facilities in 1815. By 1819, the city initiated plans to convert the steam engines to waterpower in conjunction with construction of the Fairmount Dam. The Fairmount Dam was completed in 1821 and the steam engines were replaced by water powered engines in 1822. Concurrently, the Flat Rock Dam was constructed upstream in Manayunk for the Schuylkill Navigation Company. The neoclassical Fairmount Waterworks building, reservoir, and gardens, as well as the water wheels and pumps, were a major attraction for visitors to Philadelphia. By the 1830s, this system had become the model water supply system for large urban centers in America and abroad. (Philadelphia Museum of Art, 1988)

Water supply intakes within the watershed are shown on Figure 1.2.2-2.

Figure 1.2.2-2 Locations of Water Supply Intakes in the Schuylkill River Basin



1.2.2.6 Historical Improvements in Source Water Quality

As advances were made to improve water supply to the growing region of Philadelphia, industrial development and population increased at a rapid rate along all stretches of the Schuylkill River, as did the amounts of waste discharged directly into the river. The dams on the Schuylkill River, which were constructed to facilitate transportation, provide hydropower, and secure water supply, interrupted the river's natural flow patterns and its assimilative capacity to handle the increasing amounts of pollution. This combination of activities began to adversely impact the city's source water quality as early as the 1800s.

For example, the Schuylkill Fishing Company, established in 1732, was a fishing society with a clubhouse at the foot of the falls near Fairmount. When the Fairmount Dam was constructed, the company moved to a point downstream, and approximately 90 years after its founding, it closed due to high pollution levels that destroyed fish populations in the tidal Schuylkill (Philadelphia City Planning Commission, 1982).

Pollution and silt accumulated in the Schuylkill River and posed a serious threat to the Philadelphia water supply. Prior to the turn of the 19th century, the Pennsylvania Board of Health had issued 111 orders to stop discharging untreated wastes between Reading and Philadelphia (Biesecker, 1968). Finally in 1945, legislation was passed to address two key issues: the accumulated silt which hampered navigation of the river and caused increases in flood events and flooded terrain, and the pollution from coal, industrial, and municipal wastes which threatened the ability of water treatment systems to provide pure water supplies. The Brunner Act, required the cessation of pollution from coal wastes entering the river and the Desilting Act provided for the removal and disposal of silt deposits in the waterway and on the banks from the headwaters to Norristown Dam (Biesecker, 1968).

1.2.3 Physiography, Geology and Soils

Key Points

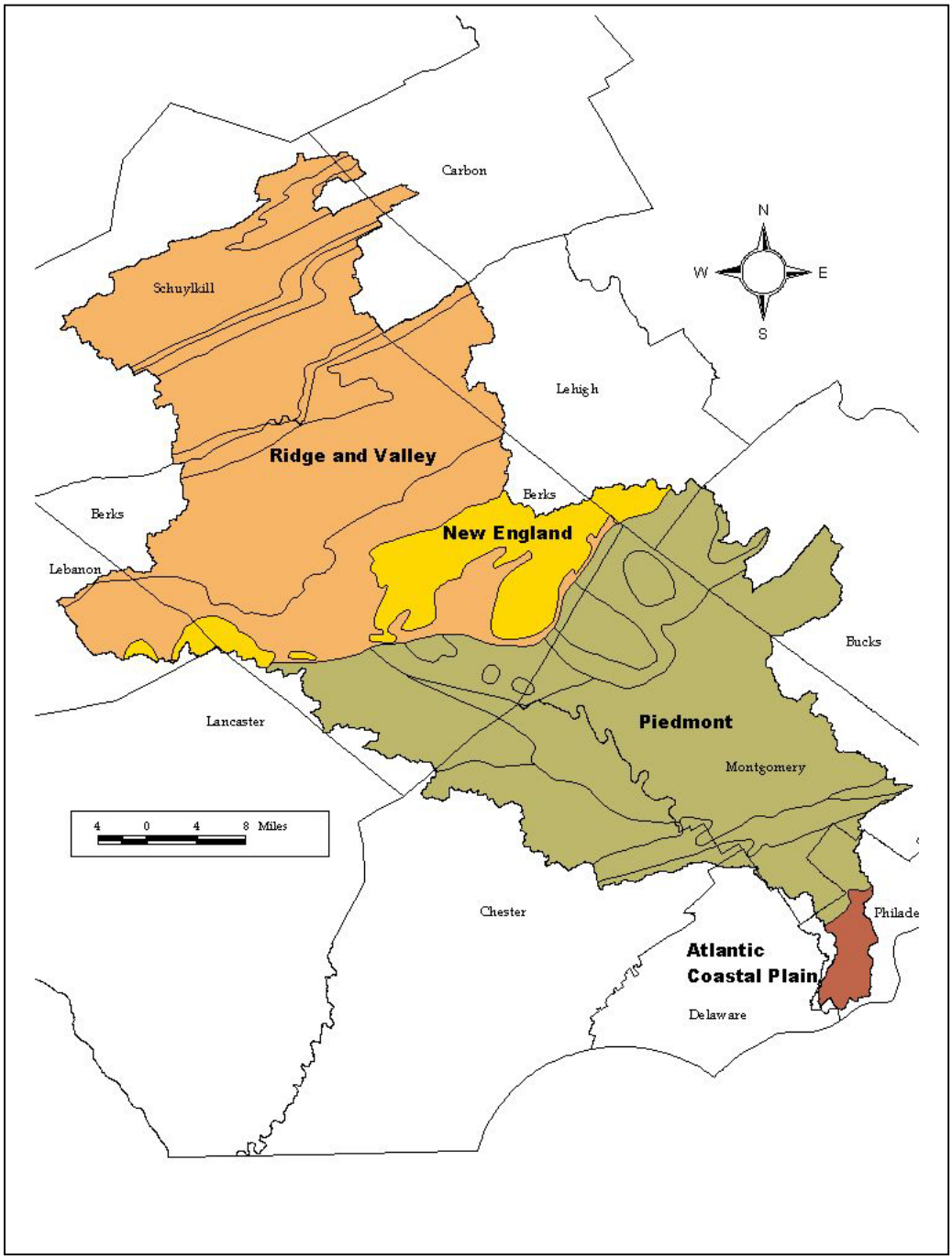
- **The Schuylkill River drains over 1900 square miles between its origins in the Appalachian Mountains and its confluence with the Delaware River.**
- **The Schuylkill River flows through the Valley and Ridge, New England, Piedmont and Atlantic Coastal Plain physiographic provinces.**
- **The physical properties of the soils in the Schuylkill River Basin determine their susceptibility to erosion.**

1.2.3.1 Regional Physiography

The Schuylkill River Basin is characterized by many diverse landforms and various physiographic provinces in southeastern Pennsylvania. It includes 12 major sub-watershed systems. The river has its origins in Schuylkill County in the Appalachian Mountains, and it drains over 1,900 square miles between the mountains and its confluence with the Delaware River at Philadelphia.

The Schuylkill River flows through four physiographic provinces. From upstream to downstream, they are the Valley and Ridge, New England, Piedmont and Atlantic Coastal Plain as shown on Figure 1.2.3-1. The Valley and Ridge Province is comprised of the mountains in the Appalachian Mountain section and rolling farmlands in the Great Valley. Elevations in the Valley and Ridge Province vary up to 1,800 feet above mean sea level (msl). The Appalachian Mountain section of the watershed is comprised the Blue Mountain Province, a long narrow mountain ridge separated by narrow and wide valleys. The Blue Mountain Province rises more than 1,200 feet above msl. The Great Valley lies south of Blue Mountain and consists of broad lowlands. The New England Province includes the Reading Prong, which is composed of the small mountains east of Reading. The Triassic Lowland of the Piedmont Province is characterized by rich farmland and low rolling hills, whereas the Piedmont Uplands include steep hills with urban development. The rolling hills of the Piedmont Province reach about 500 feet above msl. The Atlantic Coastal Plain Province is mainly lowlands with numerous streams and marshlands at about 100 feet above msl.

Figure 1.2.3-1 Physiographic Provinces of the Lower Schuylkill River Watershed



The headwaters drain approximately 300 square miles in the Appalachian Mountains and include the Valley and Ridge Province. The Appalachian Mountain section of the Valley and Ridge strata has been sharply folded along a northeast axis, and the more resistant sandstones and quartzites form prominent ridges that extend across the entire width of the basin, except where they are breached by the Schuylkill River and its major tributaries. This is a diverse, mountainous part of the basin with as much as 1,000 feet of relief between the ridges and the valley floors (USGS, 1985B). The Schuylkill and Little Schuylkill rivers cut through a series of valleys and ridges that run in a northeast-southwest direction. The valleys are narrow and surrounded by high, steep hills. A large part of the southern anthracite coal field is located in this province.

The river flows out of the Appalachian Mountain section at the water gap that forms the boundary between Schuylkill and Berks counties, and enters the Great Valley section. Rolling hills are the predominant landform in this section. Two major tributaries, Tulpehocken and Maiden creeks, drain virtually all the land in the Great Valley. Both of these tributaries enter the Schuylkill River just upstream of Reading.

Downstream of Reading, the river flows into the Triassic Lowland section of the Piedmont Province. This section is characterized by a broad, undulating plain with scattered rolling hills. Perkiomen Creek drains 362 square miles of land in this section. Other tributaries include Pigeon Creek, which drains 14 square miles, and French Creek, which drains 70 square miles. A slightly steeper section of the Piedmont, the Piedmont Upland, occupies the lower part of the Schuylkill River Basin. This is a hilly section of the province with narrow valleys and steep slopes. Wissahickon Creek, which drains 64 square miles, is the major tributary.

The last physiographic province found in the Schuylkill River Basin is the Coastal Plain. About 20 square miles of the basin are in this province, most of it is downstream of Fairmount Dam and the final water supply intakes in Philadelphia.

1.2.3.2 Subwatershed Physical Settings

Upper Schuylkill Subwatershed

The headwaters of the Schuylkill River drain approximately 270 square miles within Schuylkill County. This part of the basin is rough and mountainous with peak elevations of 1,000 feet. The valley and ridges are approximately east-west trending with the main valley and river cut narrowed by high, steep hills and ridges. A large portion of this drainage area includes the southern anthracite coal field. South of the coal field, the Schuylkill is joined by the Little Schuylkill River. This portion of the watershed lies in the Appalachian Mountain Province. Rock formations underlying this section of the watershed are sandstones and shales. The soils are characteristically well-drained or moderately well-drained shaly loan or silt loams located on slight to moderate slopes, and have a low to medium erosion potential, respectively (The Academy of Natural Sciences Patrick Center, the Natural Lands Trust, and the Conservation Fund, 2001).

From the confluence of the Little Schuylkill River, the Schuylkill flows through a gap in Blue Mountain, then across open rolling farmlands. This section of the river to the southern most portion of the watershed just south of Leesport lies in the Great Valley Province. Rock formations underlying this section of the watershed are sandstones, shales, and carbonate. The soils are well-drained silty loams with gravel and/or shale, and have a low to medium erosion potential (The Conservation Fund, 2000).

Little Schuylkill Subwatershed

The Little Schuylkill River's headwaters drain approximately 138 square miles. The Little Schuylkill River Watershed drains into the Schuylkill River just south of the coal fields. The entire watershed lies within the Appalachian Mountain Province. Rock formations underlying this section of the watershed are sandstones and shales. The soils are characteristically well drained or moderately well-drained shale loan or silt loams located on slight to moderate slopes, and have a low to medium erosion potential, respectively (The Conservation Fund 2000, Schuylkill RCP).

Maiden Creek Subwatershed

The headwaters of Maiden Creek lie in Lehigh County. This watershed drains into the Schuylkill River two miles south of Leesport. The majority of the watershed lies within the Great Valley Province with the southeastern portion in the Reading Prong section. Rock formations underlying the Great Valley section of the sub-watershed are sandstones, shales and carbonate. The soils are well-drained silt loams with gravel and/or shale, and have a low to medium erosion potential. Rock formations in the Reading Prong Province are mostly metamorphic and igneous rocks with some quartzite and limestone. The slopes in this region are very steep, and soils have a high erosion potential (The Conservation Fund, 2000).

Tulpehocken Creek Subwatershed

The headwaters of Tulpehocken Creek start in Lebanon County and join the Schuylkill River west of Reading. The drainage area is 216 square miles. The Tulpehocken Creek flows through the Great Valley Province. A small portion of the upper watershed area in Berks County lies in the Appalachian Mountain Province with the remainder in the Great Valley Province. In addition, a small portion of the southern stretch of the watershed lies in the Reading Prong Province. Rock formations underlying the Appalachian Mountain Province are sandstones and shales.
The soils are characteristically well drained or moderately well drained shaly loam or silt loams located on slight to moderate slopes, and have a low to medium erosion potential, respectively. Rock formations underlying the Great Valley section of the sub-watershed are sandstones, shales and carbonate. The soils are well-drained silty loams with gravel and/or shale, and have a low to medium erosion potential. Rock formations in the Reading Prong Province are mostly metamorphic and igneous rocks with some quartzite and limestone. The slopes in this region are very steep and soils have a high erosion potential (The Conservation Fund, 2000).

Middle Schuylkill Subwatershed

The Middle Schuylkill River is characterized as the length of the river between the confluences of Maiden Creek and Perkiomen Creek. This portion of the river flows through the Great Valley Province, then just south of Reading, it flows between the Reading Prong and South Mountain as the province changes to Triassic Lowlands. In this region, the Triassic Lowlands are characteristically rolling hills and fertile farm areas. In Berks County, there are several small tributaries to the Schuylkill River: Allegheny, Hay, Monocacy and Manatawny Creeks. Within Chester County the tributaries are French and Pickering Creeks.

Rock formations underlying the Great Valley section of the sub-watershed are sandstones, shales and carbonate. The soils are well-drained silty loams with gravel and/or shale, and have a low to medium erosion potential. Rock formations in the Reading Prong Province are mostly metamorphic and igneous rocks with some quartzite and limestone. The slopes in this region are very steep and soils have a high erosion potential. The Triassic Lowlands are comprised of mostly sedimentary rock formations including lava flow, sills, limestone, quartz, shale, sandstone, mudstone and siltstone. The soils are generally silt loams with gravel or shale and have a high to medium erosion potential (The Conservation Fund, 2000).

Perkiomen Creek Subwatershed

The mouth of Perkiomen Creek is approximately one mile north of Valley Forge. Perkiomen Creek is the largest tributary to the Schuylkill River with a drainage area of 362 square miles. This subbasin lies entirely in the Triassic Lowlands and is underlain by sedimentary rock formations. The Triassic Lowlands are comprised of several rock formations including lava flow, sills, limestone, quartz, shale, sandstone, mudstone and siltstone. The soils are generally silt loams with gravel or shale and have a high to medium erosion potential (The Conservation Fund, 2000).

Lower Schuylkill Subwatershed

Between the confluence of Perkiomen Creek and Norristown, the Schuylkill River lies within the Triassic Lowland and delineates the borders of Chester and Montgomery Counties. As the river flows through Norristown it passes into the Piedmont Uplands. In the Piedmont Uplands, a region of broad, rolling hills and valleys, the river crosses the Chester Valley, a narrow valley of low relief. Valley Creek, a small tributary to the Schuylkill in Chester County, lies in the Piedmont Uplands. The confluence with Valley Creek is just south of Perkiomen Creek's confluence with the Schuylkill River.

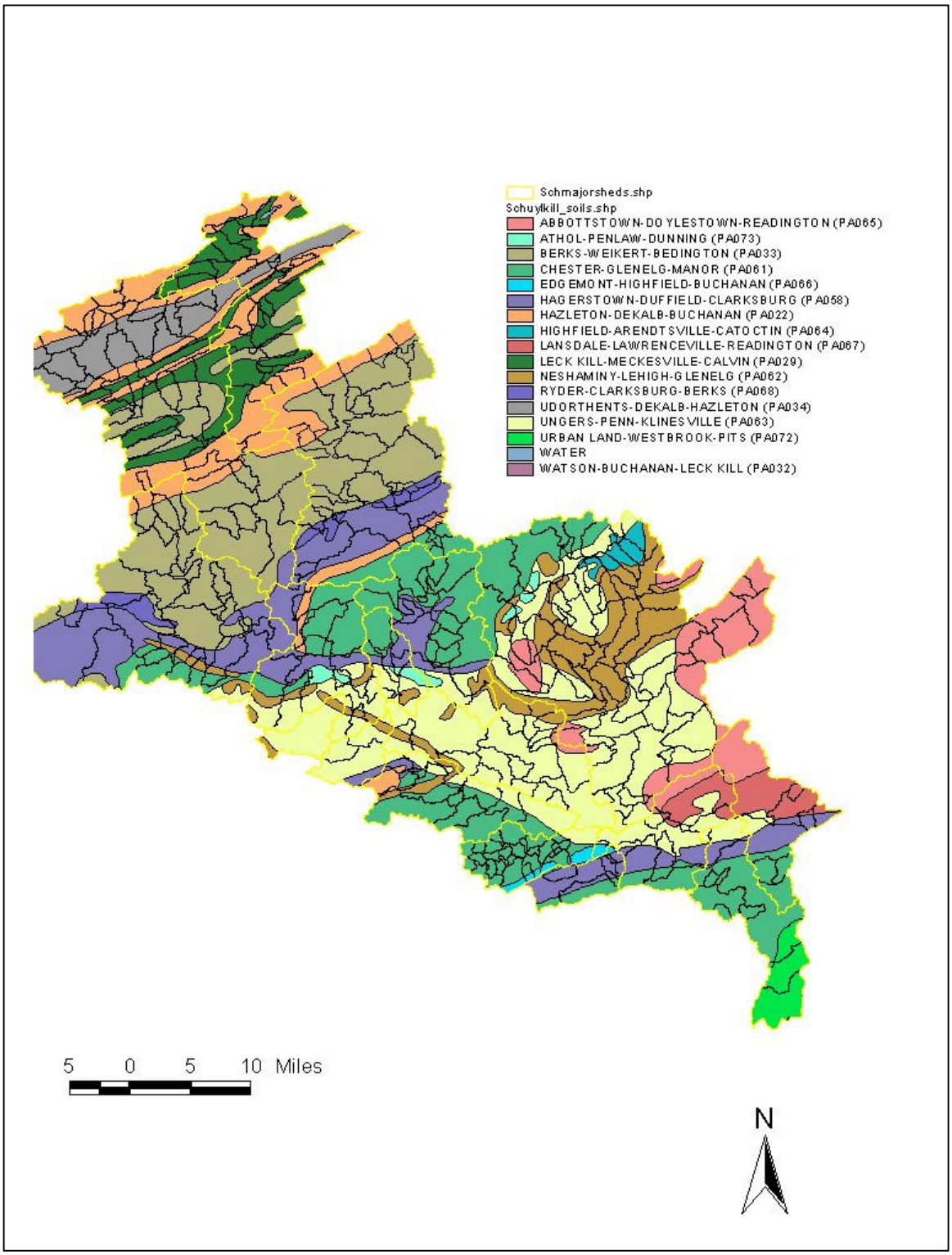
In Philadelphia County, the Wissahickon Creek Subbasin drains into the Schuylkill River south of Manayunk. Wissahickon Creek includes a drainage area of 63.8 square miles. Its headwaters are in Montgomery County in the Triassic Lowland and it flows through the Piedmont Uplands. South of the Wissahickon confluence, the Schuylkill River crosses the fall line and flows into the Atlantic Coastal Plain Province. The portion of the Schuylkill River below Fairmount Dam is an estuary with tidal fluctuations of about 5.5 feet.

The Triassic Lowlands are comprised of several rock formations including lava flow, sills, limestone, quartz, shale, sandstone, mudstone and siltstone. The soils are generally silt loams with gravel or shale and have a high to medium erosion potential. The Piedmont Uplands are underlain by metamorphic and igneous rocks with a surface of silt loam soils that have a low to high erosion potential. Rock formations in the Atlantic Coastal Plain are unconsolidated sediments including clays, sands, gravel and silt. Soils in this region are loams with some sand or gravel with medium to high erosion potential (The Conservation Fund, 2000).

1.2.3.3 Geology and Soils

The physical properties of the soils are the determining factor in the sediment-transport characteristics of the Schuylkill River and its tributaries. The soils, in turn, are determined by the geology and weathering processes of the rock material. Figure 1.2.3-2 displays the general distribution of soils and parent rocks in the Lower Schuylkill River Basin.

Figure 1.2.3-2 General Distribution of Soils and Parent Rocks in the Lower Schuylkill River Basin



Sandstones and shales primarily underlie the Appalachian Mountain section of the basin. The soils formed from these clastic rocks are generally very coarse soils formed on steep slopes. Many of the soils found in this area are classified as gravelly or stony loams. The section also contains a large part of the southern anthracite field. Much of the land surface in the coal field is occupied by strip mines, piles of unconsolidated overburden, or waste piles from coal breaker plants.

The soils of the Great Valley are formed in the residuum of shale and carbonate rocks. The northern part of the section is underlain by gray shale interbedded with sandstones, red shales and some limestones. The soils in this section are mostly stony loams and shaly, silty loams. As with the soils of the Appalachian Mountain section, erosion potential is reduced because of the size of the soil particles. The lower one-third of the Great Valley is underlain by various limestone and dolomite formations, and the soils formed from these rocks generally are silty loams. These soils are more subject to erosion because they are predominantly silts and clays.

Most soils formed in the Reading Prong section of the basin are silty loams or channery silty loams. They formed in material weathered from granitic gneiss and other metamorphic or igneous rocks that predominate in the section.

The Triassic Lowland section of the basin is underlain by several different geologic formations. The area south and west of the river, which includes the area drained by Pigeon and Angelica Creeks, is underlain by limestone conglomerates mixed with shales and sandstones. Deep, sandy loams and shaly soils are formed from these rocks. The area north and east of the river, which includes the area drained by the Perkiomen and Skippack Creeks and by part of the Manatawny Creek, is underlain by mudstones, reddish-brown shales, and siltstones. The shaly silt loams that form above the shales are shallow and subject to erosion.

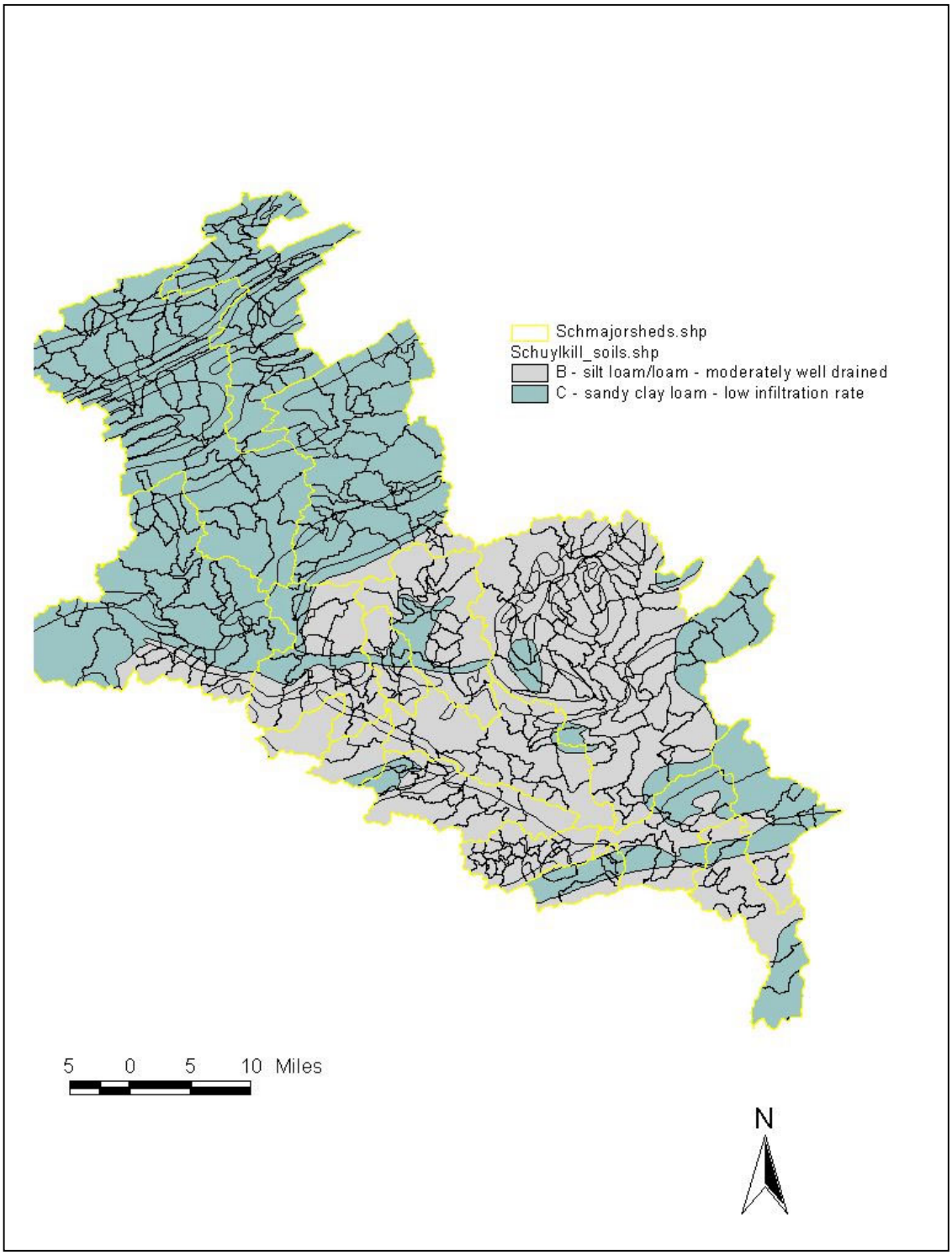
Silty loams are the dominant soils in the basin downstream from the Perkiomen Creek. The soils in the areas drained by Valley and Plymouth Creeks, and partially by Wissahickon Creek are underlain by a narrow band of limestone. The other tributaries in the lower basin are underlain by channery, silty loam soils formed in the residuum of mica, schist, and gneiss. Many of the soils in the lower basin are classified as urban land because the soil profile has been reworked during the cut-and-fill operations of construction projects. They generally have the same soil particle size distribution as the original silty loams.

New urban land or urban construction sites on Piedmont soils may contribute as much as 100 tons of sediment per acre each year (Yorke and Herb, 1978). Runoff from lawns, parking lots, and streets may contribute much of the trace metals and organic substances that enter the lower part of the Schuylkill River.

A majority of the soils in the Upper Watershed are comprised of the sandy clay loam type or Group C. Group C soils are of a moderately fine to fine texture and have low infiltration rates ranging between 0.13 and 0.38 centimeters per hour (cm/hour). The Middle Watershed is comprised of the silty loam and loam or Group B soils. These soils

are mainly moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have infiltration rates between 0.38 and 0.76 cm/hour. The Lower Watershed is comprised of both group B and C soils, as evidenced by Figure 1.2.3-3.

Figure 1.2.3-3 Soil Types in the Lower Schuylkill River Watershed



Comparing the infiltration rates, a well-drained Group B soil can infiltrate typical rainstorms that are less than 0.5 inches (1.27 cm) in less than two hours, whereas it takes the group C soils almost four hours to infiltrate the same amount of water. Lower infiltration rates increase the potential amount of runoff from the land and increase pollutant transport from streams to rivers. In addition, the topography or slope steepness in these areas also has significant impacts on pollutant transport.

Within the major hydrological classifications and groups of soils, there are 16 specific subtypes in the Schuylkill River Watershed. As shown in Table 1.2.3-1, these soil subtypes vary with location in the watershed, but mainly two or three types dominate within a given sub-watershed. In some cases, large portions of the watershed are one soil type. The Berks, Chester, Hagerstown, Hazelton, Neshaminy, and Ungers soil classifications define approximately 76 percent of the watershed soils. As shown in Table 1.2.3-1, these soils are generally well drained, generate moderate runoff during rain events, and are located on significant slopes. The only poorly-drained soil, the Abbottstown soil, is located in the headwaters areas of the Wissahickon and Perkiomen Creek watersheds.

Table 1.2.3-1 Prevalence of Various Soil Types in the Lower Half of the Schuylkill River Watershed (Pottstown to Philadelphia)

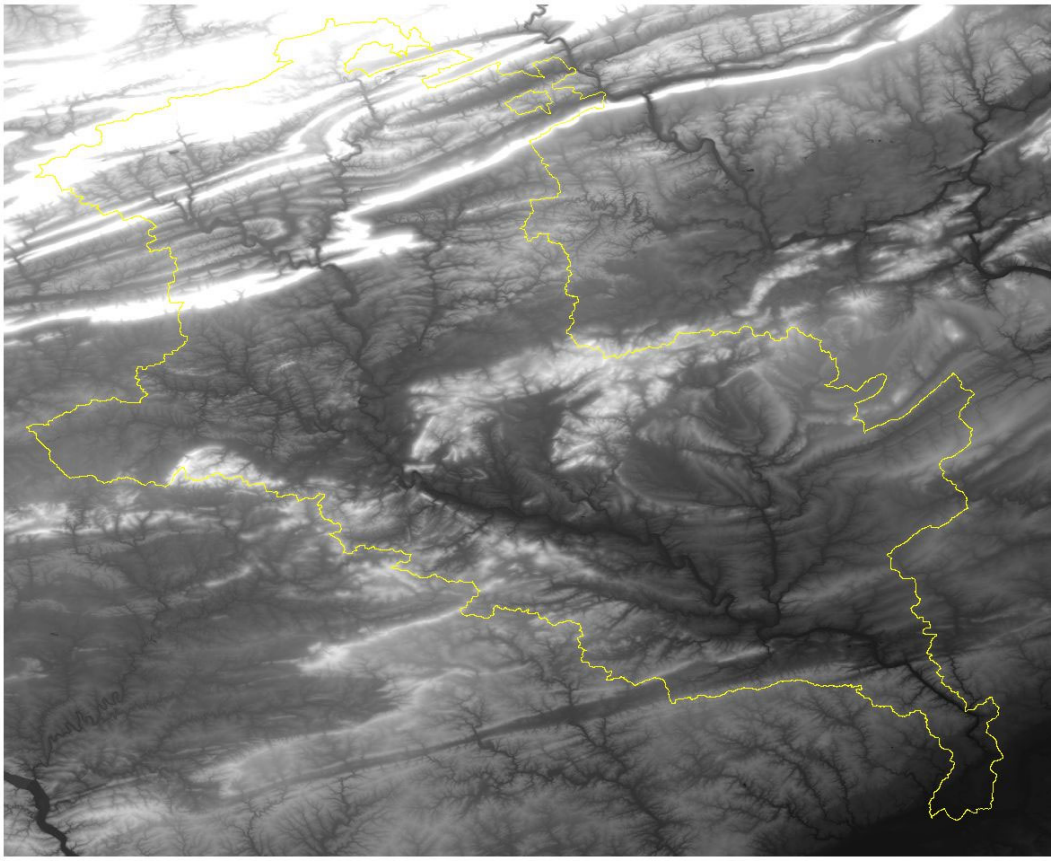
Soil Type	Percentage of Watershed	Slopes %	Permeability	Runoff	Drainage	Found on
Abbottstown-Doylestown-Readington (PA065)	13	0-15	Slow to moderate	Slow to medium	Poorly drained	Level to sloping concave upland flats, depressions and drainage ways
Athol-Penlaw-Dunning (PA073)	0	0-35	Moderate	Slow to rapid	Well drained	Level to moderately steep convex and dissected upland ridge tops and side slopes
Chester-Glenelg-Manor (PA061)	19	0-65 (mostly 3-10)	Moderate	Medium	Well drained	Upland divides and slopes
Edgemont-Highfield-Buchanan (PA066)	1	0-70	Moderate to moderately rapid	Rapid	Well drained	Sloping hills and ridges
Hagerstown-Duffield-Clarksburg (PA058)	6	0-45 (mostly 15)	Moderate	Moderate to rapid	Well drained	Valley floors and adjacent hills
Lansdale-Lawrenceville-Readington (PA067)	5	0-25	Moderate to moderately rapid	Moderate	Well drained	Rolling uplands
Neshaminy-Lehigh-Glenelg (PA062)	15	1 to 45	Moderately slow	Slow to very rapid	Well drained	Level to steep uplands
Ungers-Penn-Klinesville (PA063)	36	0-50	Moderate or moderately rapid	Medium to rapid	Well drained	Gently sloping to steep slopes

Note: Data from NRCS Official Soil Classifications and PASDA soil

These characteristics make runoff of persistent and conservative contaminants into the rivers and streams very possible if no management practices are in place. These attributes also affect the quantity of the runoff that may erode streambanks.

The general topography of the watershed can indicate where runoff issues may be important. Development on steeply sloping areas can create more of an impact on river water quality than development on gently sloped areas due to the potential to transport polluted runoff farther and faster. As shown in Figure 1.2.3-4 a digital elevation model demonstrates the elevations of the various areas of the watershed. The steep valley areas are where the color gradation changes quickly and dramatically. These would be considered sensitive areas where runoff from particular sources or activities could have a potentially significant impact on river or stream water quality. These are also areas that would be ideal for preservation and protection against development pressure to minimize future runoff issues.

Figure 1.2.3-4 Digital Elevation Model of the Lower Schuylkill River Watershed



1.2.4 Hydrology

Key Points
- Seasonal variations in Schuylkill River flow are driven by precipitation and evaporation.
- Only about half of the precipitation falling upon the Schuylkill River Drainage Basin reaches the river. The rest is lost to evaporation, transpiration and consumptive use.
- Over 75% of the total stream length within the Schuylkill River Watershed is comprised of first- and second-order streams.
- The physical properties of the soils in the Schuylkill River Basin determine their susceptibility to erosion.

The Schuylkill River Basin typically has humid climates with a wide range of both daily and annual temperatures. The physiographic features have a great effect upon the weather and climate of various areas within the basin. The tendency for equal lines of temperature is dependent on ground elevation and latitude. Greater temperature and precipitation variations are experienced in the Appalachian Mountain physiographic sections than in the Coastal Plain and Piedmont areas. The mean annual temperature in the watershed is 52°F; the winter and summer averages are 31°F and 72°F, respectively (Biesecker et al., 1968). Average annual precipitation ranges from 43 inches per year in the Coastal Plain area to 45 to 50 inches per year in the Appalachian Mountains.

Long-term historical data was initially assessed in order to gauge recent decade scale trends against the backdrop of natural regional variation in climate and hydrology. Monthly climate data based on a regional composite index developed by the National Climatic Data Center (NCDC) are available from 1895 through the present day. Historical climate data has been further summarized here by calculating annual totals for precipitation and averages for temperature based on monthly figures.

Annual precipitation in the Philadelphia area has shown a steady increase through the 1900s, with an extended period of drought in the 1960s. Precipitation was high in the 1970s and has most recently varied around the long-term mean for annual precipitation. Annual temperatures in the region have not shown such a strong trend over the entire century, although temperatures appear to have increased dramatically over the first half of the century, while decreasing since then, as shown by Figure 1.2.4-1.

Assessments of historical flow in the Schuylkill River, measured as daily averaged flow at the Fairmount Dam, indicate an increase in stabilization of flow over the recent past, particularly from 1970 through the present, as shown on Figure 1.2.4-2. Average daily flows prior to 1970 dropped below 100 cubic feet per second (CFS) at Philadelphia in eleven summers, but this has not occurred since 1966.

Recent decade scale patterns in climate and river flow for the region were also assessed to ascertain direct connections between these parameters and Philadelphia Water Department (PWD) intake water quality data. Monthly data for precipitation through

the 1990s indicates extended dry periods through 1991 and 1997, along with severe short-term drought from May through July 1999 as illustrated by Figure 1.2.4-3. February has been particularly dry through the period, while the August average has been unusually high for summer months. Departures from monthly averages indicate variation from mean precipitation levels and are often a better indicator of climatic condition than are absolute values of precipitation.

Figure 1.2.4-1 Long Term Average Annual Temperature at Philadelphia

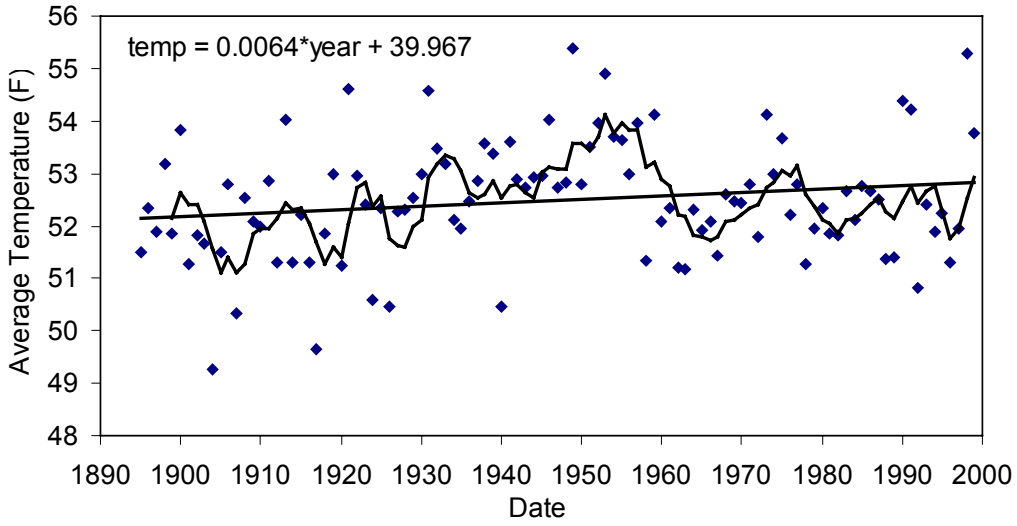


Figure 1.2.4-2 Long-Term Average Annual Temperature at Philadelphia

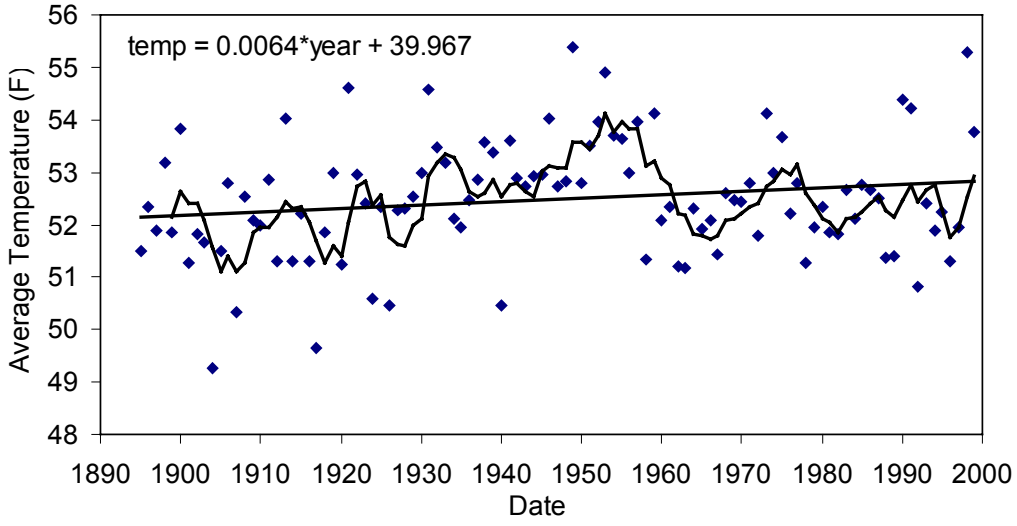
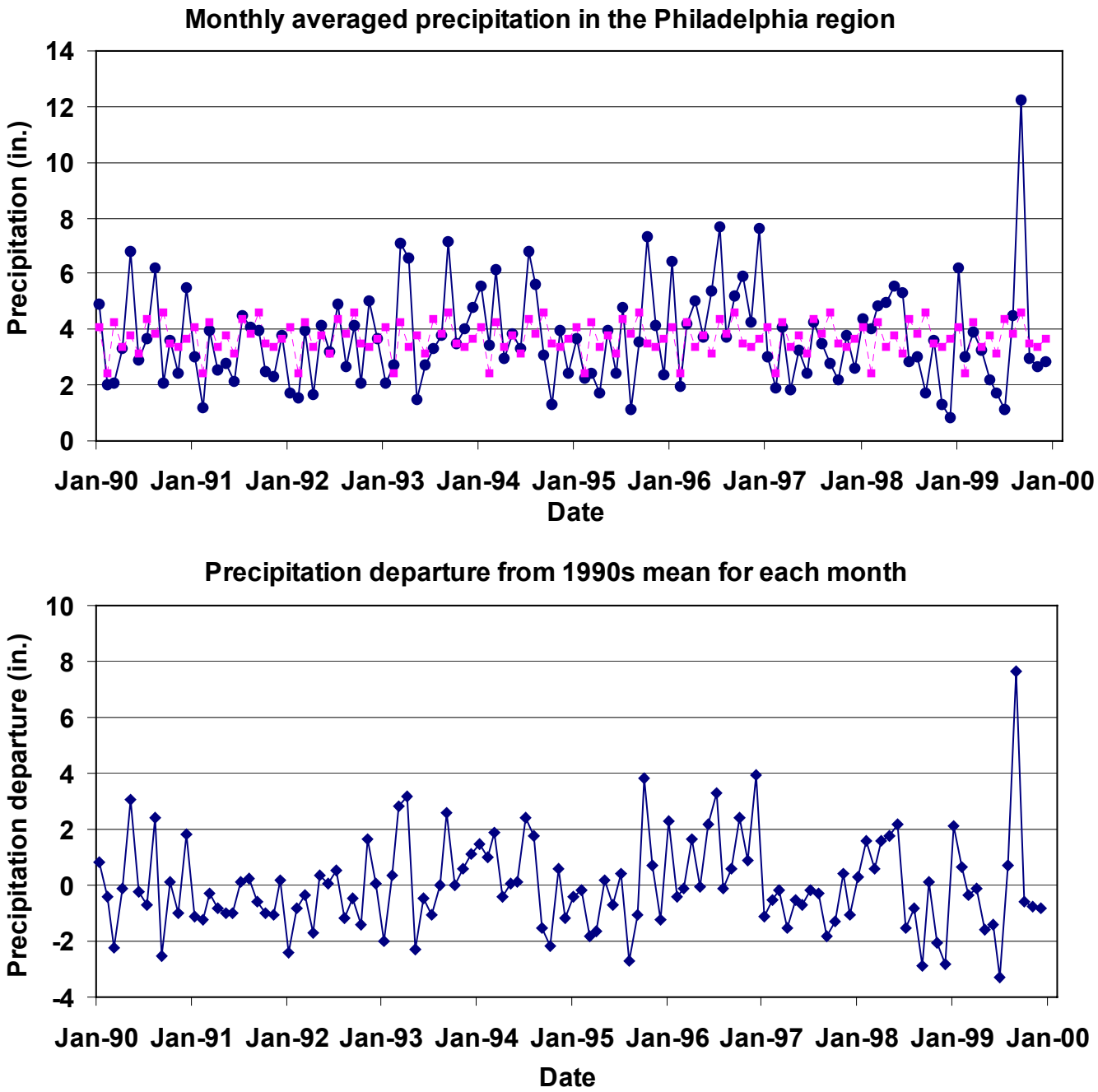


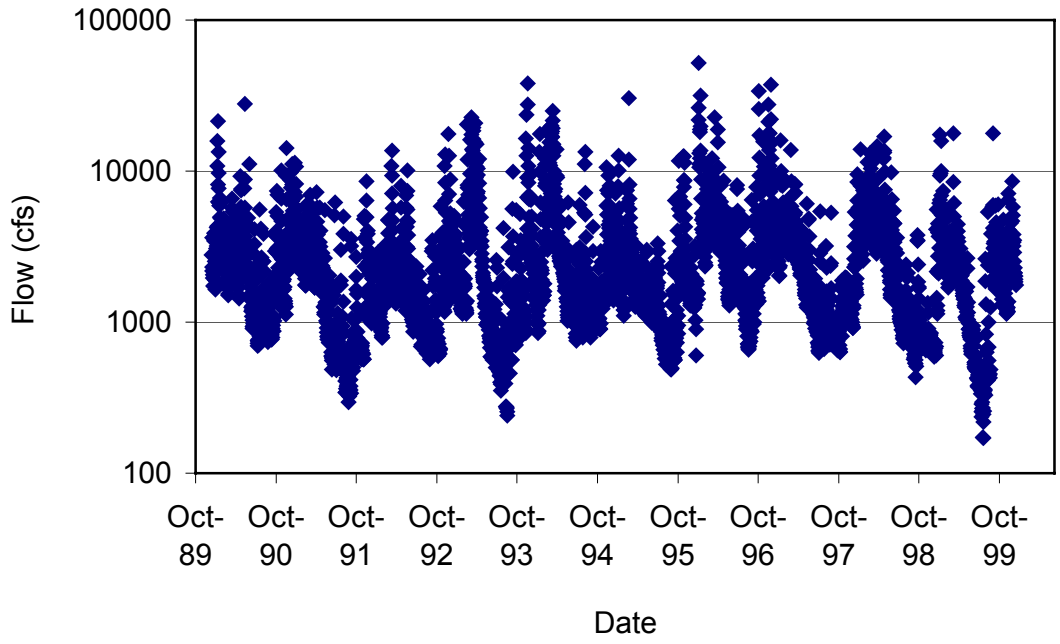
Figure 1.2.4-3 Precipitation trends in Southeastern Pennsylvania through the 1990's

Small squares in top panel indicate 1990's monthly flow averages. Deviation from monthly averages indicates interannual trends toward particularly wet or dry weather. Averages are calculated by calendar month, so deviation in January, for instance, is the difference between the 1990's average January precipitation, and that occurring in a given year.



Average annual Schuylkill River flow at Philadelphia is 2,721 CFS. Daily average Schuylkill River flow at Fairmount Dam through the 1990s is summarized in Figure 1.2.4-4 and indicates extremely low flow conditions in summer 1999, with less-pronounced low flow occurring in 1991 and 1993. Lowest flows through the decade were not always associated with extended low levels of summer precipitation, suggesting that evaporation, groundwater storage, and surface water removal are important components in the water budget of the region. Based on monthly averages, no long-term temporal trends in flow were evident through this period (n = 120, Rho = -0.013, P = 0.884 for non-parametric rank order regression).

Figure 1.2.4-4 Daily Average Schuylkill River Flow through the 1990's



Seasonal variation is driven primarily by precipitation, which is highest in spring, and evaporation, which is highest in summer months. Lowest flows occurred in 1993 and 1999. Minimum flows are consistently higher through the 1990s than earlier in the century (see Figure 1.2.4-2).

1.2.4.1 Surface Water

Runoff in the Schuylkill River Basin has a distinct seasonal variation. The most runoff occurs during winter or early spring, and the lowest amount of runoff occurs during the late summer or early fall. Runoff is chiefly dependent on the amount of rainfall that a

specific area receives; after the winter months, the accumulated snow melts in the early spring creating additional runoff. During the dry late summer months, there is very little runoff.

In the Schuylkill River Basin, Tamaqua, which is in the Appalachian Mountains, receives the most precipitation and runoff, and runoff decreases with the amount of precipitation from north to south. As a result of loss of precipitation by evaporation, transpiration, and consumptive use, only about half of the precipitation falling within the watershed reaches surface waters.

Pollution has been a serious problem in the Schuylkill River Basin for many years. Mine drainage in the headwaters has exacerbated the water quality problems caused by domestic waste discharge, because the resulting toxic environment inhibits stream self-purification. The microorganisms that would normally oxidize the organic wastes are either destroyed or hindered by the acidic environment produced by mine drainage. Thus, the organic waste is preserved until the stream environment becomes favorable for microbiological activity. Below the confluence of the Schuylkill River and Maiden and Tulpehocken creeks, stream conditions are favorable for development of decay organisms.

Table 1.2.4-1 summarizes the locations, drainage areas, annual mean flows, and annual runoff at 21 gauging stations along the Schuylkill River. The first gauging station listed is the northernmost one located along the Little Schuylkill River. The last gauging station on the chart is located along the lower portion of the Schuylkill River.

Table 1.2.4-2 and Figure 1.2.1-1 describe the size and location of the various tributaries and drainage areas within the Schuylkill River Basin. As shown, the Perkiomen and Tulpehocken creeks are the largest tributaries discharging to the Schuylkill River and can have significant impacts on Schuylkill water quality.

Table 1.2.4-1 Stream Gauging Data in the Schuylkill River Basin

Station ID	Location	Drainage Area (mi^2)	Period of Record	Annual Mean Flow (cfs)	Annual Runoff (Inches)	10% Exceeds (cfs)	50% Exceeds (cfs)	90% Exceeds (cfs)
01468500	Schuylkill at Landingville	133	1947-1953 1963-1965 1973-1999	278	28.43	560	195	75
01469500	Little Schuylkill at Tamaqua	43	1933-1999	84.2	N/A	177	51	13
01470500	Schuylkill at Berne	355	1947-1999	716	27.41	1480	450	158
01470779	Tuplehocken Creek Near Bernville	67	1975-1999	108	22.13	183	85	43
01470853	(1)Furnace Creek at Robesonia	4	1983-1999	6.87	22.33	14	4.7	1.4

Station ID	Location	Drainage Area (mi^2)	Period of Record	Annual Mean Flow (cfs)	Annual Runoff (Inches)	10% Exceeds (cfs)	50% Exceeds (cfs)	90% Exceeds (cfs)
01470960	Tuplehocken Creek at Blue Marsh Dam	175	1979-1999	273	N/A	539	174	65
01471000	Tuplehocken Creek Near Reading	211	1980-1999	320	N/A	625	213	83
01471510	Schuylkill River at Reading	880	1977-1999	1630	N/A	3330	1070	400
01471875	Manatawny Creek Near Spangsville	57	1993-1999	91	21.73	171	58	22
01471980	Manatawny Creek Near Pottstown	86	1974-1999	131	20.86	243	85	34
01472000	Schuylkill River at Pottstown	1147	1928-1999	1909	N/A	3860	1300	473
01472157	French Creek Near Phoenixville	59	1969-1999	89	20.47	170	56	20
01472198	Perkiomen Creek at East Greenville	38	1982-1999	60.4	21.59	115	37	15
01472199	West Branch Perkiomen at Hillegrass	23	1982-1999	38.1	22.43	74	23	7.9
01472620	East Branch Perkiomen Near Dublin	4	1990-1999	41.2	N/A	62	42	13
01472810	East Branch Perkiomen Near Schwenksville	59	1991-1999	126	N/A	191	72	48
01473000	Perkiomen Creek at Graterford	279	1957-1999	411	N/A	831	180	60
01473169	Valley Creek Near Valley Forge	21	1983-1999	32.3	21.09	52	23	15
01473900	Wissahickon Creek at Fort Washington	21	N/A	N/A	N/A	N/A	N/A	N/A
01474000	Wissahickon Creek Mouth at Philadelphia	64	1966-1999	104	22.02	177	60	28
01474500	Schuylkill River at Philadelphia	1893	1932-1999	2721	N/A	5850	1670	430

Table 1.2.4-2 Characteristics of Tributaries in the Schuylkill River Watershed (from Bottom of Watershed to Top of Watershed by River Mile Location)

Major Subwatershed	Drainage Area (mi^2)	River Mile Location	Length (mi)
Lower Schuylkill (Philadelphia-Conshocken)*	69.6	<20.5	20.5
Wissahickon Creek	63.6	12.8	24.2
Middle Schuylkill 1 (Norristown - Valley Forge)*	64.8	20.5-32	11.5
Valley Creek	23.3	30.6	10.4
Middle Schuylkill 2 (Phoenixville-Pottstown)*	103.0	32-63	31
Perkiomen Creek	366.3	32.3	37.8
Pickering Creek	38.8	34	14.8
French Creek	70.1	35.6	23
Manatawny Creek	91.5	54.2	23.7
Monocacy Creek	25.8	60.6	12
Middle Schuylkill 3 (Douglassville - Reading)*	98.1	63-86	23
Hay Creek	22.1	63.1	12.1
Allegheny Creek	17.9	67.7	11
Tulpehocken Creek	219.2	76.8	37.6
Maiden Creek	216.0	86.7	29.3
Little Schuylkill River	136.8	102.1	34.2
Upper Schuylkill	287.6	>135	49

**These watershed boundaries were selected for the purpose of the study.*

Table 1.2.4-3 provides information about the characteristics of the reservoirs in the watershed. As shown, the detention time in these reservoirs is significant, which impacts both water quality and zone delineation boundaries.

Table 1.2.4-3 Reservoir Characteristics in the Schuylkill River Watershed

Water Body	Average Width	Average Depth	Surface Area	Length	Volume (billions of gallons)	Detention Time
Pickering Creek	460 ft	11 ft *	4,804,020 sq ft 0.1723 sq miles	9,395 ft 1.78 miles	0.4	34 days
Green Lane Reservoir	888 ft	16.4 ft *	43,302,856 sq ft 1.5533 sq miles 996.0 acres	74,648 ft 14.14 miles	4.4 *	62 days 0.12 years or 44.2 days (dry)
Blue Marsh Lake	1073 ft	20.5 ft **	1150 acres ** 1.57 sq miles*** 1012 acres***	42,240 ft ** 63,805 ft *** 12.1 miles***	7.7 **	0.08 years (dry weather) or 30 days (wet weather)
Lake Ontelaunee	1331 ft	7.2 ft **	1100 acres** 1.61 sq miles*** 1031.4 acres ***	29,354 ft *** 5.5 miles***	3.3 **	22.8 days **

** Data from Philadelphia Suburban Water Company*
*** Data obtained from technical reports*
**** Data obtained from GIS analysis*

"Stream order" is an indicator of the relative size and location of a stream within a watershed. According to Leopold (1994), stream order is a "measure of the position of a stream in the hierarchy of tributaries". First-order streams are small streams with no tributaries. Second-order streams are formed by the confluence of two first-order streams. The tributaries of second-order streams are all first-order streams. When two second-order streams flow together, they form a third-order stream, that may have both first- and second-order streams as tributaries. When two third-order streams meet, they form a fourth-order stream and so on. In general, stream flow, velocity, width and depth increase with increasing stream order, while the gradient of the streambed decreases. Table 1.2.4-4 summarizes the length of streams within the Schuylkill River Watershed by stream order. More than 75% of the total stream length within the Schuylkill River Watershed is comprised of first- and second-order streams.

Table 1.2.4-4 Summary Length by Stream Order for the Schuylkill River Watershed

Stream Order	Kilometers	Percent of Streams
1	2476.58	56.56%
2	863.56	19.72%
3	459.85	10.50%
4	298.68	6.82%
5	124.74	2.85%
6	103.89	2.37%
7	51.34	1.17%

Source: Schuylkill River Conservation Plan (Conservation Fund), 2001

1.2.4.2 Flooding

The three branches of the Schuylkill - the West Branch, the main stem, and the Little Schuylkill River - traverse the basin above Blue Mountain. In August 1955, the greatest flooding event occurred along the Little Schuylkill River. This destructive flood was especially damaging to the Tamaqua area because Tamaqua was built in a narrow valley, and the streams that flowed through the city were overwhelmed by runoff. From Blue Mountain downstream to Reading, the flood plain was generally unoccupied. Between Reading and Philadelphia, the flood plain was occupied mostly by commercial and industrial establishments, which suffered nearly 70% of the total flood damage in that event. Within this area, the most extensive damage occurred throughout Reading, Birdsboro, Pottstown, Norristown, Conshohocken, Manayunk, and Philadelphia. In 1958, the damage from the 1955 flood was estimated to be $1,295, 000.

Tulpehocken Creek is host to Blue Marsh Lake, which has a volume of 7.7 billion gallons and is a man-made reservoir maintained and operated by the Army Corps of Engineers near the town of Reading. Other reservoirs/lakes are located within the Schuylkill River

Basin. Lake Ontalaunee, a man-made reservoir maintained and operated by the Reading Water Authority, is the primary source of water for the City of Reading.

1.2.4.3 Groundwater

There are four principal groups of aquifers in the Schuylkill River Basin: unconsolidated deposits, crystalline rocks, carbonate rocks, and clastic rocks. The best areas for large supplies of groundwater are the areas underlain by carbonate rocks in the Great Valley and the areas underlain by unconsolidated deposits in the Coastal Plain. The basin contains a wide range of rock types, as shown in Figure 1.2.3-2, impacting the capacity to store and transmit water.

All aquifers in the Schuylkill River Basin are composed of consolidated rocks, with the exception of the Coastal Plain deposits in Philadelphia and the thick, weathered mantle in a few isolated areas. Groundwater can occur under water table or artesian conditions. Water table conditions are much more common within the Schuylkill River Basin. Below the water table, the spaces between the soil particles can store or transmit water. These areas have high porosities and permeabilities. The consolidated rocks have very little porosity, except for a few of the coarse sandstone beds, and their ability to store and transmit water is small. In most aquifers throughout the basin, water moves through and is stored in openings developed along joints, fractures, faults, and cleavage and bedding planes in the rock. These conditions were formed when rocks were stressed by movements in the earth's crust, and they may be enlarged by solution, earthquakes, and earth tides.

The bedding thickness is probably not an important factor in the permeability of carbonate rocks. Chemical weathering along the fractures is a more important factor, as it enlarges the fractures so that they are large enough to transmit water. A zone of weathered rock underlies the land surface throughout the basin. The thickness of this zone ranges from a few feet to more than 100 feet over some of the limestone terrain. Weathered rock has a higher porosity than unweathered rock, and where it does not contain large amounts of clay, it may have a high permeability.

Groundwater flows with very low velocities. Water that reaches the water table is in contact with the rocks of the aquifer for a much longer time than it is in contact with the atmosphere or soil. Therefore, much of the dissolved solids in groundwater is derived from aquifers, as contact time between the water and the rock increases, the mineral content of the water also increases to the saturation point. Groundwater in many areas may be contaminated by on-site disposal of domestic waste.

1.2.4.3.1 Stressed Groundwater Areas

In 1999, The Delaware River Basin Commission (DRBC) adopted regulations that establish groundwater withdrawal limits for 76 watersheds that fall either entirely or partly within the Groundwater Protected Area of Southeastern Pennsylvania.

The Protected Area, where more stringent regulations apply to groundwater withdrawals than they do in the rest of the Delaware River Basin, was established by the

commission in 1980 at the request of the Commonwealth of Pennsylvania after it became evident that development was negatively impacting groundwater levels. The goal is to prevent depletion of groundwater and to protect the interests and rights of lawful users of the same water source, as well as balance and reconcile alternative and conflicting uses of limited water resources in the region.

Declining water tables in the Protected Area have reduced flows in some streams that are groundwater fed, resulting in some stream beds that are totally dry. This reduction in baseflows affects downstream water uses, negatively impacts aquatic life, and can reduce the capacity of waterways in the region to assimilate pollutants.

The Protected Area uses a two-tiered system of water withdrawal limits. The first tier serves as a warning that a subbasin is "potentially stressed". The second tier establishes a maximum groundwater withdrawal limit. In potentially stressed subbasins, applicants for new or expanded groundwater withdrawals are required to implement one or more programs to mitigate adverse impacts of additional groundwater withdrawals. Acceptable programs include conjunctive use of groundwater and surface water, expanded water conservation programs, programs to control groundwater infiltration, and artificial recharge and spray irrigation.

The Ground Water Protected Area Regulations for Southeastern Pennsylvania also:

- Provide incentives for holders of existing DRBC dockets and Protected Area permits to implement one or more of the above programs to reduce the adverse impacts of their groundwater withdrawals. If docket or permit holders successfully implement one or more programs, the commission will extend the docket or permit duration for up to ten years

- Specify criteria for the issuance and review of dockets and permits as well as procedures for revising withdrawal limits to correspond with integrated water resource plans adopted by municipalities for subbasins

- Establish protocol for updating and revising withdrawal limits to provide additional protection for streams designated by the Commonwealth of Pennsylvania as "high quality," or "wild, scenic, or pastoral," as defined by the state's Scenic Rivers Program.

The Ground Water Protected Area includes 1,200 square miles and 127 municipalities. In addition to the Neshaminy Creek Watershed, other large drainage areas include the Brandywine Creek, Perkiomen Creek, and Wissahickon Creek subbasins.

In addition to all of **Montgomery County**, the following areas in surrounding counties fall within the Protected Area:

Berks: the townships of Douglass, Hereford, and Union.

Bucks: the townships of Bedminster, Buckingham, Doylestown, East Rockhill, Hilltown, Lower Southampton, Middletown, Milford, New Britain, Newtown, Northampton, Plumstead, Richland, Upper Southampton, Warminster, Warrington, Warwick, West Rockhill, and Wrightstown; the boroughs of Chalfont, Doylestown, Dublin, Hulmeville, Ivyland, Langhorne, Langhorne Manor, New Britain, Newtown, Penndel, Perkasie, Quakertown, Richlandtown, Sellersville, Silverdale, Telford, and Trumbauersville.

Chester: the townships of Birmingham, Charlestown, East Bradford, East Coventry, East Goshen, East Pikeland, Easttown, East Vincent, East Whiteland, North Coventry, Schuylkill, South Coventry, Thornbury, Tredyffrin, Warwick, West Bradford, West Goshen, Westtown, Willistown, and West Whiteland; the boroughs of Elverson, Malvern, Phoenixville, Spring City and West Chester.

Lehigh: Lower Milford Township.

1.2.4.4 Water Usage

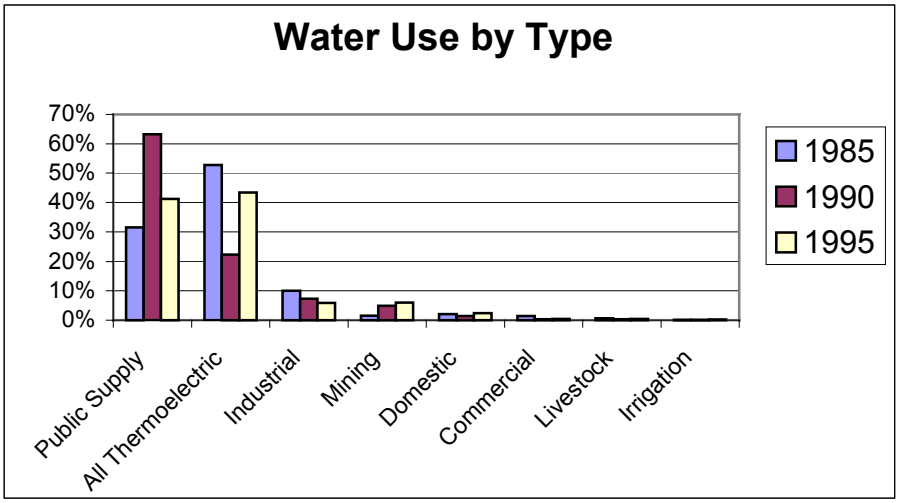
The amount of water withdrawn from the Schuylkill River Watershed is substantial and can influence water quality. USGS estimates that over 669 million gallons of water are withdrawn per day from the Schuylkill River Watershed. Over 76% of that water is withdrawn from surface sources such as streams, lakes, reservoirs, and the river itself. Most of the water withdrawn from the watershed is used for water supply and thermoelectric power for cooling (see Table 1.2.4-5 and Figure 1.2.4-5).

Table 1.2.4-5 Water Withdrawn per Day in the Schuylkill River Watershed 1985-1995 (source USGS)

	1985	1990	1995
Groundwater	96.89	219.26	127.02
Surface Water	572.15	683.3	603.62
Total	669.04	902.56	730.64

Withdrawals are Shown in Millions of Gallons Per Day

Figure 1.2.4-5 Amount of Water Withdrawal from the Schuylkill River Watershed by Use



Over 1.7 million people are supplied with surface water withdrawn from the Schuylkill River and its tributaries. As shown in Figures 1.2.4-6 and 1.2.4-7, the Philadelphia Water Department, Philadelphia Suburban Water Company, and Pennsylvania American Water Company withdraw over 80% of the water supplied for potable use and almost 75% of the population serviced from the surface supplies of the Schuylkill River Watershed.

Figure 1.2.4-6 Percentage of Surface Water Withdrawn from the Schuylkill River Watershed by Water Suppliers

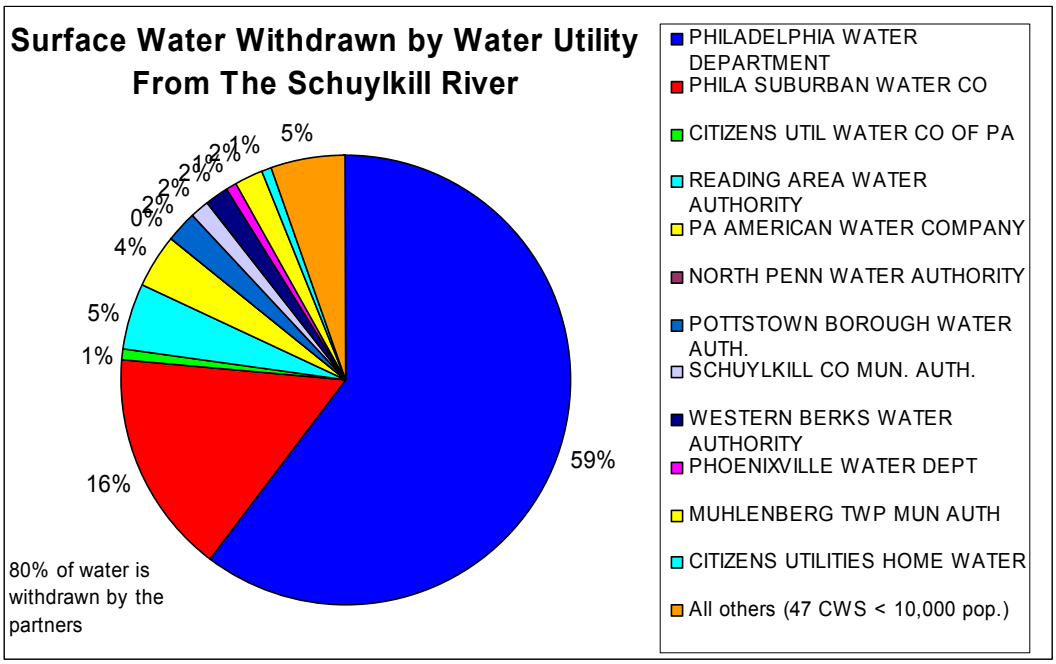
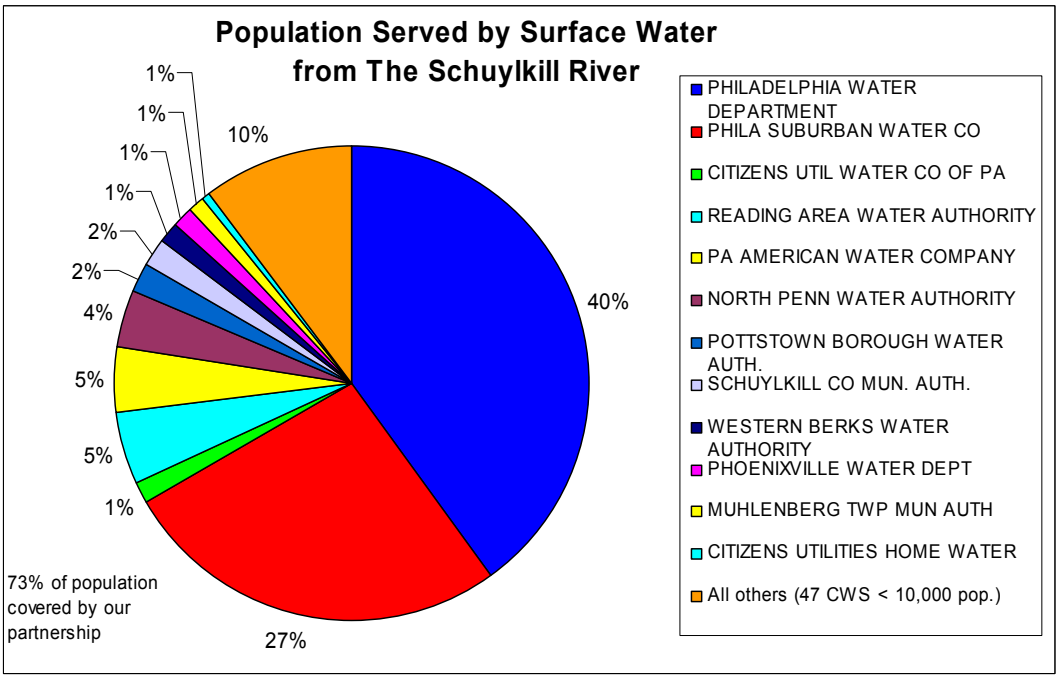


Figure 1.2.4-7 Percentage of Population Supplied from the Schuylkill River Watershed by Water Suppliers



1.2.5 Land Use in the Schuylkill River Watershed

Key Points

- Studies indicate that the amount of developed land within the Schuylkill River Watershed ranges between 14 and 30 %.
- Recent land use studies have concluded that the amount of developed land within the Schuylkill River Watershed is increasing, as agricultural and forested lands decrease.
- The developed land areas are found mainly in the lower watershed, near major cities or transportation corridors.

Parts of 11 counties are located within the Schuylkill River Watershed. Of these 11 counties, only 4 (Berks, Chester, Montgomery, and Schuylkill counties) have nearly 10% or more of the watershed within their boundaries (Figure 1.2.5-1) Berks, Chester, and Montgomery counties represent nearly 70% of the land area in the Schuylkill River Watershed. Berks County itself comprises 40%, or 750 square miles, of the watershed, and is almost completely within the watershed boundaries, suggesting that land use activities within the county can have significant impacts on river water quality. More than 80% of the total land area of Berks and Montgomery counties lies within the watershed, as shown in Figure 1.2.5-2. Between 10 and 40% of Schuylkill, Philadelphia, Chester, Lehigh, and Bucks counties are within the Schuylkill River Watershed.

Figure 1.2.5-1 Percentage of Land Area in the Schuylkill River Watershed within Each County

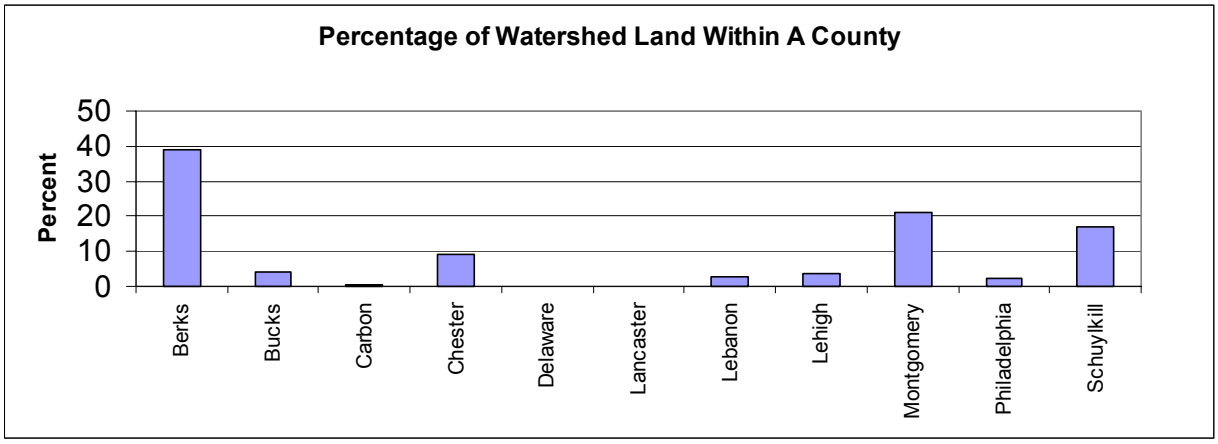
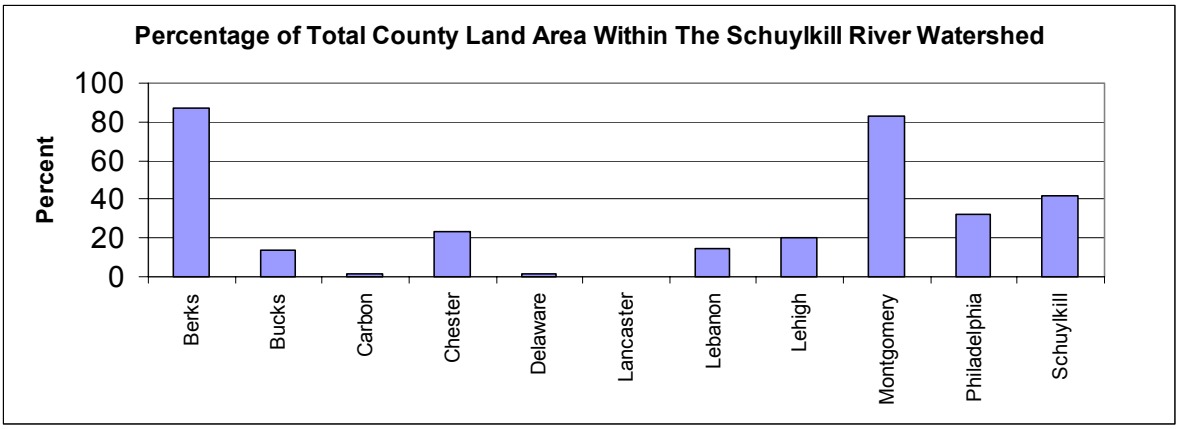


Figure 1.2.5-2 Percentage of Total County Land Area within the Schuylkill River Watershed



Philadelphia County, located at the downstream end of the watershed, includes only two percent of the watershed land area, but represents the single largest population and water supply withdrawal in the watershed. Bucks, Montgomery, Chester, and Delaware counties, which border Philadelphia, are in the middle of the watershed and represent suburban areas surrounding the city with varying amounts of development. Berks, Carbon, Lebanon, Lehigh, and Schuylkill counties make up the upper reaches of the watershed and are the least developed areas within it.

Land use characterization of the Schuylkill Watershed included a review of the United States Department of Agriculture (USDA), Delaware Valley Regional Planning Commission (DVRPC), and the United States Geologic Survey (USGS) data inventories. Development of these three characterizations of land use within the watershed differed in approach, and hence, yielded different assessments of land use. However, all three characterizations indicate that development within the Schuylkill River Watershed continues to increase. Due to the fact that the USGS's data set is more detailed and includes the entire watershed, it was selected for the susceptibility analysis, as described later in this document. The USDA, DVRPC and USGS characterizations of land use within the Schuylkill River Watershed are each described below.

USDA National Resources Inventory

As shown in Figure 1.2.5-3, the most recent studies by the USDA have estimated that the Schuylkill River Watershed is 28% developed, 34% agricultural, and 32% forested land. Table 1.2.5-1 and Figure 1.2.5-4 summarize the changes in land use that have occurred during the period from 1982 until 1997. The changes in land use during this time indicate that the amount of developed land in the watershed has increased by over 30% in the past 15 years, while agricultural land has decreased by almost 14%. Forested lands decreased by just under five percent.

Figure 1.2.5-3 Overview of Schuylkill River Watershed Land Use (%)

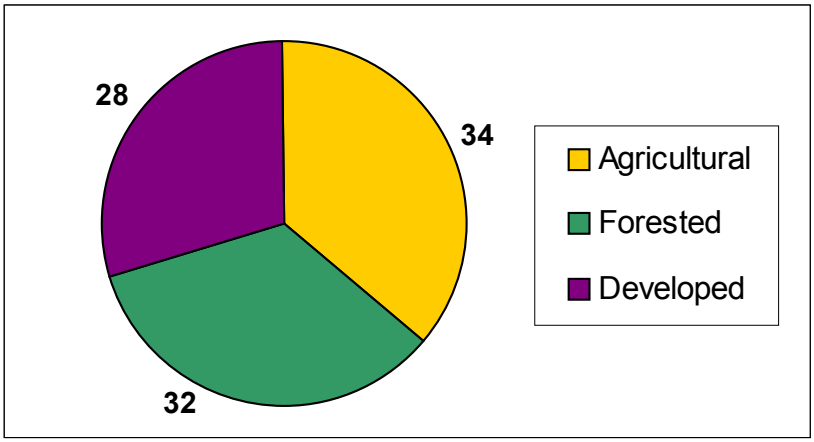
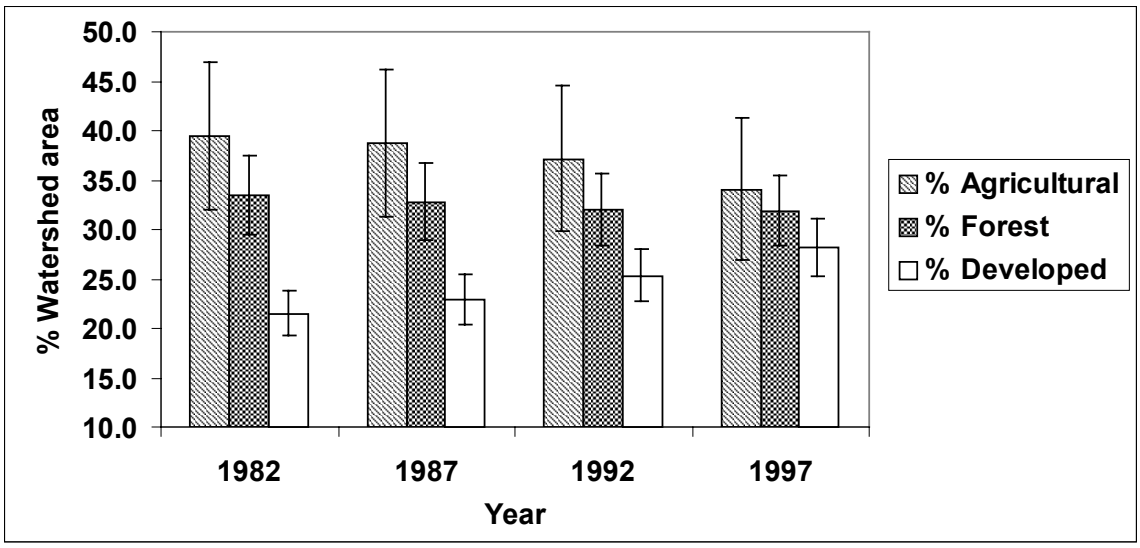


Table 1.2.5-1 Land Use Changes in the Schuylkill River Watershed: 1982-1997

Year	% Agricultural	% Developed	% Forested
1982	39.5	21.5	33.5
1987	38.8	22.8	32.8
1992	37.2	25.3	32.1
1997	34.0	28.3	31.9

Source: NRI, 2001
*Note: To calculate % change in agricultural land from 1982 to 1997: [(34.0-39.5)/39.5] * 100 = -13.9%*

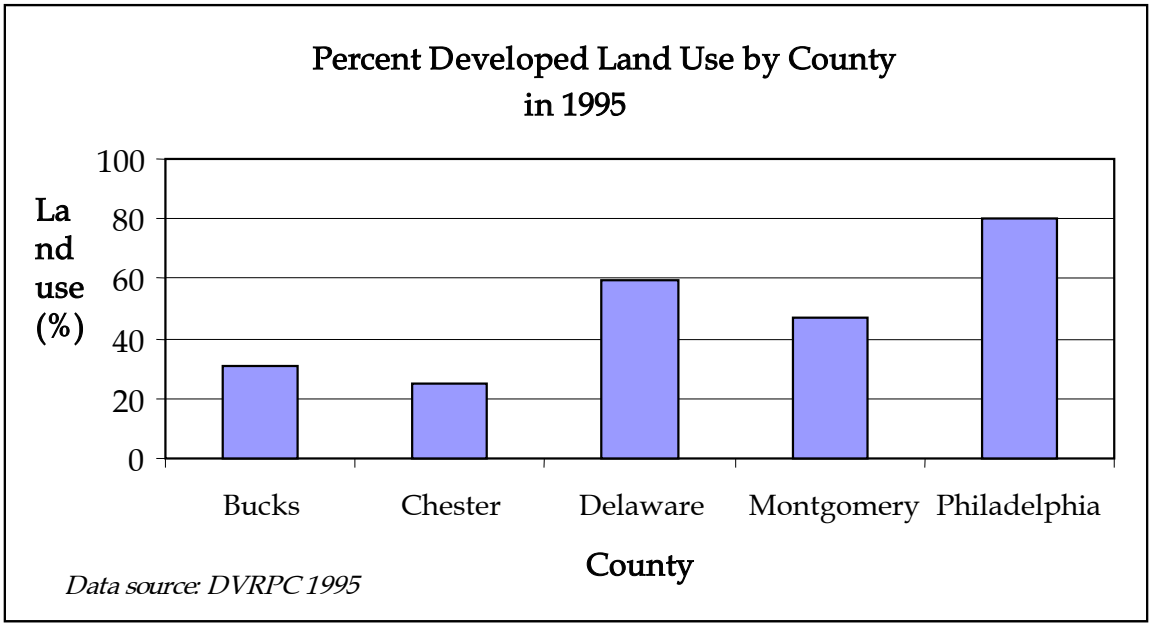
Figure 1.2.5-4 Change in Land Use in the Schuylkill Watershed
Data is from the National Resources Inventory, 2001. Error bars indicate 95% confidence intervals for data in broad land use categories. Agricultural land includes all pasture, grazing and crop lands. Developed land includes all urban land and rural transportation lands.



DVRPC Land Use Data Set

The DVRPC data includes five of Schuylkill Watershed's 11 counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia). Figure 1.2.5-5 provides a breakdown of the developed land use in 1995 for those counties, based upon the DVRPC data set.

Figure 1.2.5-5 Percent of Developed Land Use by County in 1995



The DVRPC data was supplemented with information collected from Berks County Planning Commission to show development trends in the counties. As shown in Figures 1.2.5-6 and 1.2.5-7, Philadelphia and Delaware counties have been significantly developed, have reached their development limits, and have observed decreases in their populations over the past two decades. Residents leaving the densely developed areas are suspected to have moved to nearby counties that are less developed, thus starting the cycle of suburban sprawl. The developed land area and population in Montgomery County continue to increase, making it first in total developed land area and second in population in the six county area. Twenty-five to thirty-five percent of Bucks, Chester, and Berks counties is developed, but due to the large size of these counties, they have nearly the same amount of total developed land area in square miles as Montgomery County.

Figure 1.2.5-6 Percentage of Developed Land Area by County

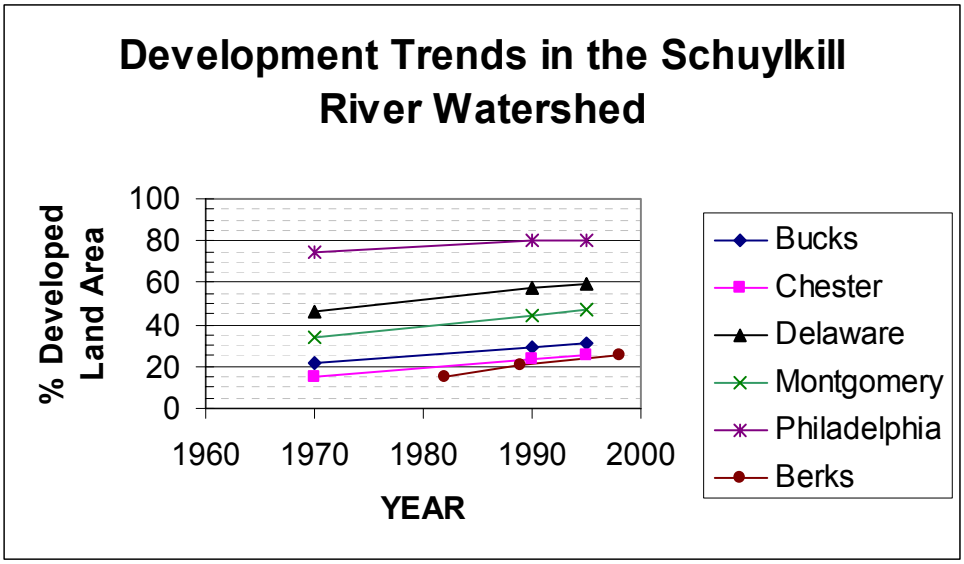


Figure 1.2.5-7Changes in Developed Land Area by County (in sq. miles)

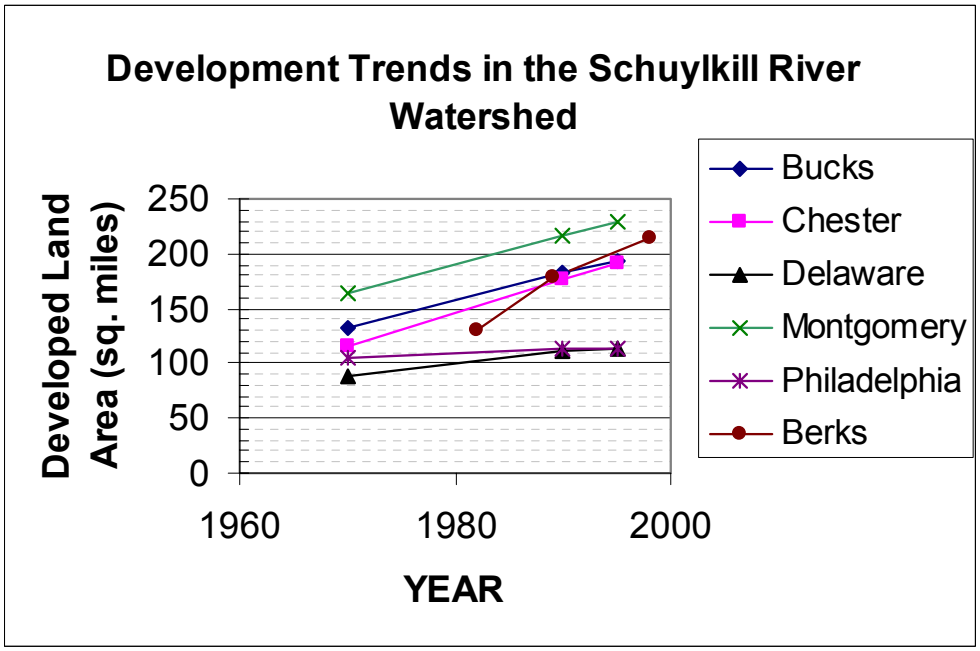
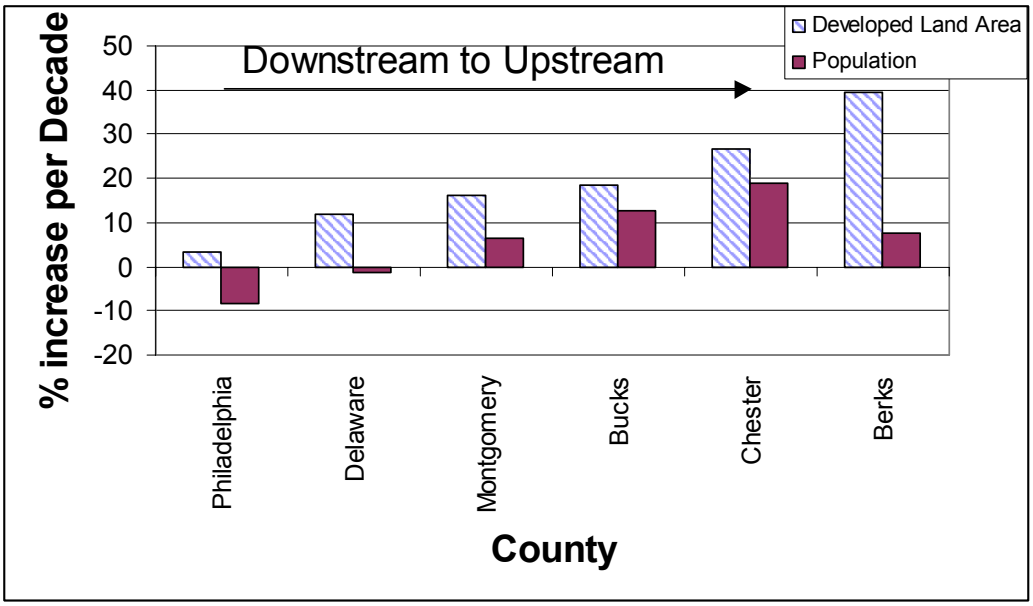


Figure 1.2.5-8 shows that population and developed land area have been increasing significantly per decade in the suburban areas of the watershed, as development expands from the city to the suburbs and beyond. These trends also show that the most significant changes area occurring in Berks, Chester, and Montgomery counties, which comprise approximately 70% of the land area in the Schuylkill River Watershed.

Figure 1.2.5-8 Percent Change in Developed Land and Population per Decade by County in the Philadelphia Region



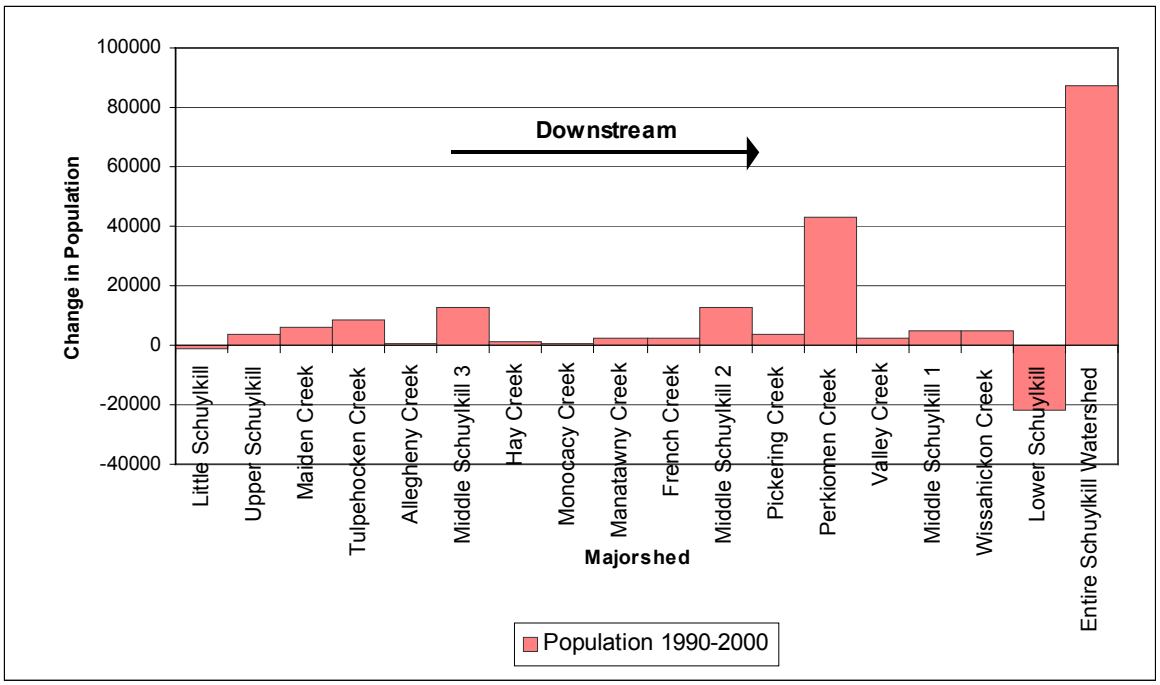
Modified Land Use Methodology for the USGS Dataset

To further characterize the Schuylkill Watershed, the National Land Cover Dataset (NLCD) was obtained from the USGS website, http://edcftp.cr.usgs.gov/pub/edcuser/vogel/states. The NLCD is a 21-class land cover classification and is based on the USGS's early-mid 1990's 30-meter Landsat thematic mapper (TM) supplemented with additional data analysis and interpretation of the Landsat data. The Schuylkill Watershed includes 14 of the 21 NLCD land cover categories: high and low intensity residential, commercial/industrial/transportation, forested, agricultural, wetlands, mining, and transitional.

Identifying and characterizing potential contaminant sources within the Schuylkill River Watershed is one focus of the Source Water Assessment Program. Reliable characterization of land use within the watershed is important for the source water assessment process, as it is the basis for estimating non-point source loadings. The USGS data set was used as the basis for the land use characterization in the Schuylkill River Watershed because it is believed to be the most accurate characterization available.

The existing land use coverage was updated with 2000 Census data populations to account for increases in residential development since the land use data was developed. The 2000 Census population was intersected with the land uses in ArcInfo GIS. The 2000 Census population intersection with the NLCD data identified residential development in areas characterized as agriculture and open space (e.g. wooded and forested) in the NLCD coverage. In these areas, the land use designations were modified as high or low intensity residential to reflect the growth in population and as a result, the increase in residential area. Figure 1.2.5-9 shows the population change by major watershed as well as the entire Schuylkill Watershed from 1990 to 2000, according to census data. The greatest increase is seen in the Perkiomen Creek Watershed. A decrease in population in the Lower Schuylkill Watershed, which includes more urban and developed areas such as Philadelphia and Montgomery counties, reflects the influence of suburban sprawl, as people move out into the surrounding suburban counties.

Figure 1.2.5-9 Population Change from 1990 to 2000 by Major Watershed



Increased commercial areas are associated with increased residential development. To incorporate the commercial development, a ratio of acreage of commercial area per person was calculated based upon the 1990 Census populations. The differences between the 1990 and 2000 Census populations were compiled for each subwatershed. These differences were used along with the estimates of commercial area per person to estimate the changes in commercial area within each subwatershed.

Figures 1.2.5-10 and 1.2.5-11 display the results of the updating methodology applied to the NLCD land use coverage. Decreases in agricultural and forested areas result from

increases in development (i.e., residential and commercial/industrial/transportation). After systematically modifying the USGS's NLCD data set, originating in the early-mid 1990's, an increase in developed area of almost 30,000 acres, or over two percent, was identified in the Schuylkill Watershed. Residential land development generally increased in the downstream reaches of the Schuylkill Watershed, especially in the larger subwatersheds.

Figure 1.2.5-10 Change in Developed Areas by Major Subwatershed

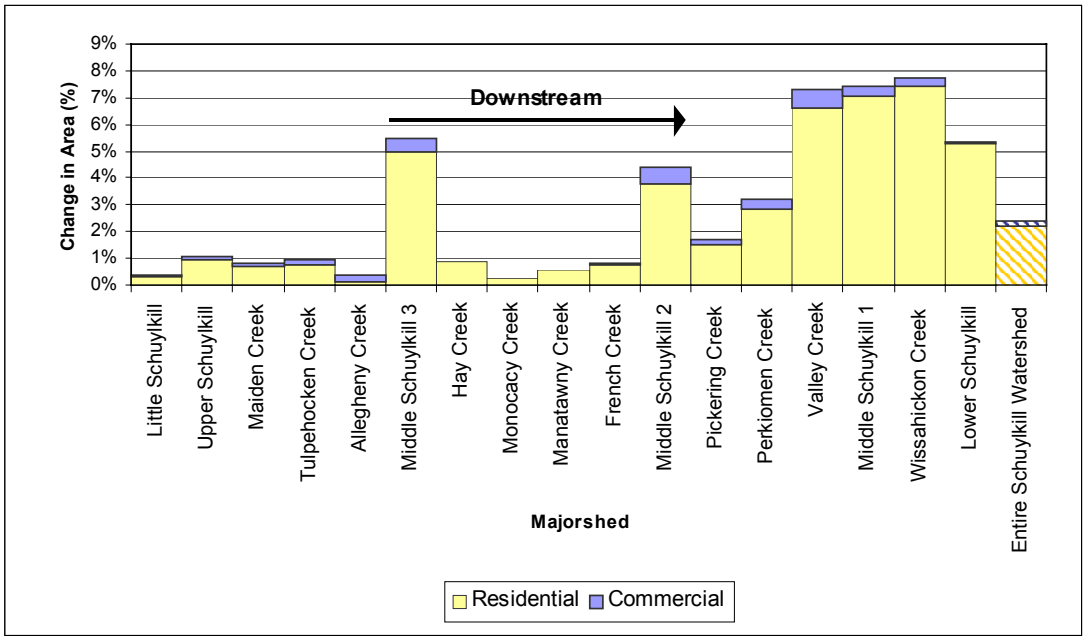


Figure 1.2.5-11 Change in Agricultural and Forested Areas by Major Subwatershed

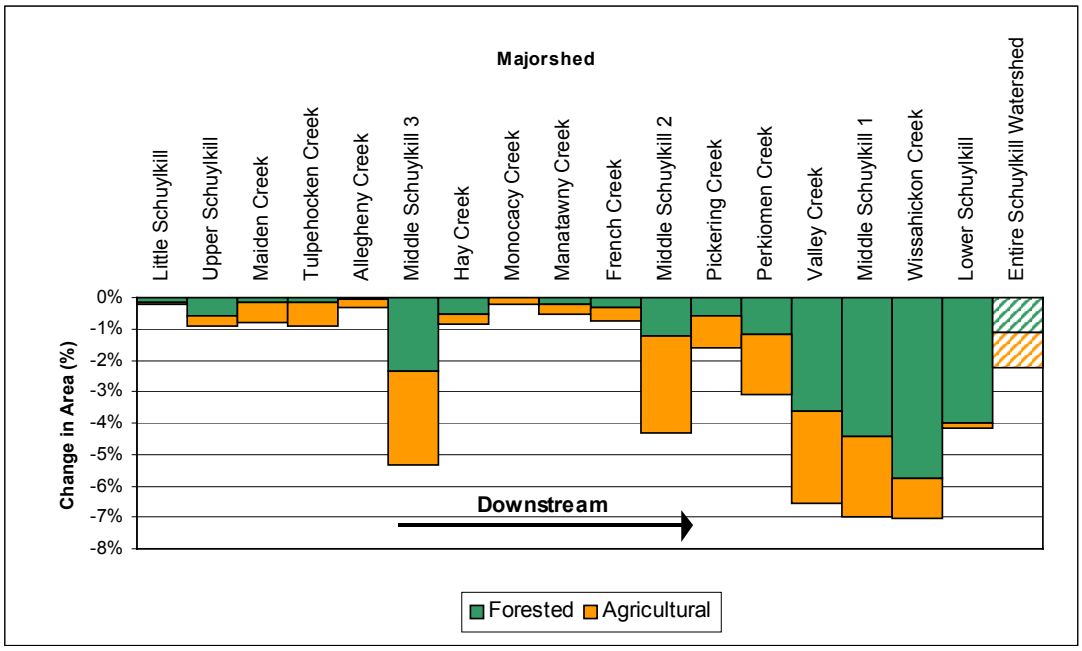


Table 1.2.5-2 summarizes the land use characterization for the Schuylkill River Watershed area and reflects modifications in residential development and increases in commercial areas. More than 83% of the Schuylkill Watershed is characterized as agriculture, forests, and wetlands. Developed and urbanized areas account for about 14% of the entire area.

Table 1.2.5-2 Updated Land Use Categories

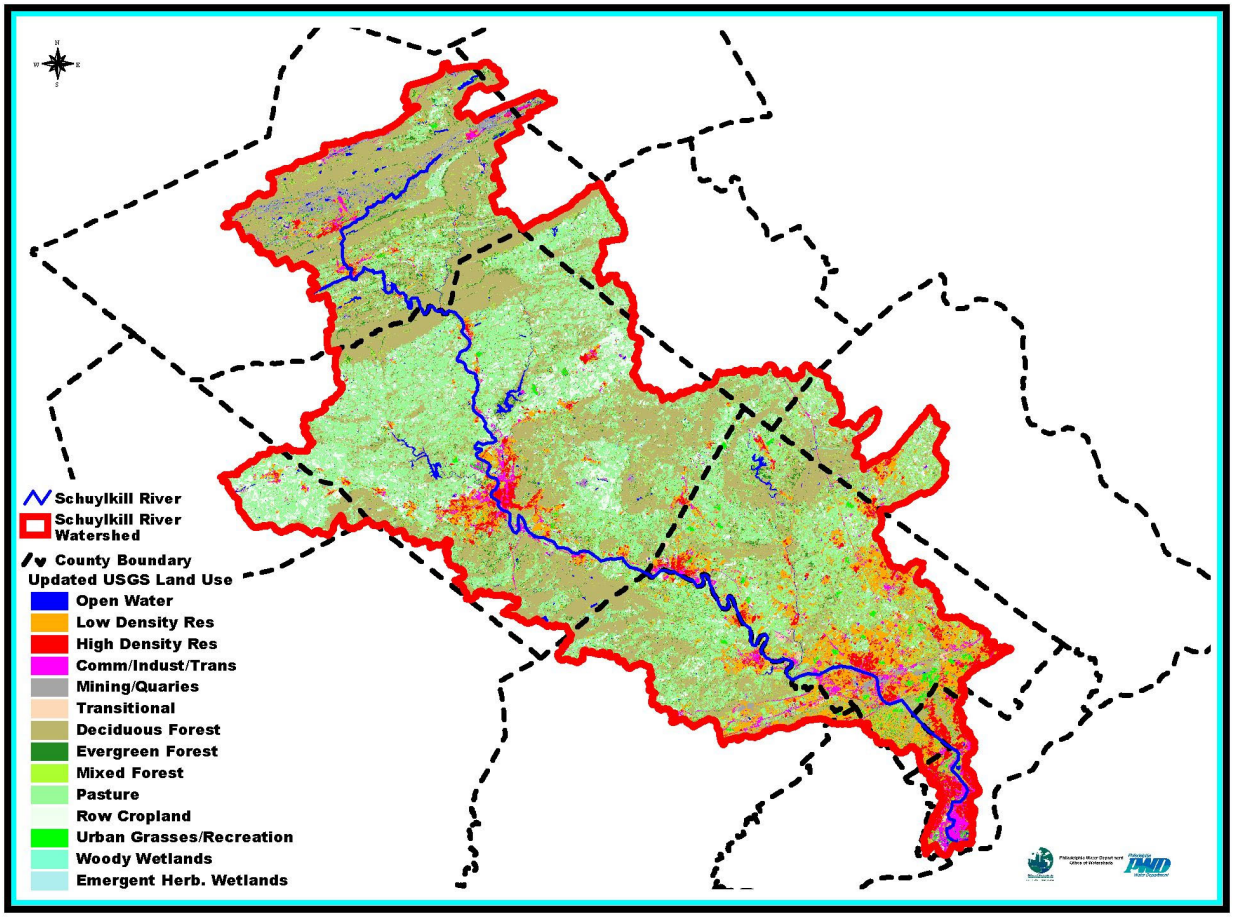
Land Use Category	Subcategory	Area (acres)	Percentage of Schuylkill Watershed Area
Agricultural	Pasture/Hay	357285	29.1%
	Row Crops	86891	7.1%
Commercial/Industrial/Transportation		35633	2.9%
Forested	Deciduous Forest	481255	39.3%
	Evergreen Forest	37569	3.1%
	Mixed Forest	52414	4.3%
Open Water		15118	1.2%
Quarries/Strip Mines/Gravel Pits		13707	1.1%
Residential	High Intensity Residential	36024	2.9%
	Low Intensity Residential	90686	7.4%
Transitional		4083	0.3%
Urban/Recreational Grasses		7427	0.6%
Wetlands	Emergent Herbaceous Wetlands	4276	0.3%
	Woody Wetlands	3738	0.3%

While this land use characterization is believed to provide the most accurate and up-to-date coverage of land use in the Schuylkill River Watershed, it results in a lower estimate of developed land than do the USDA and DVRPC characterizations. Nevertheless, all three land use characterizations demonstrate a consistent trend of increased development within the watershed. Development of a current land use map

of the entire Schuylkill River Watershed would be most useful in establishing current levels of developed land area within the watershed.

Figure 1.2.5-12 shows the updated NLCD coverage, but does not reflect the new commercial development since those areas cannot be spatially represented. As shown in Figure 1.2.5-12, the most developed areas tend to be aggregated at the bottom of the watershed and follow major transportation corridors or are located near Philadelphia, Norristown, Pottstown, and Reading. The majority of agricultural lands are located in the middle and upper part of the watershed in Berks and Chester counties. The majority of forested lands are located in the upper portion of the watershed in Berks and Schuylkill Counties.

Figure 1.2.5-12 Updated Land Use in the Schuylkill River Watershed



1.3 Summary of Past Reports and Studies

1.3.1 Introduction

Key Points
- **A number of studies have been completed to characterize the Schuylkill River and its tributaries.**

Recently, numerous governmental agencies, watershed organizations, educational institutions, and citizen groups have focused their efforts on improving the ecology of the Schuylkill River and its tributaries. A listing of reports and studies completed by these groups is given below as a resource reference. Due to the size and complexity of the Schuylkill Watershed, it should be noted that this list is not exhaustive.

1.3.2 Schuylkill River Studies

The ***Delaware Estuary Monitoring Report*** was prepared by the Delaware Estuary Program in August 1998. The objective of the report was to establish a monitoring program and an accompanying database to evaluate the current status and future trends of water quality in the estuary.

The City of Philadelphia Planning Commission delivered a technical report on ***Philadelphia's River Resources*** in June 1982. This report was prepared in order to characterize water quality on the Schuylkill and Delaware rivers, and to assist in land use planning of the riverfront. Consequently, recommendations for improved environmental and land management of the riverfront were developed.

Stephen Hammell prepared a report on ***Planning for Water Quality Monitoring and Riparian Restoration in the Schuylkill Watershed, Working Draft*** for the Schuylkill Riverkeeper Program in March 1996. The report is a compilation of extracts from other reports assessing the biological, chemical and physical conditions of the river and its tributaries.

The Delaware Riverkeeper Network published ***River for Renewal: A Look at the Restoration Potential of the Schuylkill River,*** in March 1996. The report was funded by the Wyomissing Foundation, the William Penn Foundation, and the Tortuga Foundation, and was based in part on ***Planning for Water Quality Monitoring and Riparian Restoration In the Schuylkill Watershed, Working Draft*** (Hammell, 1996). The study takes into consideration the current conditions of the river, including water quality and ecology, and assesses its potential for rehabilitation.

The ***Schuylkill River Watershed Conservation Plan*** was produced through a partnership of the Academy of Natural Sciences, the Natural Lands Trust, and The Conservation Fund in October 2000. The aim of the report was to highlight conservation issues, develop an inventory of land and water resources, and make recommendations for future projects at the site-specific, local, and community levels. The report is divided

into three main sections: water quality, landscape sustainability, and institutional assessment.

Chester-Betz Engineers prepared the ***Summary of Data Report August 1976 Water Quality Investigations Schuylkill River and Neshaminy Creek*** for the Delaware Valley Regional Planning Commission and the Pennsylvania Department of Environmental Resources in September 1978. This report was conducted after the analysis of historical water quality information conducted during the initial COWAMP phase of the COWAMP/208 program indicated that much of the past data collected was insufficient. The previous data lacked spatial and temporal continuity.

Chester-Betz Engineers prepared chapter VI ***Existing Water Use and Quality*** (revision of 12/5/77) for the Delaware Valley Regional Planning Commission and the Pennsylvania Department of Environmental Resources in May 1978. This report discusses the evaluation of existing water quality information, the large-scale stream sampling conducted under COWAMP/208, and the water quality modeling program.

J.K. Stamer, T.H. Yorker, and G.L. Pederson prepared the ***Distribution and Transport of Trace Substances in the Schuylkill River Basin from Bern to Philadelphia, Pennsylvania***. This paper is a compilation of data collected between the dates of October 1978 and March 1981, by the U.S. Geological Survey (USGS). Between these dates, the USGS assessed the water quality of the Schuylkill River Basin in Pennsylvania from the headwaters to the Fairmont Dam. In particular, they researched the transport of trace metals including arsenic, beryllium, cadmium, copper, lead, mercury, nickel, and zinc. They also tested for organic substances, particularly organochlorine insecticides and polychlorinated biphenyls.

Thomas H. Yorke, John K. Stamer, and Gary L. Pederson prepared the ***Effects of Low-Level Dams on the Distribution of Sediment, Trace Metals, and Organic Substances*** in ***the Lower Schuylkill River Basin, Pennsylvania***. This report represents the results from part of the USGS's *River Quality Assessment Program,* where they evaluated the effects of low-level dams in the lower basin on the distribution and transport of sediment and trace substances.

1.3.3 Schuylkill River Tributary Studies

L. Robert Kimball & Associates, Inc. prepared the ***Upper Schuylkill River Tributaries Assessment Report*** for the Schuylkill Conservation District. The objectives of this study were to identify major non-point source/acid mine drainage (NPS/AMD) sources within the upper Schuylkill River Watershed area. The group obtained existing analytical/physical data associated with those discharges and evaluated the impacts with regards to water quality. Based on their conclusions, a priority list of NPS/AMD sources would be produced for which general remediation strategies could be developed.

1.3.3.1 Hay Creek

The Berks County Conservancy concluded the ***Hay Creek Preliminary Assessment*** in June of 1999. The purpose of the report was to foster awareness of watershed planning, restoration and protection throughout Berks County, in an effort to forestall potentially harmful impacts on the Hay Creek Watershed.

1.3.3.2 Lake Ontelaunee

F. X. Browne, Inc. produced a ***Diagnostic Feasibility Study of Lake Ontelaunee*** in April 1994. The study was performed for the City of Reading, who uses the Lake as its primary drinking water source. The goals of the study included establishing existing water quality conditions and outlining feasible control and restoration methods.

1.3.3.3 Little Lehigh Creek

The Wildlands Conservancy issued the ***Little Lehigh Creek Stream Corridor Restoration Project Stream Status Report*** for the Harry C. Trexler Trust in January 1994. Chemical and biological testing was performed to establish baseline stream conditions, upon which future management decisions could be weighed.

1.3.3.4 Maiden Creek

The Center for Watershed Stewardship at the Pennsylvania State University prepared the ***Maiden Creek Watershed Keystone Project***, as part of the Student Technical Experience in Problem Solving (STEPS) agreement with the Berks County Conservancy, in May 2000. Data about land and water resources, biological activity, and watershed characteristics were collected, areas of concern were identified, and management options were explored.

1.3.3.5 Perkiomen Creek

In August 1999, the ***West Branch Perkiomen Creek Preliminary Assessment*** was completed by the Berks County Conservancy. The study took into account land use/recreation, historical resources by municipality, point sources of discharges and general water quality.

1.3.3.6 Sandy Run Creek

The Montgomery County Planning Commission, Abington Township, Springfield Township, Upper Dublin Township, and Whitemarsh Township prepared the ***Sandy Run Creek Watershed Conservation Plan***. This paper reviews a wide range of watershed topics, from water quality to vegetation. Also included in this document are the conservation plan goals that were established by the Sandy Run Coalition.

1.3.3.7 Saucony Creek

The Berks County Conservancy released a ***Groundwater Study of the Saucony Creek Marsh*** in May 2000, based on data collected from May through October 1988. The project began as an attempt to shed some light onto the workings of the marsh ecosystem, as a response to a proposal from Eastern Industries to discharge water from a nearby limestone quarry into the marsh.

1.3.3.8 Tulpehocken Creek

A ***Macroinvertebrate Analysis of the Tulpehocken Creek and its Tributaries*** was conducted by the Berks County Conservancy in July of 1996. The purpose of the study was to collect and identify macroinvertebrates and use this data as an indicator of water quality.

The Berks County Conservancy prepared a ***Qualitative Analysis of the Tulpehocken Creek and its Tributaries***, for the Tulpehocken Creek/Blue Marsh Lake Steering Committee, in August 1996. The intent of the report was to inform local farmers and developers how best management practices may be used to decrease contaminant loading to the Tulpehocken Creek from agricultural runoff, suburban development, and industrial wastes. This, in turn, will take steps toward improving the creek's tributaries, the largest of which is Blue Marsh Lake.

Aqua-Link, Inc. issued the ***Blue Marsh Lake Final Report*** for the Berks County Conservancy in September 1999, as a supplement to the draft report ***Blue Marsh Lake Water Quality Evaluation Assessment of Major Chemical, Physical, and Biological Parameters*** (Hall and Dougherty, September 1998). This report, funded by the United States Environmental Agency (USEPA) and PADEP under the Clean Water Act, was compiled to fill in some missing elements of the aforementioned draft, and therefore should not be considered as a "stand alone" document.

The results of a study of the ***Fish and Wildlife Resources in the Tulpehocken Creek Watershed*** were issued by the U.S. Department of the Interior and the Fish & Game Commission of State College, PA in April 1997. The report was prepared for use in development of a watershed protection plan/environmental assessment to be used in application for federal assistance under the Watershed Protection and Flood Prevention Act (PL-566). The focus was on the fish, mammal, amphibian, reptile, bird, and plant resources present in the watershed. Point and non-point sources of pollution in the watershed were also discussed in relation to their effects on the fish and wildlife.

The United States Department of Agriculture (USDA), Forest Service, and Northeastern Area State & Private Forestry prepared a ***Forest Resource Report for the Tulpehocken Creek Watershed*** in November 1996. The report identified a list of issues and concerns, and suggested the establishment/enhancement of riparian buffers along the creek's banks.

The USDA, in cooperation with the Berks County Conservation District, the Lebanon County Conservation District, and the Berks County Conservancy, completed the ***Tuplehocken Creek Final Watershed Protection Plan and Environmental Assessment*** in November 1997. The goal of the report was twofold: to develop a plan for treating non-point source pollution (in order to improve water quality and aquatic habitats), and to improve management practices (in order to sustain agricultural productivity and profitability). The plan encompasses the Tulpehocken Creek, as well as several tributaries, the most notable of which is Blue Marsh Lake.

The Berks County Conservancy and the Scenic Rivers Division, Bureau of Water Resources Management, Pennsylvania Department of Environmental Resources completed the ***Tulpehocken Creek Scenic River Study***. Under the Scenic Rivers Act, the Scenic Rivers System prescribes procedures and criteria for protecting, administrating, and establishing the system and adding new components through a set of standard procedures. The act assures the people of the opportunity to refresh their spirits with these values of unspoiled waterways. The area studied the entire Tulpehocken Creek (in Berks and Lebanon Counties) and a small section of the Cacoosing Creek.

1.3.3.9 Wissahickon Creek

Stephanie Craighead (The Fairmont Park Commission), John Wood (Montgomery County Planning Commission), and Terry Hough (The Pennsylvania Department of Conservation and Natural Resources) prepared the ***Wissahickon Creek River Conservation Plan***, in December 1999. The document is the result of a team effort that involved 14 municipalities of the Wissahickon Watershed. The document describes every aspect of the watershed, from soils and geology to water quality. As an end product it outlines the goals of the Wissahickon Creek River Conservation Plan.

1.3.3.10 Wyomissing Creek

The Berks County Conservancy presented the ***Wyomissing Creek Study Streamwalk Observations and Analysis*** in May 1992. The purpose of the study was to assess the current condition of the creek. Water quality parameters, invertebrates, and the flora and fauna in and surrounding the area were observed and analyzed.

1.3.3.11 Watershed Assessments

The ***Watershed Assessment: Reading Pennsylvania*** was prepared for the USEPA by the Cadmus Group, Inc. The Cadmus Group, Inc. studied three watersheds including Ontelaunee, as part of the PADEP's commitment to the source water assessment program. The group looked at all potential and actual pollutant sources, analyzed the susceptibility of the watershed to the sources, and prepared a management plan consisting of a series of recommendations. This document is a summary of the project for the Reading Water Authority.

1.4 Identification of Universal Water Quality Issues

1.4.1 Introduction to Water Quality

Key Points

- **Schuylkill River water quality has significantly improved over the past 20 years.**
- **As the impacts of point sources discharging to the Schuylkill River have been reduced over the years, the importance of non-point sources such as stormwater runoff from developed areas within the watershed has become evident.**
- **While dissolved solute levels have increased over the past few decades, levels of dissolved oxygen and nutrients have significantly improved, due to reductions in agricultural runoff and improved wastewater treatment.**

The Schuylkill River is a much healthier river now than it was over the past century, when it was branded as "too thin to cultivate, too thick to drink". The periods of the river running black with culm, smelling of raw sewage, covered in sheens of oils, or foaming with detergent bubbles are now gone, resulting in tremendous improvements in fish, wildlife, and water quality over the past 20 years. These improvements can be directly related to the following major events:

- The decline of the coal industry;
- The decline in the presence and size of the manufacturing industry (steel, paper mills, textiles, glass, etc) throughout the watershed;
- The increased cost of oil;
- The construction of sewers and sewage treatment plants;
- The improvements in sewage and industrial waste treatment plants;
- The Clean Water Act;
- Regulations limiting the presence of phosphates in detergents; and
- Regulations phasing out the use of certain toxic chemicals.

While some of these improvements were related to regulatory initiatives, most changes in water quality were caused by the activities that occurred in the watershed. These recent improvements in water quality have allowed us to see that in a growing number of areas, the main challenges to water quality now come from polluted runoff and not point source discharges. Therefore, the focus of activities that impact water quality are now becoming as much land use related as they are specific point source or facility related.

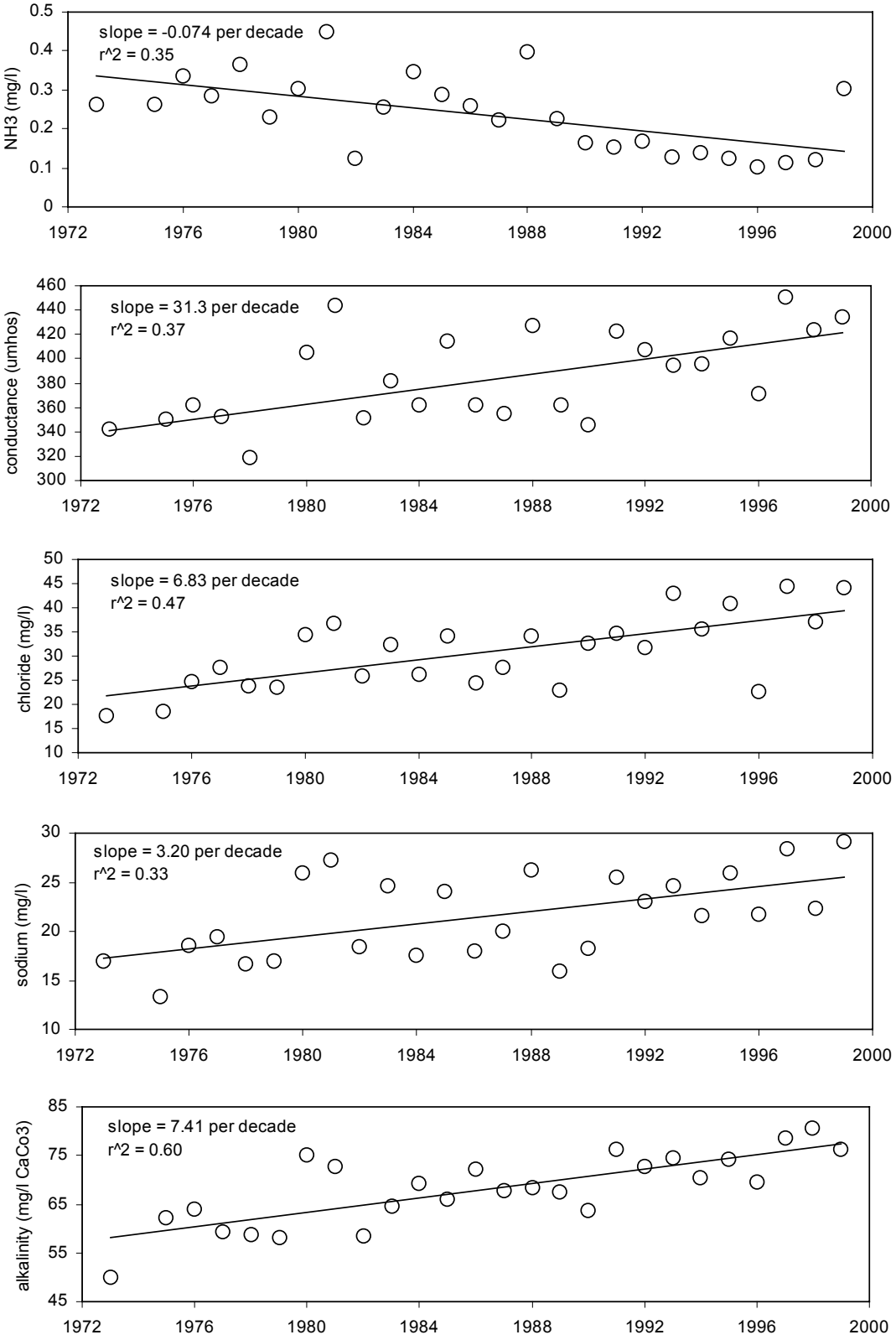
The process of examining changes in water quality over time is very difficult. The data usually is not available to characterize long periods of record for most chemical parameters. If data is available, changes in analytical methods over time can skew results. It is important to note that based on these factors, the following sections attempt to examine the trends in water quality data based on the data that is available. Therefore, just because a change is noticed at one location does not mean that it is

occurring at all locations. In addition, just because data is not available to characterize an area of the watershed does not mean that the water quality is good or bad.

General temporal analysis focused on long-term and past decade trends in water quality in the Schuylkill River at Philadelphia. This site was chosen because it is at the downstream end of the Schuylkill River Watershed, had the most significant and extensive monitoring data available, and because it provides evidence of the dominant changes in long term water quality in the watershed as a whole. Ultimately, it is believed that impacts observed at Philadelphia are possibly occurring at a number of locations along the river and throughout its tributaries to some extent. However, this does not mean that every trend observed at Philadelphia may be happening to the same extent, or at all, in other parts of the watershed. It is hoped that as coordination of watershed monitoring is improved to provide appropriate data to describe long-term trends, evaluations at other key locations throughout the watershed can be performed.

Three decades of changes in levels of water quality indicators, such as alkalinity, conductance, chlorides, sodium and ammonia, are summarized in Figure 1.4.1-1.

Figure 1.4.1-1 Changes in Water Quality Indicators in the Schuylkill River at Philadelphia



Analysis of the data yielded the following observations:

- Philadelphia Water Department (PWD) intake data indicate significant increases in dissolved solute concentrations through the 1990s, including elevated levels of sodium, chloride, alkalinity, dissolved solids, and conductivity. These trends appear to extend back through the early 1970s. If they continue, they have the potential to adversely affect drinking water treatment processes for the City of Philadelphia in the future.

- Spatial analysis of conductivity data throughout the watershed indicates that the observed trends are common throughout the watershed.

- If the increasing trends in alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, total organic carbon and turbidity in the river water continue over the next two decades, there will be impacts on water treatment process operation and/or finished water quality. This could result in additional water treatment costs or reduced consumer confidence for many water suppliers in the watershed.

- Increased mass transport levels of sodium and chloride, particularly in winter months through the 1990s, suggest that increased deposition of road salts are significantly impacting water quality at Philadelphia's Schuylkill River drinking water intakes.

- Though this study focused on adverse changes in river water quality parameters, the Schuylkill River has seen significant improvements in important water quality parameters such as dissolved oxygen, ammonia, nitrate, and phosphorous since the 1970s. Schuylkill River nutrient levels (nitrogen and phosphorus measures) have remained stable or decreased over the past decade due to decreased agricultural runoff within the watershed, along with improved wastewater treatment practices. Dissolved oxygen values have been steadily increasing over the past several decades.

1.4.2 Long-Term Water Quality, Historical Trends, and Comparison to Other Rivers

Key Points
- **Compared to other rivers in the northeastern United States, the Schuylkill River has some of the highest dissolved solute concentrations.**
- **Levels of nitrates, chlorides and total residue in the Schuylkill River have increased over the years.**

Previous assessments of century-long water quality trends in the Schuylkill River and other northeastern watersheds have demonstrated long term increases in salt concentrations through the 1900s. For instance, nitrate, chloride and total residuals all increased steadily in the Schuylkill River from 1900 through 1970 (Please see Table 1.4.2-1 and Figure 1.4.2-1). These indicators of water quality appeared to level off and remain relatively stable from 1970 through 1990, most likely as a result of improved wastewater treatment and slowing rates of development in the northeastern region (Jaworski and Hetling 1996). Increased national prosperity following the recession of the late 1980s spurred a strong increase in development in suburban regions, including parts of Bucks, Berks, Lehigh, Montgomery and Chester counties within the Schuylkill Watershed. This recent development appears to be causing increases in solute concentrations, driven by increasing wastewater discharge and increased solids transport directly related to land use change.

Recent water quality assessments have indicated long-term temporal increases in nutrient fluxes in major waterways (e. g. Bollinger et al. 1999) in the United States, which may have adverse impacts on water supplies for both drinking water and irrigation systems. These recent trends are apparently driven by major increases in diffuse loading of solutes from both agricultural and urban sources (Novotny and Olem 1994, Reimold 1998). While agricultural sources typically result in increases in nutrient and herbicide concentrations, urban sources of solutes, particularly from highway runoff, can result in increased loading rates of a more diverse suite of solutes. This analysis addresses many of the potential solutes derived from both sources. Urbanization in the Schuylkill River Watershed has resulted in decreases in land used for agricultural purposes, so long-term decreases in nutrient loading along with long-term increases in other dissolved solutes, including metals and other inorganic constituents, might be expected. Effects of increased loading of solutes to the Schuylkill River can be complicated by changes in specific ion activities which are directly related to ionic strength, organic content and other bulk water chemistry characteristics that are dynamic as well (Buckler and Granato 1999, Bricker 1999).

Recent changes in water quality are critical in the Schuylkill River in particular, as this river has some of the highest dissolved solute concentrations of all water supply sources in the northeast. Of twelve major northeastern rivers assessed by Jaworski and Hetling (1996), the Schuylkill had the highest nitrate and total residue (total solids – TS) levels,

and the second-highest chloride levels measured as averaged concentrations from 1990 to 1993. Additionally, for the period 1900 to 1993, the Schuylkill had the highest average rate of increase of all watersheds surveyed for nitrate and chloride (by a factor of two over the second-highest rates in the Potomac River) and the second-highest rate of increase in total residuals (just behind the Potomac). These changes are summarized in Table 1.4.2-1. Based on watershed area, the Schuylkill also has the highest mass transport rate for nitrate and ammonia of all major eastern rivers (Jaworski et al. 1997). As such, the Schuylkill has historically been, and is still currently, a heavily impacted major river water supply source.

Table 1.4.2-1 Summary of Historical and Current Water Quality Concentrations and Rates of Change For Northeastern Watersheds

Watershed	USGS Station No.	Timeframe	NO_3(1) (mg/l)	NO_3(2) (mg/l)	NO_3 Change (mg/l/yr)	Cl(1) (mg/l)	Cl(2) (mg/l)	Cl Change (mg/l/yr)	T Res(1) (mg/l)	T Res(2) (mg/l)	T Res Change (mg/l/yr)
Schuylkill	1474500	1913-1993	0.27	2.9	0.0329	6	30	0.3	122	229	1.3375
Potomac	1646580	1921-1993	0.6	1.76	0.0161	3.3	13	0.1347	103	203	1.3689
Delaware	1463500	1906-1993	0.25	1.01	0.0087	2.9	13	0.1161	70	104	0.3908
Blackstone	1111230	1890-1993	0.21	0.97	0.0074	5	44	0.3766	60	154	0.9126
WB Susquehanna	1553500	1906-1993	0.16	0.7	0.0062	4	8	0.046	74	137	0.7241
Rappahannock	1668000	1929-1993	0.15	0.55	0.0063	1.1	5	0.0619	43	53	0.1587
Hudson	1385000	1906-1993	0.18	0.52	0.0039	4	17	0.1494	108	119	0.1264
Connecticut	1184000	1888-1993	0.08	0.35	0.0026	1.5	11	0.0905	53	67	0.1333
Merrimack	1100000	1888-1993	0.07	0.32	0.0024	1.8	19	0.1638	43	68	0.2381
James	2035000	1906-1993	0.06	0.3	0.0028	2.3	9	0.077	89	100	0.1264
Androscoggin	1059010	1906-1993	0.02	0.18	0.0019	2.3	12.5	0.1229	42	66	0.2892
St. John	1015000	1921-1993	0.02	0.15	0.0018	0.7	2.9	0.0306	45	65	0.2778
Average			0.17	0.81	0.0078	2.9	15.4	0.1393	71	114	0.5087

Note: (1) = Earliest historical year
(2) = Four year average for the period 1990-1993
Source: Jaworski et al. 1996

Figure 1.4.2-1 Historical Nitrate, Chloride and Total Residue in Eastern US Rivers *From Jaworski et al., 1990*

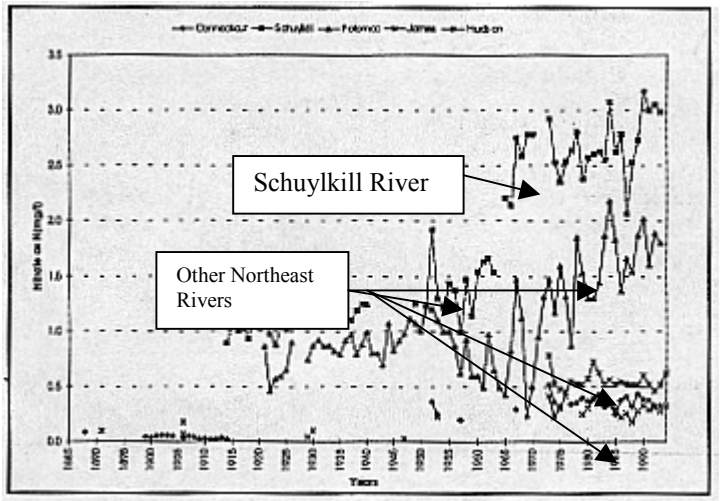


Figure 2. Nitrate Trends.

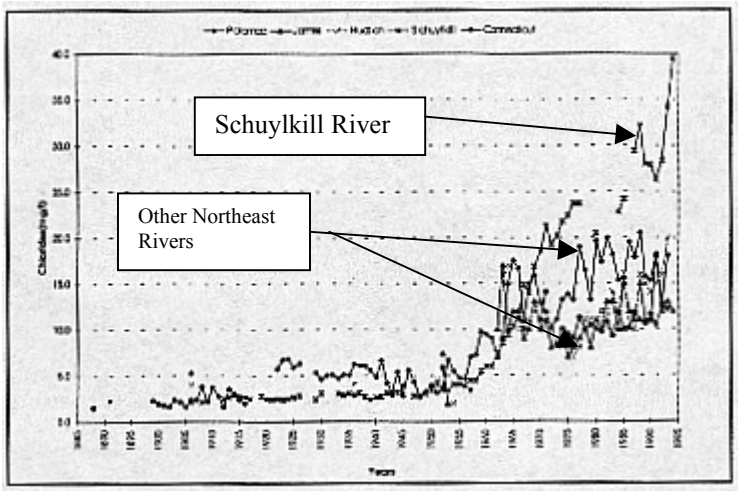


Figure 3. Chloride Trends.

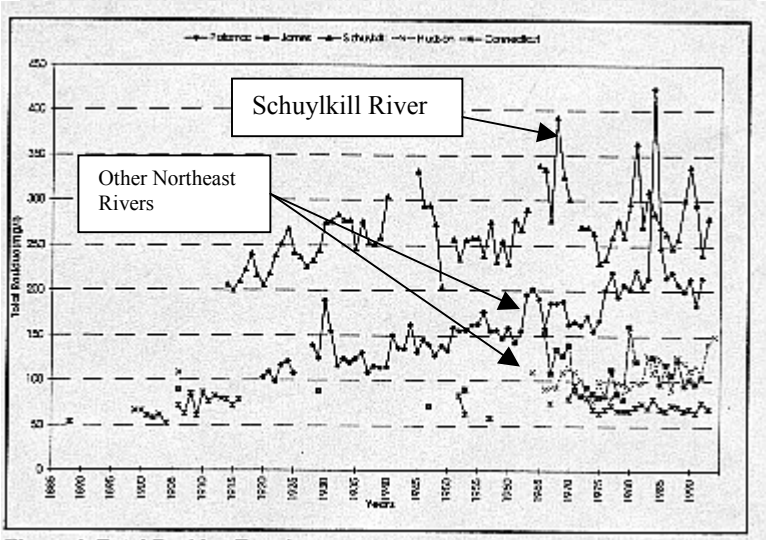


Figure 4. Total Residue Trends.

1.4.3 Changes in River Water Quality Over the Past Decade

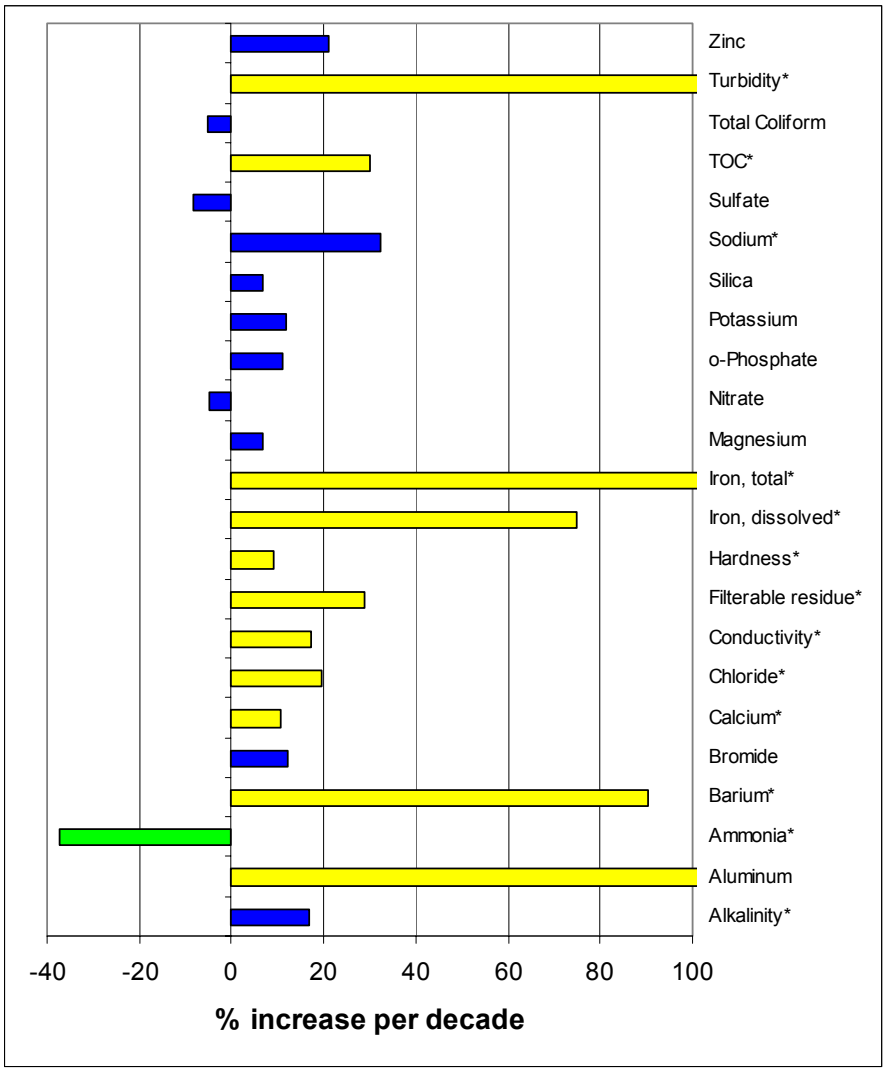
Key Points

- **Over the past decade, levels of alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, total organic carbon, and turbidity in the Schuylkill River have increased.**
- **Increases in levels of solids, salts, and metals are believed to result from contaminated runoff due to increased development, increased use of deicing chemicals, and from acid mine drainage.**
- **As point sources throughout the watershed have been abated, levels of coliforms, nitrate, and ammonia have decreased.**

Trends in river water quality over the past decade were examined in order to identify sources of contamination, and to predict future water quality concerns. This process involved the examination of data from 135 different water quality parameters measured at the Philadelphia Water Department river intakes between 1990 and 1999 and data from STORET for the Schuylkill River Watershed between 1970 and 2000. Of that data set, only 35 parameters had sufficient numbers of measurements or detectable results to conduct a proper analysis that included comparisons between parameters and regional climate and development patterns.

Analysis of the remaining data identified the following trends in water quality changes as shown in Figure 1.4.3-1 and Tables 1.4.3-1 and 1.4.3-2. Overall, 19 water quality parameters increased in concentration over the past decade, while levels of only 2 parameters (ammonia and sulfate) were observed to decrease significantly, and another two parameters changed very little (nitrate and total coliforms). Of the 19 water quality parameters exhibiting increased trends, most were salts and metals. Future increases in alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, total organic carbon and turbidity in the river water could potentially impact water treatment process operation and finished water quality and therefore required further investigation.

Figure 1.4.3-1 Percent Change per Decade in Schuylkill River Quality Parameters at Philadelphia, PA between 1990 and 1999



** Represents parameters with statistically significant increasing or decreasing trends*

The observed trends led to efforts to determine the origins and types of sources and activities that would significantly impact river water quality. These observed trends suggested that although significant improvements to protect river water quality have been made for point sources, the sources of the changes in these parameters were most likely due to polluted runoff. If all of the affected parameters were regulated for point source discharges during this period without changes, then it suggests other sources may be impacting these changes. Salts, such as sodium and chloride, that appear to be increasing at significant rates in the river can be the result of increased application of deicing chemicals in the watershed due to increased road, sidewalk, and parking lot areas in the watershed (see Table 1.4.3-3). Other parameters exhibiting increases, such as aluminum, iron, and turbidity, can be the result of increased erosion of land surfaces and streambanks due to new construction or increased flows in streams from

development and acid mine drainage. The increases in salts and metals also impact conductivity, which has significantly increased throughout the watershed.

Table 1.4.3-1 Parameters that May Have Water Treatment Operation, Distribution System, or Finished Water Quality Impacts over the Past Decade or by 2020 Given Current Trends

Parameter	Mean	Max	Min	Predicted Mean Concentration in 2020
Alkalinity (mg/l as CaCo3)	73.9	128	30	101
Turbidity (NTU)	7.85	94.5	0.15	20.9
Conductivity (umhos)	409	775	145	568
o-Phosphate	0.217	1.421	0.027	0.261
Zinc	0.03	0.5	<0.01	.055
Hardness (degrees)	133	251	0.231	162
Iron, total	0.77	40	<0.05	1.25
Iron, dissolved	0.054	0.28	<0.05	0.117
TOC	2.82	7.11	1	4.84
Chloride	41.2	128	8	56.2
Sodium	25	76	0.1	42.3
Manganese, dissolved	0.068	0.2	<0.02	0.116

Units are mg/l unless otherwise specified.
Predicted concentrations are based on linear trends from 1990-2000.

Table 1.4.3-2 Summary of Water Quality Changes in the Schuylkill River During the 1990's that May Impact Water Treatment and Possible Sources

Parameter	Group	Change	Possible Sources/Activities
Conductivity	Physical	Increasing	Polluted Runoff
Chloride & Sodium	Salts	Increasing	Road Runoff
Phosphorous	Nutrients	Increasing	Fertilizers, Farming, Wastewater Discharge
Nitrate	Nutrients	Decreasing	Improved Wastewater Treatment, Less Agricultural Activity in Watershed
Ammonia	Nutrients	Decreasing	Improved Wastewater Treatment, Less Agricultural Activity in Watershed
Total Organic Carbon	Organics	Increasing	Sewage, Decaying Material
TDS/TSS/Turbidity	Particulates	Increasing	Erosion, Construction, Farming/Tilling
Manganese, Aluminum, & Iron	Metals	Increasing	Acid Mine Drainage and Construction

Table 1.4.3-3 Reference Pollutant Concentrations (mg/l) in Roadway Runoff
Table data excerpted from Reimhold (1998), FHWA - Federal Highway Administration Study Data (Reimhold, 1998), NURP - National Urban Runoff Pollutants Study (Reimhold, 1998).

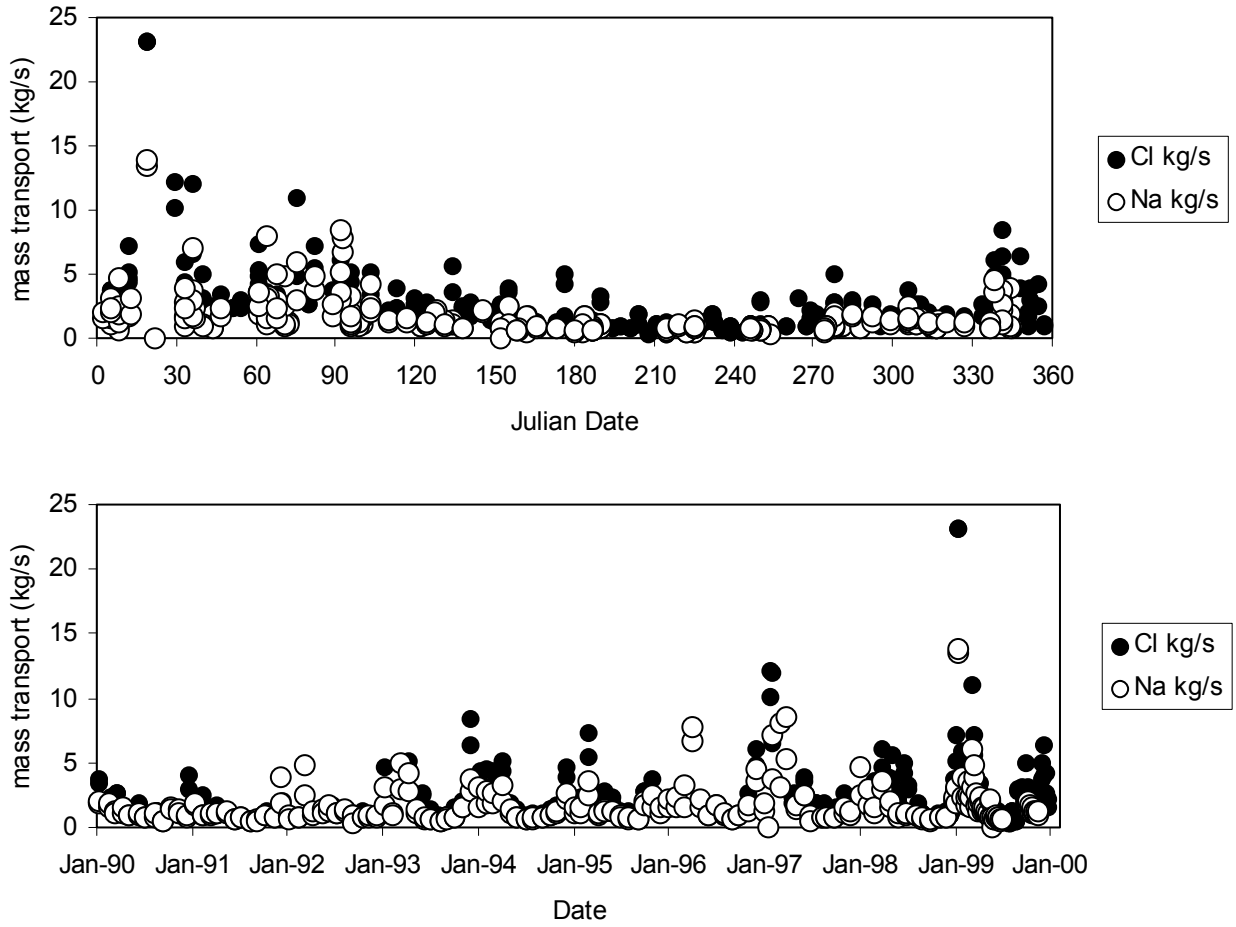
Pollutant	Normal Highway Runoff (FHWA)	Highway Snow Wash-Off (FHWA)	Urban Runoff (NURP)
Chloride	13	400 - 5600	
Total Suspended Solids	93	204	100
Nitrate	0.660	0.680	0.680
Total Phosphorus	0.293	0.570	0.330
Copper	39	91	34
Lead	234	549	144
Zinc	217	420	160

Solute mass transport rates also increased over the course of the 1990s, providing further evidence for adverse impacts of regional development on water quality. Rates of mass transport were calculated for individual samples based on the daily averaged flow rates for specific sample dates. Trends in Na and Cl fluxes indicate seasonal variation in mass transport, with highest rates of flux occurring during winter months when salt applications for road deicing can contribute dissolved solids to river water. Increases in flux rates for both ions are evident on a decade scale, with the most striking trends occurring in maximum measured flux rates through the period.

While relatively low discrete flux rates can be measured at any given time, maximum measured discrete fluxes within a given year are dramatically increasing, suggesting that major storm related discharge is driving increased solute transport in the watershed (Figure 1.4.3-2). Increased flux rates (which are calculated by multiplying an individual concentration measure by the average flow for that day) are direct evidence for increased loading rates and transport through the system.

Figure 1.4.3-2 Bulk Mass Transport of Sodium and Chloride in the Schuylkill River in the 1990's

The top panel illustrates elevated concentrations in winter months associated with stormwater discharge and deposition of road salts for deicing. The bottom panel illustrates dramatic increases through the decade possibly driven by the fast rate of development in suburban areas within the watershed.



The plausibility that changes in water quality at Philadelphia were representative of other watershed locations was analyzed by comparing trends at Philadelphia with water quality data throughout the watershed. To date, only the analysis of watershed-wide conductivity data is complete. Figure 1.4.3-3 shows the changes in conductivity in the main stem of the Schuylkill River from near its headwaters (Berne) down to Philadelphia over the past decade. As shown, conductivity decreases between the acid mine drainage-impacted headwaters and the outer boundaries of heavy suburban development in the watershed (Pottstown). However, conductivity increases significantly again between Pottstown and Philadelphia. It is not known whether these

increases are related to development, increased roadways/impervious cover runoff, or the characteristics of geology and groundwater.

Figure 1.4.3-3 Watershed-wide Trends in Percent Increase per Decade in Conductivity in the mainstem of the Schuylkill River from 1990-1999

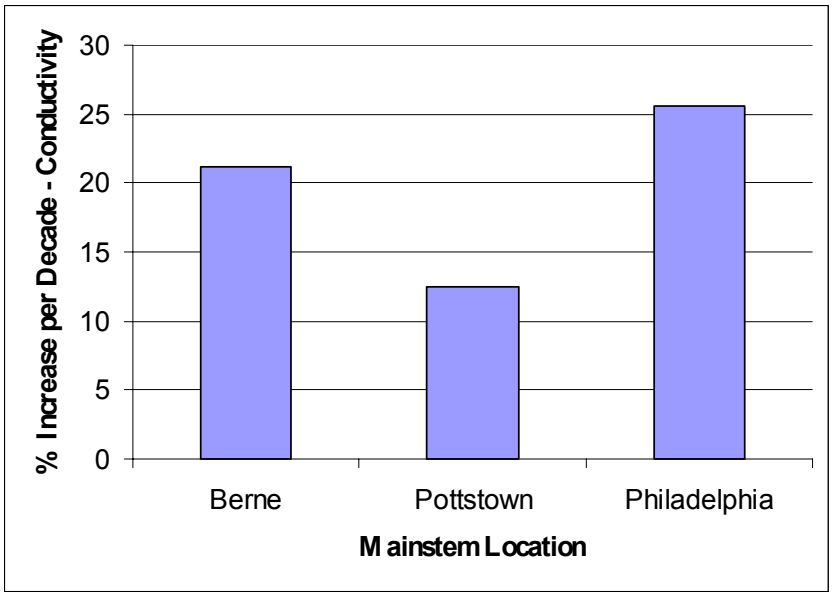


Figure 1.4.3-4 compares the changes in conductivity in the tributaries to the Schuylkill River over the past decade. As shown, several watersheds have observed significant changes in conductivity over the past decade. The median increase per decade for all locations combined was 15%, but ranged from 3 to 70%, depending upon the location. Valley Creek, Trout Creek, and French Creek in Chester County and Maiden Creek in Berks County have also observed significant increases in conductivity. As shown in Table 1.4.3-4, the greatest conductivity was observed in the Valley Creek and Wissahickon watersheds and was approximately two to three times the conductivity observed in other tributaries and locations upstream in the watershed. Figures 1.4.3-5 and 1.4.3-6 provide an in-depth view of the conductivity trends in the Maiden Creek and Valley Creek Watersheds.

Table 1.4.3-4 Spatial Comparison of Water Quality Parameters in the Schuylkill River Watershed

All parameters in mg/L unless otherwise noted.

Location	Conductivity (umhos)	Total Phosphorus	Chloride	Ammonia	Nitrate	Total Dissolved Solids	Total Organic Carbon
Wissahickon Creek	548.4	0.596		0.075	4.398	365.2	4.21
Valley Creek	508.2	0.038	65.4		2.188	400.4	1.48
Little Valley Creek	474.7	0.080			1.972		
Schuylkill River (Berne)	387.1	0.040		0.095	1.184	307.3	1.99
Schuylkill River (Philadelphia)	373.2	0.183	32.8	0.14	3.031	257.5	3.49
Tulpehocken Creek	367.6	0.077	19.4	0.086	4.735	248.8	2.65
Schuylkill River (Pottstown)	357.0	0.116		0.101	3.110	322.8	2.94
Trout Creek	304.0		23.6		1.970		
Perkiomen Creek	276.4	0.092		0.066	1.596	202.8	4.28
Maiden Creek	255.7	0.049		0.089	3.092	179.0	2.96
Crabby Creek	225.1	0.037	37.9		3.666	203.8	1.56
Green Lane Reservoir	220.7	0.228		1.07	0.065		
Pickering Creek	210.1	0.020	24.0		1.698		
French Creek	154.2	0.045	12.0		1.487		
Pine Creek(Lobachsville)	112.0	0.020	6.5	0.03	0.807	91.5	2.03
Northkill Creek	19.8	0.019	1.4	0.031	0.180	85.2	2.1

These elevated concentrations and increases in conductivity in the watershed are cumulatively translated into increased conductivity at Philadelphia's water supply intakes near the bottom of the Schuylkill River Watershed. The elevated concentrations, proximity to Philadelphia's water intakes, and amount of developed land area in the Wissahickon Creek and Valley Creek watersheds make them priorities for investigations into polluted runoff impacts and controls. In addition, the significant changes in conductivity in the Maiden Creek, French Creek, and Trout Creek watersheds indicate that these areas are worthy of in-depth investigation and protection efforts to identify and mitigate the sources of these impacts to reduce their future affect on river water quality. It appears that changing conductivity may also indicate the areas of future non-point source impacts from other contaminants for protection prioritization.

Figure 1.4.3-4 Watershed-wide Trends in Percent Increase per Decade in Conductivity in the Tributaries of the Schuylkill River from 1990-1999

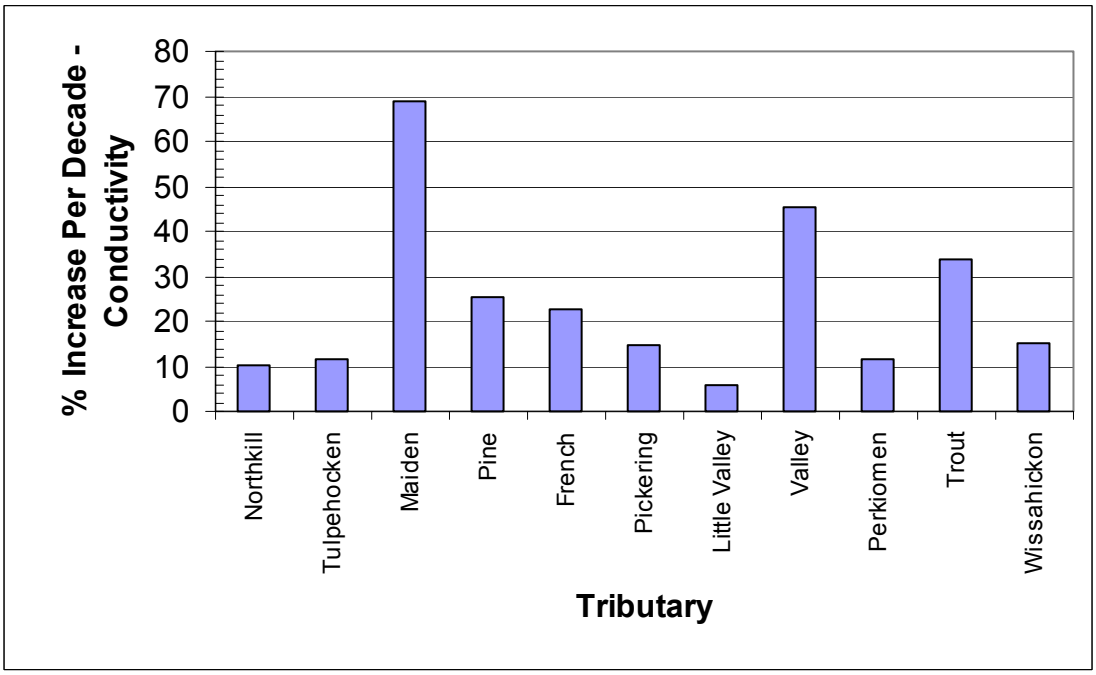


Figure 1.4.3-5 Increased Conductivity Trends in the Maiden Creek Watershed 1990-1994

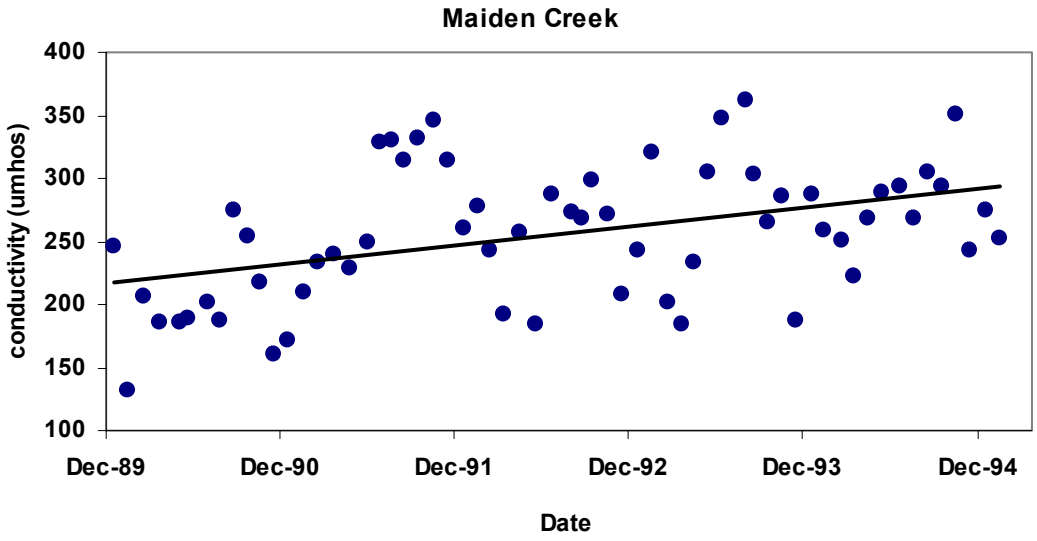
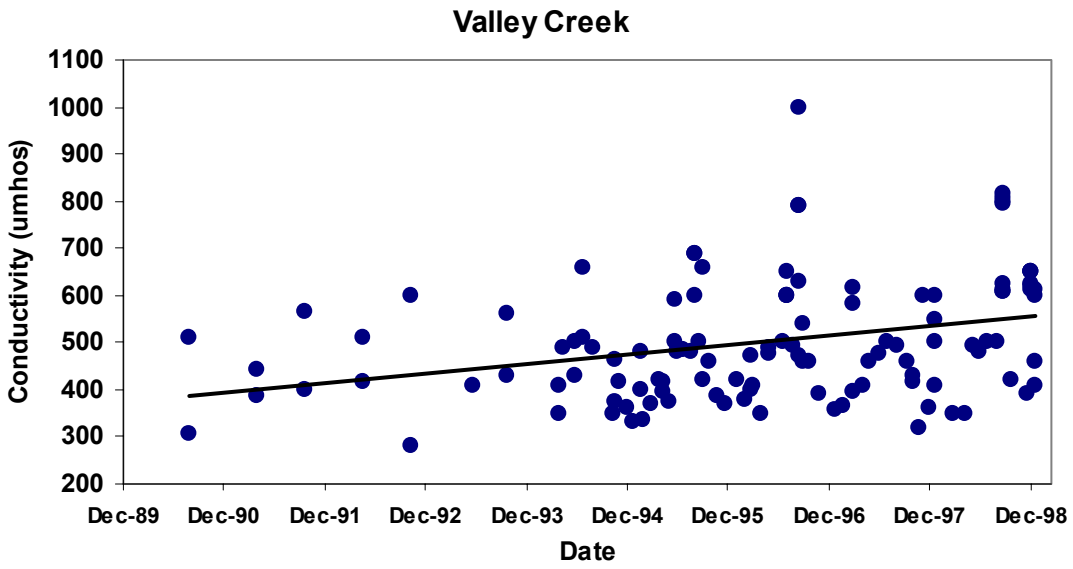


Figure 1.4.3-6 Increased Conductivity Trends in the Valley Creek Watershed 1990-1998



1.4.4 Differences in Water Quality Throughout the Watershed

Key Points
- **Subwatersheds with high levels of conductivity tend to have higher levels of phosphorus, chloride, nitrate and total dissolved solids.**
- **Conductivity measurements may serve as an indicator of areas within the watershed that are being impacted by non-point sources.**

Spatial analyses were also performed to determine if there were relationships between the mean conductivity in a watershed and other water quality parameters (see Table 1.4.3-4). Though water quality data throughout the watershed was limited, correlations between the mean conductivity and total phosphorous, chloride, nitrate, ammonia, total dissolved solids, and total organic carbon were discovered. As shown in the tables below, watersheds with higher conductivity tended to have higher concentrations of other water quality parameters. Mean watershed conductivity also correlated with mean values of total phosphorous, chloride, nitrate, and total dissolved solids (see Table 1.4.4-1). These correlations suggest that the abundant and frequently measured conductivity data may provide a useful screening tool to identify watershed areas with water quality challenges. In addition, these correlations also suggest that trends in conductivity may be useful for indicating changes in certain water quality parameters (most inorganic or ionic water quality parameters) and serve as a indicative parameter for tracking watershed health.

Table 1.4.4-1 Spearman Rank Order Correlations of Mean Conductivity and Mean Water Quality Parameters in the Schuylkill River Watershed

Mean Conductivity versus	Number of watersheds	R value	p-level
Mean Total Phosphorous	12	.672505	.016569
Mean Chloride	8	.785714	.020815
Mean Ammonia (NH3)	7	.357143	.431611
Mean Nitrate (NO3)	13	.730769	.004548
Mean Total Dissolved Solids	8	.904762	.002008
Mean Total Organic Carbon	8	.261905	.530923

Analysis of water quality data, impaired stream information, and observations from watershed surveys led to the conclusions that were made regarding the universal water quality issues which are presented in Table 1.4.4-2.

Table 1.4.4-2 Universal Water Quality Issues

Source Type	Activity	Contaminant Source	Lower Watershed	Middle Watershed	Upper Watershed
Nonpoint Source	Mining/Acid Mining Drainage (AMD)	AMD and Metals			X
	Agricultural runoff	Nutrients, herbi-cides/pesticides, pathogens		X	X
	Urban/Suburban Runoff	Salts, nutrients, metals	X	X	
	Erosion	Sediment	X	X	
	Construction	Sediment	X	X	
Point Source	Sewage Discharge	Pathogens, Nutrients	X	X	X
	Abandoned Industrial Facilities	Metals, Organics	X	X	
	Industrial Discharges	Organics, Metals	X	X	
Special/Spills	Oil Pipelines	Organics	X	X	
	Truck/Railroads	Organics	X	X	
	Tire Piles/ Junkyards	Special	X	X	X
	Dams	Contaminated sediment	X	X	
	AST / USTS	Organics	X	X	

1.4.5 Analysis of Stream Impairments and Sources in the Schuylkill River

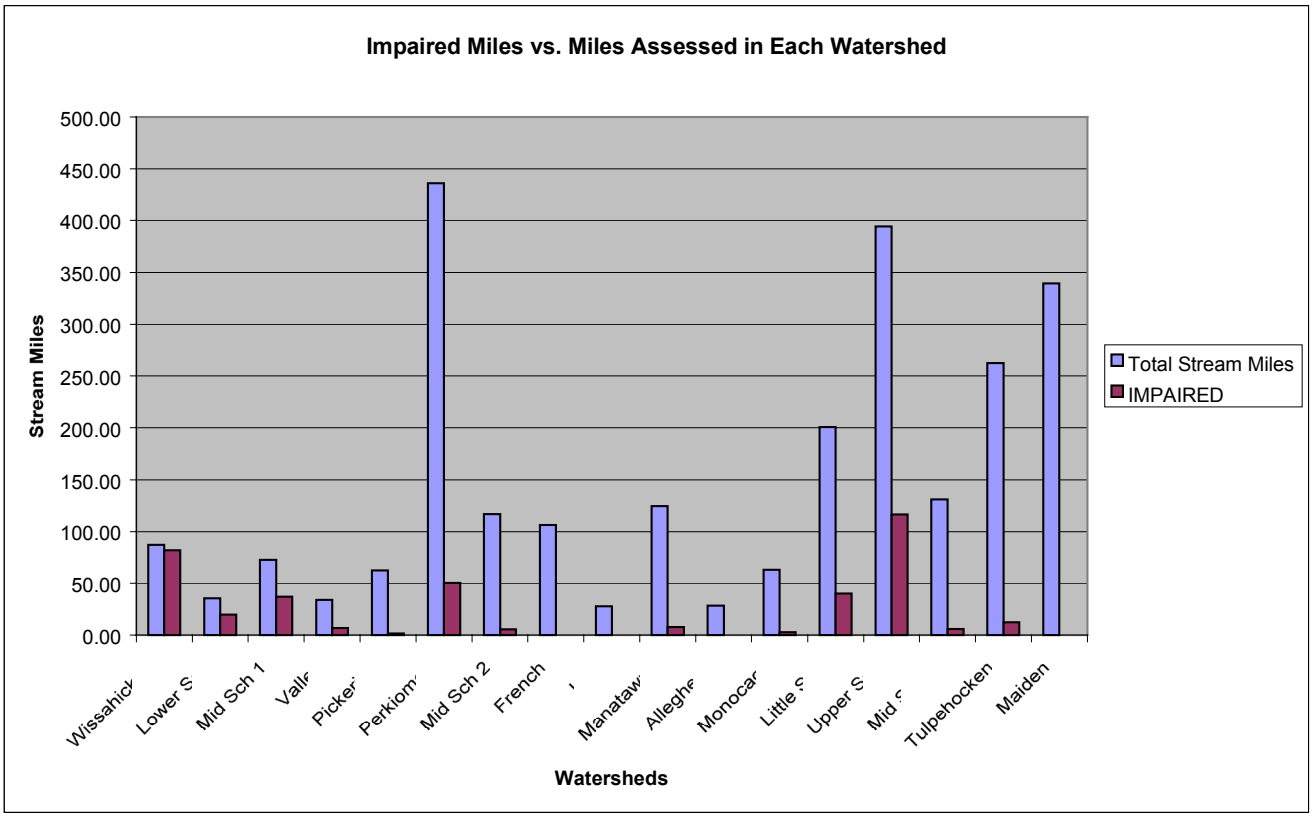
Key Points

- **Fifty-seven percent of the 2,522 miles of streams and creeks within the Schuylkill River Watershed have been assessed to determine their compliance with applicable water quality standards.**
- **Nearly 73% of the assessed stream miles have attained applicable water quality standards.**
- **Watersheds within the more highly developed downstream areas of the watershed have the highest percentage of stream length that has been impaired.**
- **Flow variability is one of the most significant causes of impairment identified within the watershed.**
- **Stormwater runoff from urban and suburban areas was identified as the cause of over half of the impaired stream lengths within the watershed.**
- **Although water quality data suggests that pathogens are a concern throughout the entire watershed, very few segments are listed as having pathogens as the primary cause of impairment.**

In accordance with Section 305 (b) of the Federal Clean Water Act, the Pennsylvania Department of Environmental Protection (PADEP) prepared a 305 (b) Water Quality Assessment Report in 2000. The Report summarizes water quality management programs, water quality standards, and point and non-point source controls. The Schuylkill River Watershed includes 2,522 miles of streams and creeks. Fifty-seven percent, or 1,428 miles, within the watershed have been assessed in order to determine compliance with applicable water quality standards. Almost 73 % of the stream miles that have been assessed – 1,039 miles - have attained the applicable water quality standards. Streams that are impacted by contaminant sources (point sources, or non-point sources such as stormwater runoff or acid mine drainage) so that water quality standards are not met, are designated as impaired. Twenty-seven percent of the stream miles (389 miles) that have been assessed do not meet applicable water quality standards and are designated as impaired. To date, 1,084 miles of streams within the watershed have not been assessed.

Figure 1.4.5-1 shows the percentage of assessed miles within each watershed that do not meet water quality standards and have been designated as impaired.

Figure 1.4.5-1 Impaired Miles vs. Miles Assessed in Each Watershed



The Wissahickon Creek, Lower Schuylkill and Middle Schuylkill (1) watersheds have the greatest percentages of impaired stream miles. No impairments were identified in the French Creek, Hay Creek, Allegheny Creek and Maiden Creek Watersheds.

Excessive algal growth, flow alterations, metals, nutrients, other habitat alterations, pathogens, PCB's, salinity/TDS/chlorides, siltation, water/flow variability, and organic enrichment/low dissolved oxygen have all been identified as causes of impairment within the Schuylkill River Watershed. Figure 1.4.5-2 and Table 1.4.5-1 summarize the miles of impairment and their primary causes throughout the Schuylkill River Watershed. The leading cause of impairment has been identified as water/flow variability.

Figure 1.4.5–2 Causes of Impairment Within the Schuylkill River Watershed

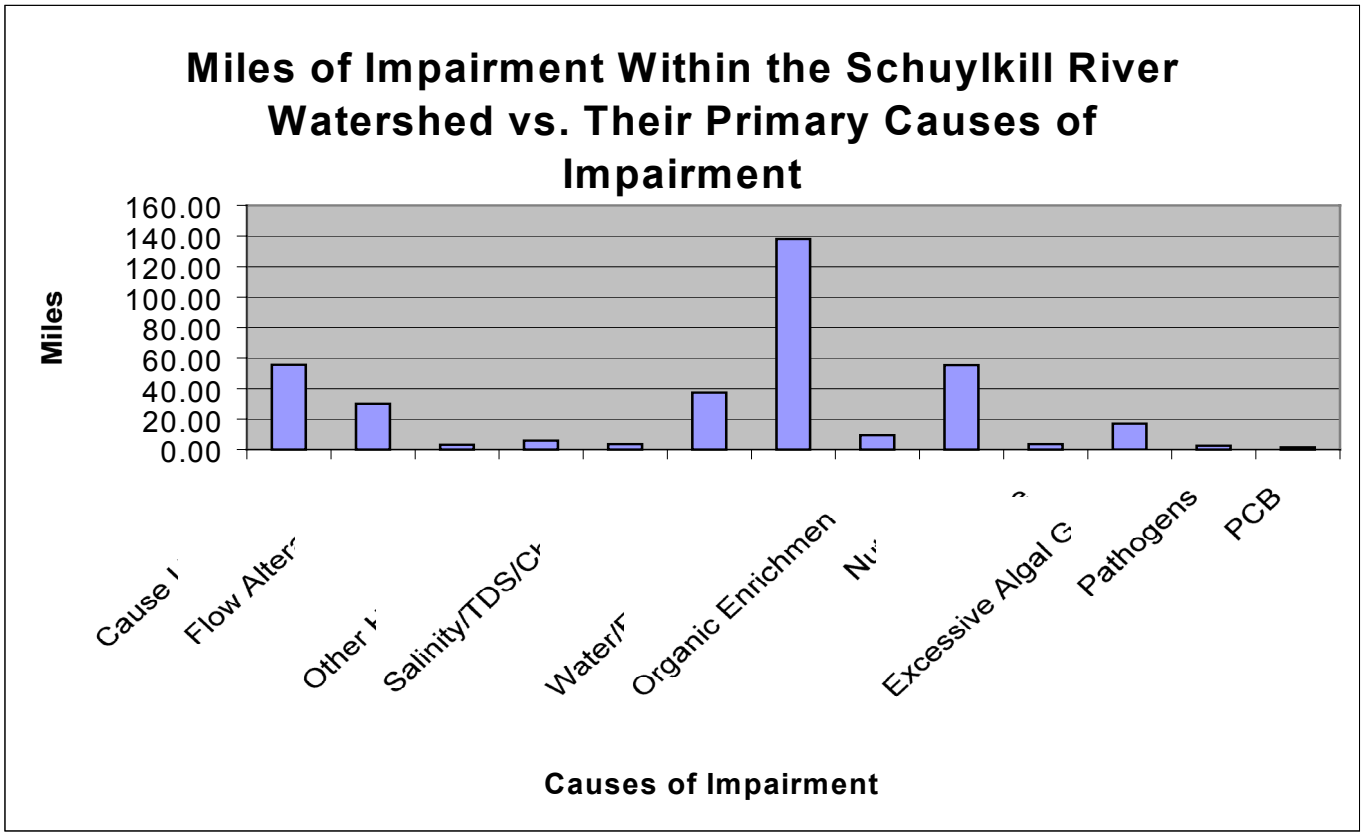


Table 1.4.5-1 Breakdown of Total Miles of Impairment by Primary Causes

Watershed	Total Miles
Cause Unknown	55.65
Flow Alterations	29.88
Metals	2.99
Other Habitat Alterations	5.86
Salinity/TDS/Chlorides	3.43
Siltation	37.48
Water/Flow Variability	138.18
Organic Enrichment/Low D.O.	9.32
Nutrients	55.38
Chlorine	3.51
Excessive Algal Growth	16.83
Pathogens	2.58
PCB	1.41

Point and non-point sources, such as agriculture, industrial and municipal point sources, urban stormwater runoff, small residential runoff, and acid mine drainage, can all contribute to impairment, as shown below by Figure 1.4.5-3 and Table 1.4.5-2.

Figure 1.4.5-3 Miles of Impairment within the Schuylkill River Watershed vs. Their Primary Sources of Impairment

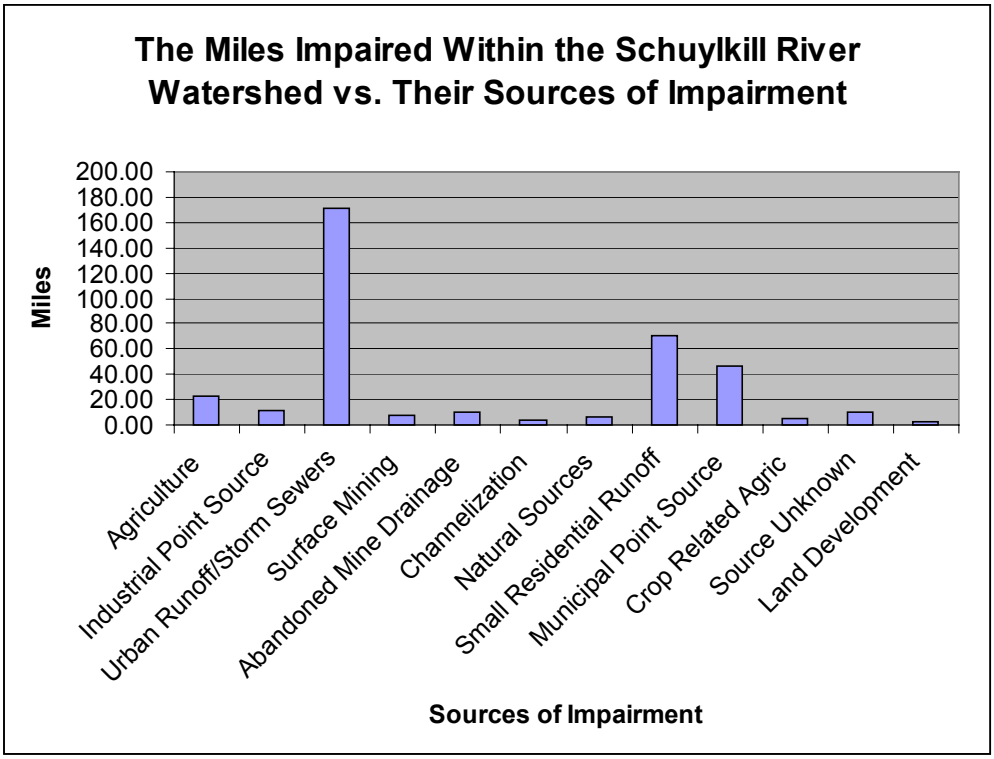


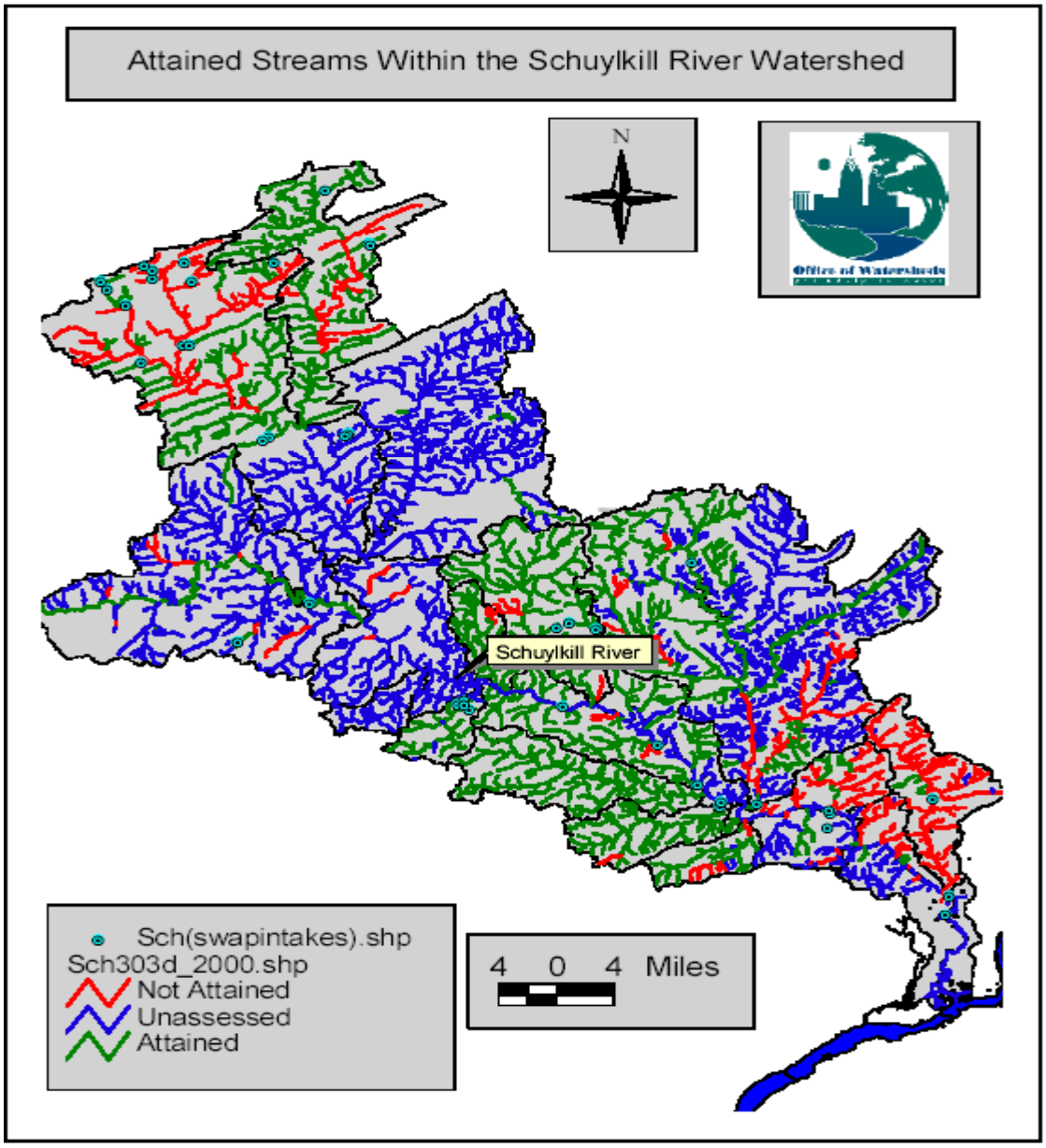
Table 1.4.5-2 Breakdown of Miles of Impairment by Sources

Source of Impairment	Total
Urban Runoff/Storm Sewers	107.09
Agriculture (General)	18.09
Small Residential Runoff	17.60
Source Unknown	10.48
Industrial Point Source	10.43
Abandoned Mine Drainage	9.84
Surface Mining	7.37
Natural Sources	6.37
Crop Related Agriculture	5.54
Channelization	3.57
Land Development	2.70
Municipal Point Source	0.19

Figure 1.4.5-4 displays the status of stream assessment within the Schuylkill River Watershed. Green lines represent streams where applicable water quality standards are being met. The red lines represent impaired streams where water quality standards are not being attained. The blue lines represent the streams that have not been assessed yet.

Impaired stream reaches are most common in the northwest and northeast sections of the watershed. The central portion of the watershed has the greatest amount of unassessed streams, compared to the rest of the watershed. More efforts should be made to assess this central portion (Berks County) of the Schuylkill River Watershed.

Figure 1.4.5-4 Stream Assessment within the Schuylkill River Watershed



1.4.6 Universal Water Quality Issues

Key Points

- Potential sources of contaminants affecting Schuylkill River water quality include acid mine drainage, sanitary wastewater, abandoned industrial sites, agricultural and construction runoff, contaminated sediments released during dam removal, catastrophic accidents, road runoff, and wildlife.
- Acid mine drainage from Schuylkill County is believed to be the largest source of metals (such as manganese) affecting source water quality throughout the Schuylkill River.
- Untreated or inadequately treated sanitary wastes can contribute significant bacterial loads to the river.
- Abandoned industrial sites and dumpsites located within the river's floodplain could significantly impact downstream water users.
- Erosion resulting from agricultural activities and pathogens from livestock wastes introduce sediment and microbials into the river.
- Erosion from construction sites without well-maintained sediment controls can significantly increase sediment loads to the river. To date, impacts from catastrophic accidents and spills have been insignificant, due to skillful, well-prepared responses.
- Storm runoff containing deicing salts and herbicides from right-of-way application cause increased levels of chlorides, sodium, SOCs, and urea in the river.
- Algal blooms resulting from excessive nutrients can significantly affect water treatment requirements.
- Increasing populations of Canada geese in the watershed have resulted in increased levels of coliform in localized stretches of the river.

Based on the analysis of the water quality data, stream impairment data, stakeholder input, and more than 12 watershed inspections, a number of specific issues were identified that have impacts throughout the watershed. These issues are:

- Acid mine drainage
- Discharges from septic systems, sewerage systems, and wastewater treatment plants
- Dumping, tire piles, salvage yards, and abandoned industry in or near the floodplain
- Agricultural runoff of herbicides, pesticides, fertilizer, sediment, and phosphorus
- Erosion and construction runoff
- Dam removal and sediment releases
- Catastrophic accidents and spills, particularly oil delivery spills, from roads, trains, and fires
- Road runoff
- Wildlife management

These topics will be discussed in detail throughout this section.

1.4.6.1 Acid Mine Drainage

There are 244 known surface and underground mining facilities in the Schuylkill River Watershed. Mining of coal, iron, calcium, and stone make up 85 % of those operations. Although coal mining has historically been the most predominant, iron mining is now just as common. Approximately 27 % (81) of the mines currently operating in the watershed are coal mines located in the Upper Schuylkill Watershed within Schuylkill County (See Figure 1.4.6-1).

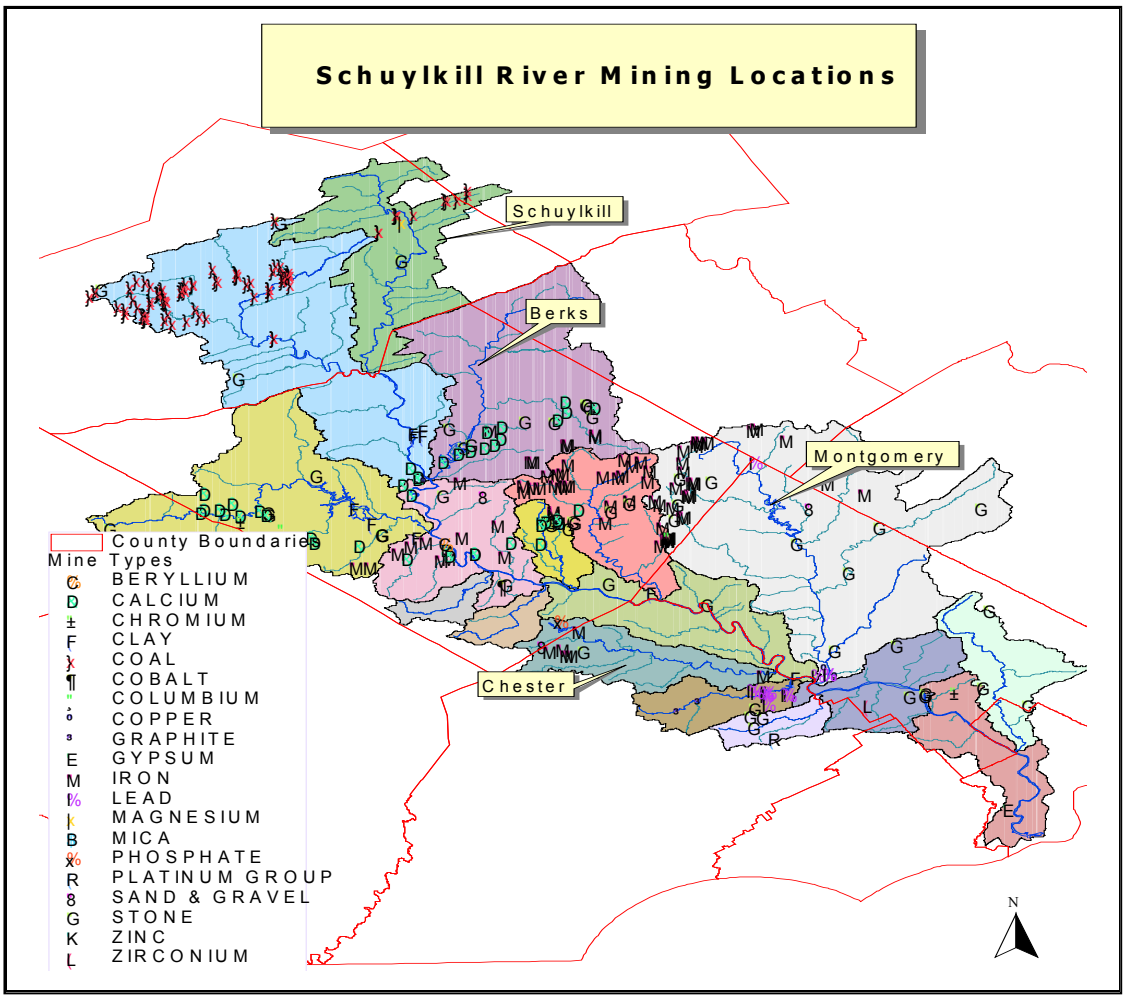
Acid Mine Drainage (AMD) is generated when the iron sulfide-bearing materials created by the interaction of the sulfate in coal beds and sulfate-reducing bacteria are exposed to oxygen in air or water during mining. The iron sulfides react with the oxygen to produce hydrogen sulfide, which makes the water more acidic. As the water becomes more acidic, its ability to leach metals from the existing rock layers increases. Therefore, the water from mines is not only acidic, but often contains increased concentrations of aluminum, iron, manganese, calcium, magnesium, and sulfate. Acid mine discharges can come from shafts, tunnels, boreholes, drifts, and seeps. AMD can also come from culm piles or spoil piles that run off into nearby streams.

According to a study sponsored by the Schuylkill Headwaters Association, Schuylkill Riverkeeper, and Eastern Pennsylvania Coalition for Abandoned Mine Reclamation, there are 108 abandoned mine drainage locations currently impacting the Upper Schuylkill River Watershed. This study documented the contaminant loadings of 35 locations for ranking, and identified 11 priority sites for remedial action.

The 11 priority sites were ranked based on their locations, feasibilities, interest, and impacts. The sites listed are as follows:

- Pine Knot/Oak Hill Mine Tunnel and Boreholes
- Pine Forest Mine Borehole
- Mary D Mine Borehole and Seeps
- Bell Colliery Drift
- Kaska Mine Outfall
- Silver Creek Mine Discharge
- Kaska Silt Dam
- Eagle Hill Mine Discharge
- Otto Mine Air Shaft
- Morea Mine
- Repplier Mine Water Level Tunnel

Figure 1.4.6-1 Mining Locations in the Schuylkill River Watershed



Concentrations of metals in acid mine drainage can be quite significant and can occur continuously or sporadically after rainfall events. PWD conducted a brief analysis of the discharge data from the 11 priority sites to determine if the loadings could be a major source impacting metals concentrations throughout the entire watershed. Metal concentrations at Philadelphia were estimated by summing up the annual metal loads produced by the AMD sites and then dividing them by the annual cumulative flow volume in the river based on the average annual mean flow. Based on this comparison, Figure 1.4.6-2 shows that AMD discharge produces large enough loads of iron and manganese to account for a majority of the concentrations observed at Philadelphia. Therefore, acid mine drainage from Schuylkill County is probably the largest source of metals, such as manganese, impacting source water quality for the entire Schuylkill River.

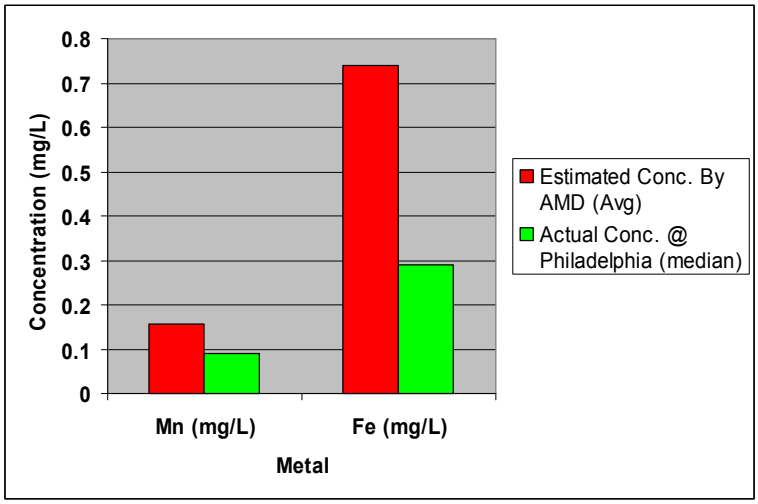
Based upon the analysis, the following 5 AMD sites in Schuylkill County account for a majority of the observed discharge of manganese into the Schuylkill River:

- Pine Knot-Oak Hill Drainage Tunnel
- Silver Creek Mine Pool Discharge
- Eagle Hill Mine Pool Discharge
- Milford Colliery Discharge/Brockton Overflow
- Otto Primary Discharge

These 5 locations stretch across all branches of the Upper Schuylkill Watershed and cover the major areas of Schuylkill County. The Oak Hill bore tunnels nearby the Pine Knot location are also the greatest observed discharge of iron into the watershed from AMD. Efforts should be focused on remediating these 6 discharges in Schuylkill County in order to improve source water quality for downstream water suppliers and over 1.8 million persons.

Figure 1.4.6-2 Comparison of Average Concentrations of Iron and Manganese Estimated in the Schuylkill River at Philadelphia by Acid Mine Discharge to Actual Concentrations Measured at Philadelphia

AMD from Schuylkill County is the most likely largest continuous source of metals that impact water quality in the Schuylkill River Watershed.



1.4.6.2 Discharges from Septic Systems, Sewerage Systems, and Wastewater Treatment Plants

Improper wastewater collection and treatment causes pathogens and nutrients to impact the quality of source water supplies, recreational water quality, and aquatic life. Improper wastewater collection and treatment may result in the following:

- Wet weather overflows of raw sewage by the sewer system (manholes and pump stations) due to treatment plant capacity limitations

- Wet weather overflows of raw sewage by the sewer system (manholes and pump stations) due to lack of collection system capacity and infiltration/inflow sanitary sewer overflows (SSOs)

- Wet weather overflows of raw sewage by the sewer system due to combined sewer overflow systems (CSOs)

- Wet weather overflows of raw or partially treated wastewater by the treatment plant due to treatment plant capacity limitations or lack of treatment upgrades.

- Dry weather overflows caused by blockages (tree roots, grease, etc.) sometimes due to poor collection system maintenance.

- Dry weather discharges of raw sewage due to defective sewer lateral connections and improperly operated CSOs

- Routine discharges of raw sewage due to lack of adequate septic systems, sewerage systems, and enforcement

- Routine discharges of raw sewage due to failing septic systems

- Periodic discharges of partially treated sewage due to treatment plant performance limitations

Most of these issues can be observed throughout the Schuylkill River Watershed. Though not as prevalent as in the original watershed inspections conducted in the 1880's, 120 years of progress still have not brought adequate and proper sewerage systems to the entire watershed, and discharges of raw sewage occur to this day. In Schuylkill County, raw sewage is known to discharge from New Philadelphia and Middleport areas from "wildcat" sewers (illegal sewers discharging directly to the river). In addition, there are numerous cabins and cottages throughout the watershed that are suspected of making illicit discharges into the river and local streams and lakes. Some are discharging raw sewage, while others are operating with septic systems that have failed, or septic systems that are not located on properly draining soils or which drain to areas of fractured rock and limestone. In addition, there are several communities with CSO discharges upstream of drinking water intakes. These include Philadelphia, Bridgeport, Norristown, Minersville, Coaldale, Mahanoy City, Ashland, Shenandoah, Tamaqua, and Pottsville.

Other than raw sewage, partially treated sewage or inconsistent limits in discharge permits are also an issue. According to a brief investigation of discharge permits in the Schuylkill River Watershed, it was observed that there are disconnects in the allowable limits of fecal coliform discharges into the Schuylkill River. In the Southeast Department of Environmental Protection (DEP) region that covers the Chester, Bucks, Philadelphia, and Montgomery County area, the fecal coliform discharge limit is 200 cfu/100ml year round. However, in Berks County, part of the Southcentral regional

DEP office in Harrisburg, fecal coliform discharge limits from wastewater discharge can reach 10,000 cfu/100mL during winter or non-recreational periods. Similar seasonal limits were observed in Schuylkill County, part of the Northeast DEP region. It was determined that these seasonal limits are related to whole effluent toxicity issues in the discharge from chlorine by the wastewater plants. The Delaware River Basin Commission (DRBC) has also decided that the toxicity of the chlorine discharges to fish during these periods was a greater concern than pathogens because little recreation was occurring.

However, the current permits allow wastewater dischargers to release more pathogens during the winter, upstream of water supply intakes. Also, the excess bacteria can and will survive in sediments in reservoirs and lakes and can be re-suspended by increased river flows, turnover, or recreational activity in the spring and summer. For example, the City of Reading Wastewater Treatment Plant (WWTP) has a fecal coliform discharge limit of 10,000 cfu/ml in the winter that extends into April. Reading is the largest wastewater discharger upstream of water supply intakes in the entire watershed. Therefore, the current discharge limits seem to encourage the discharge of more pathogens and bacteria in areas upstream of drinking water supplies.

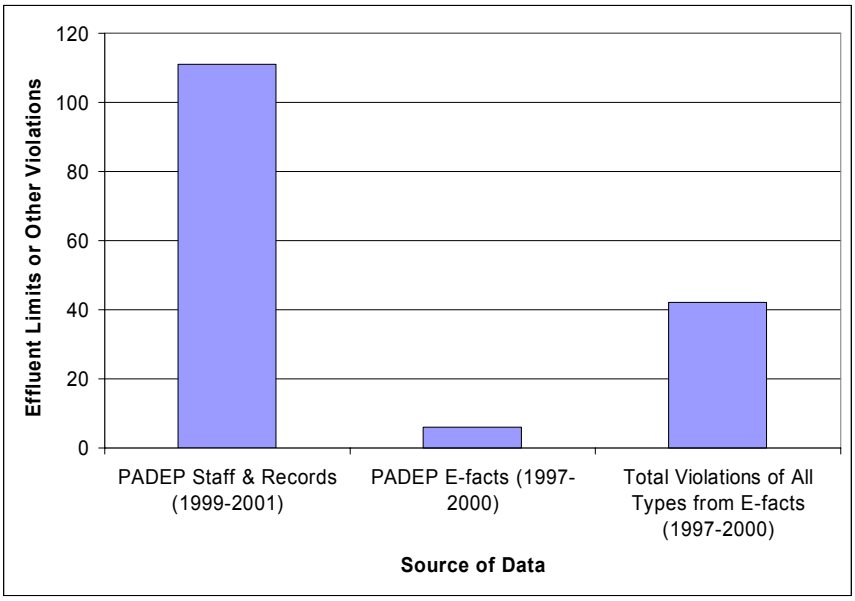
It is recommended that the DRBC and three PADEP regions develop a watershed wide approach to addressing permit requirements. One suggestion would be a uniform fecal coliform discharge limit for any wastewater discharge upstream of a drinking water intake in the watershed. For small wastewater systems that have problems meeting toxicity requirements, ultraviolet light disinfection would be recommended. Ultraviolet light disinfection is preferred because it inactivates bacteria, such as *Cryptosporidium*.

Some wastewater plants in the watershed do not perform properly and can discharge inadequately treated water on occasion. An investigation of the available electronic databases to determine the level of compliance of wastewater dischargers in the watershed was conducted. These databases are somewhat difficult to understand and often give users the impression that paper or administrative violations are equivalent to effluent limit discharge violations, because they are all considered non-compliance events. However, in reality, effluent violations represent the most severe threat to the environment and water supplies. Therefore, dischargers (or wastewater treatment plants) with more effluent violations speak of chronic problems that require greater investigation.

Utilizing the PADEP E-facts website, data on violations by 71 wastewater dischargers in the Schuylkill River Watershed were compiled from 1997 to 2000. The most frequent violation observed was an effluent limit violation. Overall, the database reported 23 effluent limit violations for this period by 12 sewage treatment plants (STPs), or 17 % of the STPs. The average number of effluent limit violations by the plants observed was approximately 2, but some plants had up to 7 effluent limit violations. In addition to effluent limit violations, 8 violations for the discharge of untreated sewage were reported for 4 plants (5 % of the STPs). Of those plants, an average of 2 violations was observed with a maximum of 3 violations reported.

The next level of the investigation focused on the types of effluent limit violations, by working with DEP inspectors in the Southeast region to compile specific violation data. Also, the exercise served as a good way to check the accuracy of the electronic databases from E-facts and Envirofacts to see if they are outdated or inaccurate. Based upon our focused comparison of 17 dischargers in the Schuylkill River Watershed, it was determined that the electronic databases tended to significantly underestimate the number of violations by some dischargers. Also, some dischargers that appeared to have no violations reported in the electronic databases actually had many violations. Figure 1.4.6-3 compares the accuracy of the electronic PADEP E-facts database to actual records compiled by PADEP staff. As shown, there are large discrepancies between the virtual information and reality.

Figure 1.4.6-3 Comparison of Sources of Violation Information for the PADEP Southeast Region: PADEP staff and records vs. PADEP E-facts Electronic Database



Note: the government databases tend to underestimate the extent of effluent limit violations occurring.

The in-depth examination of the types of violations shows that of the 111 effluent limit violations reported for the 17 sewage treatment plants, over 75 % of the violations were total suspended solids violations. The lack of ability to adequately treat total suspended solids suggests that the treatment plant and sewer system are experiencing problems during wet weather periods.

The impacts of wet weather issues extend beyond wastewater treatment plant performance. Sometimes the lack of treatment capacity by the wastewater treatment plant causes a "back up" in the sewer system entering the wastewater plant and results in overflows at manholes and pump stations (Figure 1.4.6-4). Other times, the infiltration and inflow of rainwater and groundwater into the sewer pipes themselves, either due to age or disrepair of the sewer system, will also cause manholes and pump stations to overflow. The communities most affected by these issues are older communities with decaying infrastructure and new communities without enough sewer and treatment capacity to handle the increased residential populations as people move further out from urban areas. Overall, sewer system capacity and integrity as well as treatment plant capacity during wet weather periods represent the greatest and most difficult sewage related issues in the watershed.

Figure 1.4.6-4 Overflowing Manhole Nearby a Stream

Though some communities are facing consent orders and enforcement action against them due to stormwater runoff problems, other communities are working hard to address stormwater issues. For example, Pottstown has been working hard to address inflow and infiltration issues and has become a model for other communities to emulate. The City of Philadelphia has also made strides to identify and mitigate defective laterals as well as piloting innovative stormwater reduction techniques.

There is a small percentage of dischargers that have effluent violations, while the majority (83 %) of the 71 wastewater plants work hard to protect the river by discharging properly treated wastewater. The Exeter WWTP (Figure 1.4.6-5) is an example of one the well-operated wastewater treatment plants in the watershed. The Exeter WWTP has won numerous awards for its excellent performance and was even nominated for national awards.

Figure 1.4.6-5 Exeter Wastewater Treatment Plant
The Exeter WWTP is an example of one of almost 60 well-operated wastewater treatment facilities in the Schuylkill River Watershed.

1.4.6.3 Dumping, Tire Piles, Salvage Yards, and Abandoned Industry Near the Floodplain

The Schuylkill Watershed was one of the first areas in the United States to feel the effects of industrialization and mining. However, as coal mining, metal manufacturing, and other manufacturing industries have declined, the sites of these industrial activities were abandoned, leaving valuable riparian area damaged and unrestored. Some of these abandoned sites have old spoil piles, or lagoons that still leach remnants of contaminated materials. These sites are also neglected, and therefore there is no one organization responsible for the monitoring or mitigation of the old lagoons and spoil piles. These abandoned and somewhat isolated areas also encourage dumping and general neglect by the nearby communities since they are considered to be hazardous eyesores.

In addition to abandoned industrial sites, there are numerous salvage yards and several trash transfer stations located along the river and stream banks. These sites appear to be in or near areas prone to flooding, and seem to have limited environmental practices in place to prevent contaminated runoff or debris from entering the river. Old oil tanks and chemical containers in or near areas prone to flooding have been observed at some of these facilities and warrant special concern. Other areas include tire piles, as shown by Figure 1.4.6-6, which if ignited by vandalism or accident, will result in significant damage to the entire Schuylkill River below them.

Figure 1.4.6-6 Tire Piles and Trash Dumping along the Schuylkill River
The trash dumping and dead deer on the right were recently cleaned up thanks to the Greater Pottstown Watershed Alliance.

1.4.6.4 Agricultural Runoff

Agricultural activities without proper controls can release pathogens, nutrients, herbicides, pesticides, and sediment into streams, which impacts source water quality, recreational water quality, and aquatic life. More than one-third of the Schuylkill River Watershed is agricultural land. Most of the agricultural land is located in Berks County, which is one of the top five counties in Pennsylvania for agricultural commodities, livestock, and production.

Over the past several decades, the amount of agricultural land has been decreasing in the Schuylkill River Watershed, but this does not mean that the level of agricultural activity is decreasing proportionally. It is suspected that residential development of agricultural land is concentrating agricultural activity into smaller areas that can lead to greater impacts on water quality.

Erosion and runoff of soils during tillage and farming release significant amounts of sediment and nutrients into the streams and rivers if there aren't proper riparian buffer strips in place. In addition, cattle access to streams causes significant damage to the streambank and makes it more susceptible to erosion. Runoff of livestock wastes also releases pathogens into water supplies. Figure 1.4.6-7 illustrates agricultural uses of land within the watershed.

Figure 1.4.6-7 Cows in the Stream and Farming Tillage Impacts on Sediment and Nutrients

Despite the potential for significant negative impacts by agricultural activities, agricultural lands also represent the simplest and cheapest areas for potential restoration and protection. In fact, many farmers are actively pursuing a variety of techniques to help protect and restore local streams. As shown in Figure 1.4.6-8, a number of farmers are installing specially designed cattle crossings and streambank fencing to reduce the impacts of cattle on streams. Other farmers are even establishing riparian buffers to protect the streambank and to filter out harmful nutrients.

Figure 1.4.6-8 Farmers Installing Cattle Crossings (left) and Streambank Fencing with Riparian Buffers (right) to Limit the Impacts of Livestock on Streambanks and Filter Runoff from Pastures in Berks County.

1.4.6.5 Development, Construction, and Erosion Runoff

The Schuylkill River Watershed is developing at a significant rate. With this development comes the construction of homes, highways, and businesses to support that growth. This construction usually entails significant disturbance and moving of earth. The impacts of runoff from construction sites can range from negligible to significant, depending on the characteristics of the construction site, the types of erosion controls that are implemented, and the maintenance of those control structures. There are many types of controls that include the placement of sediment barriers or fences, or bags, which trap sediment in storm drains. Erosion and sediment control plans must be submitted for review to the township and/or county Soil Conservation District. However, the amount of time and personnel available from both the township and county conservation district are limited, compared to the significant amount of submittals by the numerous developers and developed sites. In addition, the amount of time and staff available to inspect sites in order to observe if the proposed erosion controls are in place are also severely limited, and frequently, priorities are driven by complaints from citizens.

As shown in Figures 1.4.6-9 and 1.4.6-10, the impacts of runoff from construction can be severe, releasing significant amounts of sediment into local waterways. The combined impact from the sediment releases at these locations in certain areas can lead to increased dredging and reduced storage capacity in water supply reservoirs. These impacts have been observed on Lake Ontelaunee, the City of Reading's water supply

reservoir. In addition, sediments carry phosphorus into lakes and streams, causing algal blooms. The excess nutrients cause our reservoirs to become eutrophic.

Figure 1.4.6-9 Photographs of the Impacts of Runoff from Construction: Lake Ontelaunee

Top left and right: Erosion and runoff from highway construction and construction runoff. Bottom: the impacts of construction runoff that includes increase dredging of reservoirs or decreased water supply storage.

Figure 1.4.6-10 Aerial View of Green Lane Reservoir Before and After a Storm Event
Even visually the amount of sediment entering the lake can be quite significant from runoff and erosion (photos courtesy Philadelphia Suburban Water Company).

1.4.6.6 Dam Removal and Sediment Releases

There are a large number of major and minor dams along the streams and mainstem river in the watershed. A number of these dams are very old, abandoned, or in disrepair. A significant amount of sediment, some very old and containing toxic contaminants from historical industrial pollution, resides behind these dams (see Figure 1.4.6-11). Recently, there have been efforts nationwide to remove many of these dams from streams because they inhibit the ability of fish to migrate upstream and spawn. Though these activities are meant to improve aquatic life, they also can negatively impact the water quality downstream for water supplies. The dams are usually removed in such a way as to limit the initial flushing of sediment downstream. However, after heavy storms, these sediment piles that remain are washed downstream to other dams, water supply intakes, or water supply reservoirs. Therefore, in order to minimize negative water quality impacts, dam removal efforts need to be coupled with sediment dredging and sediment pile removal, as well as streambank stabilization (via plantings) to limit damage done by receding stream water.

Figure 1.4.6-11 Sediments Remaining behind Felix Dam after Breaching from Hurricane Floyd

1.4.6.7 Catastrophic Accidents and Spills

At any given time throughout the watershed, an accident that releases contaminants that can directly impact the quality of a water supply can occur. These catastrophic events can require public water supply withdrawals to stop for periods of time ranging from a few hours to several days, limiting available water to affected communities. Water suppliers and communities are prepared to deal with such accidents since their emergency response planning included preparation for just such occasions, and therefore the impacts on the public in general are limited. However, when an accident of significant nature does occur under conditions that cannot be anticipated, the impact can be quite dramatic. For example, in the Schuylkill River Watershed alone this year, there were several fuel oil spills or discharges into waterways, two railroad tanker car derail-ments, two major fires along the river at large industrial facilities, underground storage tank spills, and various spills of gasoline and oil onto roads and bridges, which leaked into local streams.

Two fires were quite significant and if not for the skill and preparation of local and government officials they could have impacted the water supply for PAWC Norristown and Philadelphia. One of the fires was the explosion of the transformer station at Barbadoes Island (see Figure 1.4.6-12). The intake for Norristown is right near the island itself. Luckily, containment dikes contained the spilling transformer coolants, and well-prepared emergency response crews did not spray additional water that would result in release of washdown to the river. The other major fire was at Bridgeport, at an industrial park that contained over 50 different businesses, including furniture stripping and painting, automotive repair, and printing activities. Though the businesses were small and did not require individual reporting of the hazardous chemicals on-site, the combined amount of hazardous chemicals on-site was quite significant and fueled the

fire and explosions for over 2 days. The industrial park was located on the riverbank. The fire washdown from the site entered the storm drains at the industrial park and was able to discharge into the canal along the river. Fortunately, emergency response and containment/clean up crews were able to contain wash down and runoff to the canal area. Therefore, no significant amounts of washdown and chemicals entered the river and water supplies were protected.

Regarding railroad hazards, fortunately, the tanker car derailments that occurred this year were located below the water supply intakes for the City of Philadelphia, but only by a few miles. One tanker car derailment accident spilled several thousand gallons of sulfuric acid into the river (see Figure 1.4.6-13). The other tanker car derailment involved an empty car, but it contained remnants of styrene, a volatile organic chemical. One tanker car can contain up to 14,000 gallons of hazardous chemicals. In this area, most railroad lines run along the Schuylkill and Delaware Rivers and pass through Philadelphia. Therefore, given the significant amount of shipping through this corridor, the risk and possibility of a tanker car derailment and release of hazardous material into the Schuylkill River is fairly low, but real.

Figure 1.4.6-12 Local Television and Newspaper Coverage of the Bridgeport Fire
Fire runoff and washdown into the river can impact water supplies.

A firefighter with the Norriton Fire Company (below) blasts water on the spreading flames. Hundreds of firefighters responded, and as municipal water reserves dropped, they drew from the Schuylkill.

(Bob Williams/ Inquirer)

Figure 1.4.6-13 Tanker Car Derailment in Philadelphia
Tanker cars can carry up to 14,000 gallons of hazardous materials.

In addition to the fires and tanker car derailments, a number of fuel oil and unidentified oil spills were reported. Some of these were due to overfilling of fuel oil into tanks and spilling into nearby storm drains. Several oil spills such as the one in Conshohocken were suspected to be due to releases from local gas stations or automotive repair areas, but the sources were never identified. In some cases, persons even dump oil down storm drains without realizing that it can enter the river and impact their water supply. The results of an oil spill from an automotive repair facility into Green Lane Reservoir are illustrated on figure 1.4.6-14.

Figure 1.4.6-14 Cleanup of an Oil Spill at Green Lane Reservoir from an Automotive Repair Facility

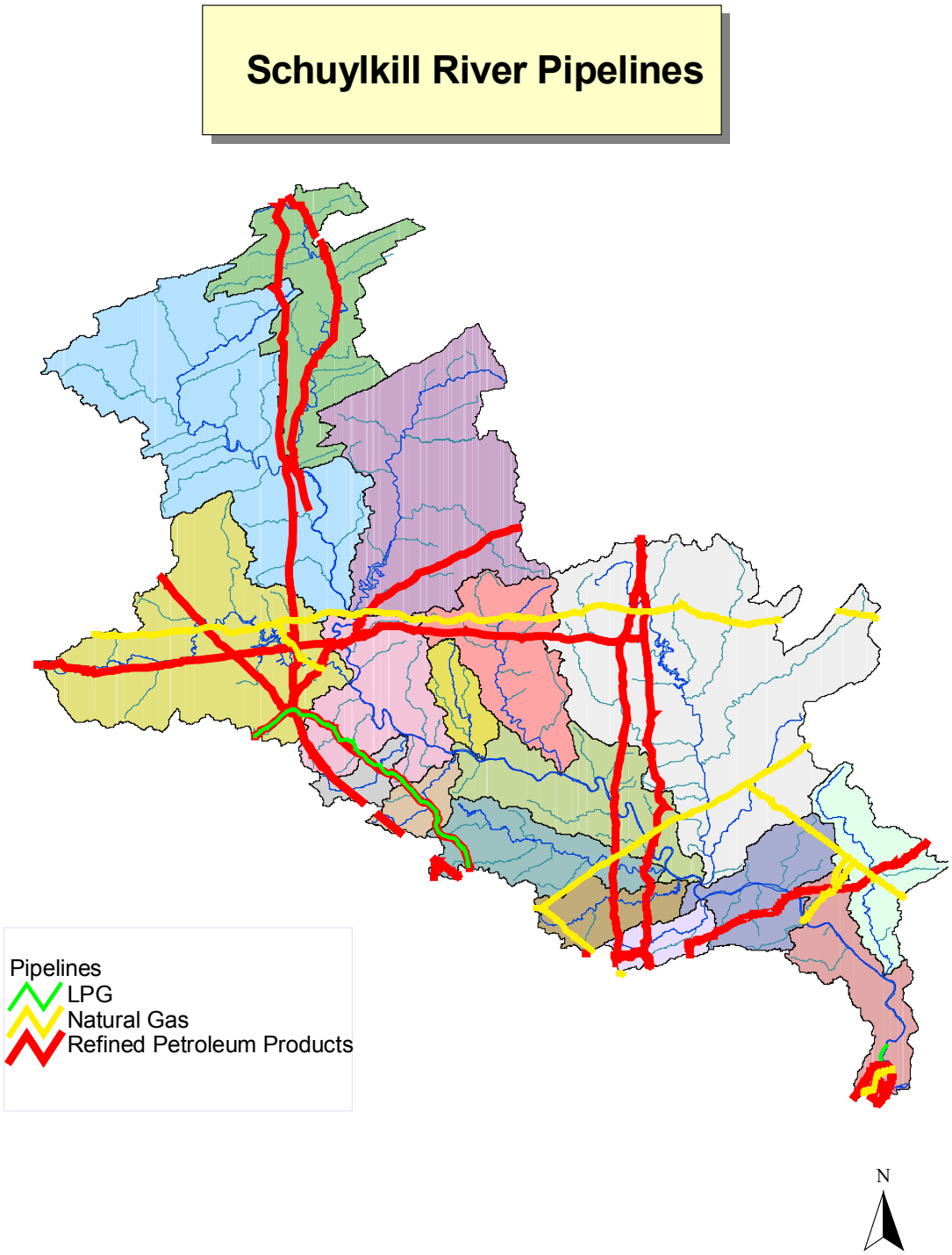
Beyond the known incidents of this year alone, there are past incidents that continue to concern water suppliers. For example, in the past, petroleum pipelines have broken, releasing thousands of gallons of petroleum into local groundwater supplies, streams, and water supplies. The river has many major petroleum pipeline crossings, unknown to many people. The age and location of these pipelines are largely unknown and the

petroleum suppliers are just now voluntarily supplying partial information to local and federal governments. It is believed that these pipelines are of significant age and nearing their service life expectancy. Locations of known pipelines are shown on Figure 1.4.6-15.

The highways and bridges that cross the Schuylkill River and its tributaries also represent significant opportunities for impacts on water supplies. In the event of an accident, tanker trucks carrying gasoline or fuel oil can spill thousands of gallons of their cargo into storm drains on roads and bridges that discharge directly into the stream or river. In some cases, since many roads follow along the banks of the river and streams, entire trucks can run off the road and into the stream or river, releasing their cargo. In addition to the possibility of impacts due to direct spills from trucks and cars, bridge maintenance activities have been known to release chemicals into the river itself. The painting of bridges can result in the release of paints and solvents if not handled properly and applied with the appropriate controls.

Figure 1.4.6-15 Petroleum and Natural Gas Pipelines in the Schuylkill River Watershed

Petroleum pipelines cross the Schuylkill River and its tributaries in many places and may be reaching the end of their service life. Due to voluntary mapping requirements, only a portion of the pipelines in the watershed may be identified on GIS.



1.4.6.8 Road Runoff

In addition to the numerous types of spills and catastrophic impacts from accidents on highways and bridges, maintenance of roadways and parks can also impact water quality. The maintenance of highway shoulders includes spraying of herbicides such as glyphosate to kill weeds growing beside the highway. The evidence of spraying can be observed in summer and fall, when it may be possible to notice a brown swath of dead plant material including portions of nearby trees within 20-50 feet of the highway shoulder. Though the application of these materials is important for the maintenance and protection of the highway, they are sometimes sprayed into storm drains or nearby waterways where they can persist and impact water quality. This effect could be significant given the significant number of miles of highway in southeastern Pennsylvania and numerous miles of roadway adjacent to streams and rivers.

Another concern from road runoff is the release of road salts during winter application periods, as illustrated by figure 1.4.6-16. Concentrations of salts, such as sodium and chloride, have increased significantly over the past several decades. These increasing trends seem to be linked to the increased development and impervious cover in the watershed as more highways, driveways, walkways, and parking lots are built in the watershed. The application of salts to these surfaces to make them safe for travel is important. However, at some time in the future, these practices may need to be addressed in order to reduce impacts on waterways before they significantly impact water supplies or aquatic life. Several water supplies in the Northeastern U.S. have similar issues with the impacts of salt application on water quality and have developed programs to reduce application and mitigate impacts in sensitive areas. Salt mist spraying before storms using special trucks is an example of a new technology that can be used in the Schuylkill River Watershed to reduce salt application and mitigate salt runoff impacts.

Another example of the negative impacts of runoff can be found in the situation that occurred in the winter of 1994 when some communities ran out of salt and began using fertilizer as a deicer on sidewalks and driveways. The urea in the fertilizer reacted with the chlorine at a treatment plant and caused major taste and odor problems. This occurrence highlights the need to educate community members about the preventable negative impacts of runoff.

Figure 1.4.6-16 Road Salt Application During the Winter

1.4.6.9 Algae Impacts

The growth and die-off of various types of algae can have significant impacts on water treatment. Diatoms can bloom and clog the filtration process requiring increased filter backwashing. When blue-green filamentous algae die, they release very minute concentrations of chemicals that are not harmful to human health, but which make the water taste and smell unpleasant. The removal of these chemicals requires additional and costly treatment. Algal blooms are caused by excess nutrients in the aquatic system, as well as the loss of shade cover from trees along the stream and river. The reduction of nutrients from agricultural runoff, sewage discharge, and lawn fertilizer application are important components in preventing these situations. Preventing the loss of riparian buffer and shade trees along the stream and river would also keep this problem from worsening. A dramatic duckweed bloom that occurred on the Schuylkill River in August of 1999 is illustrated below by Figure 1.4.6-17.

Figure 1.4.6-17 Picture of a Duckweed Bloom on the Schuylkill River (8/16/99) that Turned the River Green for Several Miles and Made the National News
(Photo from Philadelphia Inquirer)
The low flows and slow flows behind dams, large amounts of sunlight, and excessive concentrations of nutrients in the Schuylkill River provide the proper conditions for such algae blooms.

1.4.6.10 Wildlife Management

The Schuylkill River Watershed provides refuge to many wonderful birds and animals. However, there are certain conditions in which any animal can damage the land and water resources in a given area (see Figure 1.4.6-18). Damage can be caused by a significant and unnatural proliferation of a species, the inhibition of migratory activities, destruction of predatory species, or other factors. The impacts of large and ever-increasing populations of geese in this watershed and nationwide are well known. Figure 1.4.6-18 depicts a local goose population. Locally, geese have been found to impact areas for most major water supplies, which has resulted in the closing of the Deep Creek Lake (part of the Green Lane Reservoir Area) in Montgomery County to swimming. Studies by the Philadelphia Suburban Water Company identified that geese were responsible for 70 % of the *E. coli* bacteria in the Deep Creek Lake.

There are a number of techniques that are being employed in order to protect land and water resources from the geese. Some of these involve educating people not to feed the geese in sensitive areas, while others include scaring the geese with noises or dogs. The last resort used in most cases usually involves the active hunting of geese or egg addling to control skyrocketing resident populations in various areas.

Deer have also been identified in various suburban and urban areas as the cause of negative impacts on local land and water resources. Park and land areas that provide habitat for deer, but prevent hunting due to nearby homes, have experienced increasing deer populations. In some cases, the herd becomes unnaturally large and starts to damage the trees and undergrowth through heavy feeding. The loss of undergrowth in

old canopy forest areas is significant and leads to increased erosion. In addition, deer can be vectors for many pathogens.

Overall, it is recommended that water suppliers, park managers, golf course managers, state and federal wildlife officials, and wildlife experts should meet in order to develop a deer and geese management plan for the Schuylkill River Watershed. This would help to combine the resources of various individual efforts into a comprehensive and more effective form of action.

Figure 1.4.6-18 Geese Damaging Land Near a Water Supply Intake
The skyrocketing population of resident non-migratory geese throughout Pennsylvania and the entire United States is damaging land and water resources.

1.4.7 Watershed Monitoring: Current and Future Needs

Key Points

- **Monitoring within the Schuylkill River Watershed is conducted by 18 water suppliers, government agencies, academic institutions, and community and environmental groups.**
- **Water quality monitoring efforts should be coordinated, and the data should be compiled, organized and shared.**
- **There are over 200 routine monitoring locations in the Schuylkill River Watershed.**
- **Over 50 % of the monitoring sites are focused in areas that represent only 25 % of the entire watershed (French, Valley, Pickering, and Perkiomen creeks).**
- **Valley Creek has five times more monitoring locations than other sections of the watershed.**

Understanding the current and future water quality challenges facing water suppliers and the Schuylkill River Watershed requires analysis of data collected over time at different locations in the watershed. However, the current approach to monitoring has not been coordinated or planned. At any given time, there are five public agencies conducting professional routine monitoring of the Schuylkill River Watershed. Each of the 18 water suppliers in the watershed conducts some form of monitoring at their 42 intakes. In addition, community groups conducting routine monitoring of nearby streams share their data with the Schuylkill Riverkeeper. Other community organizations conduct monitoring, but do not share it with other organizations due to lack of time, technical capabilities, and resources. Overall, no coordinated compilation and analysis of water quality data to support spatial comparisons of water quality and water quality issues throughout the watershed has been observed to date.

Most of the energy and effort that goes into routine monitoring is focused upon specific issues and projects in particular subwatersheds or areas of the Schuylkill River. For example, monitoring by the U.S. Army Corps of Engineers is focused on the recreational quality of Blue Marsh Lake. The National Park Service monitors Valley, Pickering, and French creeks for recreational quality considerations. Water suppliers tend to monitor their intake water quality for process adjustment considerations. Table 1.4.7-1 provides a description of the organizations that conduct routine monitoring in the Schuylkill River Watershed and the level of monitoring that is conducted. As shown, almost one quarter of the routine monitoring sites in the watershed are staffed by volunteers (not including water supplier monitoring).

Not including water suppliers, there are 180 known locations where routine monitoring is occurring in the Schuylkill River Watershed. Figure 1.4.7-1 provides a breakdown of the number of locations within the various subwatersheds of the Schuylkill River. Including water suppliers, there may possibly be 200 routine monitoring locations in the Schuylkill River Watershed. This would suggest that there is a routine monitoring location to characterize every 10 square miles of the approximately 2,000 square-mile watershed. However, this is not the case. As shown in Figures 1.4.7-1 and 1.4.7-2, over

50 % of the monitoring sites are located in four subwatersheds that represent 25 % of the total watershed area. Those four watersheds are the French, Valley, Pickering, and Perkiomen Creek watersheds. Almost 30 % of the monitoring sites are located along the main stem of the river, covering almost 100 miles.

Table 1.4.7-1 Summary of Routine Watershed Monitoring

Organization	Focus Area (s)	Level of Monitoring	Parameter Groups	# of monitoring locations
National Park Service	Valley, Pickering, and French Creeks	Professional	Physical, inorganics, and metals	69
PADEP	Perkiomen, Maiden, Manatawny, Tulpehocken Creeks	Professional	Physical, inorganics, and metals. Limited microbiological	13
USEPA	Schuylkill River near King of Prussia	Professional	Physical, inorganics, and metals	12
USGS	Pickering, Perkiomen, and French Creeks	Professional	Physical, inorganics, organics, SOCs, and metals parameters	18
US Army Corps of Engineers	Tulpehocken Creek & Blue Marsh Reservoir	Professional	Physical, inorganics, organics, SOCs, microbiological and metals parameters	10
Schuylkill Riverkeeper	All except Maiden, Tulpehocken, & Valley Creeks	Volunteers	Simple physical parameters, limited inorganics and metals	48
Lower Merion Conservancy	Lower Merion Twp tribs – Lower Schuylkill	Volunteers	Simple physical parameters, limited inorganics and metals	8
Water Suppliers	All	Professional	Varies, but mostly inorganics, metals, microbiological Limited organics	42 possible, but 7-10 with almost weekly or daily data for many parameters

Figure 1.4.7-1 Number of Monitoring Sites in Schuylkill Subwatersheds

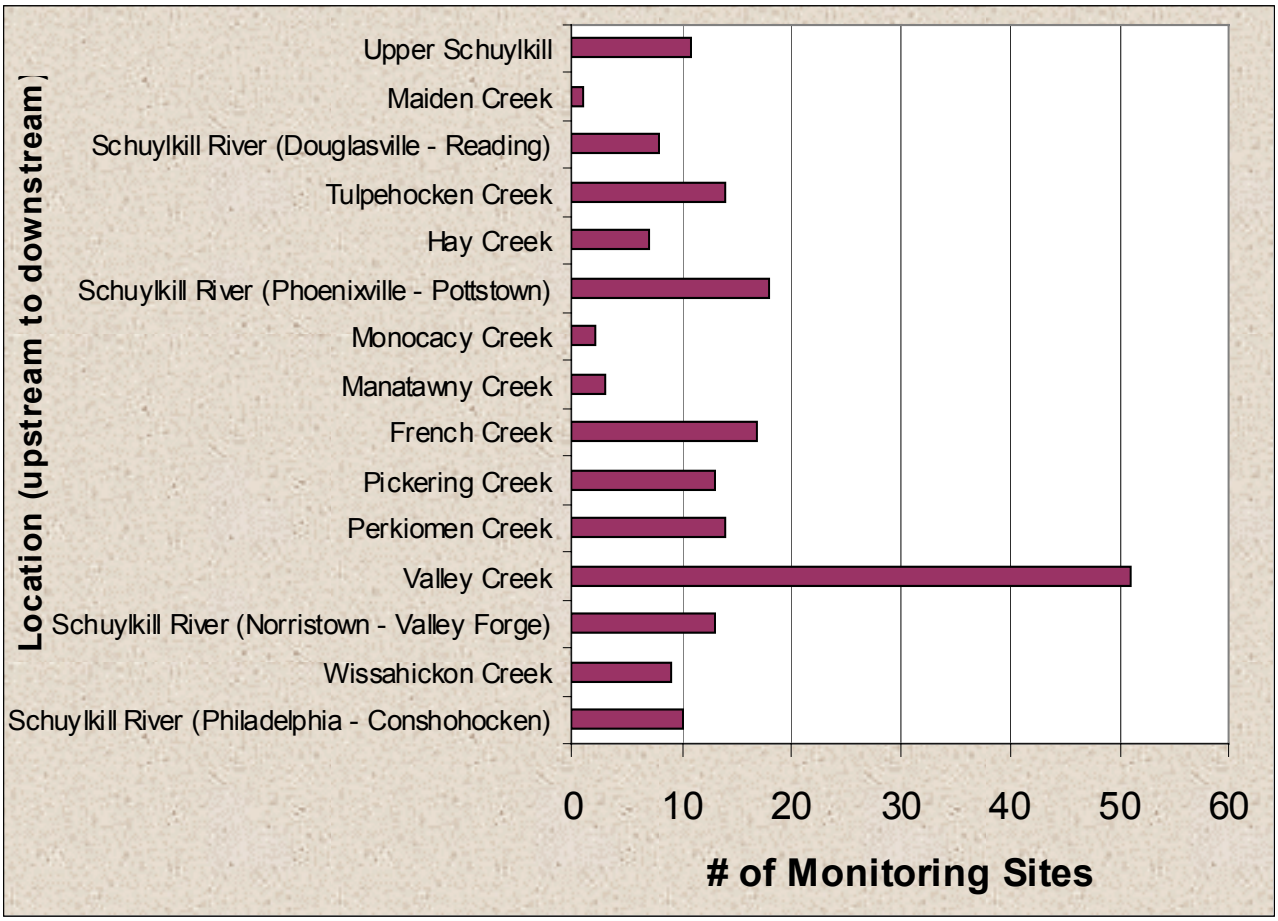
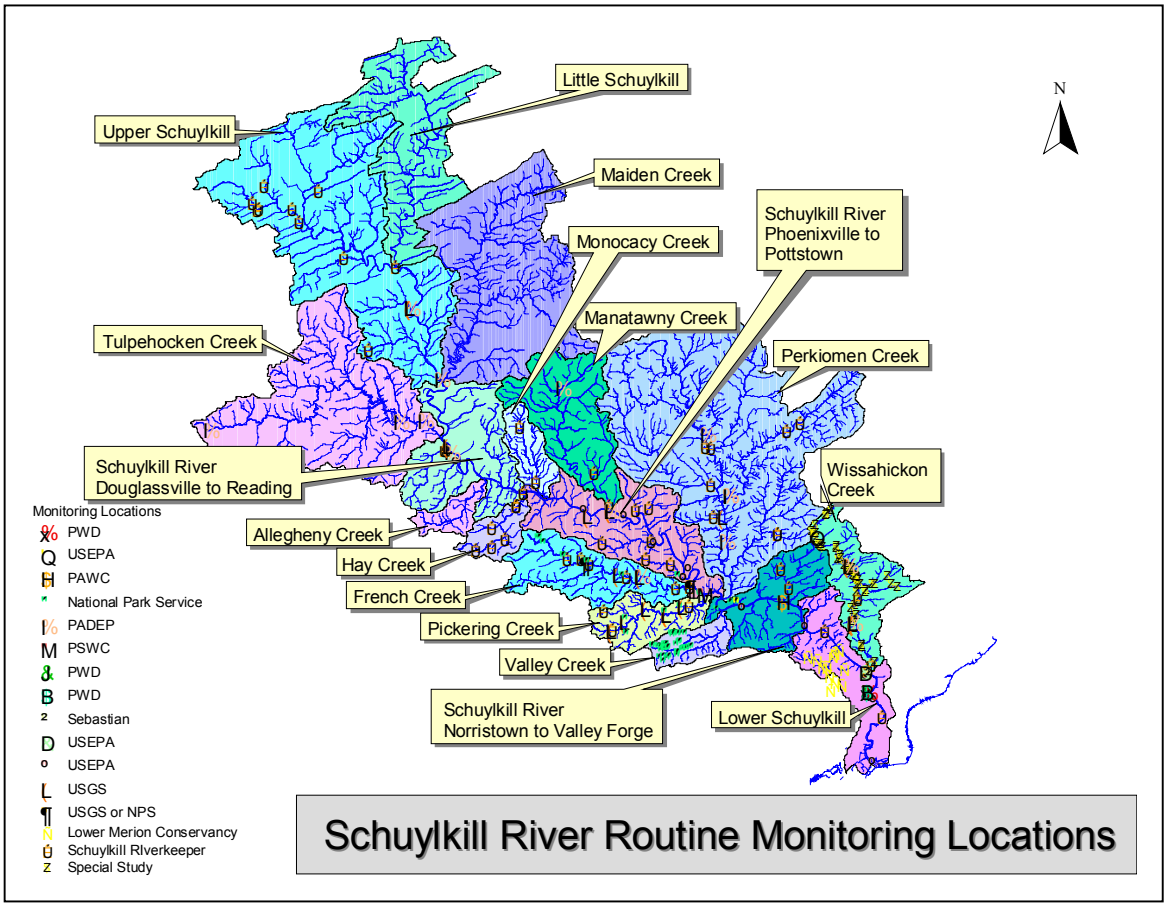


Figure 1.4.7-2 Routine Monitoring Locations by Organizations in the Schuylkill River Watershed



The quantity and type of monitoring is also important, in addition to the issue of where routine water quality monitoring is occurring. For example, though STORET indicated that a number of sites were monitored by NPS, USGS, and PADEP, that does not always mean that these sites were active for the same periods. For example, the USGS may monitor a number of locations, but it has only collected data from different time periods (70's, 80's, and 90's) for those locations. In addition, as project goals and water quality studies change, so do the selection of parameters. Therefore, monitoring may appear to be continuous at a location, but not for every desired parameter. In order to conduct any meaningful analysis of the water quality for a given watershed, sometimes data from multiple locations has to be pooled together into one data set for analysis.

In addition to the 200 potential sites for water quality data, there are numerous special studies conducted by water suppliers, community organizations, universities, county health departments, dischargers, and public agencies with little or no knowledge of one another, or of methods of coordination or data sharing. For example, although Blue Marsh Lake is extensively monitored by the U.S. Army Corps of Engineers during the spring and summer, it is also studied by Albright College and the Berks County

Conservancy. The different monitoring locations and parameters, as well as different seasons and sampling frequencies (USACE tends to conduct most of its monitoring during the summer) lead to various conclusions about the quality of the lake.

Wissahickon Creek is another example of a location where a variety of water quality monitoring programs have been conducted in recent years. As shown in Figure 1.4.7-2, various special studies were conducted by PWD at almost 33 sampling locations. At times during this period, dischargers, community groups, and a consultant were conducting various levels of monitoring for their own special studies as well. None of this data has been combined to date.

Overall, based on the information available from an analysis of the amount, types, and locations of monitoring in the watershed, the following monitoring requirements were identified:

- A data clearinghouse for water quality data needs to be created and made available to all organizations. A format for data reporting should be sent to all organizations that want to participate.

- An organization in the watershed needs to be properly funded in order to be responsible for compiling, organizing, and monitoring the water quality data from the numerous stakeholders in the watershed.

- Organizations that conduct monitoring should form a consortium for the purpose of frequent discussion of monitoring efforts and plans in order to promote better coordination and sharing of data.

- More monitoring locations are needed in locations throughout the watershed, other than the Pickering, Perkiomen, Valley, and French creeks.

- All monitoring organizations should agree on selecting standard monitoring stations for various parameters. It is recommended that the standard locations be placed close to the mouths of the major tributaries to the watershed. The long-term Riverkeeper sites and certain water supply intakes may be the best places to start when selecting these sites. Routine monitoring would be conducted at these stations over long periods of time in order to examine changes and trends in water quality over the years, seasons, or decades. This information will be used as part of a report card system for water quality improvement.

- Long term monitoring should be conducted for manganese, aluminum, iron, sodium, chloride, turbidity, total suspended solids, dissolved oxygen, temperature, ammonia, total phosphorus, orthophosphate, nitrate, *E. coli*, and fecal coliforms. Currently, most monitoring does not include coliform measurements. Efforts should be made to transfer data from hardcopy format in special studies into electronic format.

1.5 Inventory of Potential Point Sources of Contamination

Key Points
- **Potential point and non-point sources of contamination throughout the watershed were compiled from a variety of databases.**

Based on PADEP guidelines for the statewide Source Water Assessment Program (SWAP), a contaminant inventory of point and non-point sources was developed. The inventory is an essential part of assessing the source water for a drinking water supply intake, because it compiles potential contaminant sources within the 5 hour, 25 hour, and beyond 25 hour time of travel delineation zones. A watershed-wide inventory was developed because the zones for the 42 water intakes encompass the entire Schuylkill Watershed. The watershed inventory provides insight into the clustering of sources by major subwatersheds within the Schuylkill.

The focus of this discussion is the watershed-wide point source contaminant inventory. Non-point sources are discussed in the land use (section 1.2.5) section of this document and within intake-specific sections 2.2.3 and 3.2.3.

Point source data was compiled from various Federal and State databases available on the Internet, as well as from self-assessment data provided by water suppliers. Sources were checked by stakeholders, and verified for correct active status and location. An ACCESS database was developed to efficiently store and manage information describing the point sources

The following federal databases were reviewed to identify point sources in the Schuylkill River Watershed:

- Permit Compliance System (PCS)
- Resource Conservation and Recovery Act Information System (RCRIS)
- Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS)
- Toxic Release Inventory (TRI)

Regulated aboveground storage tanks (ASTs) were also compiled from the PADEP Storage Tank Program. Another initial source of data was provided by self-assessment forms. The self-assessment, required by the state SWAP, provides intake-specific input as to which sources are of priority concern.

The databases were queried for facility, process, and violation information. Facility information included name, facility identification numbers, owner, and location (street address and/or latitude, longitude). Process information included data quantifying on-

site contaminants and quantities and/or loading rates. Violation information was related to type (administrative, operation or effluent violation) and frequency.

1.5.1 Point Source Contaminant Inventory

Key Points

- **Over 3,000 potential point sources were identified within the 1,900 square-mile Schuylkill River Watershed.**

Once the database compilation and population were completed, a watershed-wide inventory of potential contaminants was developed for the Schuylkill River. The land area covered by the inventory extends over 1,900 square miles, 300 subwatersheds, and 3,000 point sources. The inventory is sorted by major sub-watershed and posted on the Schuylkill Source Water Assessment project website, www.schuylkillswa.org. The full inventory or an inventory for a subwatershed of particular interest is available for download from the website or by contacting PADEP.

An example of the inventory for the Manatawny Watershed, a major subwatershed of the Schuylkill is provided in Figure 1.5.1-1. The example shows some of the pertinent attributes associated with the various source types. If a field is blank, then the information was not available. The number of blank fields gives an idea of the incompleteness of much of the downloaded data, especially for SIC codes, contaminants, and quantities.

For PCS facilities, the name, address, NPDES ID, SIC code description, minor/major designation, flow rate, contaminant groups, and violation remark are indicated. A major facility has a flow rate of 1 MGD or greater.

Attributes shown for RCRA facilities are generally the same as for PCS. Instead of minor/major designation, RCRA facilities are differentiated on size as large quantity generators (LQG) or small quantity generators (SMG). A LQG generates more than 2,200 pounds of hazardous waste per calendar month. Flow rates do not apply to most RCRA sites, which are mostly industrial facilities with aboveground or underground storage tanks. An AST download from PADEP is used to supplement the scarce quantity information for RCRA sites. AST data attributes include fairly complete capacity and contaminant information for each site.

TRI attributes include similar fields as the PCS and RCRA facilities. Quantity information is available as ranges, such as 1,000 to 9,999 kg per year. The quantity shown is an average over all available years. If the facility had a release, then the maximum range value is used in the average, otherwise the minimum is used. TRI quantity refers to the amount used or generated on-site. Releases in TRI may be to air, water or land.

Attributes for CERCLA facilities include basic information such as name and EPA ID. In addition, a flag is shown to indicate whether the facility is on the National Priority List (NPL) or not. Quantity and capacity data for CERCLA facilities is limited to two facilities watershed wide. The number of enforced violations is also provided.

Figure 1.5.1-1 Point Source Contaminant Inventory for the Manatawny Watershed

Watershed: Manatawny Creek

AST Summary

Name: A & L HANDLES INC.					
Address: 244 SHOEMAKER RD		POTTSTOWN	19464	**Facility ID:** 46-05203	
Total Tankage (gal): 1,500	**Releases:** No		**Contaminants:** VOC		
Name: AUTO SVC					
Address: 63 W HIGH ST		POTTSTOWN	19464	**Facility ID:** 46-14902	
Total Tankage (gal): 131,000	**Releases:** No		**Contaminants:** VOC,PH		

CERCLA Summary

Name: BERKMONT IND-UNICAST DIV				**Facility ID:** PAD008129664
Address: 6TH & WASHINGTON STS		BOYERTOWN	19512	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: BOYERTOWN LANDFILL				**Facility ID:** PAD980508394
Address: UNOBTAINABLE		BOYERTOWN	19512	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: BOYERTOWN SCRAP				**Facility ID:** PAD037672062
Address: ROUTE 562		BOYERTOWN	19512	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 4			
Name: BRENAHAN, EJ INC - MCCARTER 5000TH PLT				**Facility ID:** PAD053299202
Address: RIVER & YARNELL RDS		POTTSTOWN	19464	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: COLEBROOKEDALE LANDFILL				**Facility ID:** PAD069780810
Address: SHENKEL HILL RD		AUDUBON	19407	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: DOUGLASS-EARL TCE				**Facility ID:** PAD981105075
Address: RD #2 - FANCYVILLE RD		BOYERTOWN	19512	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: FARLEY METALS				**Facility ID:** PAD002386704
Address: OLD READING PIKE (P O BOX)		POTTSTOWN	19464	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: GIBBONS WASTE OIL				**Facility ID:** PAD980537963
Address: SAINT PETERS RD STAR RTE		POTTSTOWN	19464	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: KEYSTONE GREY IRON FOUNDRY CO				**Facility ID:** PAD002378818
Address: KEIM & CROSS ST		POTTSTOWN	19464	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: PECO LOTS # 5,7,8 & 9				**Facility ID:** PAD987352200
Address: INDUSTRIAL HIGHWAY		POTTSTOWN	19464	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			
Name: POTTSTOWN ABANDONED TRAILER SITE				**Facility ID:** PAD981736604
Address: RT 100 & STATE ST		POTTSTOWN	19464	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 3			
Name: POTTSTOWN DISP SER				**Facility ID:** PAD084351026
Address: SELL RD & RTE 20		POTTSTOWN	19464	**NPL Status:** NOT ON NPL
# of Units: 1	**# of Enforcements:** 0			

1.5.2 Inventory Characterization

Key Points

- Over 3,000 potential point sources were identified within the watershed.
  - The highest concentrations of potential point sources were located in the most highly developed subwatersheds, the Middle and Lower Schuylkill subwatersheds.
  - Sewer systems, dry cleaners, and machine/metal working shops were among the most frequently identified potential point sources.
  - Monocacy Creek, Wissahickon Creek and Valley Creek had the greatest number of dischargers per acre of drainage area.

1.5.2.1 Entire Watershed Inventory Summary

The inventory has been compiled for the entire Schuylkill Watershed and its major subwatersheds. With more than 3,000 point sources throughout the watershed, the characterization highlights the types of sources (PCS, RCRA, etc.) that exist and where those sources are concentrated. Table 1.5.2-1 presents the number of facilities for a particular source type for each major subwatershed. Note that source types for some facilities overlap. For example, the same facility may be both a permit holder (PCS), and an RCRA facility or a TRI facility.

Table 1.5.2-1 Summary of Point Source Types by Major Watershed

Major Watershed	# of PCS Facilities	# of RCRA Facilities	# of ASTs	# of TRI Facilities	# of CERCLA Facilities	# of Self-Assessment Facilities
Lower Schuylkill	44	***400***	***102***	42	62	22
Wissahickon Creek	29	158	36	18	42	6
Middle Schuylkill 1	38	274	51	24	55	9
Valley Creek	14	86	20	17	17	3
Perkiomen Creek	***123***	298	71	***60***	***71***	15
Middle Schuylkill 2	41	135	45	24	15	***67***
Pickering Creek	10	13	1	5	4	15
French Creek	10	53	2	6	11	11
Manatawny Creek	17	27	12	2	12	1
Monocacy Creek	6	0	2	0	0	1
Hay Creek	3	1	2	0	5	0
Middle Schuylkill 3	45	76	57	44	23	7
Tulpehocken Creek	33	45	23	17	12	3
Maiden Creek	28	11	11	9	5	0
Upper Schuylkill	57	79	29	28	33	2
Little Schuylkill	17	26	2	8	15	3
Unknown Subshed	61	3	0	0	0	0
TOTAL	576	1685	466	304	382	165

Table 1.5.2-1 indicates that for three of the six potential source types - PCS, TRI, and CERCLA, the Perkiomen Creek Watershed has the greatest number of sites. This is consistent with the fact that the Perkiomen Creek Watershed encompasses a greater land area than any of the other subwatersheds. The Lower Schuylkill Watershed has the largest number of RCRA facilities and the Middle Schuylkill Two Watershed has the largest number of sources identified by water supplier self-assessments. The AST data indicates that the Lower Schuylkill has the greatest number of ASTs. These tallies do not necessarily mean that the sources are significant with respect to contamination of the drinking water supplies. The ranking analysis for each intake determines significance by accounting for other source characteristics, such as time of travel to the intake, water quality impact, or number of violations.

The data from Table 1.5.2-1 is further analyzed based on watersheds with the three highest occurrences of each source type. This compilation is summarized in Table 1.5.2 - 2. This table clearly shows that Middle Schuylkill One and Three, the Lower Schuylkill, and the Perkiomen have high concentrations of sources. Across all source types, with the exception of PCS, the Lower Schuylkill has one of the three highest clusters. This is consistent with the significant industrial land use within the Lower Schuylkill Watershed. Although the Upper Schuylkill Watershed is mostly agricultural or forested land, it has the third-highest number of dischargers. Many dischargers cannot be located due to missing latitude/longitude information, as indicated by the 61 sites within an unknown subwatershed. Self-assessment data indicates that water supplier

concerns generally align well with where sites are concentrated. Water suppliers listed the most sites in Middle Schuylkill Two, followed by the Lower Schuylkill, and Perkiomen Creek.

Table 1.5.2-2 Major Subwatershed Source Type Occurrence

Source Type		Major Watershed	Number of Facilities	Source Type		Major Watershed	Number of Facilities
PCS	1st	Perkiomen Creek	123	TRI	1st	Perkiomen Creek	60
	2nd	Unknown Subshed	61		2nd	Middle Schuylkill 3	44
	3rd	Upper Schuylkill	57		3rd	Lower Schuylkill	42
RCRA	1st	Lower Schuylkill	400	CERCLA	1st	Perkiomen Creek	71
	2nd	Perkiomen Creek	298		2nd	Lower Schuylkill	62
	3rd	Middle Schuylkill 1	274		3rd	Middle Schuylkill 1	55
ASTs	1st	Lower Schuylkill	102	Self-Assessment	1st	Middle Schuylkill 2	67
	2nd	Perkiomen Creek	71		2nd	Lower Schuylkill	22
	3rd	Middle Schuylkill 3	57		3rd	Perkiomen Creek	15

Table 1.5.2-3 summarizes the most frequently reported types of industrial facilities, based upon SIC codes. The most frequently occurring potential point sources are sewerage systems and dry cleaning plants. Using the PADEP land use-based activities defined in the SWAP document, industrial machine/metal working shops, industrial chemical manufacturers and industrial foundries are most prevalent in the watershed.

Table 1.5.2-3 Schuylkill Watershed Top Point Sources by Industrial Classification

SIC Code/Description	Number	PADEP Land Use/Activity	Number
4952 - Sewerage Systems	148	Industrial – Machine/Metalworking Shops	190
7216 - Drycleaning Plants, Except Rug Cleaning	120	Industrial - Chemical Manufacturer	162
2752 - Commercial Printing, Lithographic	36	Industrial - Foundries or Metal Fabricators	153
2899 - Chemicals And Chemical Preparations, Not Elsewhere Classified	27	Misc. - NPDES Locations	148
2834 - Pharmaceutical Preparations	27	Commercial - Dry Cleaners	122

Although Tables 1.5.2-1 through 1.5.2-3 identify the watersheds in which the groups of source types are located, as well as the most common industries, the drainage areas of the subwatersheds were not considered. By normalizing the number of potential sources in a subwatershed by drainage area, a better representation of clustering and cumulative impacts may be ascertained. Because existing dischargers are more of a

concern for cumulative impacts than other potential sources (such as ASTs, RCRA sites or TRI facilities), the data for PCS dischargers was normalized, as described below.

1.5.2.2 PCS Dischargers

Table 1.5.2-4 lists the number of PSC dischargers within each major subwatershed, normalized by drainage area. Although the greatest number of dischargers was located within the Perkiomen Creek and the Upper Schuylkill River watersheds, the normalized data identifies other subwatersheds of concern. A greater density of PCS facilities is found within the Wissahickon Creek, Valley Creek, and Monocacy watersheds.

Table 1.5.2-4 Watershed Clustering of Dischargers on a Drainage Area Basis

Major Subwatershed	# of PCS Facilities	Drainage Area (acres)	#/DA (#/acre)
Wissahickon Creek	29	153030	190 x 10-6
Valley Creek	14	75636	185 x 10-6
Monocacy Creek	6	34407	174 x 10-6
Hay Creek	3	24844	121 x 10-6
Perkiomen Creek	123	1598076	77 x 10-6
Manatawny Creek	17	239681	71 x 10-6
Pickering Creek	10	151869	66 x 10-6
Upper Schuylkill	57	1087682	52 x 10-6
French Creek	10	215117	47 x 10-6
Little Schuylkill	17	442667	38 x 10-6
Tulpehocken Creek	33	901705	37 x 10-6
Middle Schuylkill 1	38	1186773	32 x 10-6
Maiden Creek	28	990006	28 x 10-6
Middle Schuylkill 2	41	2400223	17 x 10-6
Middle Schuylkill 3	45	2648033	17 x 10-6
Lower Schuylkill	44	3674006	12 x 10-6
Unknown Subshed	61	-	-
Total	**576**	**15823755**	**36 x 10-6**

Discharger data is further normalized by median flow in Table 1.5.2-5. Median flow from the period of record at USGS at the nearest gauge to the major subwatershed was used. If more than one gauge was associated with the subwatershed, then a drainage area weighted average value was used. When normalized by flow, as well as by drainage area, clusters of PCS sites are found in the Wissahickon Creek, French Creek, and Little Schuylkill River watersheds.

Table 1.5.2-5 Watershed Clustering of Dischargers on a DA/Flow Basis

Major Subwatershed	# of PCS Facilities	#/DA (#/acre)	Median Flow (cfs)	#/DA/Flow (#/acre/cfs)
Wissahickon Creek	29	190 x 10-6	60	316 x 10-8
French Creek	10	47 x 10-6	56	83 x 10-8
Little Schuylkill	17	38 x 10-6	51	75 x 10-8
Manatawny Creek	17	71 x 10-6	369	19 x 10-8
Valley Creek	14	185 x 10-6	978	19 x 10-8
Monocacy Creek	6	174 x 10-6	1300	13 x 10-8
Tulpehocken Creek	33	37 x 10-6	312	12 x 10-8
Upper Schuylkill	57	52 x 10-6	528	10 x 10-8
Hay Creek	3	121 x 10-6	1300	9 x 10-8
Perkiomen Creek	123	77 x 10-6	873	9 x 10-8
Pickering Creek	10	66 x 10-6	1670	4 x 10-8
Middle Schuylkill 1	38	32 x 10-6	1670	2 x 10-8
Maiden Creek	28	28 x 10-6	1670	2 x 10-8
Middle Schuylkill 3	45	17 x 10-6	1177	1 x 10-8
Middle Schuylkill 2	41	17 x 10-6	1556	1 x 10-8
Lower Schuylkill	44	12 x 10-6	1670	0.7 x 10-8
Unknown Subshed	61	-	-	-
Total	576	36 x 10-6	1670	2 x 10-8

The inventory of dischargers or PCS facilities throughout the Schuylkill Watershed is summarized in Table 1.5.2-6. Although, in all, 576 dischargers are found throughout the watershed, only 43 are major dischargers (<1 MGD). Almost of all these are wastewater treatment plants. In fact, wastewater treatment plants comprise the largest component, 148 of 576, for both major and minor dischargers. After sewerage systems, gasoline and petroleum bulk stations, water suppliers, and mobile home sites comprise 55 of the remaining 428 dischargers.

Table 1.5.2-6 PCS Discharger Summary

Total Dischargers	576
Major Dischargers	43
Major Sewerage Systems	35
Top 5 Discharge Types by SIC Code 4952 – Sewerage Systems 5541 – Gasoline Service Stations 5171 – Petroleum Bulk Stations 4941 – Water Supplier 6515 – Mobil Home Sites	 148 15 14 14 12
Dischargers with Available DMR Data	54
Most Common Parameters with DMR Data	Total Suspended Solids Ammonia Nitrogen BOD5 Total Copper Oil & Grease
Most Common Parameters for Effluent Limits	Total Suspended Solids pH Fecal Coliform Ammonia Nitrogen Dissolved Oxygen
Discharge Flow Rate Range	0.03 – 9.75 MGD

Because so many of the dischargers are minor, Discharge Monitoring Report (DMR) data was only available for 54 sites. The data spanned June 1984 through December 2000. The most common parameters found in the DMRs and effluent limits are indicated in Table 1.5.2-6. The common DMR parameters – TSS and BOD5 - correlate with turbidity and TOC (DBP precursor), which are of concern from a source water perspective. Metals such as copper, as well as oil and grease, also pose a concern for drinking water supplies.

Discharge Monitoring Report (DMR) data is further summarized in Table 1.5.2-7 based on maximum reported quantities and parameter groups. The parameter groups generally follow those identified in the PADEP SWAP guidance document. These groupings are used to rank potential contaminant sources in the intake-specific report sections. Since the ranking analysis was based on DMR maximum quantity data, the data was compiled in Table 1.5.2-7 to provide a frame of reference. The data also gives an idea, on a pounds-per-day basis, as to the "worst case" order of magnitude of a discharge. This data was available for only 54 of the 576 dischargers in the Schuylkill Watershed and is generally linked to major dischargers. With that in mind, the data truly represents a worst-case estimate of individual loads being discharged into the Schuylkill River.

Table 1.5.2-7 Summary of Available DMR Data

Parameter Group	Parameters with DMR Max Quantities [1]	Range of Max Quantity Reported	Mean Max Quantity	Count of Max Quantities
Cryptosporidium/ Giardia	Not Available			
Nutrients	Ammonia as Nitrogen	0 - 32550	121	2837
	Nitrate-Nitrite as Nitrogen	0.0002 - 7.2	1.2	22
DBP Precursors	BOD5	0 - 70783	1883	1320
Petroleum Hydrocarbons	Oil & Grease	0 - 3753	86	603
Salts	Not Available			
Total/Fecal Coliform	Fecal Coliform (col/day)	45.75 - 84	65	2
Turbidity	Total Suspended Solids	0 - 802396	1316	6032
Nutrients	Phosphorus	0 - 527	21	581
VOC	1,1,1-Trichloroethane	0.001 - 0.09	0.03	37
	1,1,2-Trichloroethane	0.001 - 0.07	0.01	18
	1,1- Dichloroethane	0.001 - 0.02	0.01	18
	1,1-Dichloroethylene	0.0001 - 0.05	0.01	83
	1,2-Dichloroethane	0.001 - 0.02	0.01	18
	1,2-Dichloropropane	0.001 - 0.02	0.01	19
	1,2-trans-Dichloroethylene	0.001 - 0.02	0.01	18
	1,3-Dichloropropylene	0.001 - 0.02	0.01	18
	2-Chloroethylvinyl ether	0.038 - 0.08	0.07	3
	Acrolein	0.045 - 0.80	0.43	36
	Acrylonitrile	0.005 - 0.92	0.32	58
	Benzene	0.001 - 0.02	0.01	18
	Bromoform	0.004 - 0.05	0.02	14
	Carbon Tetrachloride	0.001 - 0.02	0.01	18
	Chlorobenzene	0.001 - 0.02	0.01	18
	Chloroethane	0.001 - 0.02	0.01	18
	Chloroform	0.001 - 0.51	0.07	84
	Dibromochloromethane	0.004 - 0.05	0.02	14
	Dichlorobromomethane	0.004 - 0.05	0.02	14
	Ethylbenzene	0.001 - 0.02	0.01	18
	Methyl Bromide (Bromomthane)	0.004 - 0.09	0.03	14
	Methyl Chloride (Chloromethane))	0.001 - 0.09	0.02	32
	Methylene Chloride	0.001 - 0.02	0.01	18
	Tetrachloroethene	0.001 - 0.09	0.03	56
	Toluene	0.001 - 0.02	0.01	18
	Trichloroethene	0 - 1.13	0.08	90
	Vinyl Chloride	***0.001 - 1.21***	***0.04***	***39***
SOC	1,2,4-Trichlorobenzene	0.001 - 0.02	0.01	17
	1,2-Diichlorobenzene	0.001 - 0.02	0.01	19
	1,3-Dichlorobenzene	0.001 - 0.02	0.01	17
	1,4-Dichlorobenzene	0.001 - 0.02	0.01	17
	2,4-Dichlorophenol	0.001 - 0.02	0.01	18
	2,4-Dimethylphenol	0.001 - 0.04	0.02	18
	2,4-Dinitrophenol	0.003 - 0.11	0.05	18

Parameter Group	Parameters with DMR Max Quantities [1]	Range of Max Quantity Reported	Mean Max Quantity	Count of Max Quantities
	2,4-Dinitrotoluene	0.001 - 0.02	0.01	18
	2,6-Dinitrotoluene	0.001 - 0.05	0.01	18
	2-Chlorophenol	0.001 - 0.02	0.01	17
	2-Nitrophenol	0.001 - 0.02	0.01	17
	4,6-Dinitro o-Cresol	0.001 - 0.06	0.02	18
	4-Nitrophenol	0.001 - 0.02	0.01	18
	Acenapthene	0.001 - 0.02	0.01	18
	Acenaphthylene	0.001 - 0.02	0.01	18
	Anthracene	0.001 - 0.02	0.01	18
	Benzo (A) Anthracene	0.001 - 0.02	0.01	18
	Benzo (A) Pyrene	0.001 - 0.02	0.01	18
	Benzo (B) Fluoranthene	0.001 - 0.03	0.01	18
	Benzo (K) Fluoranthene	0.001 - 0.03	0.01	18
	Bis (2-Ethylhexyl) Phthalate	0.001 - 0.02	0.01	17
	Chrysene	0.001 - 0.02	0.01	18
	Di-n-Butylphthalate	0.001 - 0.02	0.01	18
	Diethylmethyl phthalate	0.001 - 0.02	0.01	18
	Dimethylphthalate	0.001 - 0.02	0.01	18
	Fluoranthene	0.001 - 0.02	0.01	18
	Fluorene	0.001 - 0.02	0.01	18
	Hexachlorobenzene	0.001 - 0.02	0.01	18
	Hexachlorobutadiene	0.001 - 0.02	0.01	18
	Hexachloroethane	0.001 - 0.02	0.01	17
	Napththalene	0.001 - 0.11	0.06	62
	Nitrobenzene	0.001 - 0.13	0.02	18
	Phenanthrene	0.001 - 0.02	0.01	18
	Phenol	0.001 - 9.00	0.43	32
	Phenol, Total	***0 - 14.50***	***0.90***	***318***
	Pyrene	0.001 - 0.02	0.01	17
Metals	Aluminum, Total	0.00051 - 18.5	1.54	92
	Antimony, Total	0.0006 - 0.0	0.02	33
	Arsenic, Total	0.0003 - 0.1	0.01	32
	Beryllium, Total	0 - 0.3	0.02	258
	Cadmium, Total	0 - 1.1	0.07	322
	Chromium, Total	0 - 9.0	0.32	430
	Chromium, Hexavalent	0 - 2.2	0.16	587
	Copper, Total	0 - 11.1	1.16	843
	Iron, Total	***1 - 36.0***	***7.73***	***59***
	Lead, Total	0.00013 - 4.7	0.19	412
	Mercury, Total	0 - 0.0	0.00	106
	Molybdenum, Total	3.58 - 6.6	5.24	7
	Nickel, Total	0 - 19.9	0.38	427
	Selenium, Total	0.0006 - 0.0	0.02	36
	Silver, Total	0 - 1.4	0.05	184
	Thallium, Total	0.0003 - 0.0	0.01	33
	Zinc, Total	0 - 33.2	2.23	486

[1] All quantities in lbs./day, unless otherwise indicated.
[2] Shading indicates the parameter with the largest maximum DMR value.

Table 1.5.2-7 shows that total suspended solids (TSS) loads are the highest of any parameter and have the greatest number of reported quantities. Total suspended solids are related to the turbidity parameter group. Turbidity is another indicator of particulates in the water supply, but it is a more meaningful measure of performance in drinking water treatment. Maximum and average ammonia loads are greater than phosphorus loads. The table also indicates the various volatile organic compounds (VOCs) and synthetic organic compounds (SOCs) discharged into the Schuylkill River. Vinyl chloride has the single greatest VOC discharge of 1.2 pounds per day (lbs./day). Relative to the other VOC discharges, acrylonitrile and acrolein are also large average quantities. Total phenols are the largest discharged quantity for the SOCs. Otherwise, quantities of SOC discharges are similar. Of the metals, iron is clearly the largest discharged quantity. High maximum quantities are also reported for aluminum, total chromium, total copper, total lead, total nickel, and total zinc. Chromium and lead pose the greatest risk in drinking water.

1.5.2.3 RCRA/AST Facilities

As summarized in Table 1.5.2-8, RCRA facilities comprise many of the point sources in the Schuylkill River Watershed. However, only 205 of the 1,685 RCRA facilities are designated as large quantity generators (LQGs). Data describing the industry type or capacity of the facilities is limited. Taking into account the limited number of SIC codes, most RCRA facilities are dry cleaning plants, followed by printing shops, and automotive repair shops. Relatively few RCRA sites were cited for violations. Capacity information for use in ranking sites is available for merely 161 sites, and contaminant information was not available. Reported capacities ranged from 100 to 965,000 gallons for the RCRA sites with available data.

Table 1.5.2-8 RCRA Facility Summary

Total RCRA Facilities	1685
Large Quantity Generators	205
Facilities with SIC Codes	580
Top 5 RCRA Industry Types by SIC Code 7216 – Dry Cleaning Plants 2752 & 2759 – Commercial Printing 7537 – Automotive Transmission Repair Shops 3471 – Electroplating, Plating, Polishing, etc. 2834 – Pharmaceutical Preparations	 120 22 16 10 10
RCRA Facilities with Violations	161
RCRA Facilities with Capacity/Volume Data	58
Range of Capacity	100 – 965,000 gallons 107 – 8,220,000 gal/day
Most Common Parameters/Contaminants	Not Applicable – no contaminants linked to RCRA downloads

As mentioned previously, RCRA data was supplemented with AST information from PADEP. PADEP AST data included useful and detailed information relating to tank age, contaminants, and volumes. AST data is summarized in Table 1.5.2-9.

Table 1.5.2-9 AST Facility Summary

Total AST Facilities	466
AST Facility Overlap with RCRA Facilities	74
Total Number of Tanks	2077
Tank Capacity Range	250 gal – 13 MG
Tank Age Range	1 – 98
Number of Different Parameters/Contaminants	138
Most Common Parameters and Quantities by Number of Tanks Misc. Hazardous Substance Diesel Fuel Gasoline	 662 tanks/25 MG 251 tanks/6 MG 211 tanks/186 MG
Most Common Parameters/Contaminants and Quantities by Total Volume Gasoline Crude Oil Heating Oil	 183 MG 136 MG 108 MG

Table 1.5.2-9 shows that 466 facilities throughout the Schuylkill Watershed have aboveground storage tanks on-site. Of those facilities, only 74 overlap with the RCRA facilities. This may be due to RCRA sites also having underground storage tanks on-site. The AST data is useful for characterizing potential contaminant sources in the watershed. Tanks range in capacity from 250 gallons to 13 million gallons and range in age from 1 to 98 years old. Older tanks may pose a greater risk for spills and leaks. The tanks contain 138 different substances. The most common of these by volume is gasoline, followed by crude oil, and heating oil. The significance of these tanks as contamination sources depends on factors such as the total volume of substance at any one site, tank age, and the time of travel to the drinking water intake. These factors are considered in the intake-specific susceptibility ranking.

1.5.2.4 TRI Facilities

A summary of TRI sources is presented in Table 1.5.2-10. A facility is listed in the TRI if a chemical from the inventory is used or manufactured on site. These sites do not necessarily discharge the listed chemical(s). Data describing on-site chemicals, quantities of chemicals used or manufactured in a given year, and releases to air, water or the ground is available for the TRI sources.

Table 1.5.2-10 indicates that 304 TRI facilities are found in the Schuylkill Watershed. An SIC code is identified for 283 of these industries. SIC codes are linked to activities that PADEP identified in the state SWAP document. Based on activity, most TRI facilities are foundries, chemical manufacturers, or machine shops.

Chemical and quantity data is very complete for the TRI facilities, however quantities are presented as ranges. Copper, sulfuric acid, and toluene are the most common chemicals listed by the various TRI sites. Release information was available for 288 of the TRI facilities. A petroleum refinery in Philadelphia, downstream of any drinking water intake, has the greatest number of reported releases. A chemical manufacturer of dyes in Berks County and a manufacturer of medicinal chemicals in Montgomery County have the next highest numbers of reported releases.

Table 1.5.2–10 TRI Facility Summary

Total TRI Facilities	304
Facilities with SIC Codes	283
Top 3 TRI Industry Types by Activity Foundries or Metal Fabricators Chemical Manufacturer Machine/Metalworking Shops	 62 59 54
Top 3 TRI Industries by SIC Code 2899 - Chemical Preparation 2834 – Pharmaceutical Preparations 5171 – Petroleum Bulk Stations	 11 8 7
Facilities with Quantity Data	282
Most Common Parameters for Facilities with Quantity Data Copper Sulfuric Acid Toluene Chromium Nickel	 0 – 999,999,999 kg/yr. 0 – 49,999,999 kg/yr. 0 – 99,999,999 kg/yr. 0 – 99,999,999 kg/yr. 0 – 9,999,999 kg/yr.
Facilities with Release Data	288
Facilities with Greatest Number of Releases Petroleum Refinery - Philadelphia County Chem. Manufacturer–Dyes/Pigments–Berks County Chem. Man.-Medicinal Chemicals – Montgomery County	 193 releases to water 180 releases to water 96 releases to water

1.5.2.5 CERCLA Facilities

Although data characterizing CERCLA facilities in the Schuylkill Watershed is limited, Table 1.5.2-11 summarizes the available information. While 382 CERCLA facilities are located within the watershed, only 22 are on the final National Priority List (NPL). Information for about 80 of the CERCLA facilities is available through the RCRA and TRI databases, where those facilities are also listed. Only 31 sites are found in the floodplain. Since information on the Superfund sites is so limited, these sites are screened or ranked subjectively for the intakes. The low number of NPL sites and sites in the floodplain is considered in the subjective screening.

Table 1.5.2–11 CERCLA Facility Summary

Total Number of CERCLA Facilities	382
Number on the NPL List	22
Number also listed as RCRA	64
Number also listed as TRI	18
Number in Flood Plain	31

1.6 Identification of Restoration Efforts

Key Points

- **Federal, State and private grants have provided almost $20 million for environmental projects within the Schuylkill River Watershed over the past seven years.**
- **Grants were awarded to 76 recipients, with county and municipal groups receiving the majority of funds.**
- **Almost 50 % of the grants awarded were used for restoration projects.**

In order to gain an understanding of the current levels of environmental stewardship and awareness within watersheds, a compilation of grants and restoration projects was completed. State, Federal and private grant sources identified the levels of funding that they provided through various programs to respective watersheds within the Schuylkill River Basin from 1995 to 2001.

These programs include the Pennsylvania Department of Environmental Protection's (PA-DEP) 319 Nonpoint Source Program, the Growing Greener Program, the Pennsylvania Department of Conservation and Natural Resource's (PA-DCNR) Rivers Conservation Plan Program, and Pennsylvania's Coastal Zone Management Program. Also included were Pennsylvania's Natural Resources Conservation Service's (NRCS) Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Watershed Protection and Flood Prevention Act (PL-566) Program, and the Environmental Quality Incentives Program (EQIP). In addition, private sources of funding were also compiled, including the William Penn Foundation, the Pew Charitable Trusts and The Pennsylvania League of Women's Voters. Additional sources of funding included federal funds via the Army Corps of Engineers (USACOE), the United States Environmental Protection Agency (EPA), the United States Fish and Wildlife Service (FWS), and the National Science Foundation (NSF).

From the data received, the Schuylkill River Watershed had a total of $18,115,196 awarded within its boundaries for the time period of 1995 to 2001, with most of the grant dollars being awarded post-1997. The watershed with the highest funding level was the Lower Schuylkill with $5,837,791 in grants. The watershed with the lowest funding level was the Allegheny Creek Watershed with $21,578. Please see Figure 1.6-1 below for a complete comparison of watersheds.

Figure 1.6-1 Distribution of Grant Dollars within Schuylkill River Subwatersheds

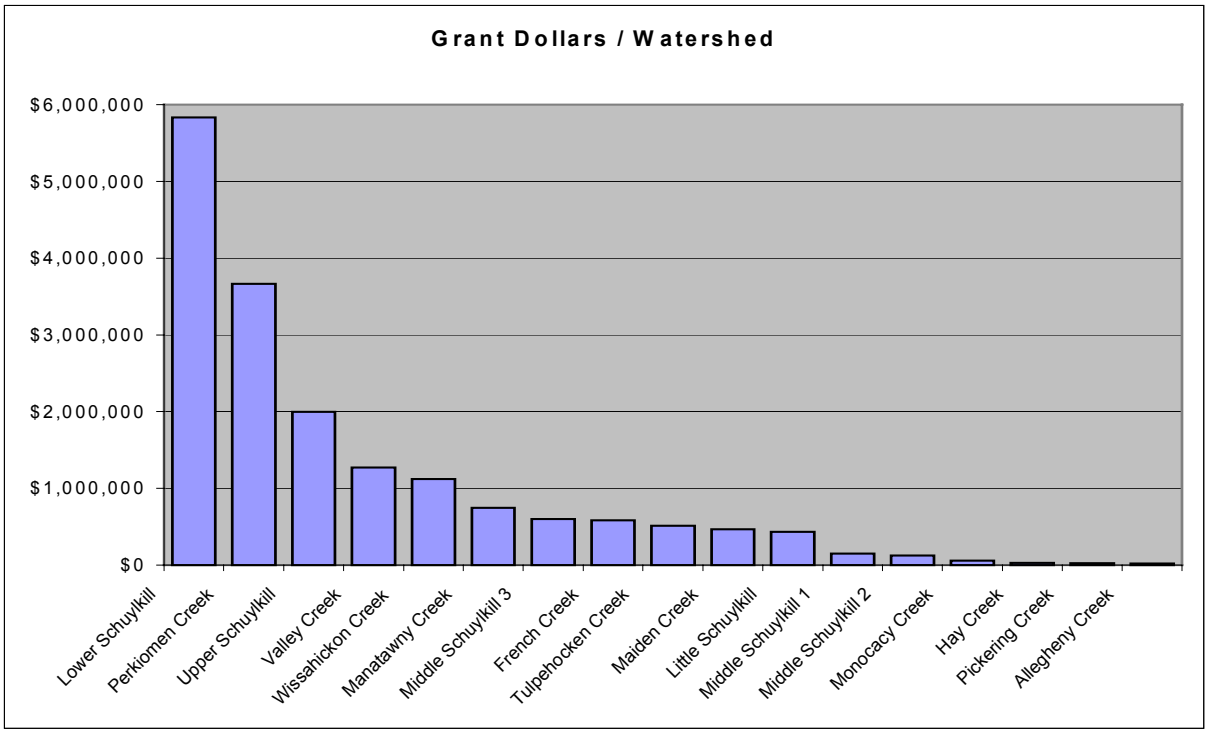
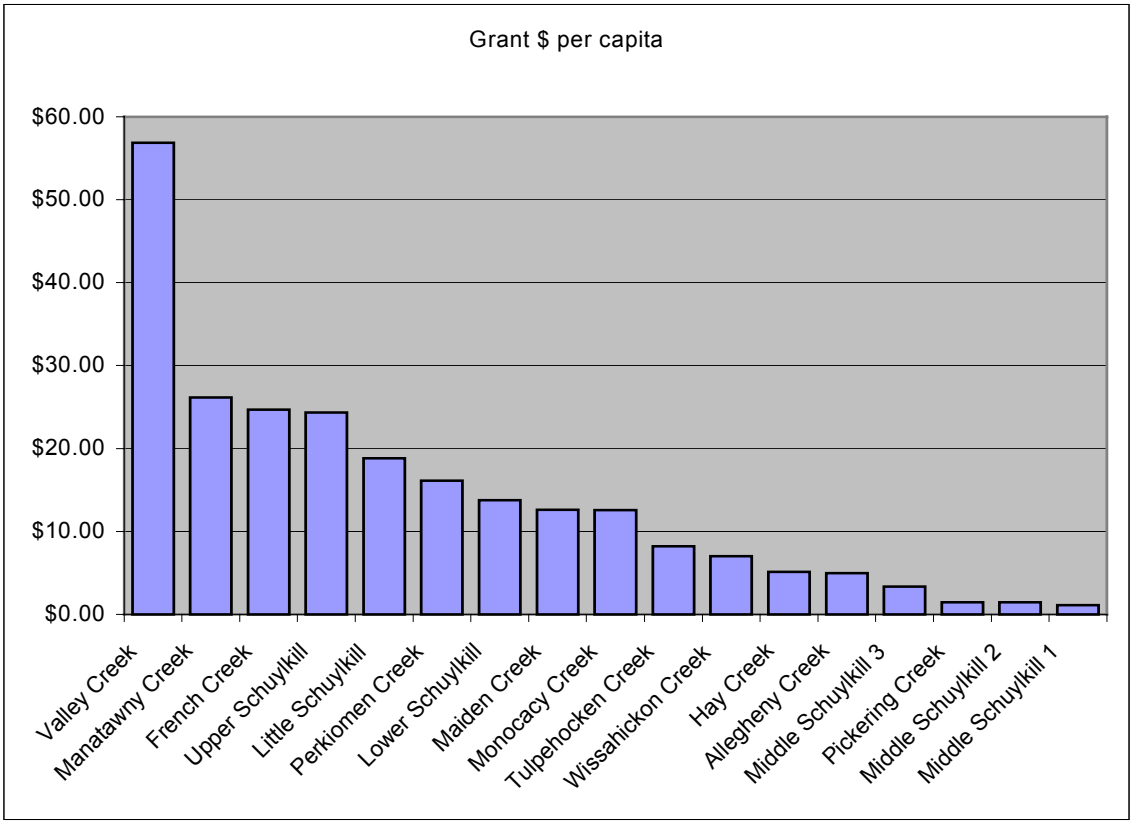


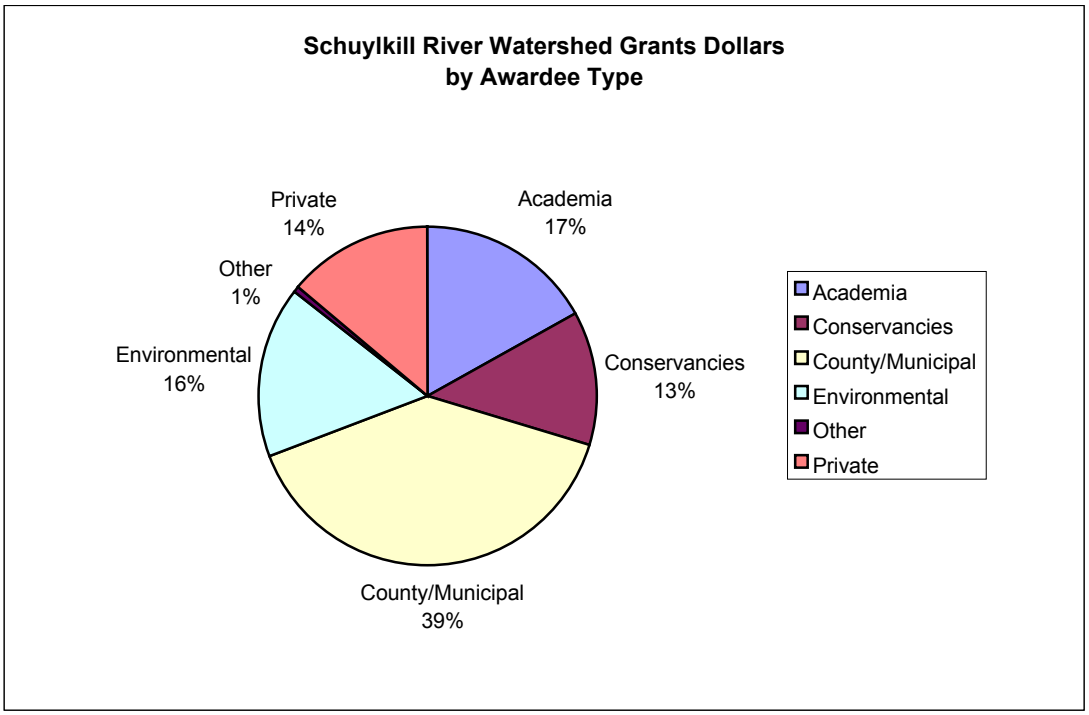
Figure 1.6-2 shows the grant dollars broken up by dollars per capita for each subwatershed. The Valley Creek Watershed ranked number one in terms of grant dollars per capita, with a total of $56.88 awarded per capita. This watershed was the recipient of a large research grant awarded by the National Science Foundation and the Environmental Protection Agency to Drexel University to study the effects of suburban sprawl on water resources. The watershed with the lowest funding was the Middle Schuylkill One, with a $1.12 per capita. The other main stem drainage basins, named Middle Schuylkill Two, and Middle Schuylkill Three, also scored very low in this category. This situation reflects the current organizational status of environmental stewards within the Schuylkill River Watershed. Most of the environmental groups are focused on the watersheds or main tributaries to the river, with very little civic focus on the main stem of the river itself.

Figure 1.6-2 Grant Money per Capita Awarded within each Schuylkill River Subwatershed



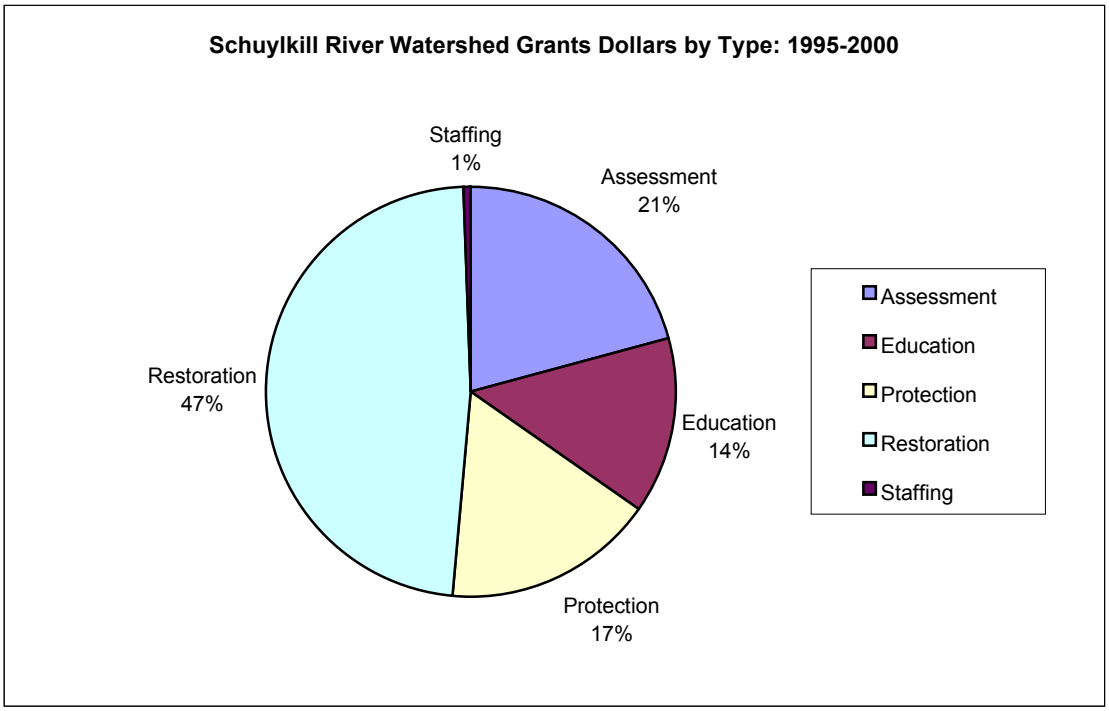
There were a total of 76 different organizations that received grants that applied to the Schuylkill River Watershed. Figure1.6-3 illustrates the percentage of grant dollars that went to each type of grant recipient. County and Municipal groups received the majority of funding within the Schuylkill River Watershed. Academic applicants, such as universities, were the next highest recipient types along with environmental groups and conservancy groups.

Figure 1.6-3 Distribution of Schuylkill River Watershed Grants by Recipient Type



Out of the total $18,115,196 awarded within the Schuylkill River Watershed, most of the grant dollars were spent for remediation /restoration projects. Figure 1.6-4 shows the breakdown in percentage of the total amount of grant dollars by project type.

Figure 1.6-4 Distribution of Schuylkill River Watershed Grants by Project Type



The listing of the stakeholders involved in restoring the Schuylkill River Watershed and its inherent values can be broken up into the following different categories: Government, Academic, Environmental, and Consultants.

1.7 Public Participation Process

Key Points
- **Public kick-off meetings, Technical Advisory Group meetings, media articles and a website were some of the methods used to involve the public in the SWAP.**

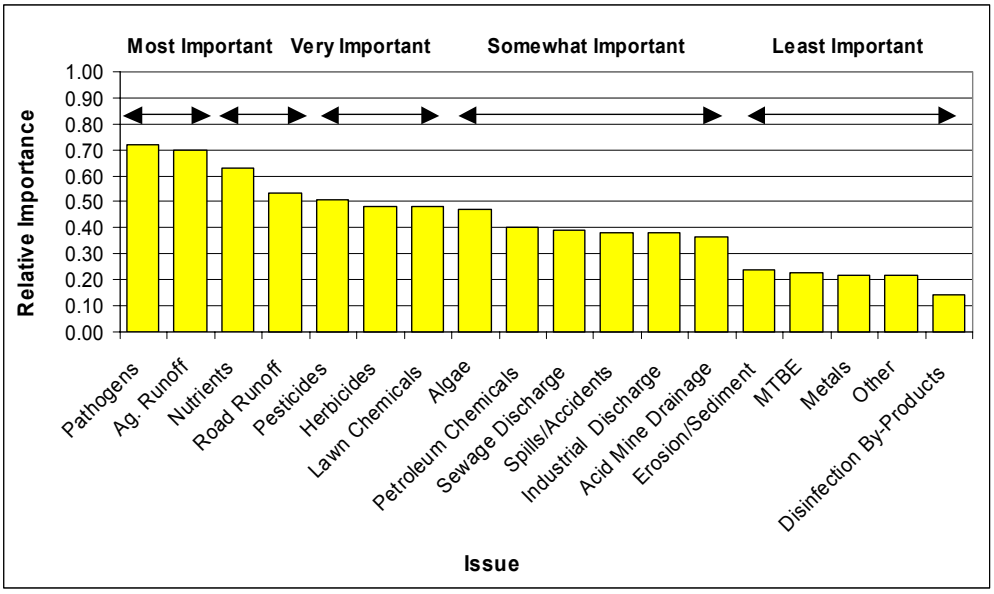
Several avenues were available for stakeholder and public involvement in the Schuylkill Source Water Assessment Program. These included:

- Public kickoff meetings
- Public wrap-up meetings
- Technical advisory group meetings
- Legal notices
- Newspaper articles
- SWAP website

This multi-faceted approach provided opportunities for the partnership to introduce the public and stakeholders to the source water assessment program and process, and for the partnership to obtain information and feedback from the public. Overall, these avenues appear to have been successful at reaching the public and stakeholders. Four public meetings resulted in 37 attendees, 5 advisory group meetings resulted in 147 attendees (about 29 persons per meeting), 9 legal notices were published, 15 newspaper articles were published about the project, and the website has been accessed 521 times to date. Public wrap-up meetings discussing the results of the project are anticipated for spring 2002.

One of the important goals of gathering stakeholder input was to determine the perceived importance of various water quality issues, so that comparisons could be conducted after the assessment was completed. According to the stakeholder input, the 17 water quality issues that were ranked fell into five general priority bins going from most important to least important (see Figure 1.7-1). Overall, pathogens, agricultural runoff, and nutrients were of greatest concern to stakeholders. Erosion and sedimentation control, MTBE, metals, and disinfection by-product precursors were considered the least important.

Figure 1.7-1 Ranking of Water Quality Issues by Stakeholders



1.7.1 Advisory Groups

Key Points
- **An open Technical Advisory Group (TAG) was established to facilitate communication among stakeholders and to gather information about the watershed.**
- **The TAG meets quarterly to assist the Source Water Assessment Partnership in the SWAP process.**

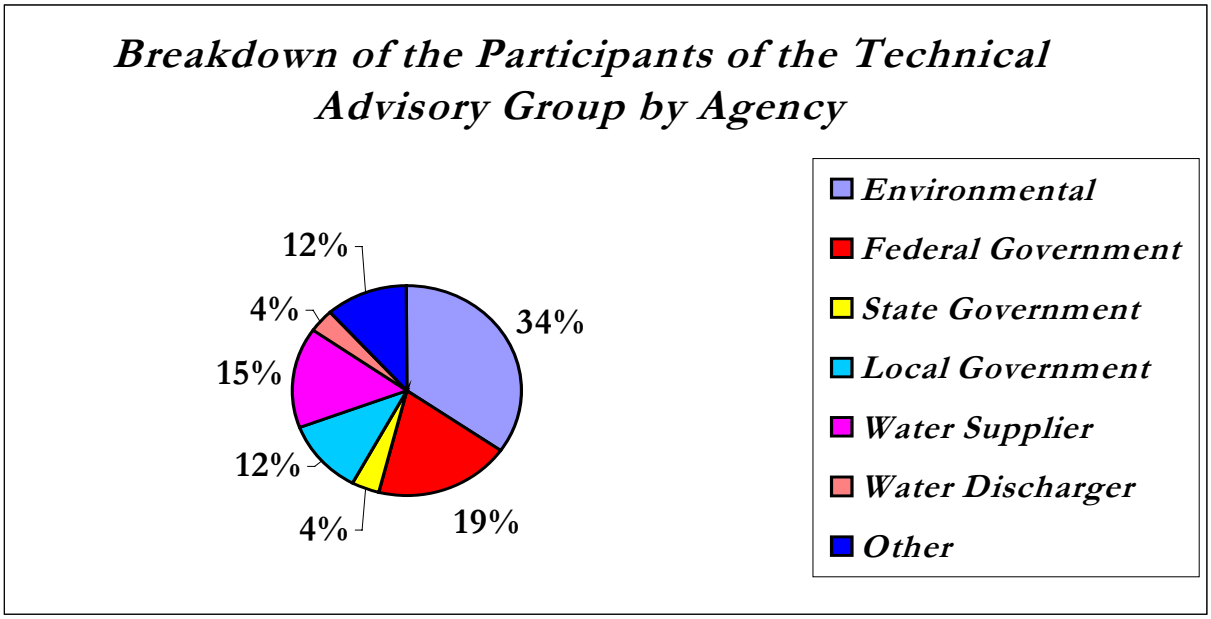
In order to better facilitate communication among the Source Water Assessment Partnership and the regions of the Schuylkill River Watershed to be assessed, an open Technical Advisory Group (TAG) was formed. This TAG was developed by the partnership as a way to closely interact with the stakeholders, and in turn, to gather integral information about each region of the Schuylkill River Watershed. All of the 200 stakeholders were invited by the partnership to participate. Meeting quarterly, it is the primary responsibility of the TAG to inject public interest into the SWA process. Moreover, others duties of this group include:

- Sharing information with stakeholders
- Verifying the information put forth by the partnership
- Providing input on the assessment techniques and criteria used by the partnership
- Offering general information regarding the areas local to each TAG
- Participating in public outreach and education
- Describing current protection activities
- Identifying "potential" sources of contamination and preservation
- Assisting in the development of summary reports

Technical Advisory Group Participants

Composed of watershed organizations, public interest groups, dischargers, suppliers, and local government agencies, the TAG offers a broad variety of perspectives and visions. The following graph is illustrative of the various types of agencies participating in the Technical Advisory Group (see Figure 1.7.1-1).

Figure 1.7.1-1 Technical Advisory Group Breakdown



The following is a summation of some of the TAG's participants:

It is the mission of the ***Department of Environmental Protection (DEP)*** to protect the air, land, and water of Pennsylvania from pollution, and to provide for the health and safety of its citizens through a cleaner environment. DEP works as a partner with individuals, organizations, governments, and businesses for the prevention of pollution and the restoration of natural resources. It achieves these goals via public service, protection, teamwork, communication, and pollution prevention. DEP is the State agency largely responsible for administering Pennsylvania's environmental laws and regulations. Its responsibilities include: reducing air pollution; making sure that our drinking water is safe; protecting water quality in our rivers and streams; making sure waste is handled properly; managing the Commonwealth's recycling programs and helping citizens prevent pollution and comply with the Commonwealth's environmental regulations. DEP is committed to general environmental education and encouraging effective public involvement in setting environmental policy.

Incorporated in 1969, the ***Western Berks Water Authority*** supplies water to the Borough of Wyomissing from its water treatment plant located on the Tulpehocken Creek, thereby meeting all of the water needs of the residents of Wyomissing, West Reading, and Shillington. The Western Berks Water Authority also supplies water to Mohnton and Lincoln Park, as well as portions of Cumru Township, and small quantities to the Citizens Utility Water Company, the Blue Marsh Lake Park and the fire companies. The authority's present water system facilities include a complete water treatment plant capable of supplying up to eight million gallons of water per day. The authority aligns with the Borough of Wyomissing's mission to provide services identified with the tradition of excellent living in Wyomissing.

PennFuture is an organization that takes pride in defending the environment. In achieving its mission of defending nature, PennFuture effectively resists those who attack the environment and rallies against those who fail to do their duty to protect it. By combating global warming, smog, acid rain, and illness, and by advocating the increase of desperately needed funding for farmland preservation, among other things, PennFuture is making great strides in assuring that polluters and their allies no longer decide the fate of the environment and the economy. Comments and concerns may be voiced to Brenna Herpmann at (800) 321-7775. PennFuture's mailing address is 212 Locust Street, Suite 410, Harrisburg, PA 17101.

In order to share the responsibility of managing the water resources of the Delaware River Basin, the ***Delaware River Basin Commission (DRBC)*** was formed by the signatory parties of the Delaware River Basin Compact (Delaware, New Jersey, New York, Pennsylvania, and the United States). Since its inception on October 27, 1961, the very day that Compact became law, DRBC has been a pacesetter in environmental protection. As mentioned in its mission statement, DRBC focuses mainly on protecting, enhancing, and developing the water resources of the Delaware River Basin for the benefit of present and future generations. In achieving their mission, DRBC has developed such programs as water pollution abatement, water supply allocation, regulatory review (permitting), water conservation initiatives, regional planning, drought management, and flood control. Questions, comments, and concerns may be forwarded to Jon Zangwill via e-mail, zangwill@drbc.state.nj.us or telephone, (609) 883-9500 x 307. DRBC's mailing address is 25 State Police Drive, West Trenton, NJ 08628.

The ***Schuylkill River Greenway Association*** is a membership organization that has been working with citizens, community groups, and a host of other partners for almost 25 years. The primary objective of the association is to promote the advocacy of river resources and open space. In 1995, with the designation of the Schuylkill River Corridor as Pennsylvania's seventh Heritage Park, the association expanded its mission to include such focal points as the conservation of the historic and cultural resources within the watershed as well as the economic development of such resources. Inquiries may be voiced to Executive Director Dixie Swenson via telephone, (610) 372-3916 or e-mail, srga@ptd.net. The Schuylkill River Greenway Association's mailing address is 960 Old Mill Road, Wyomissing, PA 19610-2522.

Clean Water Action (CWA) is a national citizens' organization that works toward the following goals: affordable water, prevention of health-threatening pollution, creation of environmentally safe jobs and businesses, and the empowerment of people to make democracy work. In addition, CWA organizes grassroots groups, coalitions, and campaigns with the common interest of protecting health and quality of life, so that they may better promote environmental well-being within a community. The mailing address of the CWA National Office is 4455 Connecticut Avenue NW – Suite A300, Washington, DC 20008-2328 (Telephone: (202) 895-0420). The mailing address of the CWA Philadelphia Office is 1201 Chestnut Street, #602, Philadelphia, PA 19107. All inquires may be directed to Bob Wendelgass at the Philadelphia Office via e-mail, bwendelgass@cleanwater.org or telephone, (215) 640-8800.

Since its inception in 1950, the ***Montgomery County Planning Commission (MCPC)*** has made great strides in promoting order and development while also preserving the elements of the Montgomery County Watershed that define the community's quality of life. The MCPC is an advisory body on the following subjects: land transportation of all types, the environment, water and sewer service, parks and open space, farmland preservation, stormwater management, site design, housing, zoning, development patterns, and the demographic trends within Montgomery County. MCPC is composed of 9 member-appointed board members as well as a professional staff of 44, all of whom provide support to municipal governments via innovative solutions to the challenges at hand. All questions, comments, and concerns may be voiced to MCPC Director, Kenneth B. Hughes via telephone, (610) 278-3722. The MCPC mailing address is P.O. Box 311, Norristown, PA 19404-0311.

The mission of the ***Schuylkill Riverkeeper Program*** is to protect and restore the Schuylkill River and its tributaries and habitats through advocacy, enforcement, and citizen action. The Riverkeeper is a field office of the Delaware Riverkeeper Network and collaborates with the Patrick Center for Environmental Research at the Academy of Natural Sciences. The primary focus of the Riverkeeper Program is to identify and restore degraded streambanks throughout the Schuylkill River Watershed while also working with landowners to address the effects of sediment and nutrient pollution on waterways, all of which is encompassed within the Schuylkill Riverkeeper's Streambank Restoration Project. All inquiries may be directed to Chari Towne via telephone, (610) 469-6005 or e-mail, srk@worldlynx.net. The mailing address of the Schuylkill Riverkeeper Program is P.O. Box 459, St. Peters, PA 19470-0459.

The ***Berks County Conservancy***, a non-profit organization established in 1974, is dedicated to preserving Berks County's unique cultural and environmental heritage for the benefit of future generations. In order to achieve this, the conservancy has focused its efforts on the preservation of agricultural land and open space, the protection of the quality of the streams and ground water of Berks County, and the preservation of historic landmarks and scenic landscapes, all of which contribute to a sustainable future for the Berks County Community. Simply put, protecting water, habitat, and the natural environment are conservancy priorities. Questions may be forwarded to Joseph Hoffman, Director of Environmental Management, via telephone, (610) 372-4992. Berks County Conservancy's mailing address is 960 Old Mill Road, Wyomissing, PA 19610.

It is the mission of the ***Nature Conservancy*** to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters needed to survive. Since its inception in 1951, the Nature Conservancy, the world's largest private international conservation group, has formed partnerships with communities, businesses, and individuals in order to pave the road for the protection of millions of acres of valuable lands and waters worldwide. It is the commitment of the Nature Conservancy to expand the boundaries of conservation in order to save Earth's last great places for future generations. All questions, comments, and concerns may be directed to Randy Gray, State Director, via telephone, (610) 834-1323 x116. The Nature

Conservancy's mailing address is 1100 East Hector Street, Suite 470, Conshohocken, PA 19428.

Formed in September 1995 when the Lower Merion-Narberth Watershed Association merged into the Lower Merion Preservation Trust, the ***Lower Merion Conservancy*** has since acted to protect the Lower Merion area's natural and historic resources, open space, and watersheds for residents and future generations by promoting collective responsibility for these resources via education, advocacy, and research. Questions and concerns may be voiced to Executive Director Mike Weilbacher at (610) 645-9030. The mailing address of the Conservancy is 1301 Rose Glen Road, Gladwyne, PA 19035.

The ***Natural Lands Trust*** is a nonprofit regional land trust that is committed to working with the region's communities to protect old-growth forests, diverse wildflower meadows, and dynamic wetlands. Through acquisition, conservation, easements, planning, and education, this organization encourages others to ensure the preservation of natural and cultural resources for many generations to come. Questions may be forwarded to Andy Pitz at (610) 353-5587. The mailing address of the Trust is 1031 Palmer's Mill Road, Media, PA 19063.

Incepted in 1964, the ***Perkiomen Watershed Conservancy*** has since been dedicated to protecting and conserving the natural resources within the Perkiomen Creek Watershed. This nonprofit organization reaches out to the surrounding community via environmental education and land conservation and protection. Questions, comments, and concerns may be forwarded to Executive Director Tish Ryan at (610) 287-9383. The mailing address of the Conservancy is 1 Skippack Pike, P.O. Box 55, Schwenksville, PA 19473.

It is the mission of the ***Pennsylvania Environmental Council (PEC)*** to improve the quality of life for all Pennsylvanians. In doing so, PEC enhances the Commonwealth's natural and man-made environments by integrating the advocacy, education, and implementation of both community and regional action programs. Director of Watersheds Programs, Ann Smith, will be accepting questions, concerns, and comments at (215) 563-0250. The mailing address of the PEC is 117 South 17th Street, Suite 2300, Philadelphia, PA 19103-5022.

Technical Advisory Group Meetings

Six TAG meetings were held as of September, 2001. The following table outlines the date, location, and number of attendees of each meeting.

Table 1.7.1-1 Summary of Technical Advisory Group Meeting Dates and Locations

Meeting	Date	Location	Number of Attendees
1	October 25, 2000	DEP Offices Conshohocken, PA	47
2	January 17, 2001	DEP Offices Conshohocken, PA	29
3	April 4, 2001	DEP Offices Conshohocken, PA	24
4	May 9, 2001	DEP Offices Conshohocken, PA	28
5	June 13, 2001	DEP Offices Conshohocken, PA	19
6	September 24, 2001	DEP Offices Conshohocken, PA	14
			Total Attendees 161

Summarization of Technical Advisory Group Meeting Minutes

These meetings were, in essence, forums for discussion during which local stakeholders were encouraged to voice their concerns and share their opinions of the project. The following is a summation of the minutes from the first five meetings:

MEETING 1

This meeting acted as an introduction to the Schuylkill River Watershed as well as to the Source Water Assessment Program. The watershed of the Schuylkill River was described as a significant industrial, agricultural, and commercial corridor, a home to three million people in Pennsylvania in which 40% of the land is forested, 48% is agricultural, and 12% is developed. The region was cited as a source of heritage, history, culture, and recreation.

The specific aspects of the Schuylkill River Watershed as a source of drinking water supply are as follows:

- 58 surface water intakes
- 47 intakes for systems serving < 10,000
- 265 MGD withdrawn on average from the river and its tributaries
- serves over 1.8 million people

The Source Water Assessment (SWA) was explained to be a multi-phase process. The process identifies potential or existing sources of contamination, evaluates the vulnerability/susceptibility of a water supply to contaminant sources, and identifies protection priorities and activities for the water supply. The ultimate goal of a SWA was specified as developing local sources of water protection initiatives and educating the public about the source of their drinking water and its challenges. The SWA was

depicted as an iterative and continuous process of assessing, planning, and implementing.

Utilities and stakeholders were encouraged to become interested in the SWAs because the program was based on federal regulations mandated by Congress. Responding to requests by the public to know more about their water supply and how to protect it, Congress included provisions for a SWA within the Safe Drinking Water Act Reauthorization of 1996. It is the goal of Congress to have 50% of the United States population enveloped under Source Water Protection Plans by 2005.

The SWAs were said to benefit the stakeholders present at the meeting because stakeholders of the TAG would be directly involved by:

- Identifying sources of contamination and areas for protection
- Having their organization highlighted for interested persons to contact/join
- Determining potential linkages between their efforts and protection efforts
- Increasing potential funding opportunities by incorporating projects into approved SWA plans

The Schuylkill River SWA area to be covered is comprised of 42 surface water intakes, 3 PADEP regions, 2,000 square miles of area, 130 miles of river, and 10 counties. The organization of the SWA was described as two distinct, but linked phases.

Phase I is inclusive of:

- 7 intakes
- 4 water systems
- 73% of the population
- 80% of river withdrawal for drinking water supplies
- Bottom of the watershed
- Industrial/urban/suburban issues

Phase II includes:

- 35 intakes
- 14 water systems
- 27% of the population
- 20% of withdrawal

- Headwaters to middle of river
- Rural, mining, agricultural, suburban issues

A schedule and timeline were presented in which Phase I, which began in July 2000, was marked for completion by December 2001. Phase II is scheduled to begin in July 2001 and end in July 2003.

MEETING 2

Phase I of the SWA was further discussed at this meeting. Of particular focus was the Stakeholder Survey, a document that was sent to stakeholders prior to the meeting, which listed key contaminant issues and requested that the stakeholders rank those issues on a relative scale of zero to one, with one being of the highest priority. Those stakeholders who responded to the survey included one municipal water supplier, one federal agency, and nine not-for-profit agencies. These respondents ranked pathogens and agricultural runoff as the issues having the highest priority with a ranking of approximately 0.7. On the opposite end of the scale, disinfection by-products were ranked as having the lowest priority with a score of 0.2.

The water quality of the Schuylkill River was also discussed. Parameters affecting water treatment were identified. When discussing contaminant source issues, it was determined that contaminant issues will vary with each perspective. For instance, the outlook of a fisherman will be significantly different than that of the upstream water suppliers and, likewise, the downstream water suppliers will have a differing perspective than that of the stakeholders. Table 1.7.1-2 outlines the parameters of concern from both a drinking water perspective and a finished water quality perspective.

Table 1.7.1-2 Perspectives on Water Quality Parameters of Concern

Drinking Water Perspective	Finished Water Quality Perspective
• Algae – clogs filters • Alkalinity and pH – affect coagulation • Turbidity – impacts coagulant and residual management costs • Metals – require additional chemicals for removal	• Algae – may cause taste and odor episodes • Salts – not removed by treatment and affects those on low sodium diets • *Cryptosporidium* – resistant to chlorine and may affect immune compromised subpopulations • Total Organic Carbon and Bromide – affect disinfection by-product formation

Water quality data, spanning a period of 30 years (1970 – 2000), for dozens of locations in the Schuylkill River Watershed had been compiled from several organizations. Of this data, conductivity, nutrients, metals, salts, and dissolved oxygen were identified as the most frequently monitored parameters, with pesticides, herbicides, and pathogens making up those parameters that are less frequently monitored.

MEETING 3

At Meeting Three, the four main sources of contaminant source compilation were established:

- Right to Know (RTK) Network (www.rtk.net)
- Envirofacts (www.epa.gov/enviro)
- Efacts (www.dep.state.pa.us/dep/efacts/resources)
- ESRI Business MapPro

Within the RTK and Envirofacts systems, four federal databases were accessed: PCS (Permit Compliance System), RCRIS (Resource Conservation and Recovery Act Information System), CERCLIS (Comprehensive Environmental Response, Compensation, and Liability Act Information System), and TRI (Toxic Release Inventory). In order to populate the databases, data was downloaded from RTK by county and then "clipped" in RTK for the purpose of eliminating those data points outside of the watershed boundaries. Missing "x-y" coordinates were filled in by geocoding in ArcView and cross-referencing the same facility with other databases and Envirofacts. Facility data was then further cross-referenced with Envirofacts. Quality and contaminant data was populated via Envirofacts.

A second keynote feature of this meeting was the discussion of the process used to evaluate and prioritize the most critical sources within the Schuylkill River Watershed.

It was determined that this process must be:

- Inclusive of all potential sources
- Equitably applied everywhere within the watershed
- Logical and well-founded
- Reproducible and defensible

In order to satisfy this need, EVAMIX was introduced. This is a computerized matrix-based mixed-data, multi-criteria evaluation method and ranking tool. EVAMIX uses a pair-by-pair comparison of each source against each other source via a criterion. This method is capable of performing hundreds of comparisons and calculations while handling units properly, as well as considering both quantitative and qualitative criteria. This method results in a single number or "appraisal score," that encompasses all of the data included in the criteria as well as the criteria weights. This number is also representative of the relative rank of "source x" against all other sources, which in turn provides a strong foundation for assigning priorities to each particular source. EVAMIX is used primarily for decision support. Using this framework, it is possible to evaluate alternatives, prioritize options, organize data to facilitate decisions, formalize and document the decision process, and act as evidence in defense of the decision made.

It was determined that the results gathered from the EVAMIX matrix will be further reviewed and "reality checked." Any results for high-ranking sources will be added to other sources outside the scope of the analysis, e.g., highway spills, pipeline breaks, etc. All high-ranking sources will be flagged for follow-up data collection in a later phase in order to verify results. Zones were broken down into categories "A", "B", and "C" and calculated using the Geographical Information System (GIS) and river time travel estimates. The zone delineation is as follows, beginning with an area-wide inventory:

- Zone A: critical segment, all potential sources
- Zone B: second segment, all significant sources
- Zone C: remainder, just area-wide inventory

The goal of the Schuylkill Source Water Assessment was again cited as gaining an understanding of which sources within the Schuylkill River Watershed are most significant and which are not as critical. In doing so, a better understanding of present water quality concerns as well as a sharper focus on the most critical sites will be provided. This, in turn, will lead to a more limited number of high priority sites within the Schuylkill River Watershed.

MEETING 4

One main topic of this meeting was the population of missing data to characterize sources. The Schuylkill River SWA Approach offers controlled screening for point sources as well as for non-point sources, which will allow for an end result of a limited number of high priority sites, i.e., approximately 50 sites per intake. Missing information including flow, quantity, chemical group, and SIC code matching PADEP activity were identified.

Another keynote point of this meeting is significance screening, which aids in the development of the best estimate of quantity, concentration at the release point, as well as the dilution at the intake. The steps to be taken regarding this approach are as follows:

- Development of the best estimate of the worst case release (quantity)
- Calculation of concentration at the release point
- Calculation of dilution at the intake
- Comparison to "Threshold Impact"

When too little data is available, screening will be conducted using the number of releases, the amount stored, the chemical stored, and the location relative to the floodplain. Other steps include choosing a Threshold Value in terms of Drinking Water Standards and Ambient Mean Concentrations, determining a background concentration, calculating discharge in order to increase concentration by ten percent of ambient or of

standard at the intake, and calculating the amount of spill of pure contaminant where appropriate.

Table 1.7.1-3 outlines the contaminant categories suggested at this meeting, as well as their potential fields, for the purpose of populating the databases.

Table 1.7.1-3 Proposed Contaminant Categories and Thresholds

Suggested Contaminant Categories	Potential Fields
Fecal Coliform	• Possible Threshold: 200 count/100ml • Threshold Type: Contact Recreational Water Standard • Discharge Volume to Exceed Threshold: 100 MGD of wastewater die off at 2,000 count/100 ml • Spill size to Exceed Threshold: Not Applicable
Turbidity (TSS)	• Possible Threshold: 10 mg/l • Threshold Type: Ambient Concentration • Discharge Volume to Double Threshold: 5 MGD at 200 mg/l (average wastewater) • Spill Size to Double Threshold: 10,000 lbs. of silt runoff in one day
Nutrients (Phosphorous)	• Possible Threshold: 0.12 mg/l • Threshold Type: Ambient • Discharge Volume to Exceed Threshold: 5 MGD to raise by 10% • Spill Size to Exceed Threshold: 110 lbs. of pure Phosphorous in one day
VOC (total)	• Possible Threshold: 5 parts per billion (ug/l) • Threshold Type: Drinking Water Standard for Benzene • Discharge Volume to Exceed Threshold: Not Applicable • Spill Size to Exceed Threshold: < 5 gallons per day of pure product
Metals (Pb as indicator)	• Possible Threshold: 0.015 mg/l • Threshold Type: Drinking water treatment trigger value • Discharge Volume to Exceed Threshold: approx. 1.5 MGD of industrial wastewater at 10 mg/l • Spill Size to Exceed Threshold: approx. 15 lbs. per day
Cryptosporidium/Giardia	• Possible Threshold: 1 oocyst per liter • Threshold Type: Drinking Water Guideline Value • Discharge Volume to Exceed Threshold: 10 oocysts per liter
Nitrates	• Possible Threshold: 10 mg/l • Threshold Type: Drinking Water Standard • Discharge Volume to Exceed Threshold: > 50 MGD • Spill Size to Exceed Threshold: 10,000 lbs.
DPB Precursors (TOC)	• Possible Threshold: 2.7 mg/l • Threshold Type: Ambient Median Value • Discharge Volume to Raise Threshold by 10%: 4 MGD of wastewater at 100 mg/l • Spill Size to Exceed Threshold: approx. 2,000 lbs. per day
Petroleum Hydrocarbons (TPH)	• No Identified Possible Threshold • Threshold Type: Ambient (data sparse) • Discharge Volume to Exceed Threshold: Not yet determined
Salts (Chloride as indicator)	• Possible Threshold: 250 mg/l • Type of Threshold: Drinking Water Standard • Discharge Volume to Exceed Threshold: 1 MGD of brine (sea water) • Spill Size to Exceed Threshold: 200,000 lbs. of salt per day

MEETING 5

The primary focus of this meeting was on Source Priority Ranking. In essence, three questions needed to be answered:

- Are criteria missing?
- Are the qualitative scores properly defined?

- Are the criteria priorities (weighting factors) satisfactory to the group?

At this meeting the diverse group including water suppliers, stakeholders, and dischargers reached a consensus on the criteria and the weighing factors to be used for ranking the sources. The group also agreed that the nine criteria of Relative Impact at Intake, Time of Travel, Existing Removal Capacity, Impact on Treatment, Potential Health Impacts, Potential for Release/Controls, Potential for Release Frequency, Violation Type/Frequency, and Location were sufficient to complete the ranking criteria. It was agreed that no other criteria were missing.

Weighing factors and qualitative definitions were determined for the criteria being used to rank sources across all contaminant categories as well as within the six individual categories, thus answering the three primary questions posed. Tables 1.7.1-4 and 1.7.1-5 outline the actual criteria, criteria type, and the percentages agreed upon for both the nine contaminant categories and the six individual contaminant categories at this fifth meeting of the SWA. These are summarized by Figures 1.7.1-2 and 1.7.1-3

Table 1.7.1-4 Consensus Weighing Values for Nine Criteria

Criteria	Type	Weight (%)
Relative Impact at Intake	Intake Related	12
Time of Travel	River Flow Related	5
Existing Removal Capacity	Intake Related	10
Impact on Treatment	Intake Related	10
Potential Health Impacts	User Related	20
Potential for Release/Controls	Source Related	14
Potential for Release/Frequency	Source Related	14
Violation Type/Frequency	Source Related	10
Location	River Flow Related	5

(To be used in the EVAMIX analysis across contaminant categories)

Figure 1.7.1-2 Summary of Criteria Types for Contaminant Categories

Contaminant Categories
Source Related Factors: 38%
Intake Related Factors: 32%
User Related: 20%
River Flow Related: 10%

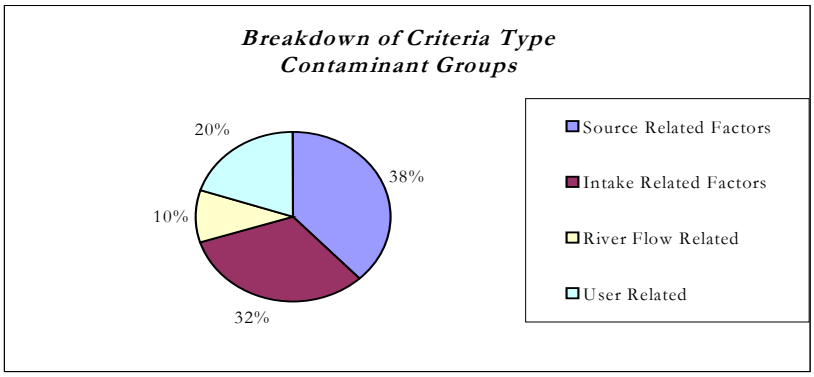


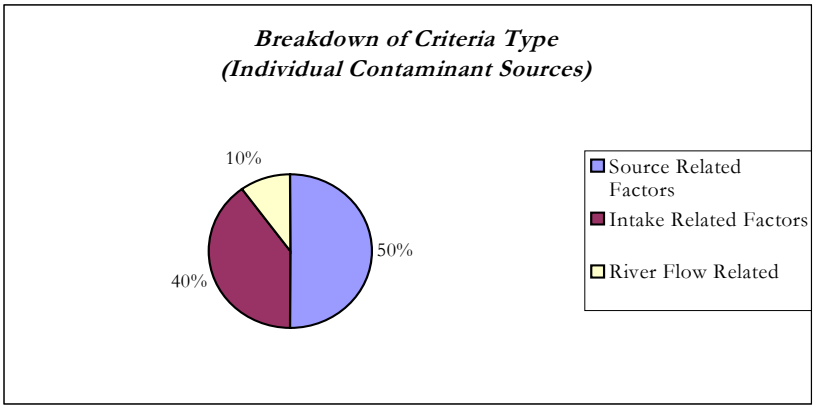
Table 1.7.1-5 Consensus Weighing Values for Six Criteria

Criteria	Type	Weight (%)
Relative Impact at Intake	Intake Related	40
Time of Travel	River Flow Related	5
Potential for Release/Controls	Source Related	20
Potential for Release/Frequency	Source Related	15
Violation Type/Frequency	Source Related	15
Location	River Flow Related	5

(To be used in the EVAMIX analysis within individual contaminant categories)

Figure 1.7.1-3 Summary of Criteria Types for Individual Contaminant Categories

Individual Contaminant Categories
Source Related Factors: 50%
Intake Related Factors: 40%
River Flow Related: 10%



These rankings will be later used to prioritize contaminant sources for source water protection efforts.

1.7.2 Public Meetings

Key Points
- **Thirty-seven people attended the four public kick-off meetings held to introduce the SWAP.**

Four public kick-off meetings were conducted to educate the public about the importance of the Source Water Assessment Program (SWAP). Each public kick-off meeting utilized the following general approach in order to generate public interest:

- Press releases produced by the Philadelphia Water Department and the local stakeholders were sent to the local media and newspapers
- Legal notices were sent to the local media and newspapers
- Advertisements were published in the Pennsylvania Department of Environmental Protection (PADEP)'s *Update*

Hosted by local watershed organizations to promote a sense of credibility as well as to establish a connection with local residents, these meetings were, in essence, informational forums where members of the public were able to voice their concerns as well as share their visions for the project. The following table outlines the host, location, date, and number of attendees for each of the four aforementioned public meetings.

Table 1.7.2-1 Public Kickoff Meetings Held for Lower Schuylkill Intakes

Meeting	Host(s)	Location	Date	Number of Attendees
1	Schuylkill Riverkeeper & Greater Pottstown Watershed Alliance	Montgomery County Community College, West Campus Pottstown, PA	2/15/01	14
2	Wissahickon Valley Watershed Association	Wissahickon Valley Watershed Association Ambler, PA	2/20/01	8
3	Perkiomen Valley Watershed Conservancy	Perkiomen Valley Watershed Conservancy Schwenksville, PA	3/13/01	7
4	Schuylkill Environmental Education Center	Schuylkill Environmental Education Center Philadelphia, PA	3/14/01	8
				Total Attendees 37

A standard meeting agenda was developed and followed at each meeting. This agenda consisted of an introduction and an explanation of the purpose of the meeting. Another component of this agenda was an overview of Source Water Assessments, which included a brief, yet thorough, description of the SWAP as well as the areas to be assessed, i.e., the Schuylkill River Watershed. In addition, a discussion of contaminant

source issues and water quality concerns was a keynote feature of the agenda. Finally, each meeting was concluded with an exercise in identification of potential contaminant sources, in which the attendees were asked to identify local sites that may impact the water supply. Questions, concerns, and comments were addressed as they were raised.

Prior to these kick-off meetings, several avenues were pursued in an attempt to notify the public of their occurrence. Letters produced by the Philadelphia Water Department, local stakeholders, and watershed groups specifying the location and directions, date, time and nature of the meetings were mailed to numerous stakeholders, including many of the businesses, government agencies, and environmental organizations located within or affected by the Schuylkill River Watershed. The information contained in these letters was also posted on the SWAP website, www.schuylkillswa.org. In order to further generate public interest, various watershed groups and local stakeholders posted flyers throughout their respective areas and sent press releases to their local newspapers. Additionally, many of those local newspapers featured articles describing the nature of the meetings as well as the outcome, where applicable. Legal notices detailing the location, time, and date of each meeting were printed in the local newspapers in each area with which the SWAP is affiliated, for the purpose of opening the meetings to everyone within the watershed. Table 1.7.2-2 is illustrative of the publications in which the legal notices appeared, the dates of publication, and the general areas reached.

Table 1.7.2-2 Legal Notices Published for Public Kickoff Meetings

Date Of Notice	Publication Name	Area Reached
2/11/01	The Norristown Times Herald	Norristown, PA
2/14/01	The Ambler Gazette	Ambler, PA
2/17/01	The Lansdale Reporter	Lansdale, PA
2/19/01	The Norristown Times Herald	Norristown, PA
2/22/01	The Pottstown Mercury	Pottstown, PA
3/11/01	The Norristown Times Herald	Norristown, PA
3/11/01	The Pottstown Mercury	Pottstown, PA
3/12/01	The Philadelphia Daily News	Philadelphia, PA
3/12/01	The Philadelphia Inquirer	Philadelphia, PA

One article, featured in the April 30, 2001 edition of The Pottstown, clearly demonstrates how these kick-off meetings have impacted the public. At the February 15, 2001 meeting, hosted by the Greater Pottstown Watershed Alliance and the Schuylkill Riverkeeper, residents of North Coventry Township were stunned by photographs of pollution sources lining the Schuylkill River on Route 724 between Scholl Road and the Union Township Line. In response to the discouraging photos they had seen, eighteen volunteers hailing from North Coventry, Pottstown, the Pottsgroves, Phoenixville, Sanatoga, and Bryn Mawr, among other places, met at the site on Saturday, March 24, 2001 and a massive clean-up ensued. Two dump trucks of trash, two pickup trucks of metal scrap, and 40 tires were picked up. The February 15, 2001 kick-off meeting acted as a catalyst in enticing the public to take the action necessary to preserve the beauty and utility of their surrounding waterways.

1.7.3 Website

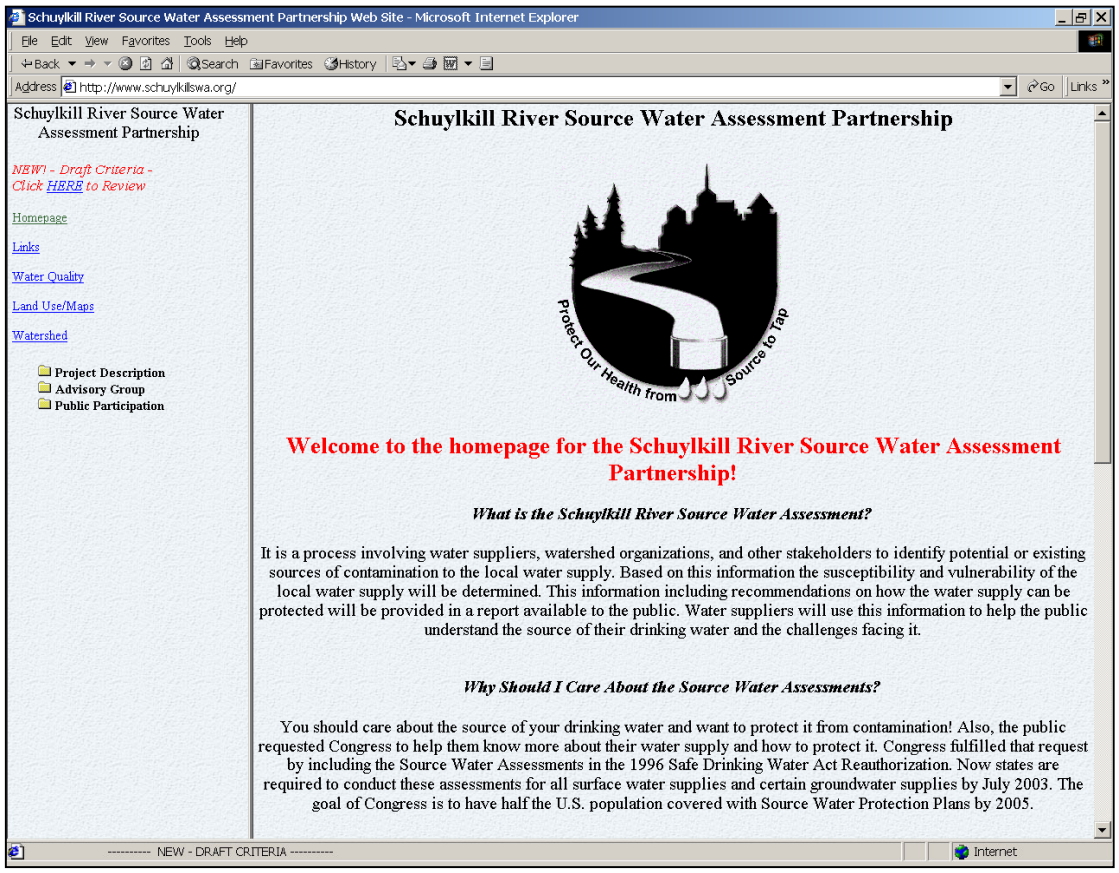
Key Points

- **SWAP project information is available through the project website, www.schuylkillswa.org.**

A website was developed for the project (*www.schuylkillswa.org*) to provide a location where information about the project could be easily accessed by the public and stakeholders (see Figure 1.7.3-1). Though this was a task beyond the scope of the contract, it was considered a necessary form of information delivery. Most importantly, the website was considered the most efficient way of providing the advisory group meeting information, meeting handouts, and meeting minutes without producing a significant burden of production on staff, given that there are more than 200 stakeholders to whom information must be mailed on at least a quarterly basis.

The website was set up to provide general information about the purpose of the SWAP and contact information. It also provided links to information about public meetings, advisory group meetings, meeting materials, general watershed information, limited maps, watershed organizations, and general water quality information. Another special feature was an on-line stakeholder survey that stakeholders could fill out to provide information about their water quality issues.

Figure 1.7.3-1 Schuylkill River SWAP Website (www.schuylkillswa.org)



1.8 General Recommendations for the Schuylkill River Watershed

The compilation of extensive field surveys, interviews with numerous stakeholders, and the examination of water quality, land use, and impaired stream information were compiled into the recommendations listed below for the Schuylkill River Watershed. These recommendations address 12 different categories, including general watershed protection ideas and specific activities related to watershed issues.

1.8.1 Grant Funding and Watershed Organizations

- Based on the protection priority areas, restoration projects, and grant funding information available, it is apparent that there is a need for more restoration projects and watershed organizations for protection of the main stem of the Schuylkill River between Philadelphia and Reading. Restoration projects in the priority corridor should be given special consideration and hopefully promote development of local sponsors in these areas more effectively.

- Development of a regional water supply/watershed coalition or council for improved coordination of watershed activities and grant funding between watershed organizations, public agencies, municipalities, and planning commissions for water supply protection. This would include a special matching source water protection grant fund for the Schuylkill River Watershed that members would contribute to the state for matching. The watershed council including representatives from PADEP, water suppliers, counties, Schuylkill Riverkeeper, and other organizations would then review the grant applications and fund projects with the most value to water supply protection.

- The Allegheny, Hay, and Pickering creeks appear to have received low amounts of grant funding for protection and restoration efforts, even though they are water supplies for Birdsboro and Philadelphia Suburban. This may be due in part to the fact that most of the watershed is protected. Therefore, the continued protection and preservation of these areas are important.

- A watershed organization should be established for the Pickering Creek Watershed.

1.8.2 Protection and Preservation

- A coordinated regional protection plan needs to be developed and adopted by water suppliers, planning commissions, and municipalities for establishment and protection of sensitive and high priority protection areas to the multiple and overlapping water supply areas between Reading and Philadelphia.

- Existing greenspace along the Schuylkill River in the protection area between Philadelphia and Reading should be preserved.

- Conservation easements should be acquired, zoning areas adjusted, or local ordinances enacted in order to reduce stormwater impacts from future development in the protection priority corridor between Philadelphia and Reading.

- The TMDL process and requirements along the Schuylkill River should include components to address drinking water impacts.

The same protection priority corridor along the main stem of the Schuylkill River for PWD's intakes overlaps significantly with the protection priority areas for Pennsylvania American Water Company – Norristown, Philadelphia Suburban Water Company, Phoenixville Boro, Citizen's Utilities – Royersford, and Pottstown Boro water supply intakes. The runoff and point sources in this corridor impact the water supplies for more than 1.3 million people that receive drinking water from these sources in the area encompassed by Berks, Chester, Montgomery, and Philadelphia counties. Therefore, the protection priority corridor requires special attention, legislation, and regulation. This includes special legislative actions and regulatory designation of this area to provide opportunities for enhanced discharges and reduced stormwater runoff impacts.

The Schuylkill River Corridor needs special assistance, as evidenced by stream impairments and recreational water quality issues. Given that many industries also withdraw water for electric generation and that the majority of persons in the watershed reside in or near the protection corridor and conduct recreation in or along it, the benefits to aquatic life, recreation, industry, and quality of life for citizens in general are significant and cannot be ignored. Coincidentally, the protection priority corridor is also the focus of significant efforts for the creation of greenways and recreational trails. In this case, the desire for increased recreational opportunities and greenways coincides with a desire to protect water supplies, and represents a significant opportunity for numerous stakeholders.

Priority for funding of Growing Greener and DCNR grants for projects in the protection priority area should be given to projects that address sustainable mitigation of stormwater impacts and restoration or preservation of areas. In addition, agricultural land within the protection priority corridor would also be given easier access and higher priority for USDA funding, such as EQUP or CRP, in order to keep sensitive land areas out of production and protect local streams. PADEP and USDA could designate farms within the priority protection area as high priority for development of nutrient management plans. Townships located within the priority protection area should also be required to adopt a uniform ordinance to address stormwater impacts from current and future activities.

1.8.3 Sewage Discharge and Regulatory Enforcement

- Overall, both the sewer system capacity and integrity and the treatment plant capacity during wet weather periods represent the greatest and most difficult sewage-related issue in the watershed. Infrastructure improvements for

adequate wastewater collection and treatment systems are needed to address infiltration and inflow or system capacity issues. These improvements will eliminate events such as overflowing manholes of raw sewage into downstream water supplies.

- Raw sewage discharges by communities such as New Philadelphia and Middleport need to be eliminated and wastewater treatment systems constructed and operated. Combined, the aforementioned communities represent raw sewage discharges from several thousand people directly into the Schuylkill River. These practices are not consistent with standard wastewater treatment requirements typically enforced nationwide.

- Discharges from combined sewer overflows (CSO) systems upstream of drinking water intakes, such as Bridgeport and Norristown, need to be reduced and controlled. These discharges can significantly impact pathogen concentrations in downstream water supplies.

- Wastewater dischargers should be encouraged and given incentives to switch to ultraviolet light disinfection and/or filtration of effluents in order to reduce *Cryptosporidium* pathogen levels and viability from discharges. Permits for discharge from new wastewater facilities or plant expansions should include ultraviolet light disinfection requirements.

- It is recommended that the DRBC and three PADEP regions covering the Schuylkill River Watershed develop a watershed-wide approach to addressing permit requirements. One suggestion would be a uniform fecal coliform discharge limit for any wastewater discharge upstream of a drinking water intake in the watershed.

- Compliance requirements for industries and municipalities discharging wastewater into the protection priority corridor between Philadelphia and Reading should be enforced.

- Encouragement of rigorous and regular revision and implementation of ACT 537 Sewage Facilities Management Plans in Montgomery, Chester, Berks, and Schuylkill counties. In addition, the sewage facility related issues from the SWAs should be incorporated into the ACT 537 plan with emphasis on monitoring and measuring progress towards addressing identified problems.

1.8.4 Stormwater Runoff Impacts

- Incentives for townships and communities along the main stem of the Schuylkill River from Reading to Philadelphia are needed to mitigate stormwater impacts on water supplies.

- The Phase II stormwater regulations should be fully implemented and enforced throughout the watershed, with first priority for compliance monitoring and

inspections recommended for communities discharging into protection priority areas for drinking water supplies.

1.8.5 Acid Mine Drainage Impacts

Acid mine drainage needs to be addressed and mitigated to reduce significant loadings of metals into downstream water supplies. The Pine Knot/Oak Hill acid mine drainage site in Schuylkill County is perhaps the greatest single known source of metals discharging into the Schuylkill River. Efforts should be focused towards the remediation of this site.

1.8.6 Spills and Accidents/Emergency Response

- Interaction and communication with petroleum pipeline owners and operators, as well as railroad, road and bridge construction crews needs to be developed and improved. It is important for these stakeholders to understand water supply issues and impacts from catastrophic accidents and spraying of herbicides on rights-of-way. Therefore, a series of emergency response workshops needs to be coordinated to include the following parties:

    - PEMA
    - PECO
    - CSX/Conrail
    - PennDot
    - Local Street Department Construction and Maintenance Managers

- Given the potentially catastrophic impacts from spills and accidents, an early warning system similar to that on the Ohio River should be installed along the main stem of the Schuylkill River to provide water suppliers warning and accurate real time data when spills and accidents occur. It is recommended that the USGS be involved in the implementation of the early warning system.

- New permits should be banned for new storage tanks and facilities that use or store toxic chemicals including petroleum products within the 100 year floodplain of the river and its tributaries. The PADEP should also develop and implement a long-term plan to relocate, reduce, or eliminate tanks and sources with toxic chemicals that are currently located within the floodplain.

- An accurate time-of-travel study needs to be conducted on the Schuylkill River to determine the time various spills will take to arrive at various water supply intakes and the amount of dilution under various flow scenarios. This should be incorporated into a computer model for emergency planning simulations using various chemicals and scenarios. This is also an important component necessary to make information from the early warning system more useful. The USGS should be involved in the implementation of this effort.

- In sensitive water supply areas along roadways and bridges, signage should be erected, which would include phone numbers to contact water suppliers during emergencies and spills. The signs should include a unique identification number corresponding to a known location for the water supplier.

- A special workshop with street departments and PennDot should be held in orderto develop a strategy to reduce salt impacts from road salt application. This may include strategies to acquire special funding for salt misting trucks to reduce salt application in sensitive areas.

1.8.7 Agricultural Impacts

- Agricultural land that is preserved should have specific riparian buffer and streambank fencing requirements included in its preservation status.

- Additional incentives and efforts should be allocated to develop nutrient management plans for farms in sensitive water supply areas.

- Active agricultural lands adjacent to streams in sensitive water supply areas should be required to have riparian buffers or streambank fencing to reduce impacts from livestock activity, pasture runoff, and crop runoff. Livestock releasing fecal material directly into a stream represent a direct waste discharge to a water body and therefore, should be subject to the similar regulations and permit requirements as other dischargers.

- Agricultural protection activities should be focused in Berks County and along the main stem of the Schuylkill River between Philadelphia and Reading.

- The targeting of USDA funding for water quality protection under EQIP and enrollment of CRP lands should give consideration to sensitive water supply areas, and the programs should be made more accessible to farmers. To maximize water supply protection, water suppliers should be consulted in connection with the allocation of EQIP and CRP funds.

- Areas of intense or concentrated agricultural activity should also be prioritized for protection and mitigation efforts.

1.8.8 Erosion and Sedimentation Issues

- Special erosion controls and ordinances to reduce stormwater impacts from future development and erosion are needed in protection priority areas for water supplies.

- Conservation Districts need more assistance in addressing erosion control and stormwater runoff issues from development.

- The sediment impounded behind dams should be removed prior to removal of the dam. Future dam removal projects funded by PADEP or DCNR must have

this component to reduce washdown impacts of impounded sediment from rain events after the dam has been removed.

1.8.9 Wildlife Impacts

- The U.S. Fish and Wildlife, PA Game Commission, park managers, golf course managers, and water suppliers should develop and implement a regional management plan to address the exploding population of non-migratory Canada Geese.

1.8.10 Public Education

- Township officials along the protection priority corridor should be educated about stormwater impacts on water supplies through meetings, workshops, or mailings.

- The results of the local source water assessments need to be presented directly to local township officials. Common issues from multiple water supplies should also be provided to show how everybody lives downstream and feels the impact from pollution.

1.8.11 Data and Informational Needs for Improved Protection and Assessment Efforts

- An accurate watershed-wide land use GIS coverage is necessary for TMDLs and runoff impact estimates.

- GIS coverages of farms, types of agriculture, farming density, and EQUP/CRP lands, or lands with conservation easements, should be developed for the entire watershed.

- GIS coverages of the sanitary and stormsewer collection systems and outfalls in watershed communities should be developed.

- Updated and accurate locations of the many known point sources, as well as their outfall locations are necessary since currently, many are off by far distances in comparisons between GIS and reality.

- Detailed GIS coverages of the age and location of petroleum pipelines in the watershed should be developed.

- Detailed GIS coverages of location, type of activity, and dollar amounts spent on various restoration, education, and protection efforts in the watershed should be compiled.

- A GIS coverage of the land use zoning for various townships and proposed future development corridors should be created to prioritize future protection and preservation efforts.

- Violation information for dischargers on the E-facts and Envirofacts websites for PADEP and EPA are incorrect and outdated. Efforts should be made to make this information more accurate and up-to-date.

- Updated information regarding the status and impacts from CERCLA sites and abandoned industry in the watershed should be compiled.

- A cumulative loading analysis of various discharges and runoff in the watershed should be performed.

- Actual and accurate estimates or reported values of contaminant concentrations from dischargers should be electronically available.

1.8.12 Water Quality Monitoring and Data Recommendations

Overall, based on the information available from an analysis of the amount, types, and locations for monitoring in the watershed, the following is needed:

- A data clearinghouse for water quality data needs to be created and made available to all organizations. A format for data reporting should be sent to all organizations that want to participate.

- An organization in the watershed needs to be properly funded and made responsible for the compilation, organization, and monitoring of water quality data from the numerous stakeholders in the watershed.

- Organizations that conduct monitoring should form a consortium for frequent discussions of monitoring efforts and plans in order to promote better coordination and sharing of data.

- More monitoring locations are needed in places other than the Pickering, Perkiomen, Valley, and French creeks.

- All monitoring organizations should agree on selecting standard monitoring stations for various parameters. It is recommended that the stations be placed close to the mouths of the major tributaries to the watershed. The long-term Riverkeeper sites and certain water supply intakes may be the best place to start in selecting these sites. These standard stations would have routine monitoring conducted over long periods of time in order to examine changes and trends in water quality over years, seasons, or decades. This information will be used as part of a report card system for water quality improvement.

- Long term monitoring should be conducted for manganese, aluminum, iron, sodium, chloride, turbidity, total suspended solids, dissolved oxygen, temperature, ammonia, total phosphorus, orthophosphate, nitrate, E. coli, and

fecal coliforms. Currently, most monitoring does not include coliform measurements.

- Efforts should be made to transfer data from hardcopy format in special studies into electronic format.

- Additional funding and training of groups such as the Schuylkill Riverkeeper Volunteer Monitoring Network, Alarm, and Stroud Center is necessary in order to enhance the quality and breadth of parameters conducted for analysis at standard sites.