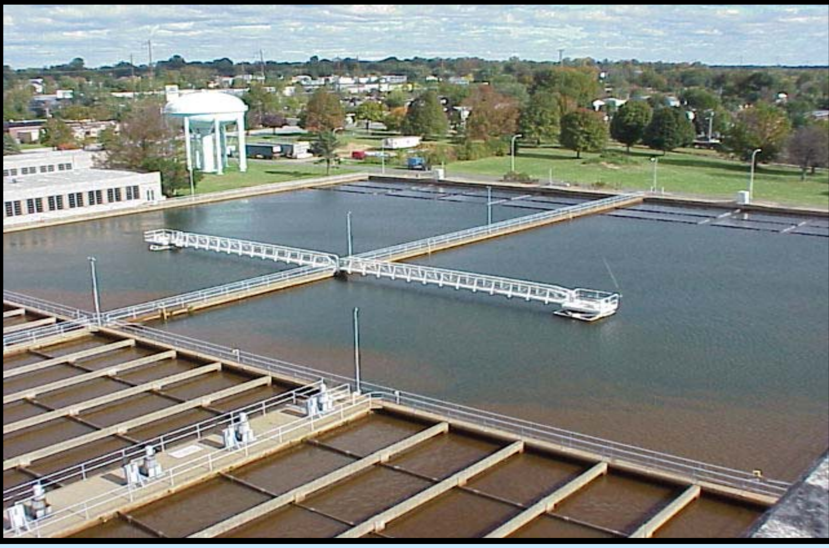



PHILADELPHIA WATER DEPARTMENT
BAXTER WATER TREATMENT PLANT (PWSID# 1510001)
SOURCE WATER ASSESSMENT REPORT
SECTION 2: DELAWARE RIVER INTAKE


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

Prepared by The Philadelphia Water Department
June 12, 2002

With support from:
Bucks County Water and Sewer
Philadelphia Suburban Water Company
Pennsylvania American Water Company
Pennsylvania Department of Environmental Protection
Camp Dresser & McKee

PADEP Contract: ME350056

Executive Summary - Baxter WTP Intake Source Water 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 Delaware 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, and the Bucks County Water and Sewer Authority conducted the assessment with stakeholders to identify water supply protection priorities in the Delaware 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 results of the analysis.

High Protection Priority Issues and Activities

Overall, the following activities were identified as having high priority for protection efforts to address:

- Sanitary Sewer Overflows of raw sewage from sewer collection systems, sewage lift stations, and manholes from upstream communities
- Urban, residential, and agricultural runoff from various areas of the watershed, mostly located in tributaries such as the Pennypack Creek, Poquessing/Byberry Creek, Neshaminy Creek, Rancocas Creek, Lehigh River, and Musconetcong River.
- Discharges from municipal and industrial sources such as sewage treatment plants and chemical manufacturing facilities between Camden and Trenton.
- Spill and accidents from cars, tanker trucks, railroad cars, pipelines, tire piles, and fires at industrial facilities near the river and its tributaries

Observations & Characterization

- Raw water is gravity fed via tidal elevation changes from the Delaware River at a daily average rate of 175 million gallons per day (MGD) with maximum capacity of 320 MGD.
- The Baxter Water Treatment Plant serves approximately 750,000 customers in Northeastern Philadelphia and Lower Bucks County.
- The water supply intake is located at Delaware River mile 11. It is the farthest downstream public water supply located on the Delaware River in Pennsylvania.
- The drainage area of the basin above the Baxter Intake is approximately 7,500 square miles. Land use of the area just upstream of the intake is primarily residential and light/heavy industrial.

- Water withdrawn from the Delaware River is coagulated, settled, filtered, and disinfected with chlorine to make it safe prior to distribution to customers. Drinking water quality meets or exceeds all state or federal requirements.

- Delaware River water quality is monitored to assess potential health risks, aesthetics, and treatment requirements.

- The Philadelphia Water Department routinely monitors pH, color, alkalinity, hardness, total dissolved solids, conductivity, turbidity, coliform, *Giardia* and *Cryptosporidium,* total organic carbon, UV absorbance, bromide, nitrogen, phosphorus, iron, manganese, sulfate, chloride and sodium at their Baxter Intake. Many other parameters are monitored as part of special studies.

- Turbidity and other suspended contaminants in the river tend to increase as a function of precipitation, runoff and river flow.

- Salt levels in the river appear to fluctuate seasonally, perhaps in response to application of road salts during the winter.

- Over the past decade, levels of alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, nitrate and turbidity in the Delaware River have increased at the Baxter Intake. Increased pollution from runoff is the most likely source of these changes.

- Stream impairments in the Lower Delaware River Watershed are primarily caused by stormwater runoff from urban and suburban areas.

- Almost 6,000 potential point sources were identified within the 2,060 square mile Baxter Intake. Most of these potential sources do not – and will never – discharge to Delaware River. They have been identified so that water suppliers can assess their potential impacts upon the water supply, and identify appropriate protective measures.

- Over 1,700 RCRA facilities are located upstream of the Baxter Intake. Most RCRA facilities are not large quantity generators.

- Sewage systems, dry cleaning plants (except rug cleaning), and gasoline service stations are most common.

- Volatile organic chemicals, petroleum hydrocarbons, and SOCs were the most frequently reported contaminants.

- The Delaware River Runoff Loading Model was developed to estimate contaminant loadings to the river from storm runoff.

- The model used the physical characteristics of the sub-watersheds, meteorological data, updated land use information, and event mean concentrations for the nine parameters of interest to estimate average daily contaminant loadings within each of the Baxter Intake's zones of contribution.

- The developed land areas associated with industrial/commercial land use and residential uses were estimated to contribute the highest per acre loadings of most of the contaminants evaluated, including disinfection by-products, metals, nutrients, petroleum hydrocarbons, salts, and coliforms.

- Unit *cryptosporidium* and turbidity loadings were higher from agricultural areas.

- A series of screenings was used to identify those sources that have the greatest potential to affect water quality at the Baxter Intake.

- Five non-conservative contaminant categories and five conservative contaminant categories were selected to represent all potential contaminants.

- For each category, a threshold value indicative of the significance of the concentrations of contaminants that could result from a potential spill or discharge was defined.

- EVAMIX, a multi-criteria software package was used to prioritize the potential significance of each of the potential point sources within Baxter's Zone A and Zone B, and to evaluate the potential significance of non-point sources estimated by the Delaware River Runoff Loading Model.

- NPDES and nonpoint source discharges within the Baxter Intake's Zone A and Zone B were determined to have the highest protection priorities in the watershed.

- The potential significance of each source of contamination was designated A (potentially significant source of highest protection priority) through F (Potential source of lowest protection priority). Those sources ranked A through C are potentially significant sources of contamination to the Baxter Intake.

- All of the highest ranked sources are either NPDES sites or stormwater loadings from specific sub-watersheds.

- Contaminant sources actually discharging to the river (e.g., NPDES permitted point sources, or stormwater runoff) are estimated to have greater potential significance than those with only the potential to release contaminants to the river (e.g., a spill or leak).

- EVAMIX was also used to rank potential sources for each contaminant category.

Protection Recommendations

- Overall, the primary protection areas to focus PWD's protection efforts to protect and improve PWD's water supply include the tidal areas of the Delaware River between Trenton and Philadelphia/Camden.

- Non point source protection should be focused in the Pennypack Creek, Poquessing/Byberry Creek, and Neshaminy Creek areas as well as portions of the Muscentong, Pohatcong, Lehigh Rivers. However other parts of the watershed may need limited attention for contaminant specific issues.

Based on the results of the susceptibility analysis, water quality data, and stream impairments, it is clear that the potential impacts from point source discharges need to be addressed from the discharges along the main stem of the Delaware River from Camden to Trenton. Efforts to reduce these impacts would require the following components:

- Enforcement of compliance requirements for industries and municipalities discharging wastewater into the protection priority corridor between Camden and Trenton;
- Facilities Management Plans in Montgomery and Bucks 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;
- Development of a coordinated regional protection plan that will be adopted by water suppliers, planning commissions, and municipalities for establishment and protection of sensitive and high priority protection areas to multiple and overlapping water supply areas between Camden and Trenton;
- Development of mechanism or framework to address source water protection and non- point source issues in the Lower Delaware River Basin area. The DRBC has a number of water resources and watershed/TMDL related committees, but they are focused only on source water protection concerns. Finding a way to include the priority areas and issues identified in the SWAPs into the existing DRBC framework for implementation and mitigation is critical;
- Development and support of watershed or local community/environmental organizations to restore and protect various segments of the protection priority corridor between Camden and Trenton and;
- Ensure that TMDL process and requirements along the Delaware River include components to address drinking water impacts;
- Development of special state or federal legislation that provides funding and authority for water supply protection efforts in the protection priority corridor between Camden and Trenton;
- Include C*ryptosporidium* impacts in the permitting process for wastewater dischargers upstream of drinking water intakes;
- Development of incentives for upstream communities to mitigate stormwater runoff;
- Acquisition of conservation easements or adjustment of zoning areas or local ordinances to reduce stormwater impacts due to future development in the protection priority runoff areas;
- Education of township officials along the protection priority corridor about stormwater impacts;
- Preservation of existing greenspace along the Delaware River in the protection area;
- Enforcement of the Phase II stormwater regulations for townships in priority runoff areas;

- Development of conservation easements, riparian buffers, and streambank fencing to mitigate impacts from agricultural activities;

- A corporate environmental stewardship program should be developed to educate, provide incentives, and engage businesses in water supply protection and stormwater mitigation;

- A workshop should be sponsored by PADEP to educate golf courses about the benefits of joining the environmental certification program by the Audobon Society;

- Efforts should be made to encourage PADEP and DRBC to address and prioritize the impacts of CSOs and untreated discharges of raw sewage upstream of drinking water.

In addition to those efforts mentioned above, the following specific actions are recommended for protection efforts in the Poquessing and Pennypack Creek Watersheds:

- Development of regulatory and financial incentives for enhanced wastewater discharge for pathogen removal and inactivation to address *Cryptosporidium* impacts;

- Development of incentives and controls for mitigation of stormwater runoff impacts. This includes requiring that current TMDL efforts in the watershed include specific components to address drinking water issues and concerns. This will provide an example of how the Safe Drinking Water Act and Clean Water Act should be integrated;

- Conduct an examination of current zonings and ordinances with the Bucks County Planning Commission, Bucks County Conservation District, and local townships to determine ways they can be enhanced to address current and future stormwater impacts. Identify areas where innovative techniques and incentives can be used to mitigate stormwater impacts and assist in the development and implementation of these efforts;

- Encourage and support the development of an Act 167 Stormwater Management Plan for the Pennypack and Poquessing Creek;

- Establish riparian buffers and steambank fencing in all agricultural areas of the Pennypack, Poquessing/Byberry and Neshaminy Creek Watersheds.

The Philadelphia Suburban Water Company already works with numerous stakeholders to protect its water supply in the Neshaminy Creek. Therefore, it is recommended that any protection efforts be coordinated with the Philadelphia Suburban Water Company environmental initiatives and programs in the Neshaminy Creek Watershed.

In addition to the previous specific geographic recommendations, the following general efforts are recommended:

  - Emergency Response Planning activities should be focused on priority AST, TRI, and RCRA facilities since they have been shown to have the greatest relative impact on water quality. Efforts should also be initiated to collect more detailed data on these sites for reprioritization.

- Long-term protection efforts should focused on improving the quality of wastewater discharges and stormwater runoff. These will have the greatest overall impacts on improving source water quality.

- Sources of pathogens appear to be the sources of greatest priority to PWD when examined in the overall rankings. Therefore, these sources should be addressed accordingly.

- A corporate environmental stewardship program should be developed to educate, provide incentives, and engage businesses in water supply protection and stormwater mitigation.

- Special mechanisms and funding should be developed to allow the distribution of monies to support or initiate specific initiatives outside the City of Philadelphia that will protect or restore the water supply. This may involve development of a quasi-governmental or non-profit organization that can raise funds and distribute them to various organizations conducting protection activities beneficial to PWD. This organization may also need the ability acquire conservation easements or land in sensitive areas to maintain protected areas.

- Efforts should be made to encourage PADEP and DRBC to address and prioritize the impacts of CSOs and untreated discharges of raw sewage upstream of drinking water intakes.

Public Meetings and Participation

- 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 Source Water Assessment Program (SWAP).

- A 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 SWAP process.

- SWAP Project information was available to the public and stakeholders through the project website at www.phillywater.org/delaware.

Table I – Summary of Protection Priorities From Various Upstream Sources

Source	Protection Priority	Description	Priority Area(s)	Contaminants
Treated Sewage	A – C (Moderate – High)	Wastewater discharges from wastewater treatment plants	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment, organic chemicals
Untreated Sewage	A (High)	Combined and sanitary sewer overflows/discharges	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients
Urban/Residential Runoff	A – C (Moderate – High)	Stormwater runoff from roads, parking lots, roofs	Watershed wide	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, metals, sediment
Agricultural Runoff	A – C (Moderate – High)	Stormwater runoff from croplands, pastures, livestock	Watershed wide	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment
Acid Mine Drainage	C (Moderate)	Discharge from abandoned coal mining areas	Lehigh	Metals
Industrial Facilities	C (Moderate)	Facilities that store or use hazardous chemicals	Camden to Trenton	Metals, nutrients, organic chemicals
Above Ground Storage Tanks	C (Moderate)	If storage tank spilled into river	Camden to Trenton	Petroleum hydrocarbons, metals, phosphorus
Landfills	C (Moderate)	Leaching of contaminants into streams	Camden to Trenton	Petroleum hydrocarbons, metals
Spills and Accidents	A – C (Moderate – High)	Car, truck, train, or pipeline accident spilling benzene	Watershed wide	Petroleum hydrocarbons, organic chemicals

Note: *Petroleum hydrocarbons include chemicals found in oils and greases.*
Organic chemicals include chemicals found in solvents, degreasers, varnishes, paints, gasoline, plastics, and insect and weed killers.

Table of Contents

Section 2 - PWD Baxter Water Treatment Plant Delaware River Intake

2.1 Watershed and Drinking Water System 2-1
2.1.1 Watershed........ 2-1
2.1.2.1 Geology and Soils 2-4
2.1.2.2 Hydrogeology 2-9
2.1.2.3 Hydrology........ 2-11
2.1.2.4 Physiography 2-19
2.1.2.5 Topography 2-21
2.1.3 Land Use........ 2-23
2.1.4 Drinking Water System 2-28
2.1.5 Raw Water Quality........ 2-31
2.1.5.1 Water Quality Summary........ 2-31
2.1.5.2 Temporal Water Quality Analysis 2-49
2.1.5.3 Spatial Water Quality Analysis........ 2-54
2.1.5.4 Analysis of Stream Impairments and Sources........ 2-67

2.2 Source Water Assessment 2-73
2.2.1 Delineation of Source Water Assessment Zones 2-73
2.2.1.1 Zone Definition........ 2-73
2.2.1.2 Non-Tidal Zone Velocity Assumptions........ 2-74
2.2.1.3 Tidal Zone Hydrodynamic Modeling........ 2-74
2.2.1.4 Zone Delineation 2-77
2.2.2 Point Source Contaminant Inventory........ 2-81
2.2.2.1 Method 2-81
2.2.2.2 Results 2-82
2.2.3 Runoff Loading Summary 2-95
2.2.3.1 Method 2-95
2.2.3.2 Results 2-99
2.2.3.3 Hydrograph Separation for Baseflow and Runoff Calibration........ 2-105
2.2.4 Susceptibility Analysis 2-107
2.2.4.1 Method 2-107
2.2.4.2 Results 2-122
2.2.4.3 Narrative Results 2-201
2.2.5 Qualitative Loading Analysis........ 2-205
2.2.5.1 Method 2-205
2.2.5.2 Results 2-206
2.2.6 Watershed Protection and Restoration Activities........ 2-215
2.2.7 Public Participation Process........ 2-219
2.2.7.1 Advisory Groups 2-220
2.2.7.2 Public Meetings........ 2-235
2.2.7.3 Website........ 2-236
2.2.8 Baxter Intake Conclusions and Recommendations........ 2-238
2.2.8.1 General Recommendations 2-241

2.2.8.2 Regional Recommendations: 2-244
2.2.8.3 Intake Specific Recommendations: Example Project List and Best Management Practices 2-245
2.2.8.4 Data Needs 2-246
2.2.8.6 Descriptions and Pictures of Technologies for Stormwater Control 2-255
2.2.9 PWD-Baxter Intake Public Summary 2-266

List of Figures

Figure 2.1.1-1 Aerial Photograph of Baxter Intake 2-2
Figure 2.1.1-2 Location of Water Supply Intakes in the Lower Delaware River Watershed 2-3
Figure 2.1.2-1 Geology of SWAP Study Area 2-6
Figure 2.1.2-2 General Distribution of Soils in the Lower SWAP Study Area 2-8
Figure 2.1.2-3 Long-Term Average Annual Temperature at Philadelphia 2-12
Figure 2.1.2-4 Annual Average Flow at Trenton Gauge of Delaware River 2-13
Figure 2.1.2-5 Precipitation trends in Southeastern Pennsylvania through the 1990's 2-14
Figure 2.1.2-6 Daily Average Delaware River Flow at Trenton through the 1990's 2-17
Figure 2.1.2-7 Physiographic Provinces Within the SWAP Study Area 2-20
Figure 2.1.2-8 Topographic Features Around the Baxter Intake 2-22
Figure 2.1.3-1 Percentage of Land Area in the Study Area Within Each County 2-24
Figure 2.1.3-2 Overview of the Study Area Land Use (2000) 2-24
Figure 2.1.3-3 Change in Development Within Each Subwatershed in the Study Area 2-25
Figure 2.1.3-4 Land Use Surrounding Baxter Intake 2-26
Figure 2.1.3-5 Updated NLCD Land Use for PWD Baxter Intake Zone B Delineation 2-27
Figure 2.1.4-1 Philadelphia Water Department's Baxter Water Treatment Plant 2-28
Figure 2.1.4-2 Schematic of Water Treatment Process at the Baxter WTP 2-30
Figure 2.1.5-1 Theoretical Pathogen Transport Cycles in a Multi-Use Watershed 2-36
Figure 2.1.5-2 Comparison of Amount Produced by Various Sources of *Cryptosporidium* and *Giardia* 2-37
Figure 2.1.5-3 Seasonal Patterns in Water Quality at Baxter Intake During 1990-1999 2-50
Figure 2.1.5-4 Trends in Water Quality at Baxter Intake by Decade During 1990-1999 2-52
Figure 2.1.5-5 Summary of Spatial Turbidity Trends: January 1990–August 2000 2-55
Figure 2.1.5-6 Spatial Turbidity Trends from January 1990-August 2000 2-56
Figure 2.1.5-7 Turbidity/ Flow Trends: January 1990-December 1999 2-57
Figure 2.1.5-8 Summary of Spatial Trends of Manganese and Iron: January 1990 - January 2002 2-58
Figure 2.1.5-9 Spatial Trends in Manganese and Iron from January 1990 - January 2002 2-60
Figure 2.1.5-10 Flow Trends in Manganese and Iron: January 1990 - July 1999 2-61
Figure 2.1.5-11 Summary of Spatial Trends of Nutrients: January 1990 - December 2001 2-63
Figure 2.1.5-12 Spatial Trends of Nutrients from January 1990 - December 2001 2-64
Figure 2.1.5-13 Flow/Nutrient Trends from January 1990 - February 1999 2-65
Figure 2.1.5-14 Historical Bromide Levels at PWD's Intakes 2-66
Figure 2.1.5-15 Summary of Miles Impaired by Primary Sources 2-68

Figure 2.1.5-16 Summary of Miles of Impairment by Primary Causes (PA Side Only) 2-68
Figure 2.1.5-17 Percentage of Watershed Miles Impaired and Assessed in the Lower Tidal Delaware River Basin 2-71
Figure 2.1.5-18 Impaired Stream Reaches in the Lower Delaware River Watershed ... 2-72
Figure 2.2.1-1 Model Grid 2-76
Figure 2.2.1-2 PWD's Baxter Intake: Zone A 2-78
Figure 2.2.1-3 PWD's Baxter Intake: Zone B 2-80
Figure 2.2.2-1 Prevalent Industry Types for the Baxter Intake 2-84
Figure 2.2.2-2 Prevalent Contaminant Categories for the Baxter Intake 2-84
Figure 2.2.3-1 Watershed Loading Model Schematic Diagram 2-96
Figure 2.2.3-2 Land Use Characterization for PWD Baxter Intake Zone B 2-97
Figure 2.2.3-3 Non-Conservative Contaminant Runoff Loadings 2-100
Figure 2.2.3-4 Hydrograph Separation Analysis for the Delaware River at Belvidere for August 1992 2-106
Figure 2.2.4-1 Source Prioritization Flow Diagram 2-108
Figure 2.2.4-2 Maximum Relative Concentration at the Baxter Intake 2-114
Figure 2.2.4-3 Screening and Ranking Process 2-123
Figure 2.2.4-4 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Lower Delaware Watershed 2-132
Figure 2.2.4-5 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Middle Delaware Watershed 2-133
Figure 2.2.4-6 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Upper Delaware Watershed 2-134
Figure 2.2.4-7 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Lower Delaware River Watershed 2-138
Figure 2.2.4-8 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Middle Delaware River Watershed 2-139
Figure 2.2.4-9 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Upper Delaware River Watershed 2-140
Figure 2.2.4-10 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Lower Delaware River Watershed 2-145
Figure 2.2.4-11 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Middle Delaware River Watershed 2-146
Figure 2.2.4-12 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Upper Delaware River Watershed 2-147
Figure 2.2.4-13 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Lower Delaware River Watershed 2-152
Figure 2.2.4-14 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Middle Delaware River Watershed 2-153
Figure 2.2.4-15 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Upper Delaware River Watershed 2-154
Figure 2.2.4-16 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Lower Delaware River Watershed 2-159
Figure 2.2.4-17 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Middle Delaware Watershed 2-160
Figure 2.2.4-18 Priority Point Sources and Subwatersheds for PWD's Baxter

Intake for Metals in the Upper Delaware Watershed 2-161
Figure 2.2.4-19 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Lower Delaware Watershed 2-165
Figure 2.2.4-20 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Middle Delaware Watershed 2-166
Figure 2.2.4-21 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Upper Delaware Watershed 2-167
Figure 2.2.4-22 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Lower Delaware River Watershed 2-171
Figure 2.2.4-23 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Middle Delaware River Watershed 2-172
Figure 2.2.4-24 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Upper Delaware River Watershed 2-173
Figure 2.2.4-25 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Lower Delaware River Watershed 2-178
Figure 2.2.4-26 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Middle Delaware River Watershed 2-179
Figure 2.2.4-27 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Upper Delaware River Watershed 2-180
Figure 2.2.4-28 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Lower Delaware River Watershed 2-185
Figure 2.2.4-29 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Middle Delaware River Watershed 2-186
Figure 2.2.4-30 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Upper Delaware River Watershed 2-187
Figure 2.2.4-31 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Lower Delaware River Watershed 2-191
Figure 2.2.4-32 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Middle Delaware River Watershed 2-192
Figure 2.2.4-33 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Upper Delaware River Watershed 2-193
Figure 2.2.4-34 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Lower Delaware River Watershed 2-198
Figure 2.2.4-35 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Middle Delaware River Watershed 2-199
Figure 2.2.4-36 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Upper Delaware River Watershed 2-200
Figure 2.2.6-1 Distribution of Tidal PA Philly Grants by Project Type 2-216
Figure 2.2.7-1 Meeting Location Preferences 2-220
Figure 2.2.7-2 Technical Advisory Group Breakdown 2-221
Figure 2.2.7-3 Assessment Schedule 2-230
Figure 2.2.7-4 Main Steps in the General Approach 2-232
Figure 2.2.7-5 Source Water Assessment: Simplified Approach 2-233
Figure 2.2.7-6 Delaware River SWAP Website (www.phillywater.org/delaware) 2-237

List of Tables

Table 2.1.2-1 Prevalence of Various Major Soil Types in the Lower Study Area 2-8
Table 2.1.2-2 Streamflow Statistics for Selected Gauging Stations 2-15
Table 2.1.2-3 Duration Table of Daily Flow 2-16
Table 2.1.2-4 Stream Gauging Data in the Lower Delaware River Basin 2-17
Table 2.1.2-5 Characteristics of Tributaries in the Lower Delaware River Watershed (in alphabetical order) 2-18
Table 2.1.2-6 Reservoirs within the Neshaminy River Watershed 2-19
Table 2.1.5-1 Baxter Intake Sampling Summary 2-32
Table 2.1.5-2 Physical Parameters of Source Water 2-33
Table 2.1.5-3 Particulate and Microbial Contaminants at Baxter Intake 2-35
Table 2.1.5-4 *Giardia* and *Cryptosporidium* Detected at the Baxter WTP Intake from March 2001 through March 2002 2-35
Table 2.1.5-5 Organic Compounds – DBP Precursors at Baxter Intake 2-38
Table 2.1.5-6 Inorganic Compounds – Nutrients at Baxter Intake 2-38
Table 2.1.5-7 Inorganic Compounds – Metals at Baxter Intake 2-39
Table 2.1.5-8 Inorganic Compounds – Secondary Contaminants at Baxter Intake 2-40
Table 2.1.5-9 Herbicides, Pesticides, and SOCs Results for the Baxter WTP 2-41
Table 2.1.5-10 SOCs Detected in Lower Delaware River Watersheds During Fall 2000 Monitoring Study 2-42
Table 2.1.5-11 Comparison of SOCs Detected To Date by USGS NAWQ A Study in the Delaware River Watershed 2-42
Table 2.1.5-12 Uses and Possible Sources of Herbicides, Pesticides, and SOCs Detected at the PWD WTPs 2-43
Table 2.1.5-13 Regulatory VOCs Tested for in PWD's Drinking Water 2-44
Table 2.1.5-14 Volatile Organic Compound Summary at or near Baxter Intake 2-45
Table 2.1.5-15 Summary of Detectable VOCs at or near Baxter Intake 2-46
Table 2.1.5-16 Radionuclides in PWD Drinking Water Effluents (1999) 2-47
Table 2.1.5-17 Monthly Concentrations of Algae and Diatoms at the Baxter WTP Intake - 1999 2-48
Table 2.1.5-18 Summary of Seasonal Water Quality Trends at Baxter Intake During 1990 - 1999 2-51
Table 2.1.5-19 Summary of Trends in Water Quality at Baxter Intake During 1990 - 1999 2-53
Table 2.1.5-20 Miles of Impairment by Primary Source and Watershed (PA side only) 2-69
Table 2.1.5-21 Breakdown of Miles of Impairment by Primary Cause and Watershed (PA Side Only) 2-70
Table 2.1.5-22 Breakdown of Miles of Impairment by Primary Cause and Watershed (NJ Side Only) 2-70
Table 2.2.2-1 Summary of Point Source Types Delineation Zone 2-83
Table 2.2.2-2 PCS Discharger Summary 2-85
Table 2.2.2-3 Summary of Available DMR Data 2-86
Table 2.2.2-4 RCRA Facility Summary 2-91
Table 2.2.2-5 AST Facility Summary 2-92

Table 2.2.2-6 TRI Facility Summary 2-93
Table 2.2.2-7 CERCLA Facility Summary 2-94
Table 2.2.3-1 Updated Land Use Categories........ 2-97
Table 2.2.3-2 Calculated Average Daily Contaminant Loadings........ 2-101
Table 2.2.3-3 Daily Contaminant Loads for Major Subwatersheds........ 2-102
Table 2.2.3-4 Daily Contaminant Loads per Acre for Major Subwatersheds........ 2-103
Table 2.2.4-1 Final Ranking of Sources for Combined Contaminant Categories........ 2-126
Table 2.2.4-2 Contaminant Source Ranking Designations........ 2-129
Table 2.2.4-3 Contaminant Category Ranking for Salts (Chlorides) 2-136
Table 2.2.4-4 Contaminant Category Ranking for *Cryptosporidium*........ 2-141
Table 2.2.4-5 Contaminant Ranking for Fecal Coliform........ 2-148
Table 2.2.4-6 Contaminant Category Ranking for Metals........ 2-155
Table 2.2.4-7 Contaminant Category Ranking for Nitrates 2-162
Table 2.2.4-8 Contaminant Category Ranking for Petroleum Hydrocarbons........ 2-168
Table 2.2.4-9 Contaminant Category Ranking for Phosphorus 2-174
Table 2.2.4-10 Contaminant Category Ranking for Total Organic Carbon (Disinfection By-product Surrogate)........ 2-181
Table 2.2.4-11 Contaminant Category Ranking for Total Suspended Solids 2-188
Table 2.2.4-12 Contaminant Category Ranking for Volatile Organic Compounds........ 2-194
Table 2.2.4-13 County Rankings in PA for Number of NPL Sites 2-202
Table 2.2.4-14 Most Frequently Detected Chemicals at NPL Sites in Various Counties Draining into the Delaware River Watershed 2-202
Table 2.2.4-15 Potentially Significant CERCLA Sources for the Baxter WTP Intake........ 2-204
Table 2.2.5-1 Qualitative Combined Contributions to River Water Quality........ 2-207
Table 2.2.6-1 Projects Receiving Grants in the Lower Delaware River Watershed (several SWAP Study areas) 2-216
Table 2.2.7-1 Summary of Technical Advisory Group Meeting Dates and Locations 2-227
Table 2.2.7-2 Final Products and Purposes 2-228
Table 2.2.7-3 Source Water Protection Issues 2-229
Table 2.2.7-4 Stakeholder Criteria Weightings........ 2-234
Table 2.2.8-1 Summary of Protection Priority of Various Types of Potential Contaminant Sources 2-239
Table 2.2.8-2 Summary of Protection Priority Ranking of Various Main Stem Delaware River Areas for Point and Non-point Sources........ 2-240
Table 2.2.8-3 Summary of Protection Priority Ranking of Various Tributaries for Point and Non-point Sources in Pennsylvania and New Jersey Streams........ 2-241
Table 2.2.8-4 Structural BMPs for Stormwater Control........ 2-248
Table 2.2.8-5 Nonstructural BMPs for Stormwater Control 2-249
Table 2.2.8-6 Base Costs of Typical Applications of Stormwater BMPs 2-250
Table 2.2.8-7 Operation and Maintenance Cost Estimates 2-251
Table 2.2.8-8 Land Consumption of Various BMPs........ 2-251
Table 2.2.8-9 Non-Structural BMPs Suited to Controlling Various Pollutants:........ 2-252

Pollutant Appropriate BMPs 2-252
Table 2.2.8-10 Structural BMP Expected Pollutant Removal Efficiency 2-253
Table 2.2.8-11 Pollutant Removal by Infiltration Practices 2-253
Table 2.2.8-12 Pollutant Removal by Retention Basins 2-254
Table 2.2.8-13 Pollutant Removal Efficiency of Constructed Wetland Systems 2-254
Table 2.2.8-14 Pollutant Removal Efficiency of Open Channel Vegetated Systems 2-255
Table 2.2.9-1 Summary of Protection Priorities for Various Upstream Sources 2-268
Table 2.2.9-2 Who to Call to Report Various Situations 2-269
Table 2.2.9-3 Getting Involved: Places to go for More Information About Local Organizations 2-269

Section 2
PWD - Baxter Water Treatment Plant

2.1 Watershed and Drinking Water System

Key Points

- **The Philadelphia Water Department's Baxter Intake is a public water supply intake on the Delaware River located at river mile 11.**
- **It is the farthest downstream public water supply located on the Delaware River in Pennsylvania.**

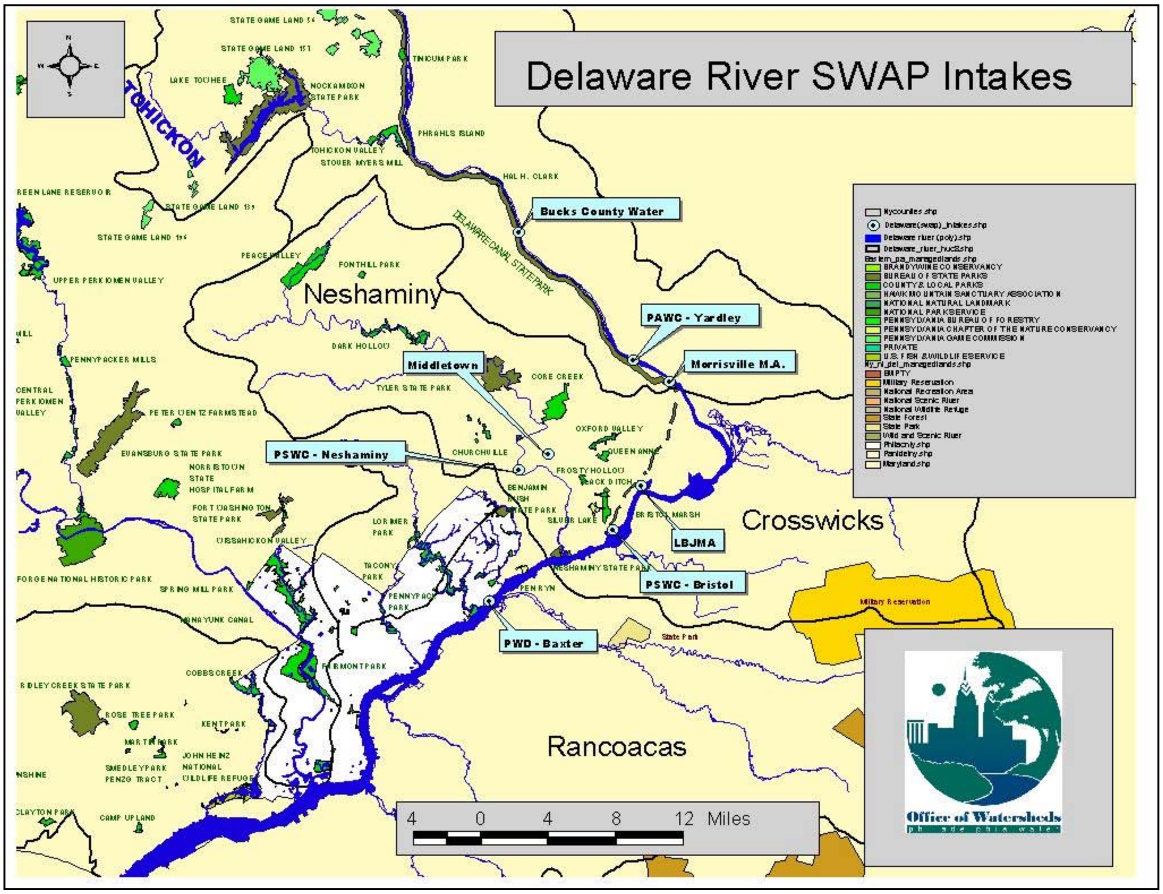
2.1.1 Watershed

The Philadelphia Water Department's Baxter Intake is located at Delaware River mile 11. As shown in Figure 2.1.1-1, the intake is located directly upstream of the confluence of the Pennypack Creek and the Delaware River. The Baxter Intake draws water into the "raw water lagoon" during high-tide. The Delaware River is tidal up until the natural fall line located between Morrisville, PA and Trenton, NJ.

The drainage area of the basin above the Baxter Intake is approximately 7,500 square miles. Land use of the area just upstream of the intake is primarily residential and light/heavy industrial. The closest active USGS flow monitoring station is located at Trenton, New Jersey. Moving upstream from the Delaware Estuary, the Baxter Intake is the first public water supply intake (see Figure 2.1.1-2) above the river's confluence with the Atlantic Ocean.

Figure 2.1.1-1 Aerial Photograph of Baxter Intake

Figure 2.1.1-2 Location of Water Supply Intakes in the Lower Delaware River Watershed



2.1.2 Geology, Soils, Hydrology, Physiography and Topography

Key Points

- **The Baxter facility is located in Northeast Philadelphia in the Atlantic Coastal Plain Province, which covers a large part of Southeastern Pennsylvania.**
- **Topography and types of soils in the watershed affect the amount and quality of runoff produced during precipitation events.**
- **Soils in the Lower SWAP Study Area are generally well drained, and generate moderate amounts of runoff.**
- **The soils surrounding the Baxter Intake are classified as urban land. They generally have the same soil particle size distribution as the original silty loams.**

2.1.2.1 Geology and Soils

The Baxter Intake is located within the Atlantic Coastal Plane Province, with the Piedmont Province lying to the north. The area surrounding the intake is characterized by several different types of geologic formations, as illustrated in Figure 2.1.2-1. Additional information on the Atlantic Coastal Plane Province can be found in section 2.1.2.4 of this report. The major rocks are briefly described here.

Middle Paleozoic Sedimentary Rocks

Silurian strata include the Bloomsburg, High Falls, and Shawangunk Formations. These are sedimentary rocks, and include coarse conglomerate, quartzose sandstone, and shale. Mudrocks are dominant in the Devonian section, however, small amounts of chert and limestone are important constituents in the lower half, and siltstones, sandstones, and conglomerates dominate parts of the upper half. Mississippian rocks are distributed at the surface in the Delaware Basin in the Anthracite region, and consist of the Mauch Chunk Formation (red siltstone and sandstone, and tan to brown sandstone and conglomerate), the Mount Carbon Member (coarse grained sandstone and conglomerate), The Spechty Kopf Formations (cominantly sandstone),and the Beckville Member (finer grained sandstone and conglomerate).

Lower Paleozoic Sedimentary Rock

In the Lehigh Valley region, a resistant Cambrian unit (Hardystone Formation) reaches a maximum of nearly 800 feet thick. It consists of conglomerate and arkose, feldspathic sandstone, siliceous sandstone, and silty shale. Above this unit lies a carbonate sequence of fine to coarse-grained dolomite. The sedimentary rocks of the Ordovician age crop out in southeastern Pennsylvania. They are mainly dolomite-limestone rocks, dominated by thin to thick bedded dolomite and interbedded limestone.

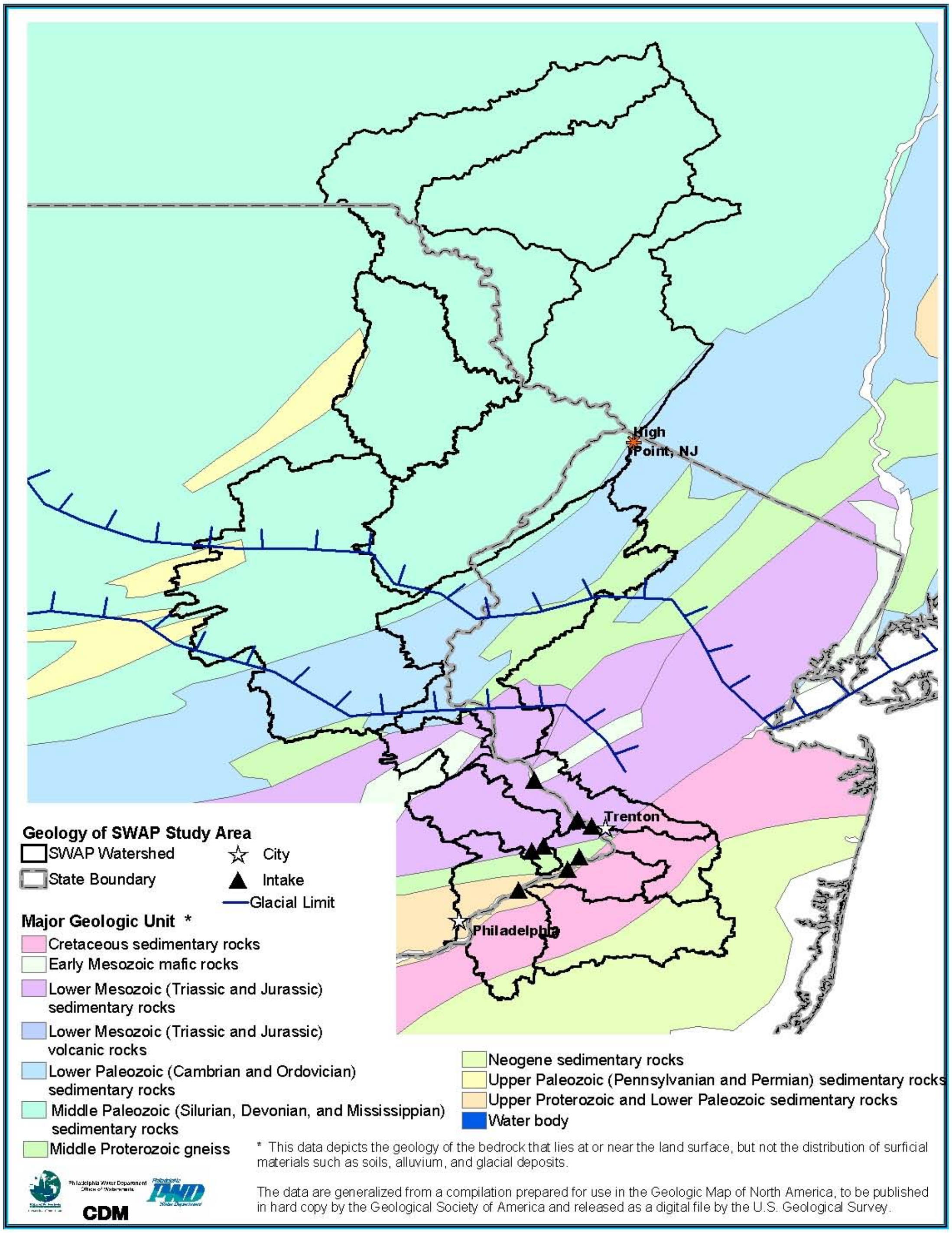
Lower Mesozoic Sedimentary Rocks

In the Jurassic time, about 200 million years ago, the mountains in the area began to erode to low foothills, and the ancestral Delaware River developed. The first deposits of the southward flowing Schuylkill and Delaware Rivers occurred at this time. Some of the formations within the Newark Basin include the Stockton Formation (arkosic sandstone and siltstone), The Lockatong Formation (fossiliferous black shales), and the Brunswick Group (red and gray silty mudstones and shales). These are sedimentary rocks consisting of fluvial and lacustrine deposits that can exceed 20,000 feet in thickness.

Cretaceous Sediments

Cretaceous and Tertiary sediments (onconsolidated) crop out in a narrow zone along the Delaware River in southeastern Pennsylvania. The coastal plain sediments are largely a sequence of sands, clays, and gravels, and form the most extensive aquifers of the Lower Delaware Basin. The sources of sediment deposited are diverse and related directly to the fluvial systems entering the coastal area, including the ancestral Schuylkill and Delaware Rivers. The sediments varied from that which was highly feldspathic and rich in metamorphic minerals to that which was nonfeldspathic and impoverished in heavy minerals. They are subdivided into four units: Potomac Formation (oldest, thick beds of pale-gray to grayish-orange sand interbedded with clay), Bryn Mawr Formation (isolated sand and gravel deposits), Bridgeton Formation (sand interspersed with gravel beds), and Pensauken Formation (youngest, mainly sand).

Figure 2.1.2-1 Geology of SWAP Study Area



* This data depicts the geology of the bedrock that lies at or near the land surface, but not the distribution of surficial materials such as soils, alluvium, and glacial deposits.

The data are generalized from a compilation prepared for use in the Geologic Map of North America, to be published in hard copy by the Geological Society of America and released as a digital file by the U.S. Geological Survey.

The physical properties of the soils in the Delaware River drainage basin are the determining factor in the sediment-transport characteristics of the Delaware River and its tributaries. The soils, in turn, are determined by the geology and weathering processes of the rock material. Many of the soils surrounding the Baxter Intake are classified as urban land, because the soil profile has been reworked during the cut-and-fill operations and construction projects. They generally have the same soil particle size distribution as the original silty loams.

The Delaware River Watershed is comprised of a variety of soils, which determine the landscape of the watershed and the transport properties of the river and its tributaries. Within the major hydrological classifications and groups of soils, there are 58 specific subtypes in the SWAP study area. The Wellsboro, Valley, Hagerstown, Hazelton, Berks, Washington, Wurtsboro, and Willowemoc soil classifications define approximately 50 percent of the watershed soils. More detail about these soil types is provided in the general section of this report. As shown in Figure 2.1.2-2, the predominant soils surrounding the Baxter Intake include Chester, Downer, Pocomoke, Hammonton, and Sulfaquen types. Table 2.1.2-1 indicates that these soils are generally well drained and produce moderate runoff. The Pocomoke and Sulfaquent soils are the two soils that are very poorly drained. However, both of these soil types do not surround the Baxter Intake and are located within New Jersey.

Figure 2.1.2-2 General Distribution of Soils in the Lower SWAP Study Area

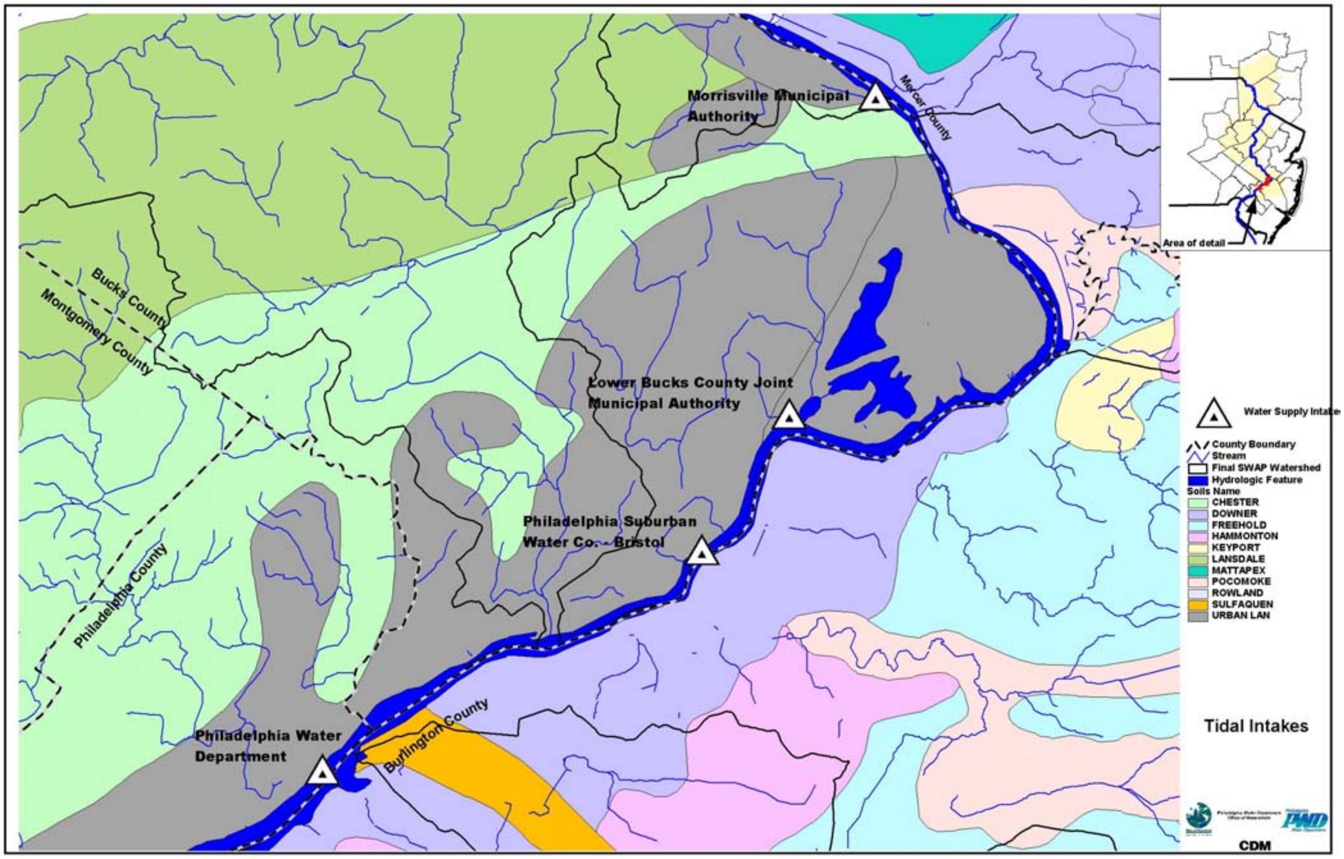


Table 2.1.2-1 Prevalence of Various Major Soil Types in the Lower Study Area

Soil Type	Percentage of Entire Study Area	Slopes %	Permeability	Runoff	Drainage	Found on
Chester	2	0-65	Moderate	Medium	Well drained	Upland divides and upper slopes
Downer	1	0-5	Moderate to moderately rapid	Slow to rapid	Well drained	Hills and ridges
Pocomoke	1	0-2	Moderate	Medium to rapid	Very poorly drained	Level uplands and closed depressions
Hammonton	1	0-5	Moderately rapid	Slow	Well drained	Low hills, flats, and depressions
Sulfaquent	Less than 1	0-2	Moderate	Medium to rapid	Very poorly drained	Tidal flats, adjacent to bays, and tidal streams

Source: United States Department of Agriculture. Natural Resources Conservation Service. Pennsylvania Soil Survey. Official Series Descriptions.

2.1.2.2 Hydrogeology

The Baxter facility is located in Northeast Philadelphia in the Atlantic Coastal Plain Province, which covers a large part of Southeastern Pennsylvania. The sediments of this province are primarily unconsolidated formations of sands, clays, and gravels. In the Wilmington-Philadelphia, these formations are (in ascending order) the Cretaceous Raritan and Magothy formations and the Quaternary Pensauken and Cape May formations. The Wissahickon Formation occurs near the Fall Line as a result of streams having worn through the Pensauken Formation. The Raritan Formation, which consists mainly of unconsolidated sandstones and gravel, is a major source of groundwater and an excellent aquifer on account of the contact between the unconsolidated sandstone and the crystalline rock, which serves as a cap rock.

The Pensauken and Cape May formations have thicknesses between 30 and 40 feet. The wells in these formations are typically less than 200 feet deep, and yield between 400 and 800 gpm, although most of the water is contaminated and must be treated before use. Together with the upper sand deposits of the Raritan Formation, the Pensauken and Cape May formations comprise the most extensive aquifer in the Lower Delaware River Basin. (Majumdar, Miller, and Sage 1988)

In Pennsylvania, where the sediments are mainly Cretaceous and Tertiary, they have been divided into four sections: the Potomac Formation (the oldest, including its subdivisions: Patuxent, the Arundel, the Patapsco, and the Raritan formations), the Bryn Mawr Formation, the Bridgeton Formation, and the Pensauken Formation (youngest).

The Potomac Formation is located along the Delaware River between Delaware and Trenton, NJ, and is almost completely covered by the river and more recent deposits. In Pennsylvania, the Potomac Formation is Late Cretaceous. This formation dips gently to the southeast and ranges from 0 to 150 feet thick, with variation in thickness due to the presence of deep channels. The thick beds of pale-gray or grayish-orange sand are interbedded with beds of pale-red or pale-gray unctuous clay of varying thickness. There are gravel beds interstratified with the sands, particularly near the base of the formation. Quartz and quartzite comprise most of the gravel, with small concentrations of the heavy metals zircon, rutile, tourmaline, and staurolite mixed in, as well as ilmenite, whereas the sand beds contain some feldspar as well as quartz and are crossbedded for the most part, and horizontally stratified in some places. The finer sands usually contain mica. Kaolinite is the principal mineral in the clay beds, which occur in varying thicknesses, some of which contain high concentrations of illite. There are small concentrations of mixed-layer illite/smectite. Some of the white and pale-gray clay beds contain small, reddish-brown to pale-gray concentrations of siderite.

The Bryn Mawr Formation, also known as the Bryn Mawr Gravel, is comprised of isolated sand and gravel deposits on uplands greater than 180 feet above sea level. Most of these deposits with yellow gravel, some sand, and a little clay, are in Delaware County, west of the Schuylkill River. Quartz and quartzite comprise clasts in this region. The gravel has frequently been formed into hard rock by iron oxide. The exact thickness and age of this formation are still unknown. It is estimated that the thickness of the Bryn Mawr Foundation is about 20 feet. The age of this formation is still debated. While it is often thought to be Quaternary or Pliocene, there is evidence that it may be from a Miocene age, and different reports place it at the pre-middle Miocene, the late Miocene, or the late Oligocene.

The Bridgeton Formation is part of an extensive stretch of gravelly sands that covers much of the northern Atlantic Coastal Plain. It is primarily composed of sands interspersed with gravelly beds and boulders. The sands were deposited in a series of laterally migrating and upward-building channels in what is thought to be a braided stream complex, with some channels reaching depths of 60 feet. The pale orange to white sand, which is much less mature than that in the Bryn Mawr Formation, is locally stained with reddish brown iron oxide and small masses of manganese oxide in the more weathered parts of the sand. A dark maroon clay-like sand, thought to be a result of deep weathering, overlays most outcrops of the formation. The clay contains vermiculite, kaolinite, gibbsite, and a large amount of feldspar (compared to the older Potomac and Bryn Mawr formations). Common heavy minerals in the sands include hornblende, epidote, tremolite, and actinolite. Major opaque minerals include ilmenite and its weathering products, as well as locally abundant magnetite. The Bridgeton Formation is thought to be weathered to great depth on account of the high concentrations of halloysite and endellite in the clay-silt portion of the sands below the upper clay. As part of the undifferentiated Pensauken-Bridgeton Formation, Bridgeton deposits in Pennsylvania occur in a discontinuous band paralleling the Delaware River between Delaware and Trenton, NJ. For the most part, the deposits are located on hilltops at elevations between 100 and 140 feet, and are the highest level of gravelly sands within the Amboy-Salem trench (a former depositional lowland that parallels the Fall Line from Amboy to Salem, NJ. Due to its stratigraphic relationship with the Pensauken Formation which cuts through the Bridgeton, the age of the Bridgeton Formation is dated to the late Miocene. This formation covers a heavily urbanized area with minimal exposure. (Schultz, 1999).

The Pensauken Formation is a younger, similar-appearing gravel formation, but with lower elevations in comparison with the Bridgeton. It was deposited on the erosion surface east of Philadelphia, near Palmyra, NJ on a deltaic complex bordered by shelf deposits on its distal end in Delaware and Maryland—a common sedimentary association in most coastal formations in the Atlantic Coastal Plain. The only part of this formation in Pennsylvania is located in Turkey Hill, near Morrisville in Bucks County, a locale that has almost been completely removed by mining. The Pensauken Formation is dated to the upper middle to late Miocene due to biostratigraphic evidence to the south in Delaware. This formation is mainly sand, although the Pennsylvania portion is very gravelly. Quartzite boulders of up to 5 feet in diameter can be found at Turkey Hill. The sands are generally medium to very coarse grained, poorly sorted, and often cemented by iron oxides, with large-scale crossbedding averaging 3 feet or more in thickness. The horizontally bedded gravel beds range from a few inches to a few feet in thickness. Heavily weathered plagioclase and potassium feldspar make up 50% of the sand, with potassium feldspar being dominant. The Pensauken Formation has a similar heavy mineral makeup to the Bridgeton Formation, although Pensauken has more glauconite and reworked sand from the Coastal Plain formations of New Jersey. Due to heavy erosion, the Pensauken sediments in eastern Pennsylvania have a scattered distribution and a maximum thickness of 40 feet (Schultz, 1999).

2.1.2.3 Hydrology

The Delaware River Basin experiences the Humid Continental climate pattern. This pattern encompasses relatively normal variations in weather, which are predominantly the result of a series of high and low-pressure systems. Precipitation and cloudy weather are products of the frontal systems that are associated with low pressure. In contrast, the passage of a high-pressure system results in clear skies. In general, annual average variations of temperature and precipitation are primarily due to differences in elevation and exposure to wind direction within the Delaware River Basin (Majumdar, Millar, and Sage, 1988).

Although the Delaware River Basin experiences a continental climate, temperatures often reach extreme conditions. Maximum temperatures range from approximately 94°F in the northern basin to 105°F in the southern basin, whereas minimum temperatures vary from approximately –34°F in the north to -11°F in the south. Therefore, the maximum temperature range across the basin is 140°F. With respect to seasonal climate, winter temperatures fluctuate between approximately 23°F in the Upper Basin and 35°F in the Lower Basin. Conversely, summer temperatures normally average between 65°F in the Upper Basin and 77°F in the Lower Basin. Annually, the average temperature varies from about 48°F in the Upper Basin to about 54°F in the Lower Basin (Climate and Man, 1941, Climates of the States – Pennsylvania, Annual in Majumdar, Millar, and Sage, 1988).

Annual average precipitation rarely fluctuates within the Delaware River Basin; the area normally receives about 45 inches of precipitation per year. The driest month is normally February, with precipitation totals ranging from 2.7 to 3 inches. In contrast, July and August are the months with the most precipitation, measuring from 4.5 to 4.7 inches of precipitation. The precipitation in the cold months results from the passage of fronts in the low-pressure systems of the westerly wind belt. During the warm months, much of the precipitation occurs as convectional storms, which are supplemented by the occasional passage of a front (Climate and Man, 1941 in Majumdar, Millar, and Sage, 1988).

Long-term historical data in Philadelphia 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 2.1.2-3.

Figure 2.1.2-3 Long-Term Average Annual Temperature at Philadelphia

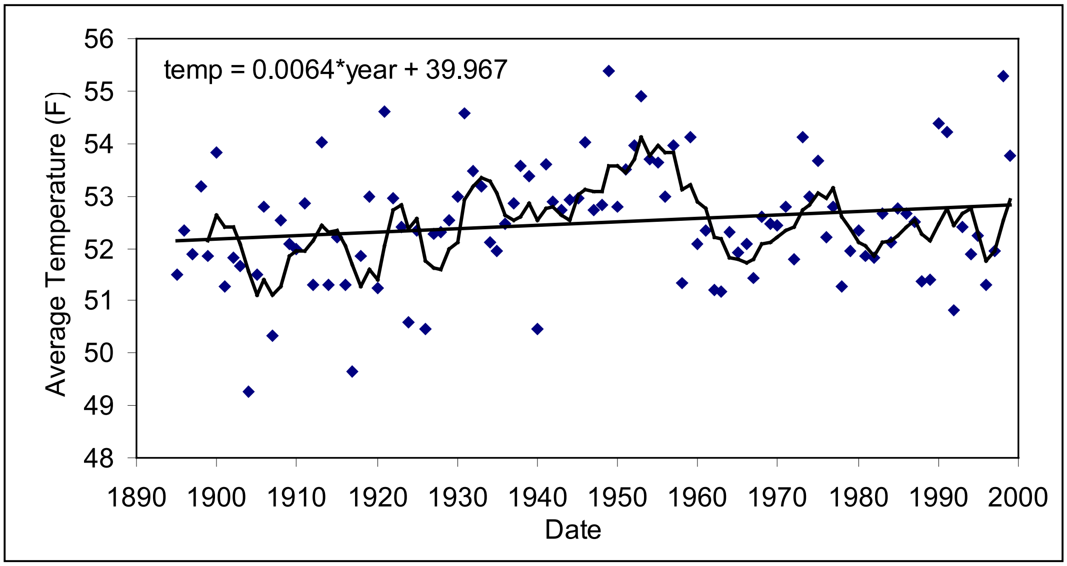
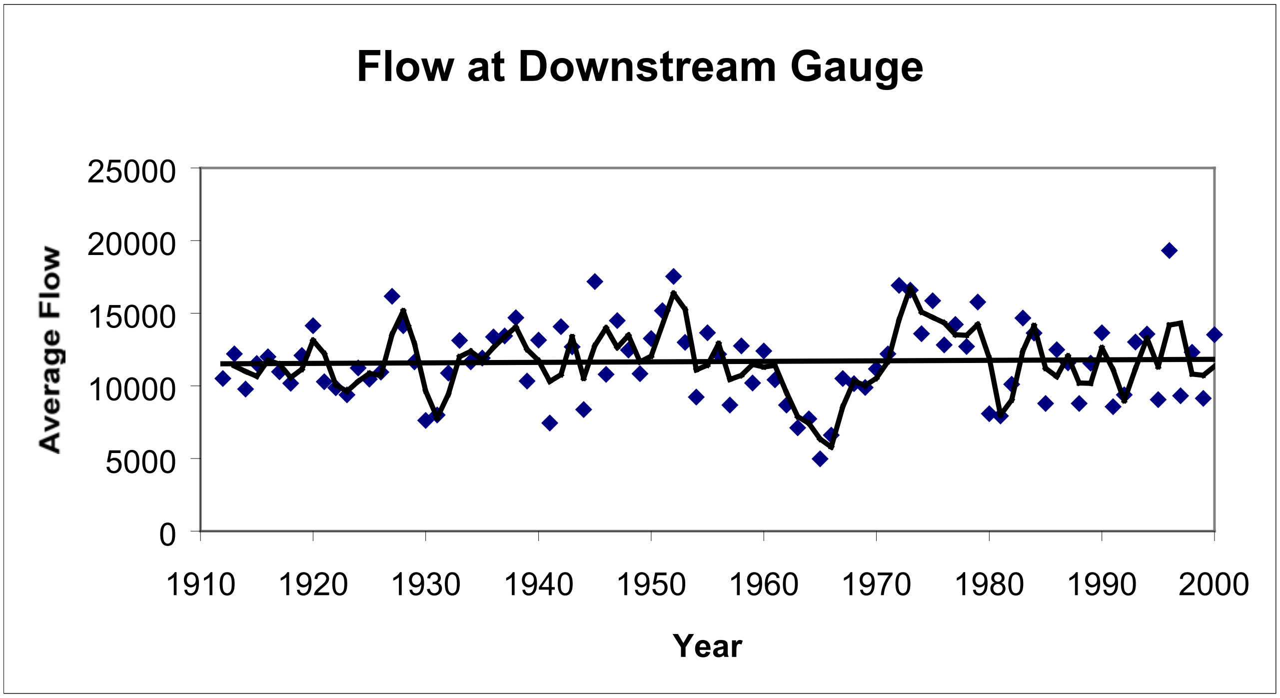


Figure 2.1.2-4 Annual Average Flow at Trenton Gauge of Delaware River

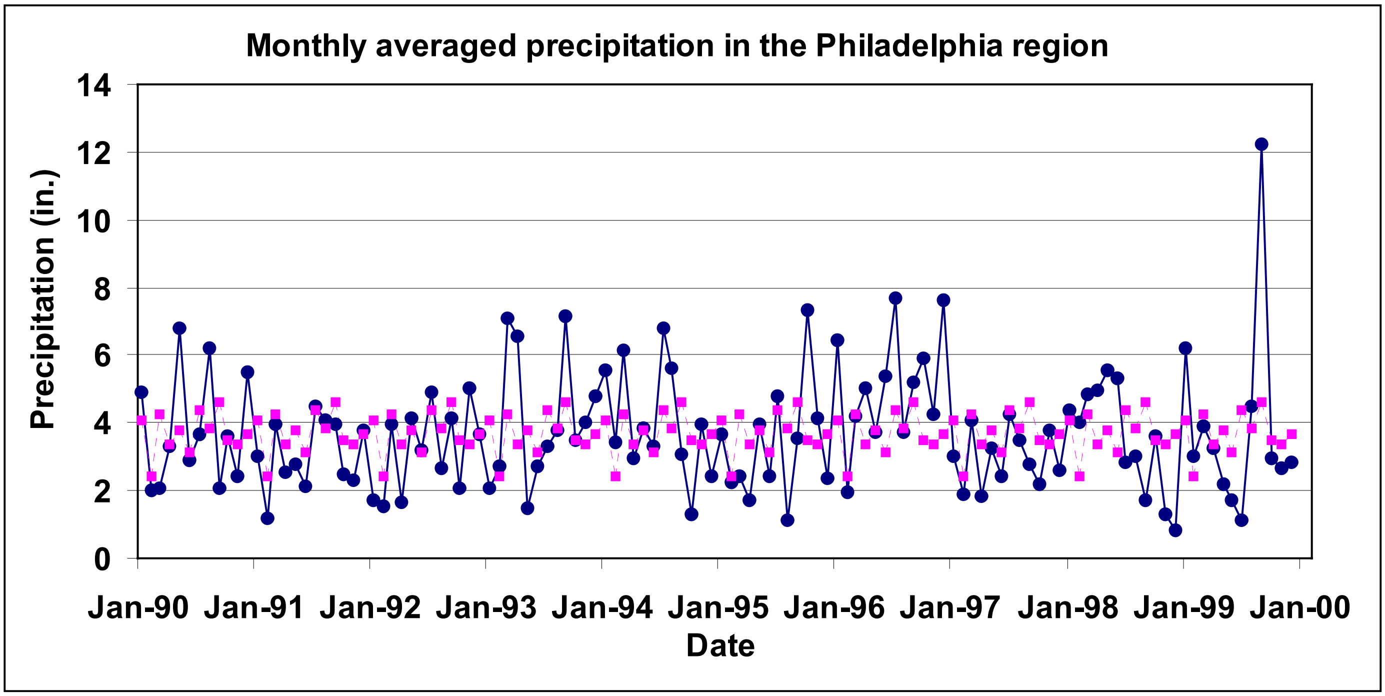


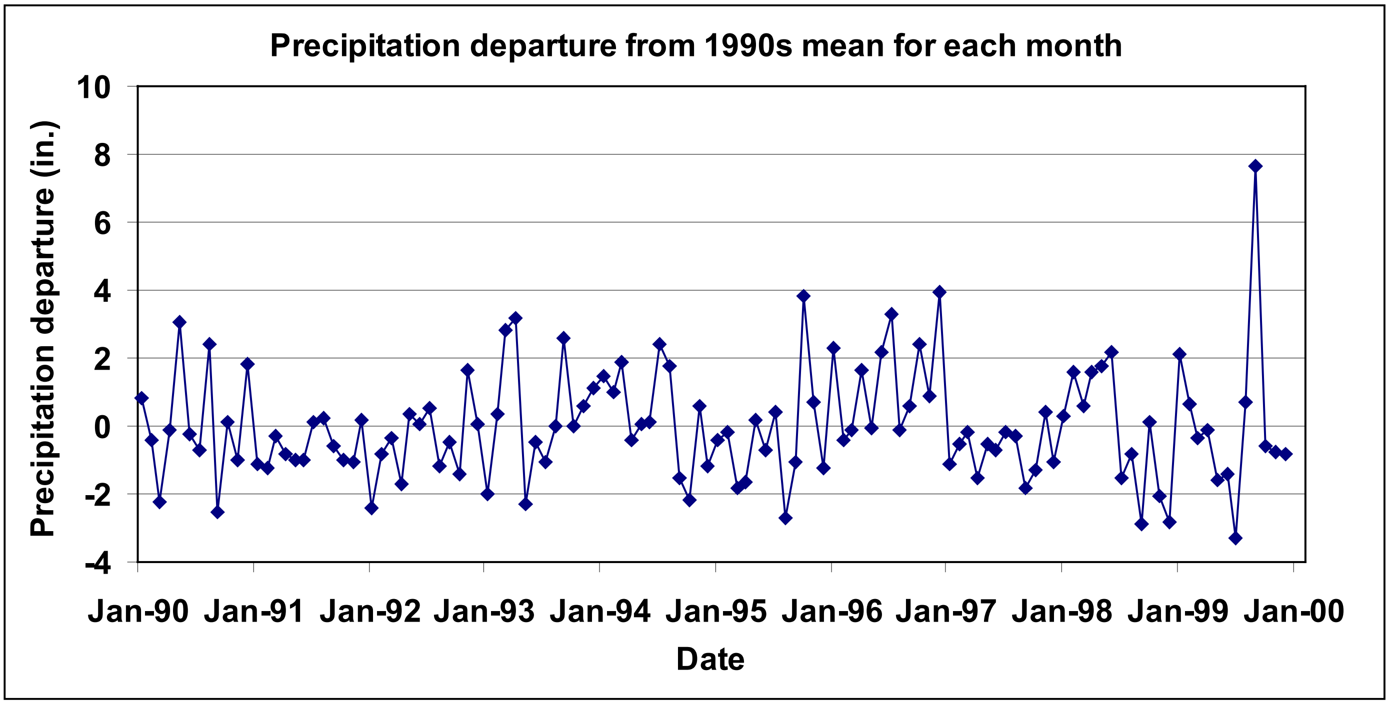
Historical flow in the Delaware River, measured as daily averaged flow at the Trenton gauge from 1910 through the present, is shown in Figure 2.1.2-4. Average annual flow dropped below 5000 cubic feet per second (CFS) only once over the period of record shown during the drought of the 1960s.

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 2.1.2-5. 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 2.1.2-5 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.





Stream flow within the Delaware Basin fluctuates immensely, as evidenced by Table 2.1.2-2. The maximum discharge occurs after the periods of heaviest precipitation with the passage of a tropical storm. The seasonal variation in terms of the amount of runoff recorded is driven by the melting of snow and the thawing of the ground in the late winter and early spring (maximum flows), as well as the time when evaporation of surface waters is highest (low flows), which occurs in late summer and early autumn. (Page, 1977 in Majumdar, Millar, and Sage, 1988).

Table 2.1.2-2 Streamflow Statistics for Selected Gauging Stations

	Years of Record	Drainage Area (sq.mile)	Average Annual Runoff (CSM)*	Mean Annual Flood (CSM)*	Ratio of 100-year to Mean Annual Flood	7-Day 10-Year Low Flow (CSM)*
Central Delaware River						
Neshaminy Creek near Langhorne	1934-72 38	210	1.3	60.6	3.4	0.04
Lower Delaware River						
Perkiomen Creek at Graterford	1914-72 58	279	1.3	56.4**	2.9**	0.05
Brandywine Creek at Chadds Ford	1911-53 1962-71 52	287	1.3	27.4	3.0	0.31

** Cubic feet per second per square mile*
*** Flood data for period 1957-72, 15 years*
***Source:** State Water Plan, Upper Delaware Basin, Central Delaware Basin, Lower Delaware Basin, 1983. Department of Environmental Resources, Office of Resources Management, Bureau of Water Resources Management, Harrisburg, PA. SWP2, SWP3, SWP4 in Sutton, O'Herron, and Zappalorti, 1996.*

Table 2.1.2-3 Duration Table of Daily Flow

	Delaware River												
Percent	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**95**	**98**
Trenton, NJ	47,500	33,500	24,800	17,400	13,200	10,400	8,300	6,600	5,100	3,850	2,750	2,180	1,780

Discharge, in cubic feet per second that was equaled or exceeded for indicated percentage of time.
Source: Busch, W.F. and L.C. Shaw, 1966. Pennsylvania Streamflow Characteristics, Low-Flow Frequency and Flow Duration. Pennsylvania Department of Forest and Waters. Harrisburg, PA, Water Resources Bulletin No. 1 in Sutton, O'Herron, and Zappalorti, 1996.

Average annual Delaware flow at Trenton is 9,149 CFS for the period 1912 through 1999 (USGS gauge data). Daily average Delaware River flow at Trenton through the 1990s is summarized in Figure 2.1.2-6 and indicates extremely low flow conditions in summer 1999, with less-pronounced low flow occurring in 1991. 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.

Seasonal variation is driven primarily by precipitation, which is highest in spring, and evaporation, which is highest in summer months.

Figure 2.1.2-6 Daily Average Delaware River Flow at Trenton through the 1990's

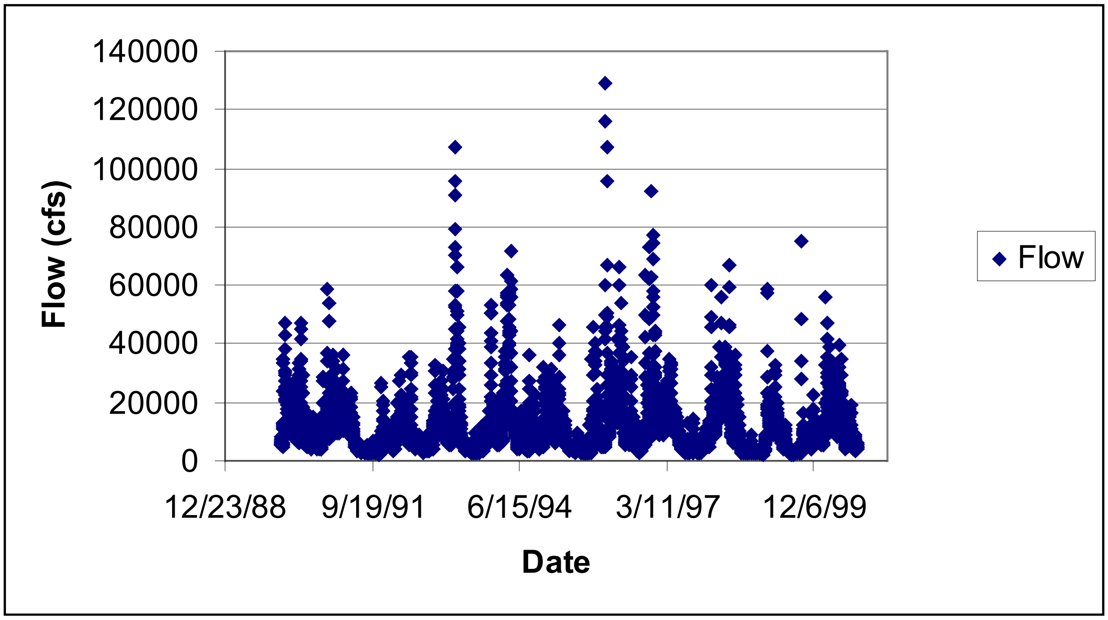


Table 2.1.2-4 summarizes the locations, drainage areas, annual mean flows, and annual runoff at gauging stations along the Lower Delaware River. The Trenton gauging station is the lowest station on the Delaware River that is not influenced by tidal patterns. Below Trenton, the Delaware River is influenced by the tides, and flows vary within the tidal cycle.

Table 2.1.2-4 Stream Gauging Data in the Lower Delaware River Basin

Station ID	Location	Drainage Area (mi2)	Period of Record *	Annual Mean Flow (cfs)	Annual Runoff (Inches)	10% Exceeds (cfs)	50% Exceeds (cfs)	90% Exceeds (cfs)
1463500	Delaware River at Trenton NJ	6780	1913-2000	11670	N/A	24600	7940	3000
1464000	Assunpink Creek at Trenton	90.6	1923-2000	133.64 **	N/A			
1465500	Neshaminy Creek near Langhorne PA	210	1935-2000	299	N/A	580	140	32
1465798	Poquessing Creek at Grant Ave. at Philadelphia PA	21.4	1965-2000	32.7	N/A	61	12	4.4
1467048	Pennypack Creek at Lower Rhawn St. Bridge Philadelphia PA	49.8	1965-2000	90.9	1.83	169	49	21

Table 2.1.2-5 gives a summary of the major tributaries in the Lower Delaware River (below Trenton New Jersey), their drainage areas, river mile location, and length. These Tributaries are located within the tidal zone, and are therefor affected by tidal changes. The Neshaminy River and the Rancocas Creek are the two largest Tributaries in this area. Both of these tributaries drain into the Delaware River above the location of the Baxter Intake and would therefor affect the water quality at the intake.

Table 2.1.2-5 Characteristics of Tributaries in the Lower Delaware River Watershed (in alphabetical order)

Major Tributary	Drainage Area (mi^2)	River Mile Location	Length (mi)
Assiscunk Creek	45.9	119	16.31
Big Timber Creek	55.2	96	16.00
Bustleton Creek	2.6	121	2.91
Byberry Creek	18.7	112	10.595
Cooper Creek	40.2	102	15.81
Crafts Creek	13.8	125	11.38
Crosswicks Creek	138.5	129	26.46
Martins Creek (Lower)	11.5	123	5.05
Mill Creek	19.8	119	39.96
Mill Run	37.0	105	14.81
Neshaminy River	232.4	116	51.37
Newton Creek	10.6	97	10.58
Pennsauken Creek	36.1	106	13.06
Pompeston Creek	7.7	109	5.37
Rancocas Creek	347.7	111	33.65
Rockledge Branch	55.1	110	15.57

Table 2.1.2-6 provides some information on three reservoirs located within the Tidal Delaware River Zone. Each of the Reservoirs is located within the Neshaminy River Drainage Area.

Table 2.1.2-6 Reservoirs within the Neshaminy River Watershed

RES #	STATE	RESERVOIR NAME	DAM NAME	RIVER NAME	DRAINAGE AREA (mi2)	PERCENT OF BASIN AREA	WATER TOT (DAYS)	DISCHARGE (gal/s)	NORMAL CAPACITY (billions of gallons)	SURFACE AREA (mi2)
	PA	Churchville Reservoir		Ironworks Creek	1.63		30*			0.26
	PA	Silver Lake		Mill Creek	1.45		30*			0.09
	PA	Core Creek		Core Creek	3.28		30*			0.27

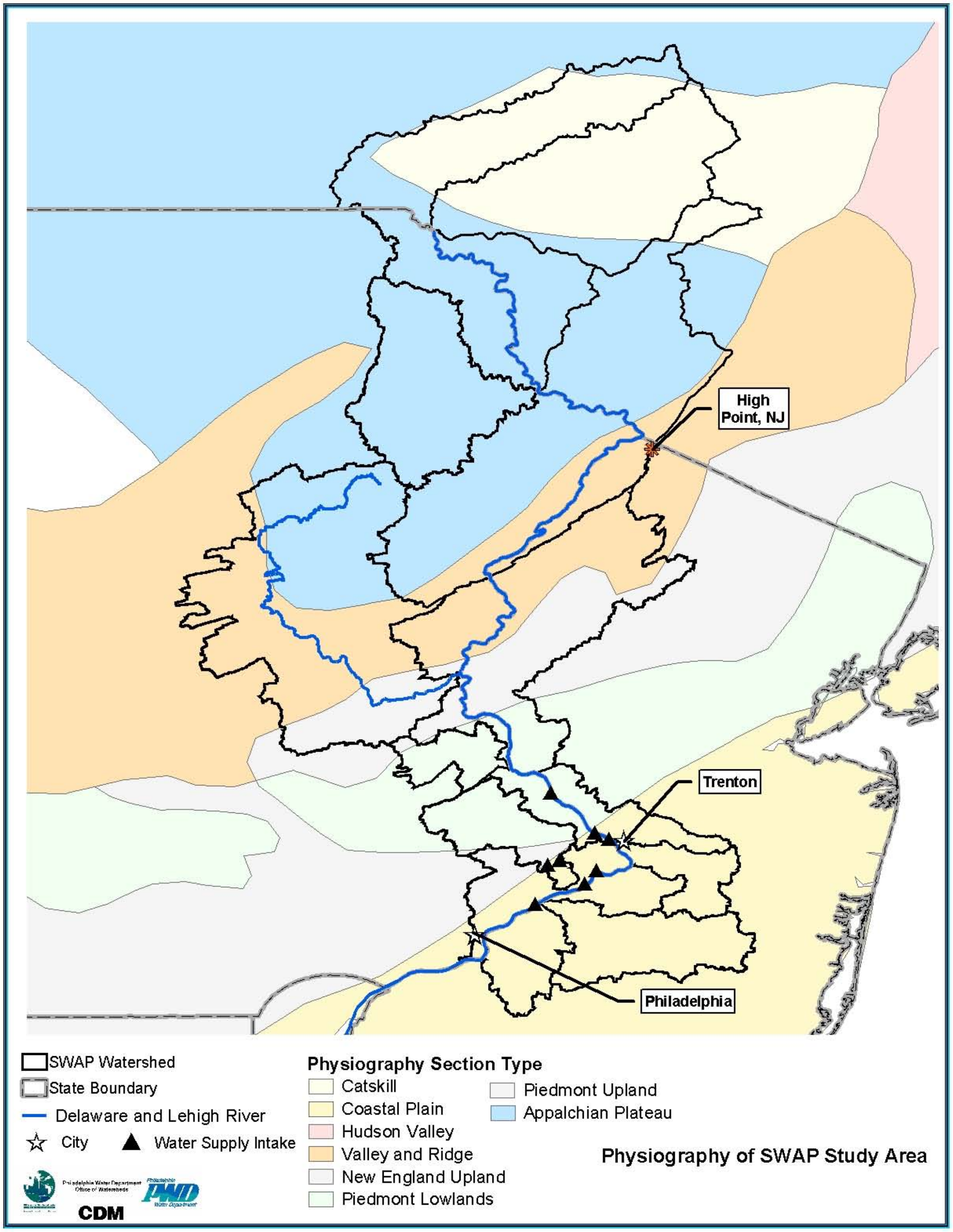
2.1.2.4 Physiography

The Delaware River Watershed covers a variety of physiographically distinct regional provinces. A physiographic province is an area of land that is composed of a particular type(s) of rock as a result of having undergone certain environmental processes over time which distinguish it from other surrounding areas. Each province is distinguishable by its physical landforms, unique rock formations, and groundwater characteristics.

From north to south, the five physiographic provinces in the SWAP study area are: the Appalachian Plateau, the Valley and Ridge, the New England Upland, the Piedmont, and the Atlantic Coastal Plain. (River Places (see Figure 1.2.3.1-1) http://www.riverplaces.com/drguide/DRGuideGeology.html). The physiographic section types are shown in Figure 2.1.2-7 below.

The Philadelphia Water Department Baxter Intake is located within the Atlantic Coastal Plain Providence. The Atlantic Coastal Plain Province is mainly lowlands with numerous streams and marshlands at about 100 feet above mean sea level (msl). The province is divided into two sections: the Outer Coastal Plain, which is comprised of southern New Jersey and eastern Delaware, and the Inner Coastal Plain, which consists of a narrow belt in Pennsylvania, northern Delaware, and an area in New Jersey located roughly 20 miles (32 km.) to the east of the Delaware River. Both sections, which are divided by a line of hills, contain clays, gravels, sands, and silts, but were formed in different geological time periods: the Inner Coastal Plain in the Cretaceous and Pleistocene Eras, and the Outer Coastal Plain in the Tertiary Era.

Figure 2.1.2-7 Physiographic Provinces Within the SWAP Study Area

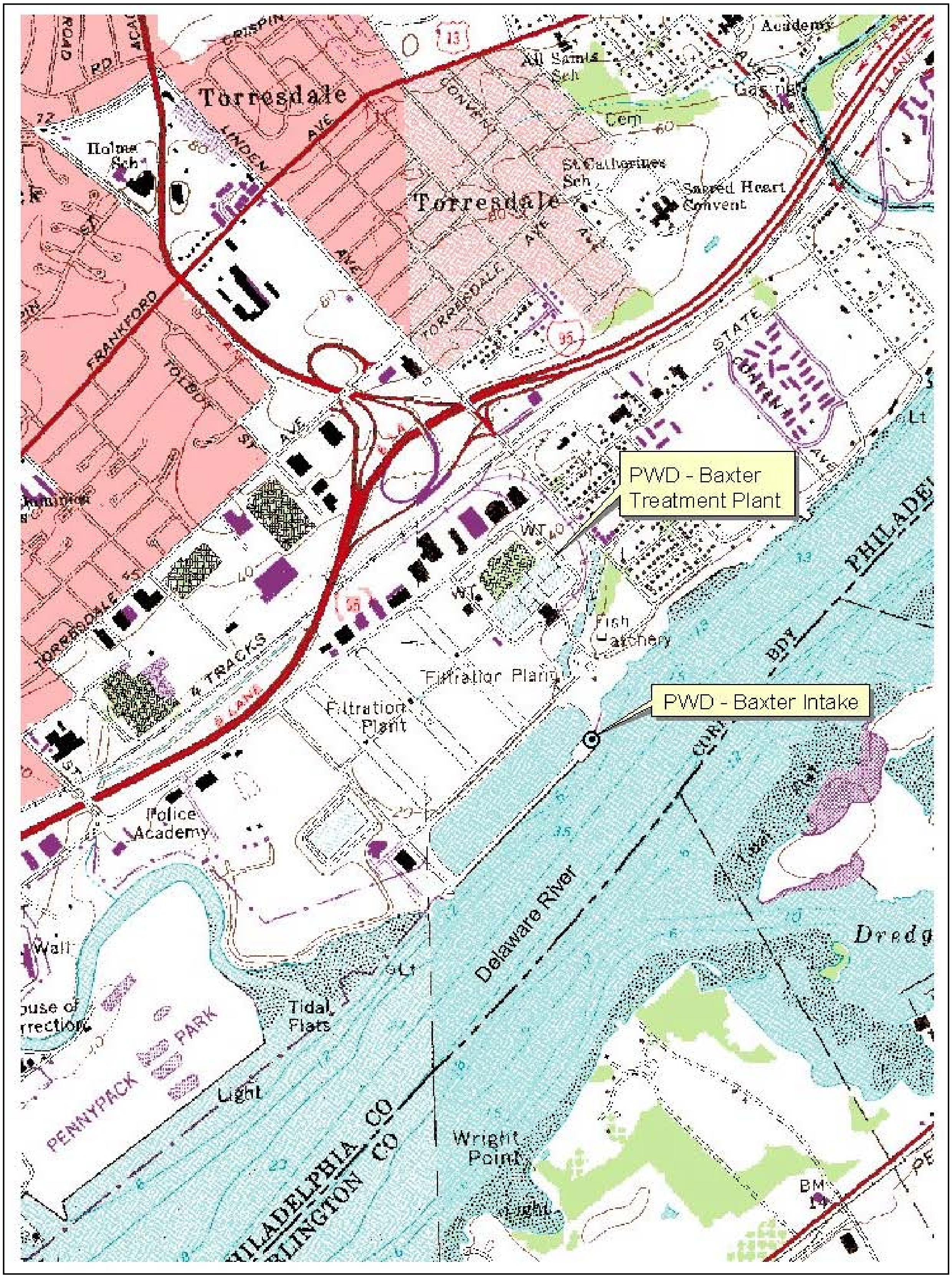


2.1.2.5 Topography

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. Topography of the area surrounding the Baxter Intake is shown in Figure 2.1.2-8. Understanding the topography of the area is an important aspect of source water assessment. The steep valley areas 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.

The combination of geologic, soil, and hydrologic characteristics found in the watershed make runoff of conservative contaminants from land activities into the adjacent surface waters very possible if no mitigation strategies are implemented. These characteristics also affect the quantity of the flow that can erode streambanks and deposit sediment in reservoirs.

Figure 2.1.2-8 Topographic Features Around the Baxter Intake


PWD - Baxter Treatment Plant

PWD - Baxter Intake

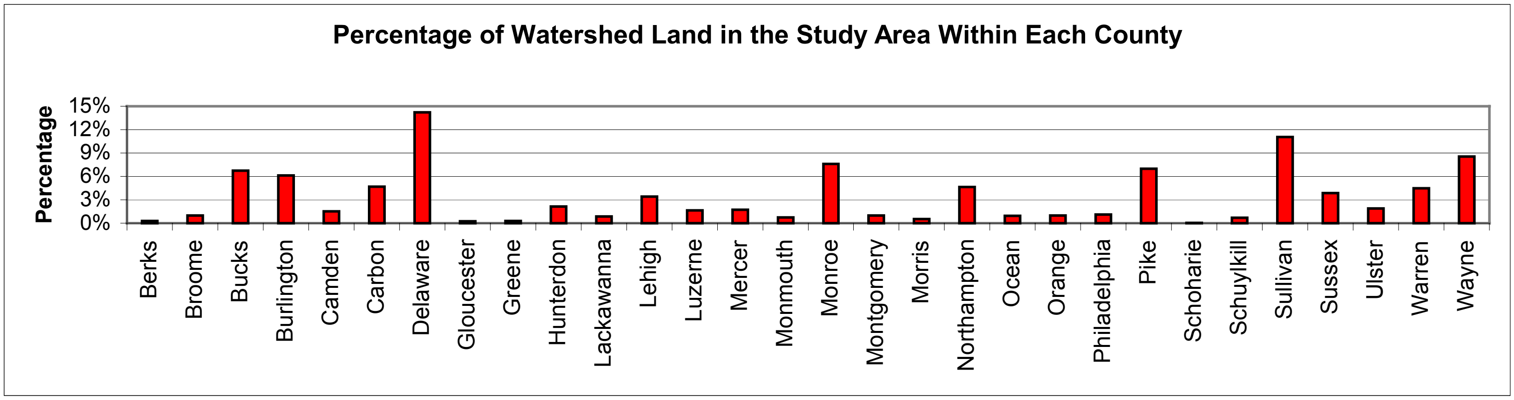
2.1.3 Land Use

Key Points

- **Recent land use studies conclude that the amount of developed land within the SWAP study area is approximately 10%. Forested lands account for about 70% of the land use.**
- **Studies of changing land use patterns in the watershed agree that the amount of developed land is increasing, as agricultural and forested lands decrease.**
- **Developed land areas are found mainly in the lower Delaware River Watershed, near major cities and transportation corridors.**
- **The effects of rapid development and increase in impervious surfaces in the Tidal NJ Lower, PA Bucks Direct, and Neshaminy Subwatersheds can be damaging to the area's natural environment and may impact the Philadelphia Water Department's drinking water supply.**

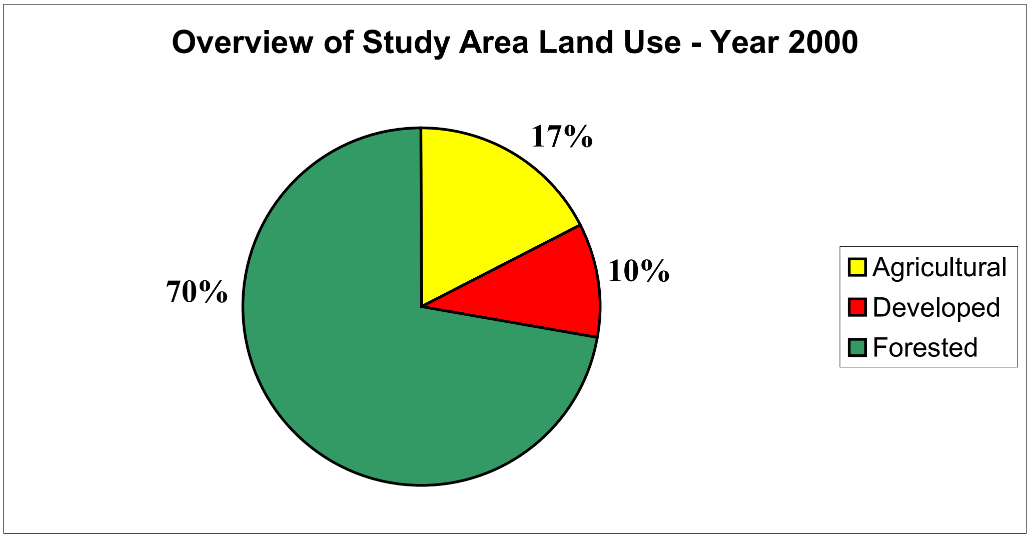
The SWAP study area is comprised of 30 counties located within Pennsylvania, New Jersey, and New York. Of these 30 counties, four (Warren County in New Jersey, Monroe, Northampton, and Pike Counties in Pennsylvania) are located entirely within the boundaries of the Delaware River Watershed. Sixty percent of Philadelphia County, where the Baxter Intake is located, is included within the watershed's total area. The USGS's National Land Cover Dataset (NLCD) land use coverage, detailed in Section 1.2.5, characterizes the entire study area. Figure 2.1.3-1 shows the percentage of watershed land in the study area within each county, and Figure 2.1.3-2 shows a general overview of the land use within the study area. Ten percent of the study area is characterized as developed. The majority of the remaining area is forested.

Figure 2.1.3-1 Percentage of Land Area in the Study Area Within Each County



Source: USGS National Land Cover Data 1992

Figure 2.1.3-2 Overview of the Study Area Land Use (2000)

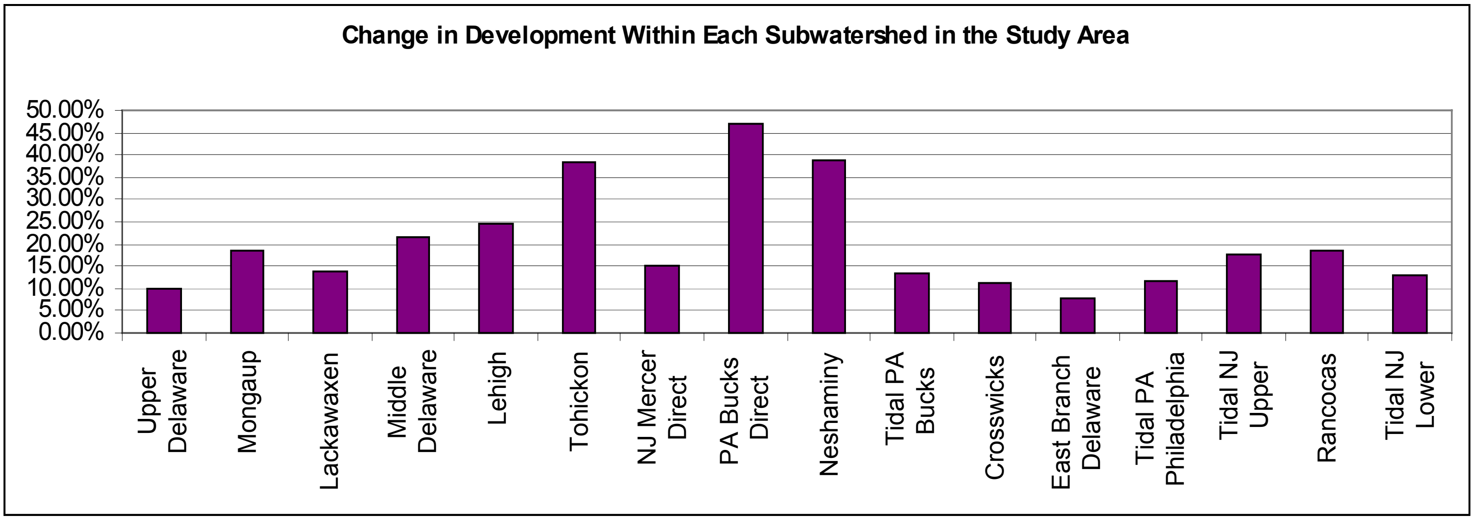


Source: USGS National Land Cover Data 1992

The Baxter Water Treatment Plant is the southern most intake within the Delaware River Watershed and SWAP study area and is located within the Tidal PA Philadelphia Subwatershed. This is the most developed subwatershed within the study area with a development rate of almost 80%. According to the 2000 Census, this subwatershed also has the single largest population in the study area. Heavy urbanization has run its course in the Philadelphia area and the Tidal PA Philadelphia Subwatershed did not experience a large increase in development activities between 1990 and 2000 as seen in some of the other subwatersheds. (Figure 2.1.3-3)

For example, the Tidal NJ Lower Subwatershed experienced a 13% change in development between 1990 and 2000. While 13% may not appear to be a large increase, this percentage is deceiving because it equals development of approximately 16.4 square miles. South Jersey currently depends upon groundwater for its water supply. If suburban sprawl in this area continues at this rate, the supply will be quickly depleted and New Jersey may ultimately need to use the Delaware River or possibly the Baxter Intake to obtain drinking water. The Neshaminy and PA Bucks Direct Subwatersheds had the highest change in development activities from 1990 to 2000. Both are located directly upstream from the Baxter Intake. Developed land use areas increased by approximately 35 square miles in the Neshaminy Watershed Subwatershed and by 5 square miles in the PA Bucks Direct Subwatershed.

Figure 2.1.3-3 Change in Development Within Each Subwatershed in the Study Area



Source: USGS National Land Cover Data 1992

The effects of this rapid development and increase in impervious surfaces can be damaging to the area's natural environment and possibly to the Philadelphia Water Department's drinking water supply. Municipalities within the study area need to recognize the potential impacts of this loss of agricultural and forested land and begin implementing ordinances that will help to protect these areas as well as the drinking water supply.

As shown in Figure 2.1.3-4, the area surrounding the Baxter Intake is primarily high density residential and commercial/industrial/transportation. This is to be expected, as the intake is located along the river within the City of Philadelphia and these types of land uses continue beyond the immediate area surrounding the intake. The Baxter Water Treatment Plant is adjacent to the Holmesburg Prison on the south and City-owned police and fire academies to the north. A fish hatchery is located directly on the Baxter Water Treatment Plant property at the southern end of the property. Further north of the intake, along the river, is a small area of forested lands and woody wetlands. Across from the intake in New Jersey, the land uses are predominantly low intensity residential with some commercial/industrial/transportation uses. The New Jersey side of the Delaware River also contains more forested and wetlands than the Pennsylvania side near the Baxter Intake. Areas indicated as industry may actually be abandoned or inactive property based on field inspections and tours of this watershed area. Figure 2.1.3–5 characterizes the land use percentages for the Baxter Intake's Zone B delineation.

Figure 2.1.3-4 Land Use Surrounding Baxter Intake

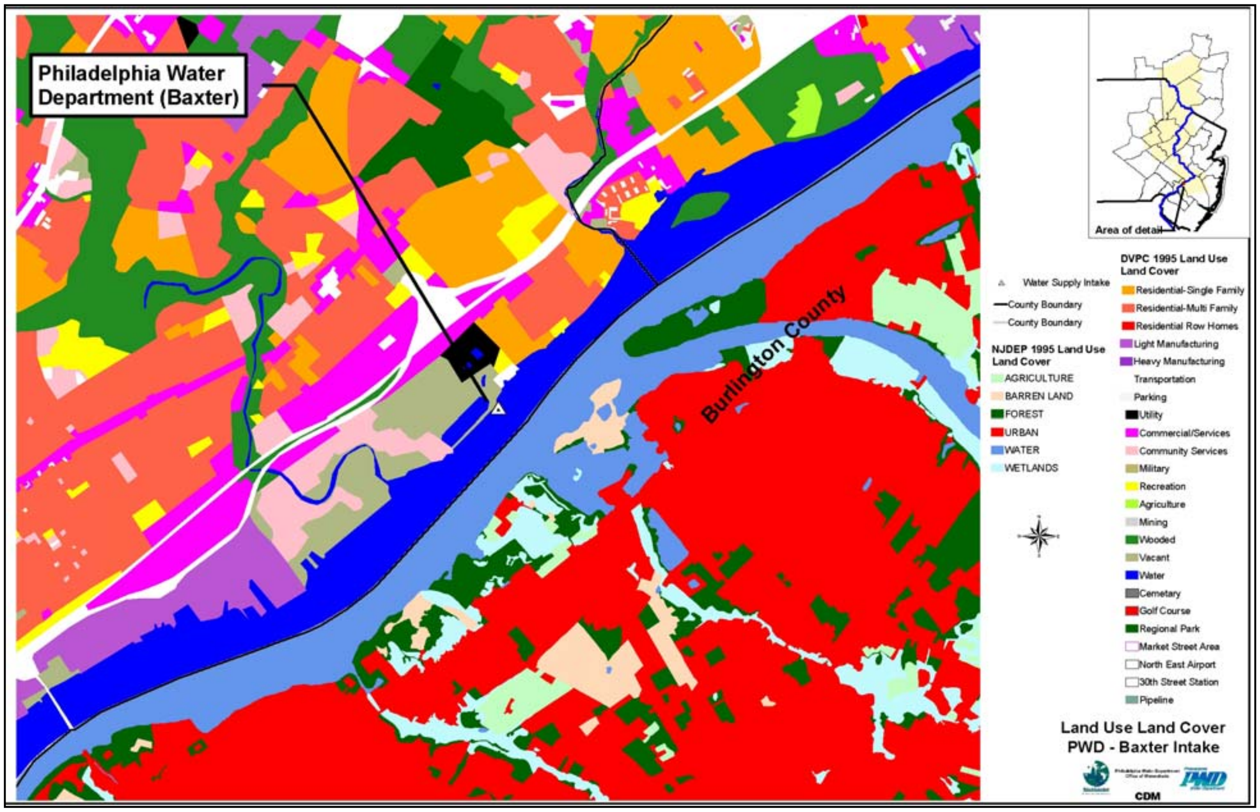
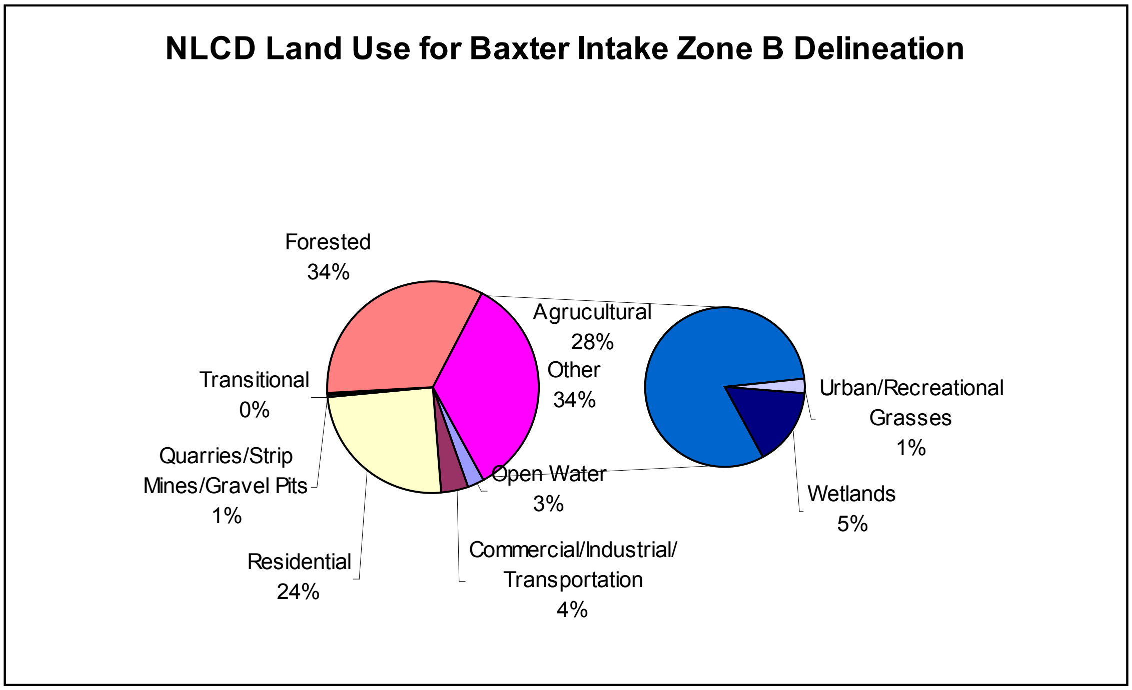


Figure 2.1.3-5 Updated NLCD Land Use for PWD Baxter Intake Zone B Delineation



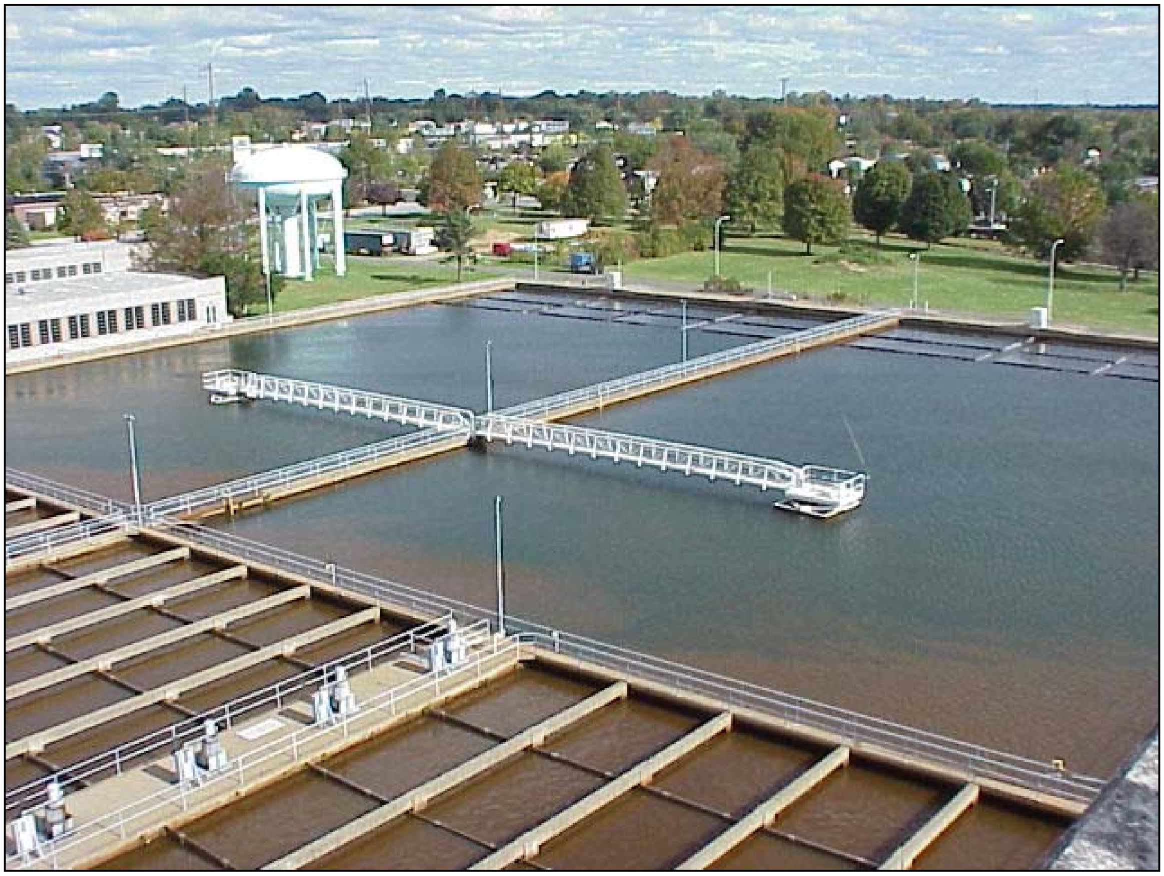
2.1.4 Drinking Water System

Key Points

- **The 175 million gallon per day (MGD) Baxter Water Treatment Plant (WTP) provides water to 750,000 people in Northeastern Philadelphia and Lower Bucks County.**
- **The Baxter Water Treatment Plant has won several awards for its outstanding treatment performance.**

The Baxter Water Treatment Plant (PWSID 1510001) of the Philadelphia Water Department is located in Torresdale just upstream of the confluence of the Pennypack Creek and Delaware River in Philadelphia County. Raw water is gravity fed via tidal elevation changes from the Delaware River at a daily average rate of 175 million gallons per day (MGD) with a maximum capacity of 320 MGD. The Baxter Water Treatment Plant services the entire region of Philadelphia east of Broad Street and parts of Lower Bucks County. Treated water from the Baxter WTP is delivered to about 750,000 people or 50% of the population of the City of Philadelphia. The treatment plant is shown below in Figure 2.1.4-1.

Figure 2.1.4-1 Philadelphia Water Department's Baxter Water Treatment Plant



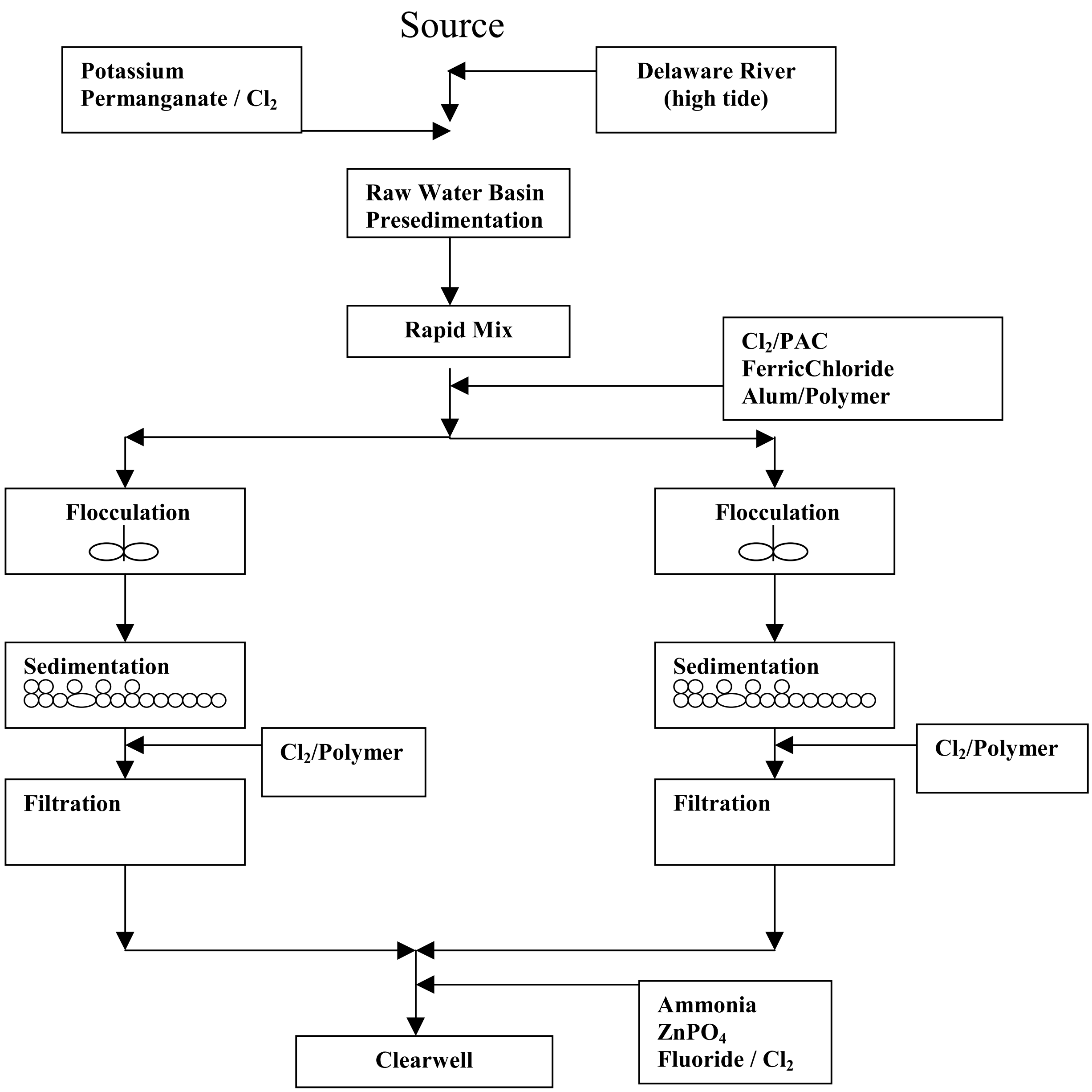
A process treatment schematic is found in Figure 2.1.4-2. As the raw water flows into the raw water basin during the high tide from the Delaware River Intake, it passes through screens for removal of large debris (leaves, branches, etc.) and is then held in a large basin at the Baxter WTP for at least 24 hours. The basin allows silt, sand, and other large particles to settle prior to conventional treatment. The pre-sedimentation basin has particular importance to remove pollutants during rain events or high flow conditions, when high concentrations of silt and large particles result from re-suspension of river sediment and runoff. Additionally, an oxidant or powdered activated carbon (PAC) may be added to the pre-sedimentation basin to mitigate algae or taste and odor episodes.

After pre-sedimentation, the coagulant ferric chloride is typically used to destabilize particles such as clay and viruses. Following coagulant addition, two stages of flocculation with gentle mixing are provided to allow the destabilized particles to agglomerate. Flocculation detention time is about 60 to 70 minutes. After floc is formed, it settles in basins with two to four hours of detention time. The floc that settles to the bottom of the basin is removed as sludge, which is sent to a City of Philadelphia Water Pollution Control Facility (WPCF). A chemical addition point, for chlorine, polymer, or pH adjustment is available after sedimentation.

Clarified water is then treated with dual media filtration. Dual media consists of anthracite and sand and removes remaining suspended material. Filters are usually terminated after two days time, prior to severe headloss or breakthrough. Ninety-four filters are available at the Baxter WTP. At average daily flow, the loading rate is less than two gallons per minute per square foot (gpm/sf). Upon termination, a filter is backwashed and spent backwash water is sent to the WPCF.

Disinfection at Baxter is achieved through addition of chlorine in the pre-sedimentation basin and after sedimentation. After filtration, ammonia is added for chloramination. This maintains a total chlorine residual of about two milligrams per liter (mg/L) in the distribution system for microbial control. After filtration, fluoride and zinc orthophosphate are also added to prevent tooth decay and for corrosion control, respectively. Filtered water is then stored in a clearwell and eventually pumped through a high-service pump station to the distribution system of the east and northeastern sections of Philadelphia and Lower Bucks County.

Figure 2.1.4-2 Schematic of Water Treatment Process at the Baxter WTP



2.1.5 Raw Water Quality

Key Points

- **Delaware River water quality is monitored to assess potential health risks, aesthetics, and treatment requirements.**
- **The Philadelphia Water Department routinely monitors pH, color, alkalinity, hardness, total dissolved solids, conductivity, turbidity, coliform, *Giardia* and *Cryptosporidium*, total organic carbon, UV absorbance, bromide, nitrogen, phosphorus, iron, manganese, sulfate, chloride and sodium at their Baxter Intake. Many other parameters are monitored as part of special studies.**
- **Turbidity and other suspended contaminants in the river tend to increase as a function of precipitation, runoff and river flow.**
- **Salt levels in the river appear to fluctuate seasonally, perhaps in response to application of road salts during the winter.**
- **Over the past decade, levels of alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, nitrate, and turbidity in the Delaware River have increased at the Baxter Intake. Increased pollution from runoff is the most likely source of these changes.**
- **Stream impairments in the lower Delaware River Watershed are primarily caused by stormwater runoff from urban and suburban areas.**

2.1.5.1 Water Quality Summary

Water Quality Parameters and Their Significance

A variety of parameters can be used to measure the health of our streams and rivers, as well as the suitability of these surface waters as a source of potable water supply. Table 2.1.5-1 summarizes the specific parameters sampled for at PWD's Baxter Intake. Table 2.1.5-1 also identifies the time period over which sampling was conducted, and the frequency of sampling. Most of the data is collected regularly by staff at the water treatment plant (WTP). That data is supplemented by measurements collected for compliance with the Information Collection Rule and by raw water measurements obtained at a pilot treatment facility located at the WTP.

Table 2.5.1-1 shows that an extensive amount of data has been collected to characterize almost all parameter groups at the Baxter Intake. Data generally spans 1990 to the present. A significant data set for parameters such as total suspended solids, metals, and nutrients, was available for detailed analysis of spatial and temporal trends. Data was very sparse for synthetic and volatile organic compounds, as well as for radionuclides. Data was supplemented by nearby sampling location of PWD Baxter Intake Pilot Plant. VOC, SOC and radionuclide data measured at the intake was limited and consequently supplemented by data from on-line databases.

Statistical summaries were developed for those parameter groups with sufficiently large data sets. Available water quality data for VOCs, SOCs, and radionuclides are analyzed separately due to incompleteness. In the statistical summaries, the minima and maxima are presented to show the range of values and variability of the data.

The means and medians are presented to show the central tendencies of the parameters – typically measured levels. A mean that is significantly greater than the median indicates that one or two high values are affecting the mean. Similarly, a mean that is significantly lower than the median indicates that one or two low values are reducing the average. The number of samples shows how many measurements were included in the computation of the statistics. The number of samples is related to the sampling frequency and time period given in Table 2.1.5-1. The number of non-detect measurements and the detection limit are also listed, where applicable. These were not included in computations of the minima, maxima, means and medians.

Table 2.1.5-1 Baxter Intake Sampling Summary

Parameter Group	Parameter	Frequency of Sampling	Time Frame	
Physical Parameters	pH	Weekly	Jan-90	Dec-99
	Apparent Color	Weekly	Jan-90	Aug-93
	Alkalinity	Weekly	Jan-90	Dec-99
	Hardness	Weekly	Jan-90	Jul-99
	Total Dissolved Solids	Sporadic	Jan-90	Jan-99
	Conductivity	Weekly	Jan-90	Dec-99
Particulates & Microbial Contaminants	Turbidity	Weekly	Jan-90	Dec-99
	TSS	Sporadic	Jan-90	Jun-99
	Total coliform (mf)	Sporadic	Mar-90	Dec-99
	E. coli (nut. Agar)	Weekly	May-95	Dec-99
DBP Precursors - (Organic Compounds & Bromide)	TOC	Weekly	Sep-93	Dec-99
	UVAbs@254nm	Bi-Weekly (look for data gap)	Jul-93	May-99
	Bromide	Weekly	May-95	Dec-99
Inorganic Compounds – Nutrients	Ammonia	Weekly	Jan-90	Feb-99
	Nitrite	Quarterly	Jan-90	Jun-99
	Nitrate	Bi-monthly	Feb-90	Dec-97
	D. Orthophosphate	Weekly	Jan-90	Feb-94
	T. Phosphate	Monthly	Jan-90	Jun-93
Inorganic Compounds – Metals	Iron, Total	Weekly	Jan-90	Jun-99
	Manganese, Total	Weekly	Feb-90	Jul-99
	Arsenic, Total	Quarterly	May-90	Jul-99
Inorganic Compounds – Secondary Contaminants	Sulfate	Monthly	Feb-90	Dec-99
	Chloride	Monthly	Jan-90	Feb-99
	Sodium	Monthly	Jan-90	Nov-99

Statistical results are discussed with respect to drinking water standards, which apply to the treated water. Although these standards or Maximum Contaminant Levels (MCLs) apply to treated water, they provide a good perspective on the quality of the raw water. Raw water quality results are also discussed with respect to impacts on treatment and finished water quality.

Physical Parameters

Physical parameters such as pH, alkalinity, color, taste, odor and conductivity may not be directly related to health risks but can be important measures of consumer satisfaction, as well as treatability.

The presence of very low levels of compounds that cause taste and odor events in drinking water can generate consumer complaints. Color, if not treated properly, can affect public perception of the water. Colored water generally indicates a higher level of organics or iron. Acid mine drainage from the Lehigh River Watershed may be contributing to manganese, and consequently, the color. Excessive nutrients can cause algae to bloom, which are also related to taste and odor compounds. Compounds that cause taste and odor or color do not generally pose health risks. However, they must be controlled to produce water that consumers want to drink. Expensive chemicals such as powdered activated carbon, potassium permanganate or ozone may need to be added during treatment to control formation. Effective watershed management can potentially save significantly on chemical treatment costs.

Two important parameters in maintaining effective treatment of drinking water are pH and alkalinity. They are monitoring tools that are essential to the drinking water treatment process. A water supply with high alkalinity may have increased chemical costs, because more pretreatment chemicals will be required for pH adjustment. Higher alkalinity is usually a naturally occurring phenomenon based on the hydrology of the region. Elevated pH levels can be indicative of algal blooms in the raw water supply. Algae are a concern because they can potentially clog WTP filters and because they can release very low levels of taste and odor compounds.

Conductivity measures the amount of ions (positive and negative) in the water and the ability of the water to conduct electricity. High levels of conductivity usually indicate high levels of salts, metals, or nutrients in the water. This parameter is a cheap and easy measurement used frequently in water quality studies. Table 2.1.5-2 summarizes the levels of physical parameters measured at PWD's Baxter Intake.

Table 2.1.5-2 Physical Parameters of Source Water

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
pH	pH units	6.3	8.5	7.5	7.5	504
Apparent Color	CU	5	100	32	25	175
Alkalinity	mg/L as CaCO3	18	86	41	41	504
Hardness	mg/L as CaCO3	1	121	63	64	309
Total Dissolved Solids	mg/L	70	240	125	121	65
Conductivity	umhos/cm	95	607	204	201	488

The statistics for the physical parameters show that the Delaware River is typical of most rivers in the northeast. The maximum pH of 8.5 at Baxter results from the algal blooms that can occur in late spring and early summer. The great range in apparent color, with the maximum of about 100 color units, is related to rain events. Apparent color measures color due to particulates and turbidity, as well as naturally occurring dissolved organic material. Consequently, apparent color values are influenced by rain events that increase the turbidity in the river.

The range in alkalinity is quite wide. In general, changes in alkalinity are related to base flow changes in the river. The median alkalinity and hardness of 41 and 64 milligrams per liter (mg/L) as $CaCO_3$, respectively, are reflective of moderately hard water. Increased hardness and alkalinity can increase chemical costs associated with reducing pH at the water treatment plant. Variability in total dissolved solids and conductivity may be due to changing salt levels in the river. Salt levels appear to fluctuate seasonally with the use of road salt in winter. Some of these seasonal and flow related trends are described in more detail in the spatial and temporal analysis sections.

Turbidity and Microbial Contaminants

Turbidity measures the clarity of the water. As water gets cloudier, the turbidity increases. This indicates that fine suspended particles that obscure light rays are present in the water. Turbidity can be caused by nearby roads, construction, erosion, and agricultural runoff. Levels of turbidity depend on the type of soils, slopes, land cover, and rain intensity.

Levels of microbial contaminants or pathogens determine whether a stream is safe for recreational swimming and help gauge the amount of fecal pollution entering it. Typical pathogen testing includes total coliforms, fecal coliforms, viruses, *E. coli*, *Giardia*, and *Cryptosporidium*.

As Table 2.1.5-3 shows, statistics for the particulates and microbial parameters are influenced by rain and runoff. On average, river turbidity and total suspended solids at Baxter are quite low with medians of 6 nephelometric turbidity units (NTU) and 16 mg/L, respectively. Maximum values of 65 NTU and 171 mg/l show how turbidity and solids can increase significantly as a result of rain events. As river flow increases above the annual median flow of 1,600 cubic feet per second (cfs), turbidity generally increases. Consequently, rain events may increase chemical usage at the WTP, but observed levels of turbidity are treatable. The pre-sedimentation basin at the WTP at Baxter is used to settle out much of these solids, prior to treatment.

Table 2.1.5-3 Particulate and Microbial Contaminants at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Turbidity	NTU	0.3	65	8	6	502
Total Suspended Solids	mg/L	0.2	171	33	16	60
Total Coliforms	col/100mL	14	45000	3269	890	229
E. coli	#/100 mL	0.03	8000	433	120	216

Microbials will also increase during rain events, similar to the other particulates. Accordingly, median values for total coliforms and *E. coli* are one to two orders of magnitude lower than the maximum values. Although these parameters increase during rain events, disinfection with chlorine kills the *E. coli* and total coliform prior to distribution to consumers. However, disinfectant demand and associated costs may increase.

Table 2.1.5-4 *Giardia* and *Cryptosporidium* Detected at the Baxter WTP Intake from March 2001 through March 2002

Pathogen	No. of Samples	Min (oocysts/L)	Max (oocysts/L)	Mean (oocysts/L)	% Positive
Giardia	26	<0.1	2.1	0.367	69
Cryptosporidium	26	<0.1	0.2	0.032	27

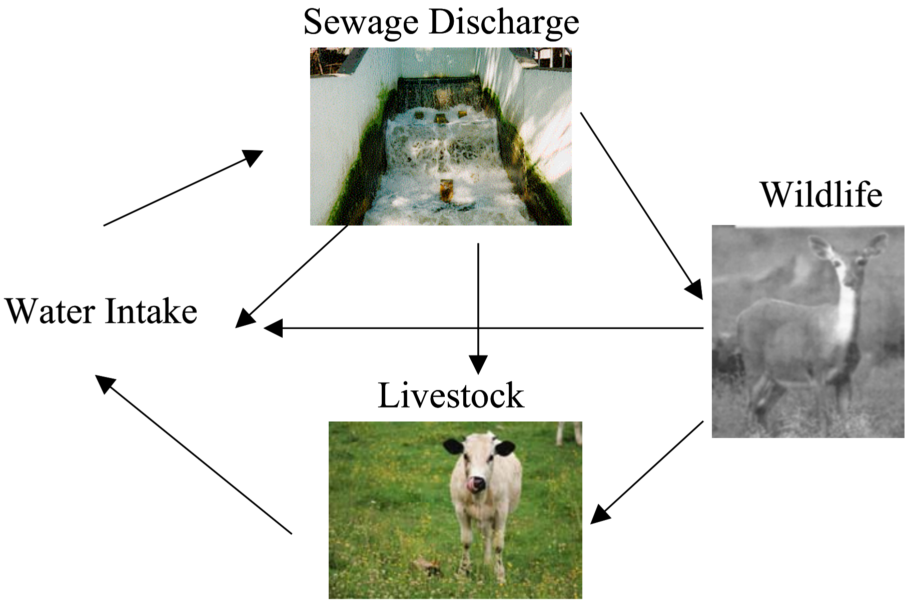
Table 2.1.5-4 summarizes the most recent results from March 2001 through March 2002. As shown, *Giardia* is found frequently indicating routine impacts by sewage discharges upriver, while *Cryptosporidium* is detected in only one of four samples collected.

PWD has been studying *Giardia* and *Cryptosporidium* in their water supply since 1994. Since then a number of special studies have been conducted to identify the sources and influences on the concentrations of these pathogens in the river. However, the technology to adequately detect and analyze water samples for *Cryptosporidium* is not considered reliable or accurate enough for risk assessments and detailed quantitative comparisons. Given the limitations of the analytical methods, the following have been determined:

- *Giardia* and *Cryptosporidium* are detected more often in the river during storm events.
- *Giardia* and *Cryptosporidium* are typically found at higher concentrations in the river during storm events and correlate with higher turbidity concentrations.
- *Giardia* and *Cryptosporidium* are typically found at higher concentrations during winter and spring when water temperatures are colder and oocyst survival is improved.
- *Giardia* and *Cryptosporidium* are routinely found in sewage effluents and the feces of neonatal animals.

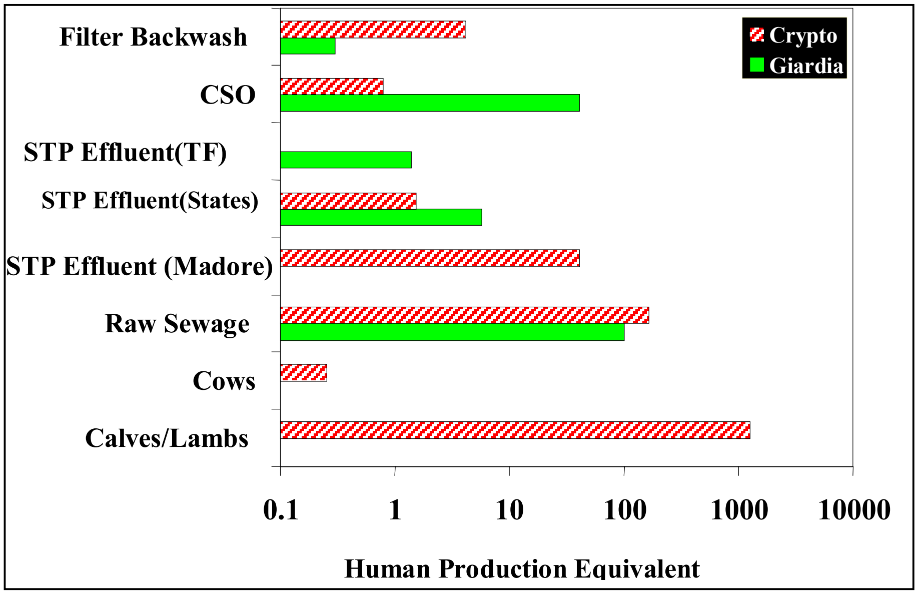
The previous findings indicate that runoff and sewage discharge influence the presence and concentrations of *Cryptosporidium* and *Giardia* in the Lower Delaware River Basin. Figure 2.1.5-1 provides a theoretical description of the cycle of how the pathogens are moved from one source to another and eventually into the river or water supply. As shown in Figure 2.1.5-2, one calf can produce as much *Cryptosporidium* in a day as 1,000 infected persons or over 100 adult cattle. Therefore, keeping young animals away from sensitive water supply areas is prudent.

Figure 2.1.5-1 Theoretical Pathogen Transport Cycles in a Multi-Use Watershed



Information to date suggests that treatment processes are sufficiently removing these pathogens. According to cases of cryptosporidiosis reported in Philadelphia from 1997 to 1999, none were related to drinking water. In fact, the main risk factors for cryptosporidiosis were identified as travel, swimming, contact with an infected person, day care, or farm animal contact. This is further corroborated by the observation that more cases of cryptosporidiosis are reported during the summer months when travel and swimming occur. During the summer months, *Cryptosporidium* and *Giardia* are found at their lowest levels in the local rivers and streams.

Figure 2.1.5-2 Comparison of Amount Produced by Various Sources of *Cryptosporidium* and *Giardia*



Disinfection By-product Precursors
Precursor compounds react with other chemicals (such as chlorine or ozone) used in the disinfection process to treat drinking water and may create disinfection by-products (DBPs). High levels of DBPs may cause human health impacts. Some of the precursors that are tested for include bromide, total organic carbon, and UV absorbance.

Total organic carbon (TOC) may include volatile organic compounds (VOCs) and synthetic organic compounds (SOCs), but is mostly comprised of natural organic matter from the decomposition of leaves and plants. The naturally occurring compounds that comprise TOC form chlorinated organic compounds, such as chloroform. These chlorinated organics may be carcinogens at certain levels of exposure. Absorbance of UV light is a good surrogate for dissolved natural organic matter and does not require the same level of technical laboratory analysis as TOC.

Bromide is a concern because it reacts with ozone to form bromate, a potential carcinogen. Bromide also reacts with chlorine and organics to form brominated chlorine by-products that may pose health risks.

The analytes shown in Table 2.1.5-5 are typical measures of DBP precursors. The agreement between the mean and median TOC values indicate that TOC at Baxter is typically less than 2.8 mg/L. This is a relatively low level of natural organic matter. The maximum TOC of 5.4 mg/L may be rain/run-off related, because TOC measures particulate organics. However, TOC increases in the summer and early fall due to more plant growth and decomposition. Formation of chlorination by-products is of particular concern during those seasons. UV absorbance shows similar trends as TOC.

Table 2.1.5-5 Organic Compounds – DBP Precursors at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Total Organic Carbon	mg/L	0.7	5.4	2.8	2.6	250
UV Absorbance at 254nm	cm^{-1}	0.017	0.205	0.090	0.081	168
Bromide	mg/L	0.015	0.136	0.036	0.032	85

Bromide levels in the Delaware River are considered to be elevated compared to other rivers nationally. The maximum value, close to 0.136 mg/L, was typical of levels measured during the drought in the summer of 1999. As base flow in the river decreases, bromide levels increase significantly. This can be a potential concern for use of ozone as a disinfectant since bromate has a MCL of 0.01 mg/L. Bromide may also form harmful by-products in the presence of chlorine and organic matter.

Inorganic Compounds - Nutrients

Nutrients can cause excessive algal growth that can harm fish and impact water treatment. These measurements can determine the impacts of nutrient runoff from lawns, gardens, farms, and other sources. Some of the major nutrients measured are nitrite, nitrate, ammonia, phosphorus, and orthophosphate. High levels of nutrients cause algal blooms. The algae can then clog filters at the water treatment plant, or upon dying, release very small amounts of chemicals (parts per trillion levels) that can make the water taste or smell bad. Though these chemicals are not harmful, they must be removed during water treatment, using powdered activated carbon. Table 2.1.5-6 provides an overview of nutrient levels at the Baxter Intake.

Table 2.1.5-6 Inorganic Compounds – Nutrients at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Ammonia	mg/L as N	0.01	0.95	0.11	0.08	431
Nitrite	mg/L as N	0.02	26	2.1	0.02	28
Nitrate	mg/L as N	0.85	2.53	1.19	1.17	59
Dissolved Orthophosphate	mg/L as P	0.01	0.15	0.06	0.06	167
Total Phosphate	mg/L as PO4	0.05	0.42	0.11	0.10	38

Median levels of the nutrients are fairly low and do not significantly affect drinking water treatment. Nitrite values are of particular concern in drinking water treatment due to blue baby syndrome. A general guideline for this is one mg/L of nitrite, of which the median value at Baxter is well below. However, the mean value of 2.1 mg/L and the maximum value of 26 mg/L are well above the general guideline and require careful observation. The maximum value of total nitrate of 2.53 mg/L is well below the MCL of ten mg/L. (DeZuane, 1997).

Inorganic Compounds – Metals

The presence of metals can cause various types of impacts on drinking water. Some metals, such as lead, may pose health risks at certain concentrations, if not removed at the WTP. The presence of lead in raw water is usually indicative of an industrial source. Lead is usually removed from the raw water by filtration. It may later leach into the water supply from distribution system pipes, but this can be controlled by chemical treatment.

Manganese is a concern for drinking water treatment because it can cause an unsightly color in the water at very low concentrations. Treatment of manganese with powdered activated carbon or potassium permanganate can be very costly. High levels of metals may also impact aquatic life. Metals are usually found at high levels in those areas of the Delaware River Watershed impacted by acid mine drainage, acid rain, or by erosion and earth disturbances. PWD monitors levels of arsenic, lead, iron and manganese, as shown in Table 2.1.5-7.

Table 2.1.5-7 Inorganic Compounds – Metals at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples	No. of Non-Detects	Detection Limit
Arsenic	mg/L	0.001	0.002	0.001	0.001	19	13	0.0005-0.01
Lead	mg/L	0.001	18	0.39	0.004	47	1	0.001
Iron	mg/L	0.050	8.3	0.88	0.61	329	0	
Manganese	mg/L	0.010	0.63	0.08	0.07	332	0	

Lead and arsenic data are shown because they may pose potential health risks if present in the water supply. Median values at the intake are below the current MCLs of 0.050 mg/L and 0.015 mg/L for arsenic and lead, respectively. The iron values shown in Table 2.1.5-7 are quite variable, with a median of 0.6 mg/L and a maximum of 8.3 mg/L. Iron levels can increase significantly at Baxter due to rain events. Higher iron increases treatment costs for chemical addition and sludge disposal. The manganese data also shows variability that can be attributed to rain events. The median value of 0.07 mg/L for raw water at the intake is in excess of the Maximum Contaminant Level Goal for finished water of 0.02 mg/L. At Baxter, this is treated by using potassium permanganate or chlorine, resulting in increased treatment costs.

Inorganic Compounds – Secondary Contaminants

Salts are the secondary contaminant considered. Salts indicate whether the stream is a freshwater or saltwater environment. Salts are not typically removed by the water treatment process. High levels of salt in drinking water are not desirable for those with low-sodium diets. Sodium and chloride are the two major constituents of salts measured.

Table 2.1.5-8 presents statistics for sodium and chloride. Salt levels increase during the winter, as described further in the temporal analysis sections. From a drinking water perspective, high sodium values are of concern for individuals with hypertension. The median/mean value of about 22 mg/L is slightly above the EPA guidance value of 20 mg/L. Use of road salts in the winter should be limited or applied using more effective techniques.

Table 2.1.5-8 Inorganic Compounds – Secondary Contaminants at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Chloride	mg/L	8	71	23	21	148
Sodium	mg/L	0.02	44	12	12	140

Synthetic Organic Compounds

Pesticides and herbicides comprise most of the synthetic organic compounds (SOCs). SOCs are manufactured chemicals that generally last a long time in the environment and may have toxic effects on human and aquatic life. Dozens of pesticides and herbicides, which can be tested for in water, exist. Generally, atrazine, a herbicide used for farming and agriculture is the most heavily used and widely found. The EPA website has more details about pesticides and herbicides, if more information is required.

Table 2.1.5-9 lists the SOCs tested for at the PWD intakes. Table 2.1.5-10 shows the SOCs that were detected in the Delaware River during a fall 2000 monitoring event. As shown in tables 2.1.5-9 and 2.1.5-10, a number of SOCs that have been banned or have limited use are still being detected in the river or its tributaries. In addition, though some of the SOCs detected were related to farming, the others appear to be related to urban, residential, commercial, transportation, or industrial activities (please see Table 2.1.5-12). It is also interesting to note the diversity of chemicals detected in upstream watershed areas such as the Wissahickon Creek. The detection of a number of pesticides and herbicides in this stream suggests that there is still significant use of herbicides and pesticides in this mainly residential watershed.

Table 2.1.5-11 compares the SOCs detected in or near the PWD Delaware intakes with those detected in the Delaware Watershed based upon preliminary results of the USGS NAWQA study. As shown, there are a number of common SOCs such as atrazine, alachlor, metolachlor, and simazine. These were all herbicides that are associated with agricultural activities. The similarities suggest that these activities have impacts on water resources throughout the Delaware River Basin and are not unique to the Delaware River.

Table 2.1.5-9 Herbicides, Pesticides, and SOCs Results for the Baxter WTP

	1995	**1996**	**1997**	**1998**	**1999**	**2000**
PESTICIDES						
Alachlor	ND	ND	ND	NA	NA	ND
Aldicarb	ND	ND	NA	NA	NA	NA
Aldicarb Sulfone	ND	ND	NA	NA	NA	NA
Aldicarb Sulfoxide	ND	ND	NA	NA	NA	NA
Atrazine	NA	+	ND	+	ND	+
Carbaryl	ND	ND	NA	NA	NA	NA
Carbofuran	ND	ND	ND	NA	NA	ND
Chlordane	ND	ND	ND	NA	NA	ND
Hexachlorocyclopentadiene	ND	ND	ND	NA	NA	+
Lindane	ND	ND	ND	NA	NA	+
Methomyl	ND	ND	NA	NA	NA	NA
Methoxychlor	ND	ND	ND	NA	NA	ND
Oxamyl	ND	ND	ND	NA	NA	ND
Simazine	ND	ND	ND	NA	NA	ND
3-Hydroxcarbofuran	ND	ND	NA	NA	NA	NA
HERBICIDES						
Dalapon	NA	+	NA	NA	NA	NA
Dicamba	ND	ND	NA	NA	NA	NA
Endothall	ND	ND	ND	NA	NA	ND
Metolachlor	+	ND	NA	NA	NA	NA
Metribuzin	ND	ND	NA	NA	NA	NA
Pentachlorophenol	ND	+	ND	ND	ND	+
Picloram	ND	ND	ND	NA	NA	ND
Propachlor	ND	ND	NA	NA	NA	NA
SYNTHETIC ORGANIC CHEMICALS						
Benzo[a]Pyrene	ND	ND	ND	NA	NA	ND
Di-2(ethylhexyl)Adipate	ND	ND	ND	NR	NR	ND
Di-2(ethylhexyl)Phthalate	ND	ND	+	NA	NA	ND
1, 2-Dibromo-3-Chloropropane	ND	ND	ND	NA	NA	ND
Ethylene Dibromide	ND	ND	ND	NA	NA	ND

Notes: NA - Not Analyzed; NR - Not Reported; ND - Not Detected

Table 2.1.5-10 SOCs Detected in Lower Delaware River Watersheds During Fall 2000 Monitoring Study

Chemical	MDL	Concentration Ranges	Pennypack Creek	Poquessing Creek	Tacony/ Frankford Creek
Lindane*	0.0038		ND	ND	ND
Dieldrin	0.0038	0.004-0.03	ND	Yes	Yes
Alachlor	0.15		ND	ND	ND
Diethylphthalate	0.04	0.05-0.13	Yes	Yes	Yes
Fluorene	0.02	0.02	ND	ND	Yes
Phenanthrene	0.02	0.02-0.06	Yes	Yes	Yes
Dibutylphthalate	0.11	0.11-0.19	Yes	ND	Yes
Pyrene	0.02	0.05-0.09	Yes	ND	Yes
Benzo(a)anthracene	0.02	0.03 - 0.05	Yes	ND	Yes
Chrysene	0.02	0.03 - 0.05	Yes	ND	Yes
Benzo(a)flouranthrene	0.05	0.05 - 0.07	ND	ND	Yes

Note: *All concentrations in ug/L (ppb)*
ND - Not Detected
**Insecticide for seed, lumber, livestock, pest control, most use restricted in 1980's*

Table 2.1.5-11 Comparison of SOCs Detected To Date by USGS NAWQA Study in the Delaware River Watershed

Chemical Name
Atrazine
Metalochlor
Simazine
Prometon
Diazinon
Carbaryl
Tebutheiuron
Trifluralin
Alachlor
Chlorpyrifos
Cyanazine
Acetochlor

Note: Shaded chemicals were also detected at the PWD WTPs in the Delaware River Watershed

Table 2.1.5-12 Uses and Possible Sources of Herbicides, Pesticides, and SOCs Detected at the PWD WTPs

Synthetic Organic Chemical	Use	Associated Activity
Atrazine	Herbicide	Farming (96percent used for corn & soybeans)
Hexachlorocyclopentadiene	Pesticide	Chemical/Petroleum Processing
Simazine	Herbicide	Farming
Dalapon	Herbicide	Farming
Metolachlor	Herbicide	Farming - used to control certain broadleaf and annual grassy weeds in field corn, farming, highway right of ways, and orchards
Pentachlorophenol*	Herbicide	Wood finishing / furniture
Di-2(ethylhexyl)phthalate	SOC	Unknown
Lindane**	Insecticide	Farming, golf courses, orchards, landscaping
Dieldrin	Insecticide, termiticide	Residential/agricultural termite / pesticide application
Alachlor	Herbicide on corn and soybeans	Farming
Diethylphthalate	Plasticizer, component in the processing of polyvinyl chloride (PVC)	PVC manufacturing, solvent; aircraft lubes; insect repellent, stp effluents, landfill leachate, tire manufacturing
Fluorene	Resins and dyes	Wastewater, petroleum production, landfill leachate, urban runoff, combustion, resins, dyes
Phenanthrene	Dyes, explosives, pharmaceuticals, fossil fuels	Wood and fossil fuel combustion, garages, metal foundries, timber processing
Dibutylphthalate	Insect repellent, plasticizer, solvent	Plastic production, landfill leachate, wastewater, pulp mills
Pyrene	Biochemical research and fossil fuels	Crude oil, tire manufacturing, fossil fuel combustion, aluminum manufacturing
Benzo(a)anthracene	Coal Tar/Crude Oil	Exhaust emissions, plastics production
Chrysene	Coal Tar	Exhaust emissions, telephone poles, railroad ties
Benzo(a)flouranthrene	Fossil Fuels	Exhaust emissions

**wood preservative, herbicide, defoliant - non-wood uses banned in 1987; antimicrobial disinfectant*
***insecticide for seed, lumber, livestock, pest control, most use restricted in 1980's*

Volatile Organic Compounds

Volatile organic compounds (VOCs) are synthetic, lightweight compounds that vaporize or evaporate easily. Some VOCs such as vinyl chloride and benzene are known to be carcinogenic, while others such as chloroform are suspected to be cancer-causing agents. Industrial point sources account for most direct discharges into surface waters, but municipal wastewater plants constitute a second major source. In general, VOCs are used in solvent and degreasing compounds. Some VOCs are frequently connected with hazardous waste sites. These pollutants, a result of industrialization, are usually present at extremely low concentrations that do not appear to pose immediate health risks.

Note that most organic compounds in water are naturally occurring and VOCs comprise ten percent of the total organic material found in water. (DeZuane 1997).

Measurements of volatile organic compounds (VOCs) at the Baxter Intake are sparse compared to the other parameters. Table 2.1.5-13 summarizes the VOCs analyzed for in PWD's drinking water. For VOCs, the DRBC data for the Betsy Ross Bridge and Ben Franklin Bridge sampling locations are combined with the PWD Baxter data in Table 2.1-14 and Table 2.1.5-15. Table 2.1.5-14 is a summary of VOCs analyzed at or near the PWD Baxter Intake. The data was broken into three sets depending on the location of sampling.

Table 2.1.5-13 Regulatory VOCs Tested for in PWD's Drinking Water

Contaminant Name	MCL	MDL
Benzene	0.005	0.0005
Carbon Tetrachloride	0.005	0.0005
1, 2-Dichloroethane	0.005	0.0005
o-Dichlorobenzene	0.6	0.0005
p-Dichlorobenzene	0.075	0.0005
1, 1-Dichloroethene	0.007	0.0005
cis-1, 2-Dichloroethene	0.07	0.0005
Trans-1, 2-Dichloroethene	0.1	0.0005
Dichloromethane	0.005	0.0005
1, 2-Dichloropropane	0.005	0.0005
Ethylbenzene	0.7	0.0005
Monochlorobenzene	0.1	0.0005
Styrene	0.1	0.0005
Tetrachloroethene	0.005	0.0005
Toluene	1	0.0005
1,2,4-Trichlorobenzene	0.07	0.0005
1, 1, 1-Trichloroethane	0.2	0.0005
1, 1, 2-Trichloroethane	0.005	0.0005
Trichloroethene	0.005	0.0005
m,p-Xylenes	10	0.0005
o-Xylene	10	0.0005

Results in mg/L

MCL = Maximum **C**ontaminant **L**evel

MDL = Method **D**etection **L**imit

(Note: These chemicals were not detected in the finished water)

Table 2.1.5-14 Volatile Organic Compound Summary at or near Baxter Intake

Data Set	Data Source	# of Parameters Analyzed	Parameters	Frequency of Sampling	Total # of Samples	# of Non-Detects	Time Frame
Set 1	PWD Baxter	13	chloroform; dibromochloromethane; dichlorobenzene-p; dichlorobromomethane, diss; methylene chloride; methyltbutylether; nonadienal-t2,c6; toluene; totalthm; trichloroethane-1,1,1; triclanisole-2,3,6; triclanisole-2,4,6; xylene-m,p	sporadic	135	63	Jan-90 – Oct-99
Set 2	BRBC – Betsy Ross Bridge Sampling Location	31	benzene; bromodichloromethane, whole water; bromoform; bromomethane, recoverable; carbon tetrachloride; chlorobenzene; chloroethane; chloroethylvinylether-2, total water; chloroform; chloromethane; dibromochloromethane; dichlorodifluoromethane, total; dichloroethane-1,1; dichloroethane-1,2; dichloroethene-t1,2, total; dichloroethylene-1,1; dichloropropane-1,2; dichloropropene-cis-1,3; dichloropropene-trans-1,3; dimethylcyclopentane; ethyl benzene; ethylbenzene, total; methyl bromide, total; methyl chloride, total; methylene chloride; tetrachloroethane-1,1,2,2; tetrachloroethylene; toluene; trichloroethane-1,1,1; trichloroethane-1,1,2; trichloroethylene; trichlorofluoromethane, total; vinyl chloride	sporadic	1595	1594	Jul-89 – Jun-97
Set 3	BRBC – Ben Franklin Bridge Sampling Location	31	benzene; bromodichloromethane, whole water; bromoform; bromomethane, total, water; carbon tetrachloride; chlorobenzene; chloroethane; chloroethylvinylether-2, total water; chloroform; chloromethane; dibromochloromethane; dichlorodifluoromethane, total; dichloroethane-1,1; dichloroethane-1,2; dichloroethene-t1,2, total; dichloroethylene-1,1; dichloropropane-1,2; dichloropropene-cis-1,3; dichloropropene-trans-1,3; dimethylcyclopentane; ethyl benzene; ethylbenzene, total; methyl bromide, total; methyl chloride, total; methylene chloride; tetrachloroethane-1,1,2,2; tetrachloroethylene; toluene; trichloroethane-1,1,1; trichloroethane-1,1,2; trichloroethylene; trichlorofluoromethane, total; vinyl chloride	sporadic	1392	1388	Jul-89 – Jun-97

Thirteen different parameters were analyzed in the first data set at the Baxter Intake yielding a total number of 135 samples. However, VOCs were only detected in 72 of those samples. Thirty-one different parameters were analyzed in the second data set at the Betsy Ross Bridge yielding a total number of 1594 samples. However, VOCs were detected in only one of the samples. Thirty-one different parameters were analyzed in the first data set yielding a total number of 1392 samples. However, VOCs were not detected in only four samples. This data suggests that more accurate sampling is occurring at the Baxter Intake.

Table 2.1.5-15 summarizes the results of the monthly sampling conducted from 1990 to 2000. Of those compounds detected, chloroform, p-dichlorobenzene, dichloroethane, methylene chloride, trichlorethane, and toluene are currently regulated. All chemicals measured in the river, were well below their regulatory drinking water MCL limits. Chloroform, dibromochloromethane, and total trihalomethanes all constitute trihalomethanes. Their presence is indicative of chlorine in the river, either due to an industrial source, chlorinated wastewater discharges, or road salt. The maximum value noted for chloroform of 9 µg/L is well below the drinking water MCL of 100 µg/L.

Table 2.1.5-15 Summary of Detectable VOCs at or near Baxter Intake

Compounds Detected	Sampling Location	Units	Min	Max	# of Samples Detected	Detection Limit	MCL
Chloroform	PWD-Baxter	µg/L	0.3	7.3	28	0.3	100
Dibromochloromethane	PWD-Baxter	µg/L	0.3	0.3	1	0.3	TTHM
Dichlorobenzene-p	PWD-Baxter	µg/L	0.3	0.3	1		75
Dichlorobromomethane	PWD-Baxter	µg/L	0.3	1.4	5		
Dichloroethane-1,2	DRBC - Ben Franklin Bridge	µg/L	1	2.5	4		5
Dichloroethane-1,2	DRBC - Betsy Ross Bridge	µg/L	1.3	1.3	1		5
Methylene chloride	PWD-Baxter	µg/L	0.4	1	4	0.3	5
methyltbutylether	PWD-Baxter	µg/L	1.01	1.01	1		
nonadienal-t2,c6	PWD-Baxter	µg/L	35.9	35.9	1		
Toluene	PWD-Baxter	µg/L	0.3	0.5	2	0.3	1,000
Total Trihalomethanes	PWD-Baxter	µg/L	0.3	9	28	0.3	TTHM
Trichloroethane-1,1,1	PWD-Baxter	µg/L	0.3	0.3	1		5

Note: the sample results that were (with qualifier J) estimated, were excluded form this table.

A further examination of regulatory VOC monitoring of 21 chemicals at the Baxter Intake from 1994 to 1999 did not identify VOCs related to source water impacts. Typically, other than the occasion of a gasoline, fuel oil, petroleum pipeline break, or related spill, VOCs from point or non-point sources have not had a routine or regulatory compliance impact on water quality in the 1990s at the Baxter WTP Intake.

MTBE is a specific VOC produced as a gasoline additive used to reduce air pollution. However, it is quite persistent and is easily tasted or smelled at very low concentrations and can impact drinking water aesthetics. Monitoring was conducted by PWD for methyl tertiary-butyl ether (MTBE) during periods from 1996 to 2000. Maximum concentrations detected were 3.8 ug/L, which is well below the recommended limits of 20 ug/L. Data to date for the Delaware River indicates that concentrations are highest during the summer periods when recreational boating is at its peak in the river. Recreational boat engines and in particular, jet skis or wave runners, have been observed by studies in California to represent the most significant source of MTBE. Boat engines and jet skis can release uncombusted gasoline directly into the water.

Radionuclides

Radioactivity is not typically a major health concern in surface waters based on actual concentrations and frequency of detections. Nevertheless, surface waters may be susceptible to radioactive contaminants from nuclear industrial accidents. Increased use of radioisotopes in the health industry may also be a potential source of pollution. Some radionuclides are naturally occurring due to soil and rock decomposition. Naturally occurring radionuclides are found at much higher concentrations in groundwater, than in surface water. The major concern with radionuclides is that they cannot be removed by known chemical or physical treatment and are generally very persistent in the environment. Natural decay can be an extremely slow process.

Radioactivity in water may be caused by four general categories of radiation: alpha and beta particles, gamma rays and neutrons. Chronic effects of radiation are still not well identified, so pending further research, health authorities have followed a basic tenet of keeping exposure to the lowest level. Maximum contaminant levels (MCLs) of gross alpha particles, gross beta particles and combined radium isotopes (226 + 228) are 5 pCi/L, 4 mrem/yr., and 5 pCi/L, respectively. Strontium-90 is another isotope of particular concern due to its toxicity and persistence (DeZuane, 1997).

In Table 2.1.5-16, radionuclides data in PWD's finished drinking water is presented for 1999. As shown in Table 2.1.5-16, no radionuclides have been detected.

Table 2.1.5-16 Radionuclides in PWD Drinking Water Effluents (1999)

Parameter	MCL	MDL	Effluent Concentration (pCi/L)
Gross Alpha	15 pCi/L	3 pCi/L	ND
Gross Beta	50 pCi/L ~ 4 mrem	4 pCi/L	ND
Strontium-90	8 pCi/L	10 pCi/L	ND
Tritium	20,000 pCi/L	1000 pCi/L	ND

MCL = Maximum **C**ontaminant **L**evel – a regulatory limit by the USEPA or PADEP

MDL = Method **D**etection **L**imit – the level of a contaminant that can be detected by current testing methods

NA = Not **A**nalyzed

ND = Not **D**etected (less than the MDL)

Algae and Taste and Odor Compounds

Blue green algae can have significant impacts on the taste and odor of water and require costly treatment to remove its unpleasant impacts. Typically, blue-green algae impacts occur during the spring in April and May, when water temperatures are colder, but they can occur in the fall and winter. Diatoms typically impact treatment operation by clogging filters and reducing filter run times. Diatom blooms usually occur during the summer months. Table 2.1.5-17 provides a summary of the monthly total algae and diatom concentrations in the Delaware River. They are mainly dictated by the availability of nutrients. As shown, diatoms make up a significant portion of the total algae observed in the water supply during the summer months.

Table 2.1.5-17 Monthly Concentrations of Algae and Diatoms at the Baxter WTP Intake - 1999

	BAXTER WTP INFLUENT					
	TOTAL ALGAE (count/ 1 mL)			TOTAL DIATOMS (count/ 1 mL)		
MONTH	AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
April	2,167	1,000	3,300	2,033	1,000	2,900
May	3,750	3,000	4,700	3,500	2,900	4,700
June	2,740	2,100	3,300	2,560	2,100	3,300
July	4,660	400	17,400	4,580	400	8,200
August	8,400	2,300	15,100	8,300	2,100	14,900
September	1,400	600	2,300	1,300	600	2,300

2.1.5.2 Temporal Water Quality Analysis

Temporal water quality analysis consisted of assessing variation in climate, flows and water quality over a variety of time scales. Weather patterns and river flow rates were studied over the period of record, typically on the order of the past century. General trends in water quality were assessed using data collected at the Baxter Intake at Philadelphia by PWD over the period 1990-1999. Trends in precipitation chemistry and water quality data collected exclusively at the Baxter Intake were assessed for the past decade, with available data from 1990 through 1999.

Seasonal trends in water quality at the Baxter Intake from 1990 through 1999 (Figure 2.1.5-3) were typical of those found in north temperate river systems, although solute concentrations in the Delaware are at the high end of the range for these rivers in general. Observations from this figure also have been summarized in Table 2.1.5-18. Dissolved orthophosphate (ortho-P) was typically low in winter and spring months and higher in summer months. Despite seasonal fluctuations driven mainly by flow variation, dissolved ortho-P remained well above limiting levels for phytoplankton growth in all seasons. Ammonia exhibited its highest levels in the wintertime, although it was nearly always a small fraction of the total dissolved inorganic nitrogen (which was mostly nitrate). Nitrate levels were measured less frequently, but were typically lowest in spring associated with high flows and peaks in phytoplankton growth. Highest nitrate concentrations were generally in the fall and winter, but these were never near the MCL of 10 mg/l. Bulk measures of dissolved solutes, including conductivity and alkalinity, exhibited clear seasonal trends, with maximum levels occurring in summer and fall when flows were lowest. In a watershed with little impacts from impervious cover, concentrations of conductivity would be expected to reach their highest levels occurring in late summer. Also, relatively stable conservative ions like chloride and fluoride would generally be expected to mirror the conductivity trends when impervious cover impacts are not dominant. However, the highest levels of conductivity and chlorides were observed intermittently in wintertime, suggesting impacts of de-icing treatments to roadways during winter storms. Fluoride exhibited the expected trends for stable ions in watersheds not impacted by impervious cover suggesting influences by point source discharges. Turbidity appeared to be lowest in general during summer months, when precipitation and flow levels are lower and storms are infrequent. Manganese displayed no apparent trend, but was periodically at levels as high as 0.63 mg/l through the period of study.

Long-term variation at the intake is dominated by the previously mentioned patterns of increasing solute levels including measures of conductivity, alkalinity, chloride and sodium. Ammonia levels have generally decreased through the 1990s, although levels were elevated in winter months in all years (Figure 2.1.5-4). Conductivity, alkalinity, chloride and sodium levels all increased through the decade at Baxter, with sodium levels increasing at the fastest rate relative to initial (1990) concentrations. These observations also have been summarized in Table 2.1.5.19.

Figure 2.1.5-3 Seasonal Patterns in Water Quality at Baxter Intake During 1990 - 1999

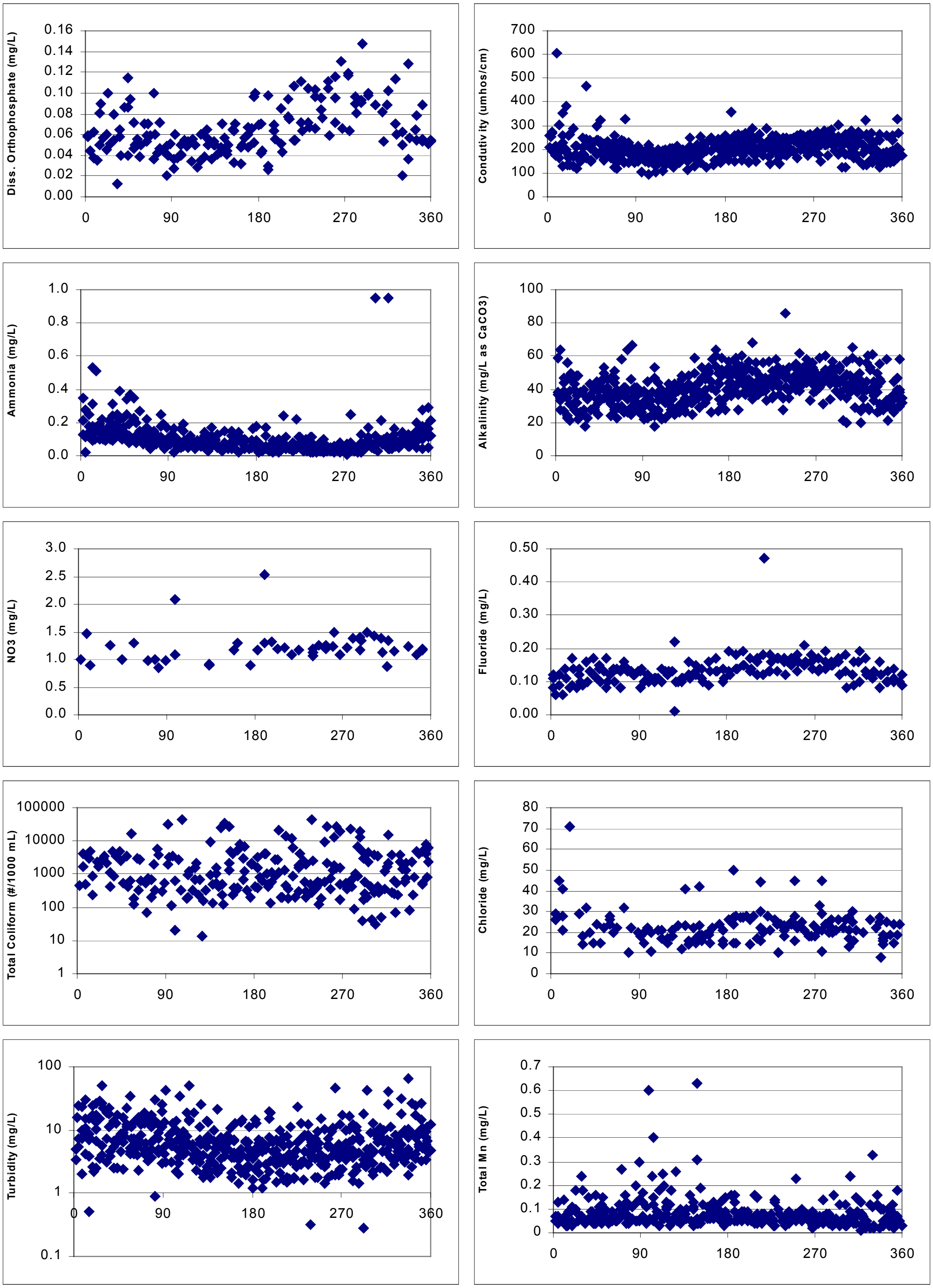


Table 2.1.5-18 Summary of Seasonal Water Quality Trends at Baxter Intake During 1990 - 1999

Parameter	Seasonal Trend	Peak During	Minimum During	Cause of Higher Values	Cause of Lower Values	Suspected Activities	Suspected Area(s)
Orthophosphate (Phosporus)	Yes	Fall / Winter	Summer	Lack of Biological Activity	Biological Activity	Wastewater Discharges, Agriculture	Watershed Wide
Ammonia	Yes	Winter	Summer	Lack of Biological Activity	Biological Activity	Wastewater Discharges, Agriculture	Watershed Wide
Nitrate	No	N/A	N/A	N/A	N/A	N/A	N/A
Total Coliform	No	N/A	N/A	N/A	N/A	N/A	N/A
Turbidity	Yes	Winter/Spring	Summer	Rainfall	Lack of Rainfall	Construction, Agriculture	Watershed Wide
Conductivity	Yes	Summer/ Fall	Spring	Road Runoff Low Flows	High Flows	De-icing of roadways	Lower Delaware
Alkalinity	Yes	Summer/ Fall	Spring	Low Flows High Groundwater Contribution	Rainfall, Acid Mine Drainage	Acid Mine Drainage, Acid rain	Lehigh River / New York
Fluoride	Yes	Summer/ Fall	Winter	High Flows	Low Flows	Wastewater Discharges, Groundwater	Unknown
Chloride	Yes	Summer/ Fall/ Winter	Spring	Road Runoff Low Flows	High Flows	De-icing of roadways	Lower Delaware
Manganese	No	N/A	N/A	N/A	N/A	N/A	N/A

Figure 2.1.5-4 Trends in Water Quality at Baxter Intake by Decade During 1990 - 1999

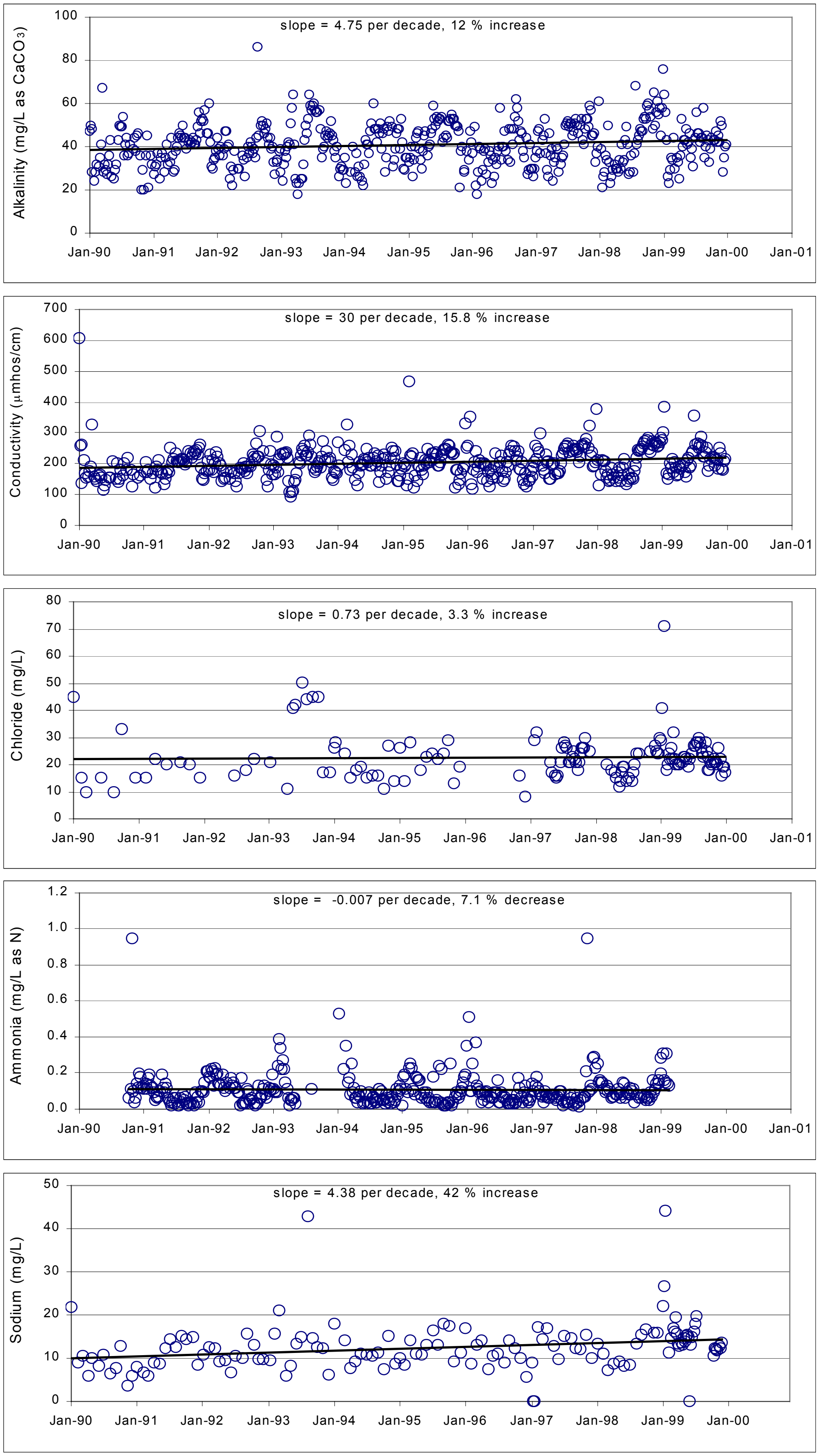


Table 2.1.5-19 Summary of Trends in Water Quality at Baxter Intake During 1990 - 1999

Parameter	**Trends**	**Peaks**	**Peak Value**	**Peaks Typically Runoff/Flow Associated**	**Suspected Activities**	**Suspected Area(s)**
Alkalinity (mg/L as $CaCO_3$)	Increasing	8/26/1992	86	Yes	Acid Mine Drainage / Acid Rain	Lehigh River / New York
Conductivity (μmhos/cm)	Increasing	2/9/1995	467	Yes	Residential / Road Runoff / Wastewater Discharge	Lower Delaware
Chloride (mg/L)	Increasing	1/19/1999	71	Yes	Residential / Road Runoff / Wastewater Discharge	Lower Delaware
Ammonia (mg/L as N)	Decreasing	10/30/1990, 11/12/1997	0.95	No	Improved wastewater treatment & reduced agriculture	Watershed Wide
Sodium (mg/L)	Increasing	1/19/1999	44	Yes	Residential / Road Runoff / Wastewater Discharge	Lower Delaware

2.1.5.3 Spatial Water Quality Analysis

Spatial analysis of water quality along the lower and middle Delaware is completed for the parameters of interest. This enables a determination as to whether the order of magnitude of data at Baxter agrees with other nearby intake and sampling locations along the river. The parameters of interest are plotted in box plots for six different locations. The locations are: the Ben Franklin Bridge at river mile 101, Betsy Ross Bridge at mile 105, PWD Baxter Intake at mile 111, Philadelphia Suburban Water Company Bristol Intake at mile 120, Trenton sampling location at mile 135 and Port Jervis sampling location at mile 255. It should be noted that for a given parameter the data from all six locations might not be available or as comprehensive.

Spatial analysis also shows whether temporal peaks and dips at Baxter agree with the other intake and sampling locations. Agreement among the various locations helps to validate trends. Also, the parameter of interest is plotted against the average daily river flow to investigate existence of any correlation between increase/decrease of the parameter value with river flow. For these plots, the PWD Baxter Intake data is used for the parameter of interest, however, for the average daily flow the Trenton sampling location data is used. The Delaware River transitions in the tidal zone after Trenton, therefore, the flow data from a location downstream of Trenton would not be valid in developing correlation. There is about 24 river-mile distance between these two locations along Delaware.

Turbidity
A box plot summary of turbidity data at the various locations in the Lower and Middle Delaware River Watersheds is found in Figure 2.1.5-5. Turbidity data is readily available for the drinking water intakes, since it is the basis of a standard for finished water quality. Turbidity is a surrogate of suspended material. The statistics were based on data over the same time frame, January 1990 through August 2000.

Figure 2.1.5-5 Summary of Spatial Turbidity Trends: January 1990 – August 2000

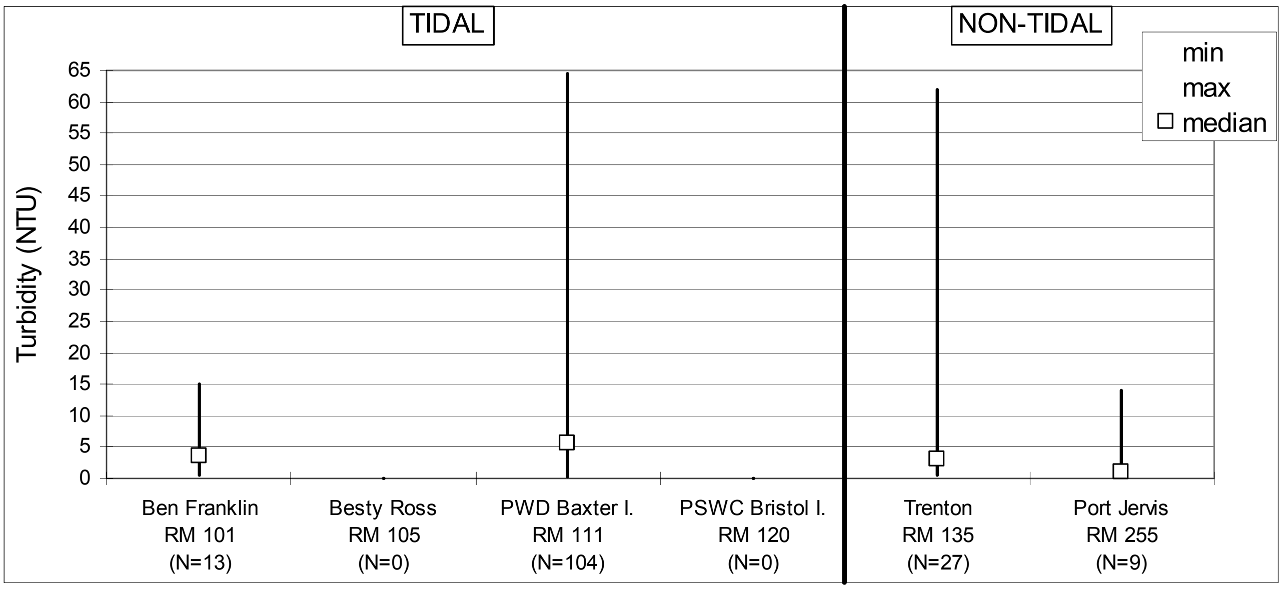
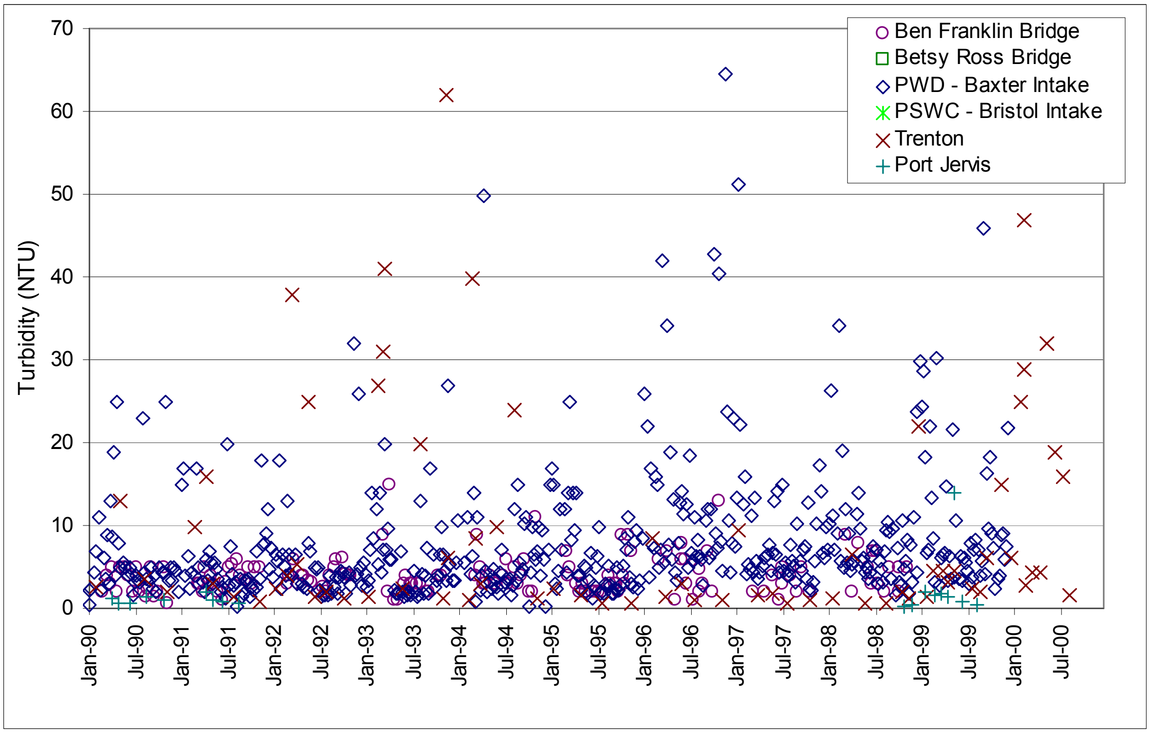


Figure 2.1.5-5 shows that median turbidity agrees well at the different locations and is about five NTU. Relatively a greater degree of variability is evident in the maximum values compared to the minima and medians. This variability is tied to run-off of particulates during rain events. Differences in the magnitude of the maximum values with location are due to disparities in the amount and time of sampling. Some locations such as Baxter, with more data, captured a wider range of turbidity. The discrete turbidity data for these locations over the same time frame is found in Figure 2.1.5-6.

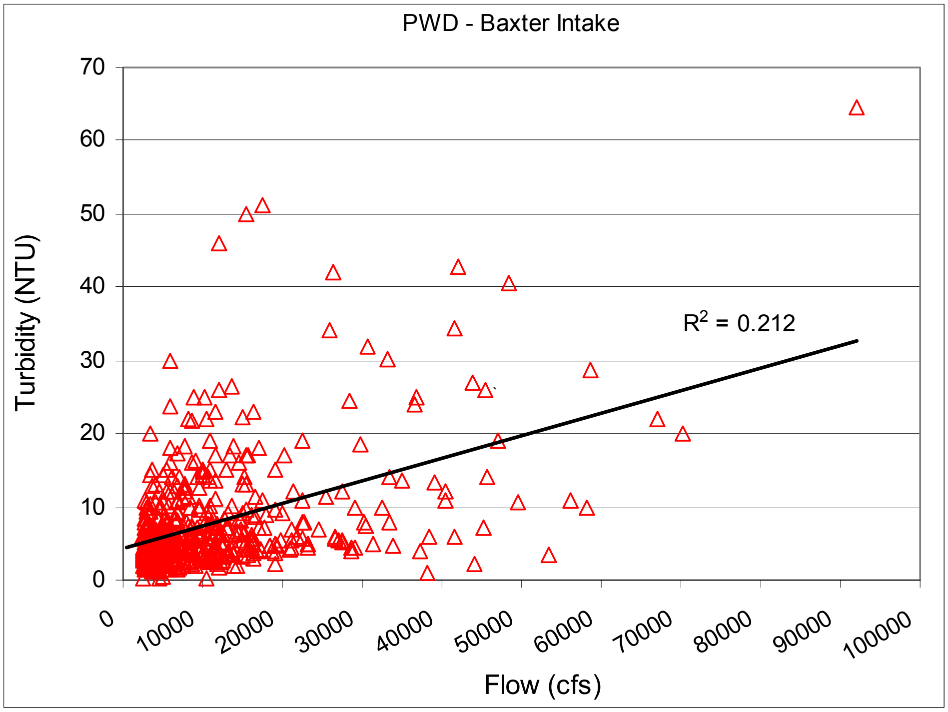
Data at the various locations in Figure 2.1.5-6 follow similar temporal trends. Times of peaks agree well as shown by the high concentrations at multiple locations during the same period. Locations that do not show the same peak are because sampling frequency was not as regular and the event was not captured. This supports that the peaks are run-off related because run-off and rain events generally affect the watershed regionally.

Figure 2.1.5-6 Spatial Turbidity Trends from January 1990 - August 2000



A plot shown in Figure 2.1.5-7 of average daily river flow and turbidity further substantiates the effect of runoff on increased turbidity levels in the river. Turbidity measurements from Baxter were plotted as a function of average daily flow at Trenton for days where data for both parameters were available. An increasing linear trend is observed, however the correlation is not very strong due to the tidal impacts on water quality in this area.

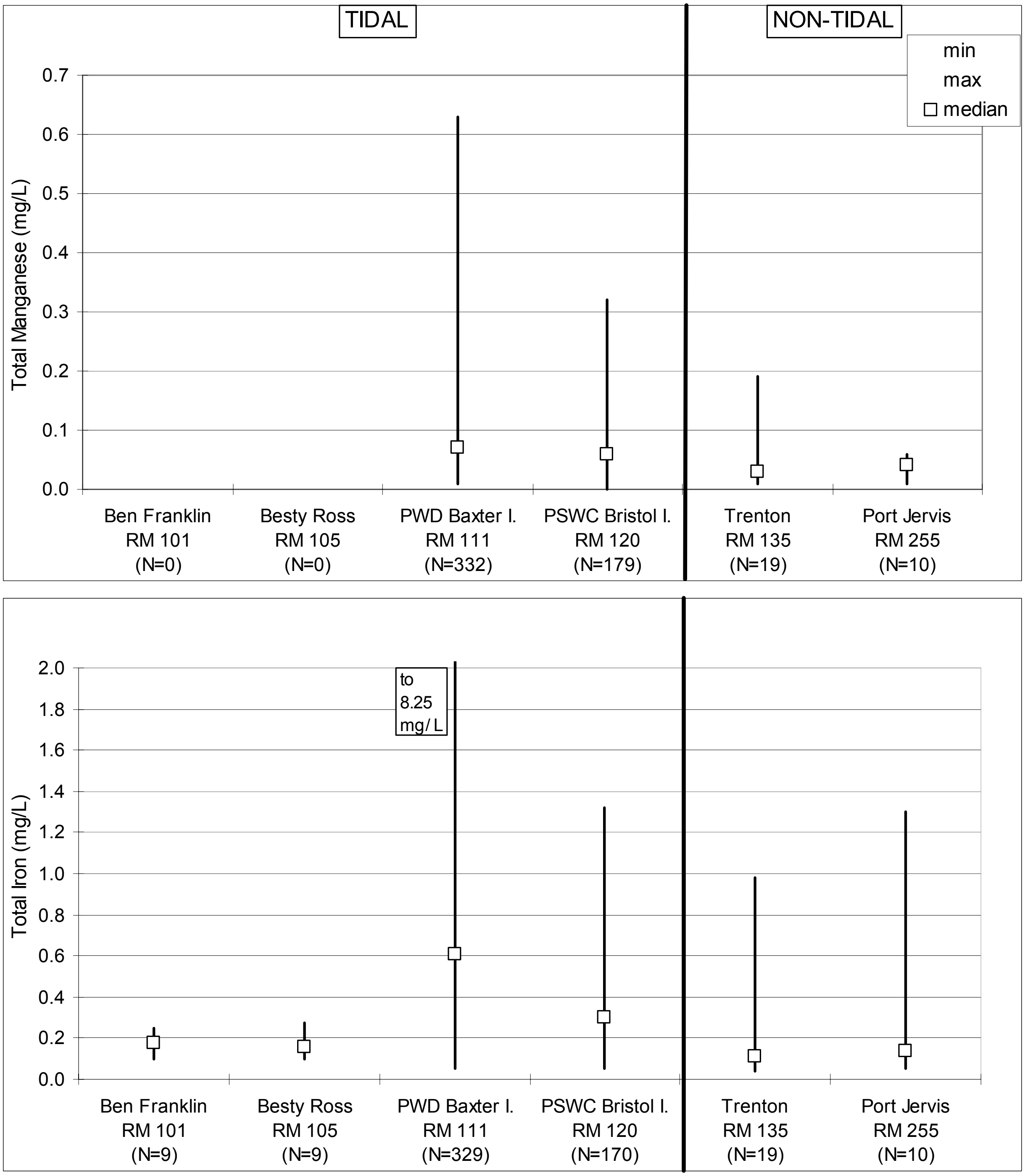
Figure 2.1.5-7 Turbidity/ Flow Trends: January 1990 - December 1999



Metals: Iron and Manganese

Figure 2.1.5-8 presents a box plot summary of total manganese and iron data at the same locations in the Lower and Middle Delaware River Watersheds. The box plot for manganese shows that the median is fairly constant across the locations at about 0.05 mg/L. Similar to turbidity, iron and manganese variability at each location, as indicated by the maximum values compared to the minima and medians, may be attributed to rain events. Rain events can increase runoff from land or increase acid mine drainage from Upper Delaware Watershed upstream locations. Differences in the magnitude of maximum values among the locations may also be due to different sampling dates and times.

Figure 2.1.5-8 Summary of Spatial Trends of Manganese and Iron: January 1990 - January 2002



The box plot for iron shows more variability of median values with location than manganese. Median iron ranges from 0.11 mg/L to 0.61 mg/L with the highest median value observed at PWD Baxter Intake. Perhaps this is due to different sampling dates over the time frame, but it may also indicate that certain locations are more susceptible to other point or non-point sources of iron. Maximum values are also highest at the Philadelphia intakes. Iron, similar to manganese and turbidity, has a great deal of variability at each individual location. The differences in median iron concentration at the various locations in the box plot suggests that iron concentrations are highly variable in the river and require high monitoring frequencies to get a true measure of the median concentrations. This may be attributed to sources related to rain events. To further examine some of these trends, discrete iron and manganese data for the time frame of January 1990 to January 2002 is presented in Figure 2.1.5-9.

Figure 2.1.5-9 demonstrates that temporal trends are generally consistent across the various locations where data is available. Similar to Figure 2.1.5-8, the plot shows that at each location, total manganese is less than 0.65 mg/L. More variability is seen in the iron data. Specifically, data at Baxter is quite scattered. Iron and manganese trend similarly with time and location, in terms of peaks and dips suggesting similar sources or mechanisms are impacting their concentrations in the water column. Peaks are believed to be related to either increased particulate loads from run-off from upstream or acid mine drainage from the Lehigh River Watershed.

As seen in Figure 2.1.5-10, there were no statistically observable relations between rain events/flow and maximum manganese and iron as shown in Figure 2.1.5-10. This suggests that a combination of runoff sources impacting during wet weather periods and sporadic point source impacts (acid mine drainage or industrial discharges) during dry weather periods have alternating periods of dominant influence on manganese and iron. Rain may be a primary driving mechanism for acid mine drainage impacts, but due to the time of travel from the Lehigh River Watershed, acid mine drainage impacts would not be observed until after flows due to recent rains have decreased. This “lag” effect would need to be examined in more detail in future water quality studies.

Figure 2.1.5-9 Spatial Trends in Manganese and Iron from January 1990 - January 2002

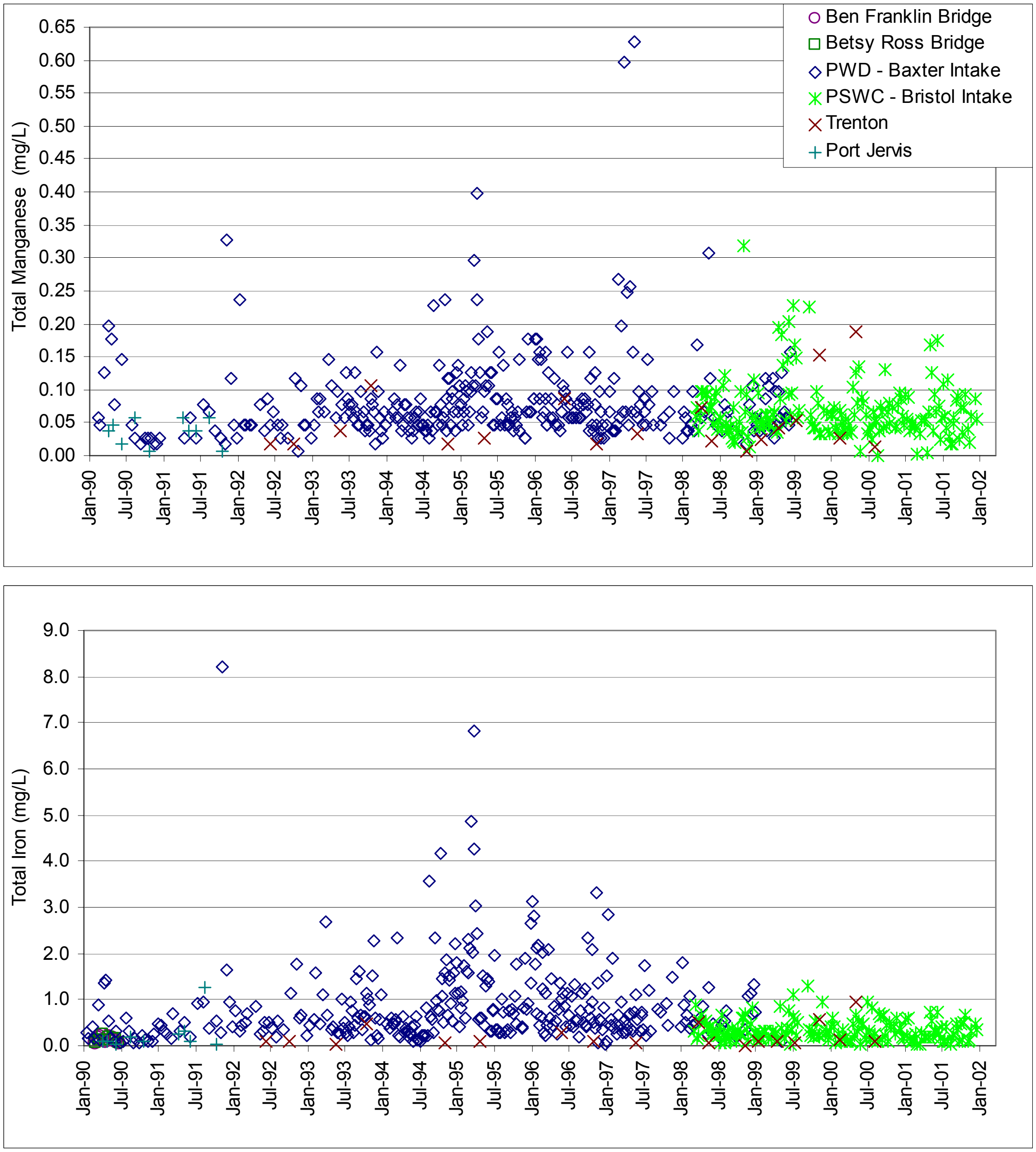
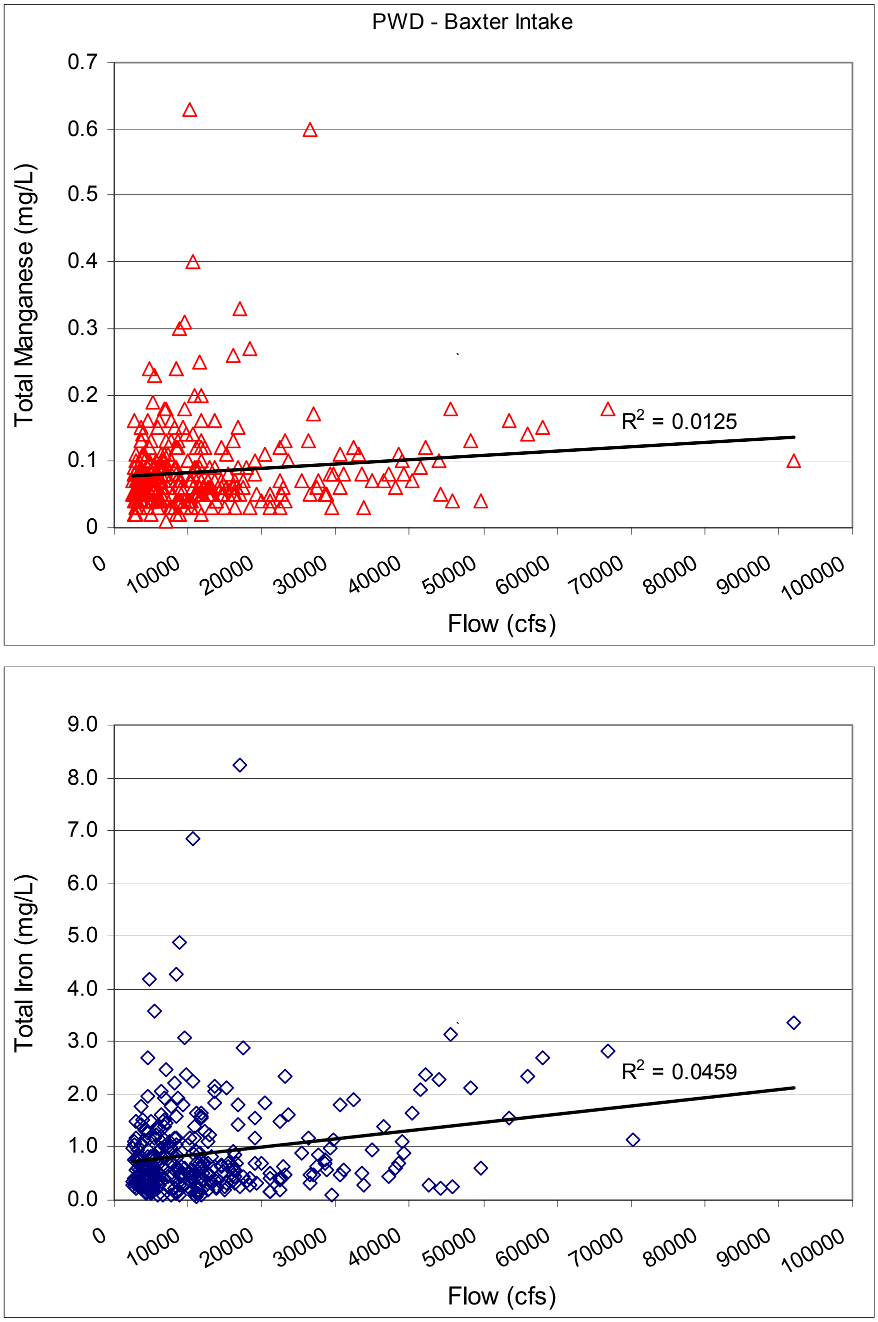


Figure 2.1.5-10 Flow Trends in Manganese and Iron: January 1990 - July 1999



Nutrients

Figure 2.1.5-11 presents a box plot summary of available nutrient data for the Lower and Middle Delaware River Watershed Intakes. Data was available for total ammonia, total nitrate, and dissolved orthophosphate over the time frame from January 1990 through December 2001. Median values for all three parameters are fairly consistent irrespective of sampling location. However, the median value for total ammonia and dissolved nitrate is relatively lower for upstream sampling location such as Trenton and Port Jervis. Maximum values vary most significantly from median and minimum values.

Overall, concentrations of nutrients in the tidal portion of the Delaware River are greater on average than those observed in the non-tidal section between Trenton and Port Jervis. It is suspected that point source discharges in the tidal area may be having the greatest influence on these concentrations. Though levels of nutrients are lower in the tidal Delaware River than the Schuylkill River, they are not limiting for biological growth.

The discrete data used in the summary is found in Figure 2.1.5-12. Temporal trends, as discussed in section 2.1.5.2, are also evident. Ammonia shows distinct peaks in the winter. This is due to either lack of biological nitrification in the cold water or use of urea as road salt. Nitrate and dissolved orthophosphate trend together.

Lastly, Figure 2.1.5-13 examines whether any of the available nutrients trend with river flow. Positive trends would indicate river concentrations of nutrients are runoff related. Ammonia levels in Figure 2.1.5-13 do not increase significantly with flow. Nitrate and dissolved orthophosphate levels decrease with flow, although the linear correlation is poor. This suggests that these nutrients are not greatly influenced by rain and runoff. This is probably because the nutrients analyzed are in dissolved form and are not affected by particulate runoff loads.

Figure 2.1.5-11 Summary of Spatial Trends of Nutrients: January 1990 - December 2001

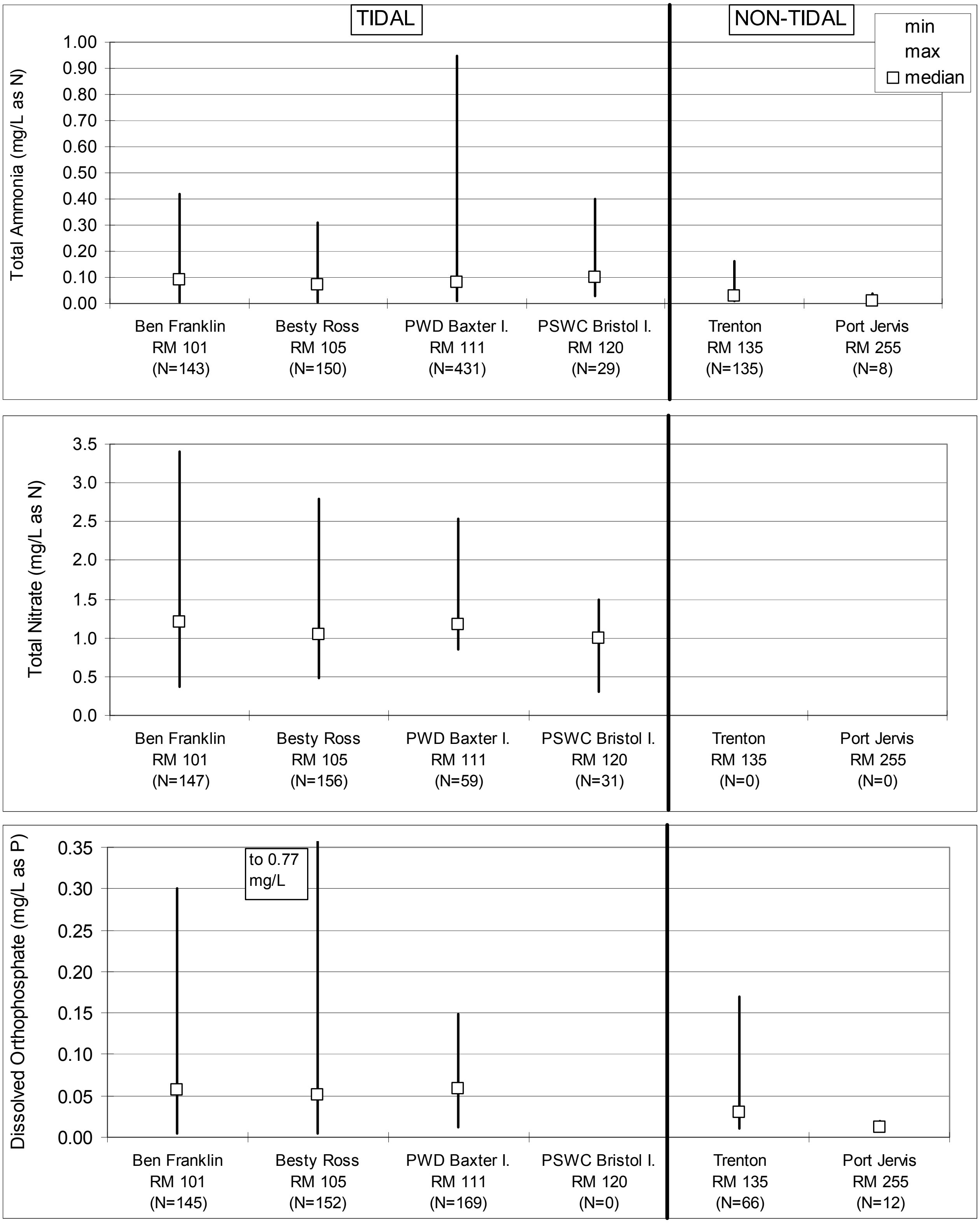


Figure 2.1.5-12 Spatial Trends of Nutrients from January 1990 - December 2001

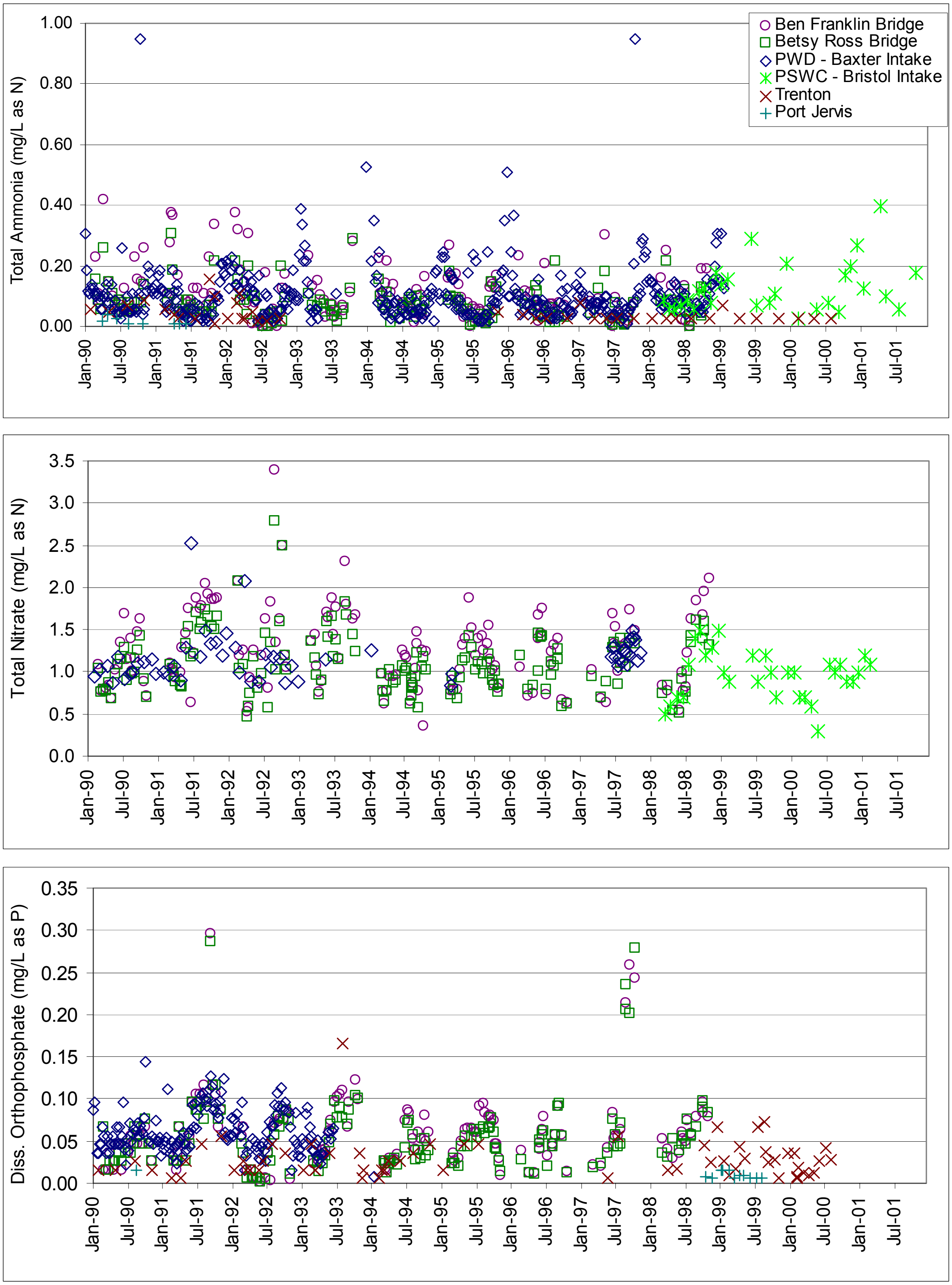
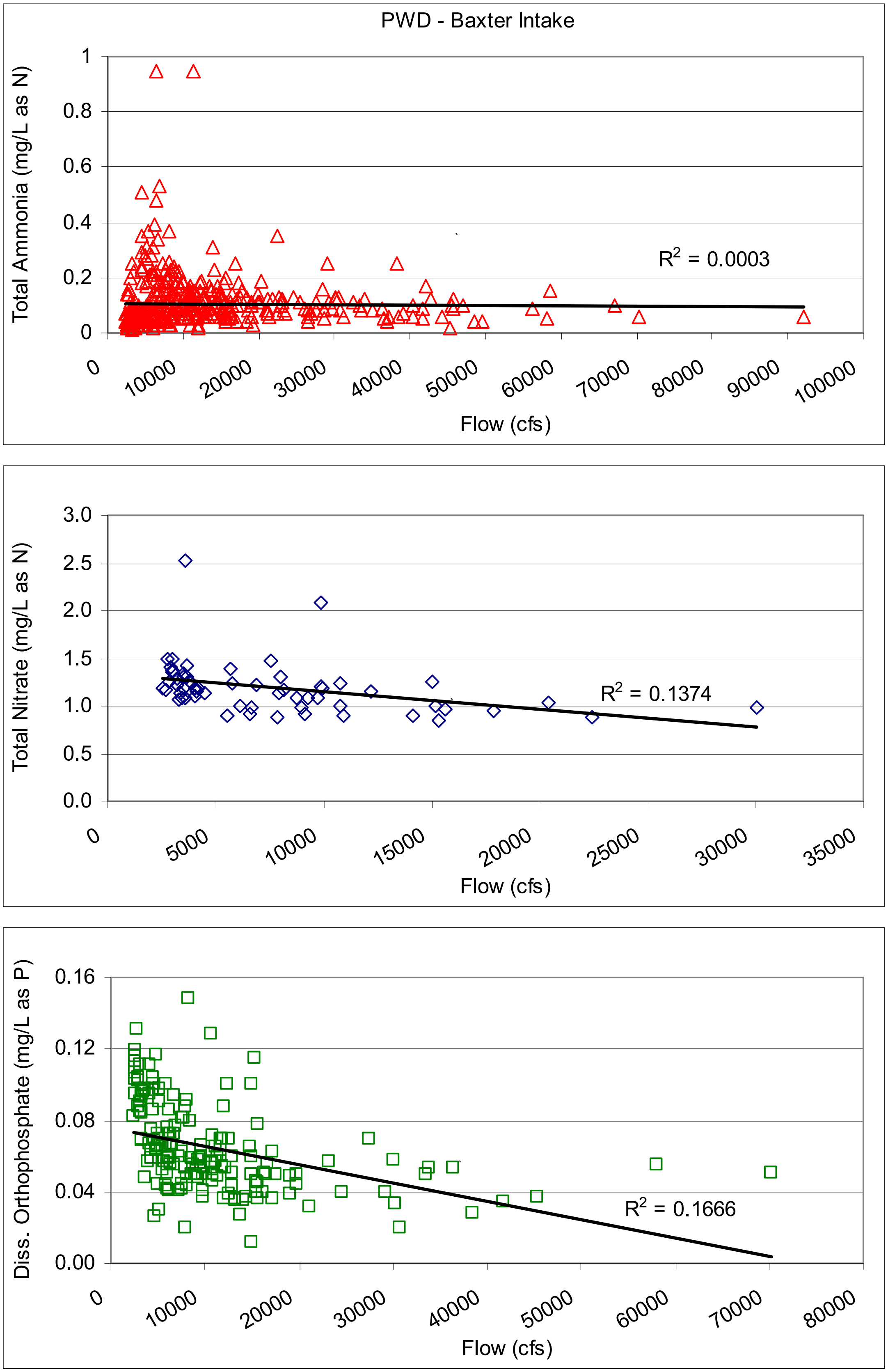


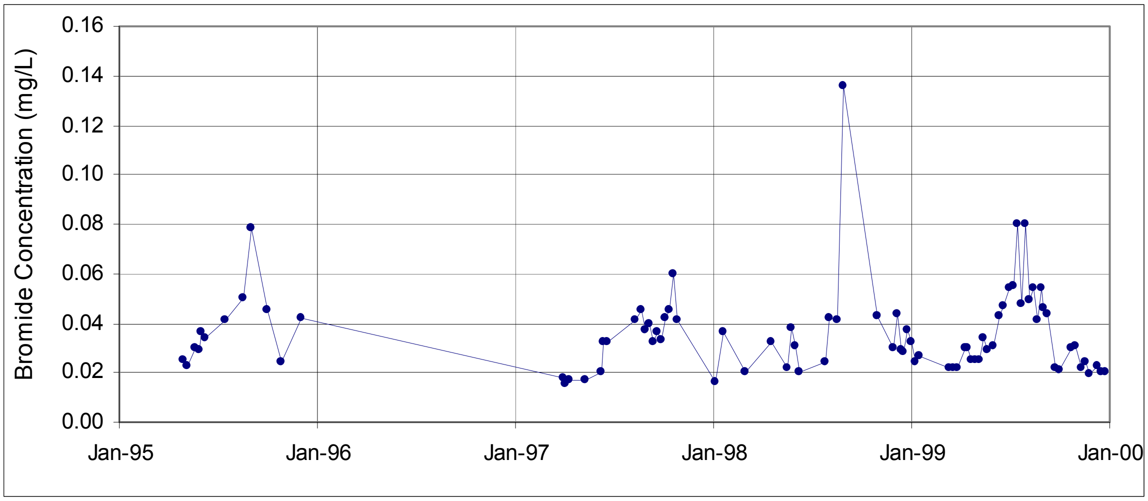
Figure 2.1.5-13 Flow/Nutrient Trends from January 1990 - February 1999



Bromide Temporal Analysis

Bromide is a concern for water treatment because under certain conditions and levels it can react with the chemicals used for disinfection such as chlorine or ozone to create disinfection by-products (DBPs). Exposure to specific DBPs over a lifetime could create chances for chronic illnesses such as cancer. Therefore, identifying and understanding the sources of these chemicals that can create potential DBPs is important. As shown in Figure 2.1.5-14, bromide is typically at its highest levels during periods of low river flow. This association suggests that the sources of bromide are typically point sources (discharges) or from groundwater that feeds the river during low-flow periods.

Figure 2.1.5-14 Historical Bromide Levels at PWD's Intakes



Notice the highest levels are associated with periods of low flow suggesting a groundwater or point source influence.

2.1.5.4 Analysis of Stream Impairments and Sources

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 tidal portion of the Delaware River Watershed includes 2,782 miles of streams and creeks. Over 41% (1,148 miles) of these stream miles have been assessed to determine compliance with water quality standards. Applicable water quality standards were attained in one-third of the stream miles that were assessed (367 miles). Streams that are impacted by contaminant sources, (point sources, or non-point sources such as storm water runoff) and do not meet water quality standards, are designated as impaired. Two-thirds of the stream miles that have been assessed (781 miles) do not meet applicable water quality standards, and are designated as impaired. To date, 1635 miles, or 60%, of the stream miles have not been assessed.

Figure 2.1.5-15 displays sources of impairment throughout the tidal portion of the Delaware River Watershed in Pennsylvania. Stormwater runoff from urban and residential areas and municipal point sources were responsible for the majority of the stream impairments identified in the tidal portion of the Delaware River Watershed in Pennsylvania. The sources of impairment were not identified for the New Jersey portions of the watershed by NJDEP.

Figure 2.1.5-16 displays the causes of stream impairments throughout the tidal portion of the Delaware River Watershed in Pennsylvania. The leading causes of impairment are lead, mercury in fish tissue, siltation, and water/flow variability. Table 2.1.5-20 summarizes the number of miles impacted by each of the listed sources for each of the subwatersheds within the tidal portions of the Delaware River Watershed in Pennsylvania. A detailed breakdown of the causes of impairment for New Jersey and Pennsylvania are shown in Table 2.1.5-21 and 22. As shown, the causes of impairment in New Jersey focus on toxic substances and metals where in Pennsylvania the focus is mainly on impairments that impact habitat and diversity. It is not known that these different sources of impairment are due to true differing impacts, differing methods of assessment, or both. It is recommended that efforts be made to unify impairment protocols and determinations in multi-state watersheds.

As shown in Figures 2.1.5-17 and 2.1.5-18, the streams draining into the tidal sections of Philadelphia and Lower New Jersey showed the highest percentages of impairment. This includes smaller streams such as the Tacony-Frankford Creek, Pennypack Creek, and Poquessing Creeks. The level of impairment reduced in streams as they were located further upstream from Philadelphia and Trenton where there are less urbanized areas. However, impairments are still significant in the Neshaminy Creek, Rancocas Creek, and Mercer County area streams.

Figure 2.1.5-15 Summary of Miles Impaired by Primary Sources (Source PADEP)

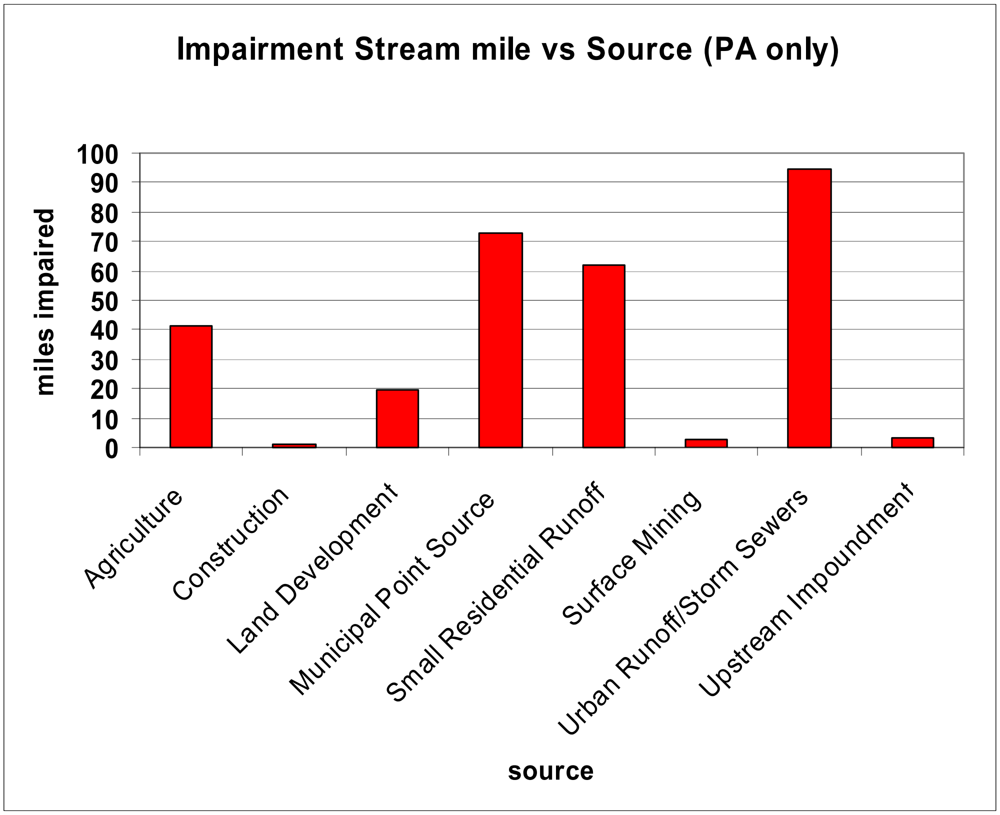


Figure 2.1.5-16 Summary of Miles of Impairment by Primary Causes (PA Side Only)

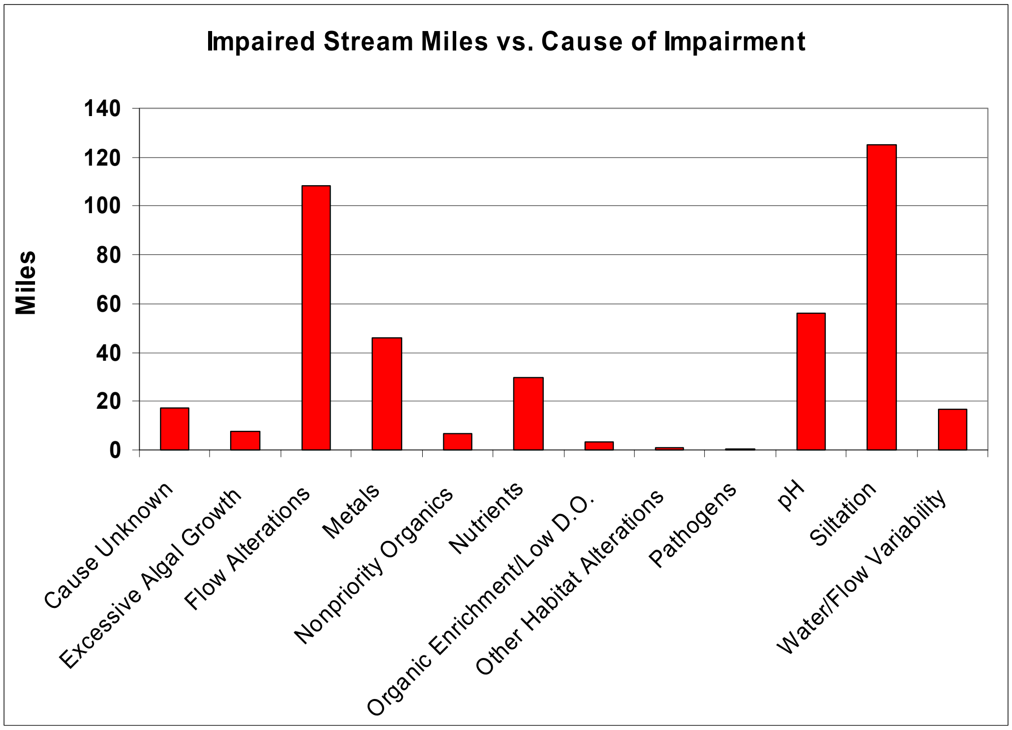


Table 2.1.5-20 Miles of Impairment by Primary Source and Watershed (PA side only)

IMP Sources	Neshaminy Creek	PA Bucks Co. Direct	Tidal Bucks Co.	Tidal PA Phila. Co.	Total
Abandoned Mine Drainage	0	0	0	0	0.00
Agriculture	**40.5**	**0**	**0**	**0.8**	**41.3**
Construction	1.3	0	0	0	1.3
Erosion from Derelict Land	0	0	0	0	0
Habitat Modification	0	0	0	0	0
Industrial Point Source	0	0	0	0	0
Land Development	**19.4**	**0**	**0**	**0**	**19.4**
Municipal Point Source	**72.3**	**0**	**0**	**0.3**	**72.7**
Natural Sources	0	0	0	0	0
Small Residential Runoff	**3.9**	**0**	**0**	**58.1**	**62.0**
Surface Mining	2.7	0	0	0	2.7
Urban Runoff/Storm Sewers	**38.3**	**0**	**0**	**56.5**	**94.8**
Upstream Impoundment	3.3	0	0	0	3.3
Package Plants	0	0	0	0	0
Other	0	0	0	0	0
Subtotal	181.7	0	115.7	0	297.4

Note: miles of stream impaired by a given source.

Table 2.1.5-21 Breakdown of Miles of Impairment by Primary Cause and Watershed (PA Side Only)

IMP Causes	Neshaminy Creek	PA Bucks direct	Tidal Bucks Co.	Tidal Pa Phila Co.	Total
Cause Unknown	1.42	0	0	10.53	11.95
Excessive Algal Growth	7.77	0	0	0	7.77
Flow Alterations	**3.4**	**0**	**0**	**104.81**	**108.21**
Metals	0	0	0	0	0.00
Nonpriority Organics	0	0	0	0	0.00
Nutrients	**29.95**	**0**	**0**	**0**	**29.95**
Organic Enrichment/Low D.O.	0	0	0	0	0.00
Other Habitat Alterations	0	0	0	0	0.00
Pathogens	0.12	0	0	0.34	0.46
pH	**36.85**	**0**	**0**	**0**	**36.85**
Siltation	**85.59**	**0**	**0**	**0**	**85.59**
Water/Flow Variability	**16.63**	**0**	**0**	**0**	**16.63**

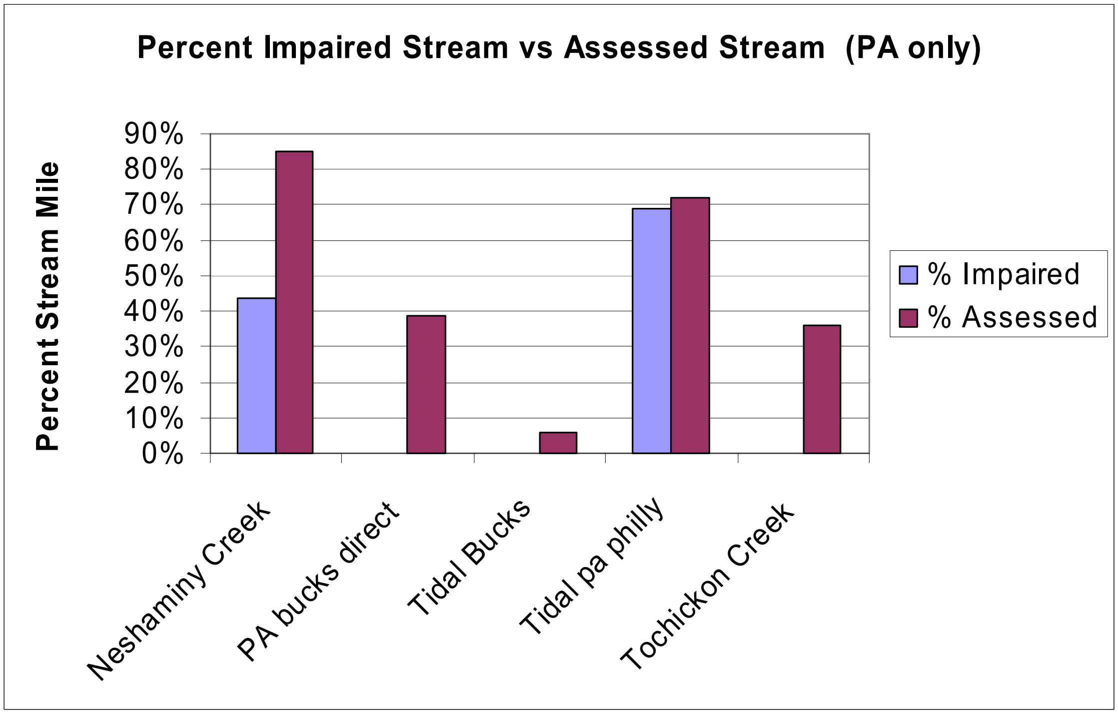
(Source: PADEP)

Table 2.1.5-22 Breakdown of Miles of Impairment by Primary Cause and Watershed (NJ Side Only)

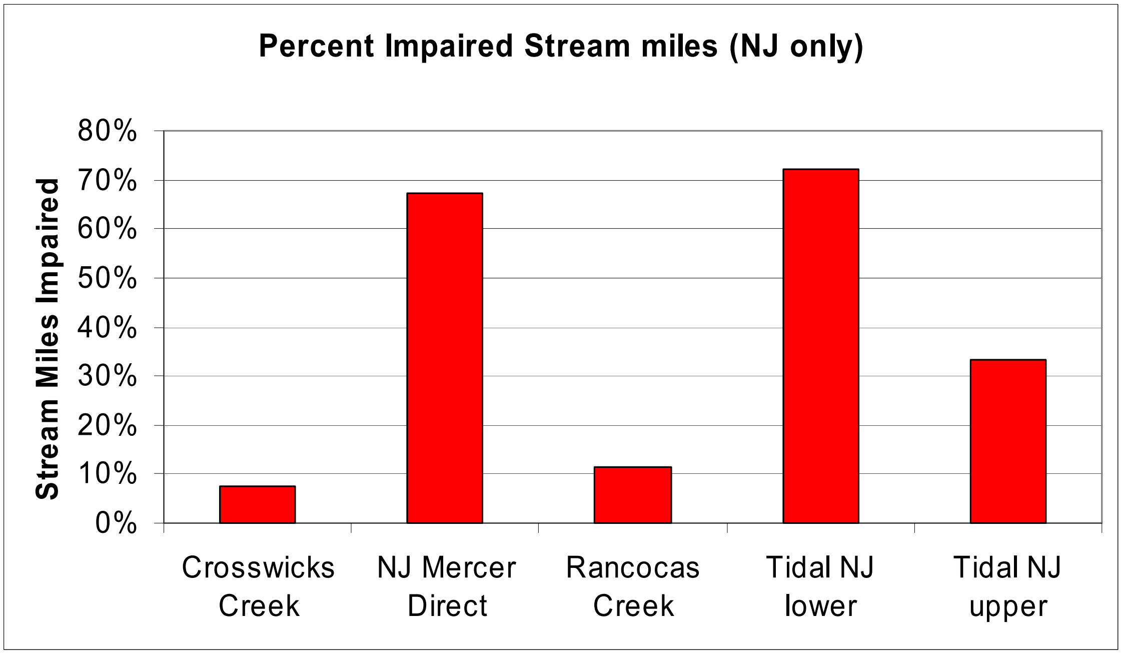
Impairment	Crosswicks Creek	NJ Mercer Direct	Rancocas Creek	Tidal NJ Lower	Tidal NJ Upper	Total
1,2-Dichloroethane	0.00	0.00	0.00	0.16	0.00	0.16
Algae	**0.42**	**5.51**	**10.39**	**7.02**	**0.46**	**23.80**
Arsenic	**2.65**	**0.00**	**0.00**	**0.00**	**27.72**	**30.37**
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	3.60	0.00	3.60
Chlordane in Fish Tissue	0.00	0.00	0.00	7.45	0.00	7.45
Chromium	**0.00**	**0.00**	**0.00**	**10.66**	**16.25**	**26.91**
Copper	0.00	0.00	0.00	11.76	0.00	11.76
Lead	**0.00**	**0.00**	**26.13**	**31.70**	**27.72**	**85.55**
Mercury	**0.00**	**0.00**	**36.47**	**0.00**	**0.00**	**36.47**
Mercury in Fish Tissue	**13.45**	**138.33**	**9.89**	**37.97**	**8.06**	**207.71**
PCBS & Chlordane in Fish Tissue	**0.00**	**0.00**	**0.00**	**36.57**	**0.00**	**36.57**
PCBS & Chlordane in Sediment	0.00	0.00	0.00	3.60	0.00	3.60
PH	**0.00**	**0.00**	**0.00**	**31.70**	**0.00**	**31.70**
Phosphorus	2.75	0.62	0.00	1.49	0.00	4.86
Sedimentation	0.00	0.00	0.00	1.20	0.00	1.20

Source: (USEPA)

Figure 2.1.5-17 Percentage of Watershed Miles Impaired and Assessed in the Lower Tidal Delaware River Basin

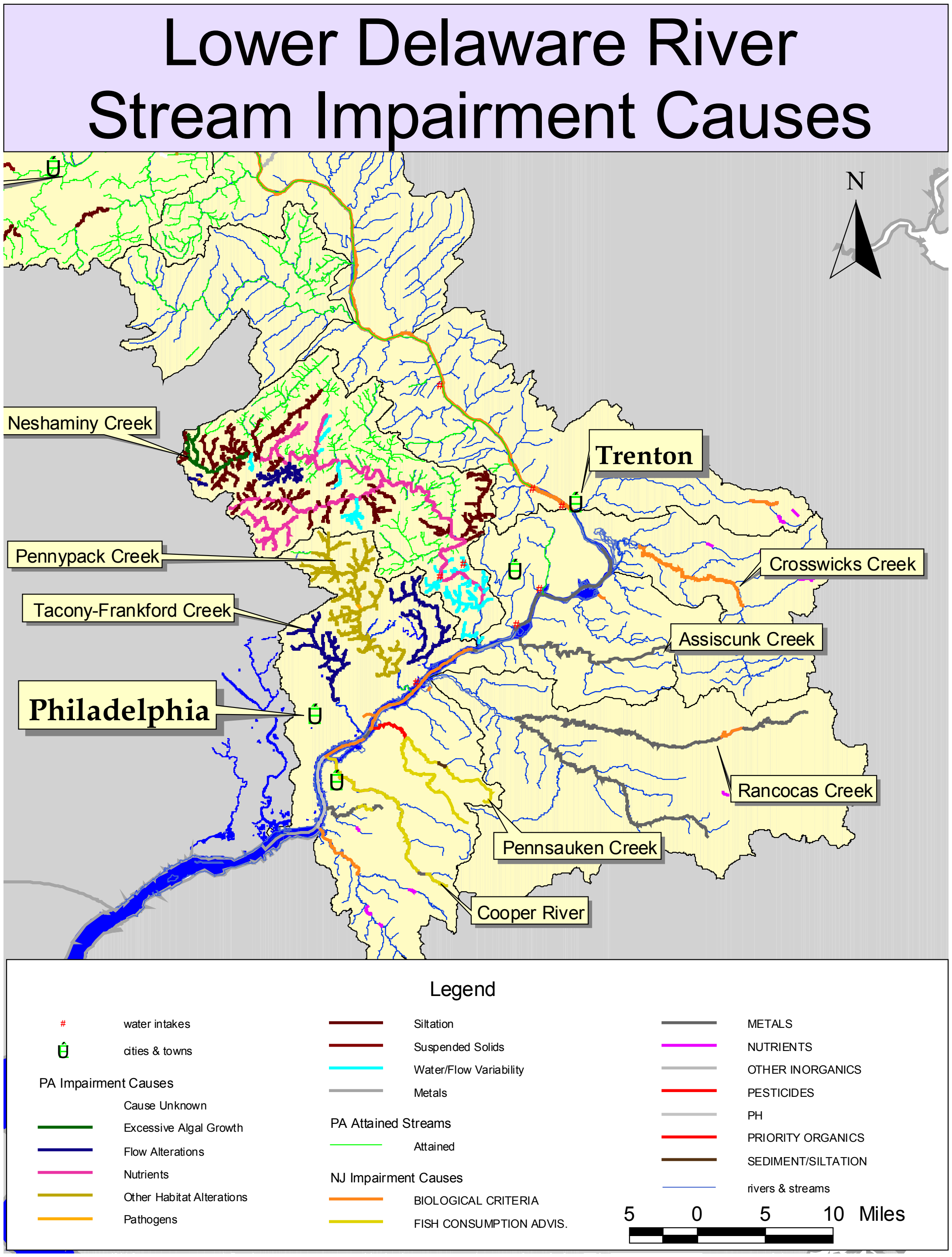


Source: PADEP



Source: PADEP

Figure 2.1.5-18 Impaired Stream Reaches in the Lower Delaware River Watershed



2.2 Source Water Assessment

2.2.1 Delineation of Source Water Assessment Zones

Key Points

- **Zone A, the area within a 5-hour time of travel of Philadelphia Water Department's Baxter Intake, includes 205 square miles of the Delaware River Watershed.**
- **Zone B, the area between the 5-hour and the 25-hour time of travel of the Baxter Intake, includes 2,060 square miles of the watershed.**
- **Zone C, the area beyond the 25-hour time of travel incorporates the remainder of the 8,100 square-mile Delaware River Watershed.**

2.2.1.1 Zone Definition

The Baxter Water Supply Intake receives water from a drainage area greater than 8,100 square miles. Identification of all potential contaminant sources within such a large area requires a systematic approach to examine the area in such a way as to identify all pertinent sources. This approach, as defined by the PADEP's Source Water Assessment Plan, involves a segmentation approach that divides the watershed into zones based on the proximity of a potential contaminant source to a water supply intake. This method assumes that proximity is directly linked to a potential source's impact on a water supply in most cases. Using this logic, the PADEP's SWA Plan divided the source water assessment area for a given intake into the following three zones and prioritized all contaminant source identification accordingly:

Zone A - This is the critical area of highest potential impact on the water supply, as proximity to the water supply's intake results in reduced response times and potential lower dilution and attenuation of a contaminant. Any potentially significant source within a five-hour time of travel of the water supply including one-quarter mile downstream and within a one-quarter mile-wide area on either side of the river/stream from the water supply should be included in the contaminant inventory. These may include large and small discharges, catastrophic event related sources (broken oil pipelines and chemical storage tanks), large runoff sources, or special contaminant sources.

Zone B - This is the area between the 5-hour and 25-hour time of travel to a given water supply intake, including a two mile-wide area on either side of the river or stream extending upstream to the 25-hour time of travel boundary. Only significant potential sources of contamination are identified for inclusion in the contaminant inventory. This generally represents larger discharges (>one million gallons per day), catastrophic event related sources (broken oil pipelines and chemical storage tanks), large runoff sources, or special contaminant sources.

Zone C - This is the area greater than 25-hour time of travel to a given water supply intake. All major potential sources of contamination are identified for inclusion in the contaminant inventory. This generally represents larger discharges (>one to ten million gallons per day), catastrophic event related sources (broken oil pipelines and chemical storage tanks), large runoff sources, or special contaminant sources.

The Source Water Assessment Program (SWAP) for the Delaware River includes delineation of the watershed into zones within 5 hours, between 5 and 25 hours, and greater than 25 hours travel time from water intakes. The delineation for the Philadelphia Water Department's Baxter Water Supply Intake has been developed with consideration of the fact that this intake is located in the tidal portion of the Delaware River. Water intakes located on free flowing streams or rivers can only be affected by contaminant discharges to locations upstream of the water intake. In tidal rivers and estuaries, tidal current oscillations can transport contaminants in an upstream direction during the flood portion of the tidal cycle. Therefore, this source water assessment zone delineation includes evaluations of portions of the Delaware River Watershed both upstream and downstream of this water intake.

2.2.1.2 Non-Tidal Zone Velocity Assumptions

The time of travel and zone delineations are based on high flow, and thus on high velocity conditions. The USGS provided estimates of high flow condition velocities, and delineated Zones A and B for the Baxter Intake. These zone calculations show that 5.5 feet per second is the underlying assumed velocity for the zone delineation, and this same average velocity was assigned to all river segments above Trenton. This same velocity was used in all time of travel calculations during the source prioritization.

2.2.1.3 Tidal Zone Hydrodynamic Modeling

The delineation of the source water assessment zones for this intake, located in the tidal portion of the Delaware River, requires an understanding of the unique circulation characteristics of tidal rivers and estuaries. The movement and mixing of contaminants introduced to tidal riverine or estuarine environments are controlled by three basic processes: tides, winds and river inflow. The tides generate the oscillatory currents and water surface variations in an estuary. Saltwater from the ocean is transported into an estuary by the tidal oscillations; mixing of saltwater and freshwater is caused by the turbulence generated by the tidal action. Wind can be a source of water column turbulence, with a strong wind tending to increase the vertical mixing in the water column. The speed and direction of estuarine currents, particularly near the surface, can also be affected by the wind.

Freshwater inflow to an estuary creates water density variations, referred to as density gradients. Because freshwater is less dense than seawater; freshwater will float on top of seawater. The estuarine density gradients, in both the horizontal and vertical directions, cause a quasi-steady circulation pattern to develop that is quite different from the oscillatory flow due to the tides. Generally, freshwater flows into an estuary and is transported to the ocean in a layer of water near the surface. Saltwater is transported to the upstream reaches of an estuary in the bottom layers of the water column, in the opposite direction of the fresher flow in the surface layer.

The amount of mixing that occurs between the fresher surface layer and the level of turbulence in the vertical direction determines the saltier bottom layer. More turbulence increases the mixing of the water column. A thoroughly mixed water column where salinity is nearly constant in the vertical produces what is known as an unstratified condition. Low vertical mixing produces a stratified situation where the surface layer has a significantly lower salinity than the bottom layer, with the differential usually ranging between five parts per thousand (ppt) and 15 ppt. The level of stratification in an estuary can dramatically affect the circulation pattern and hence, the transport and fate of contaminants introduced into the estuary. In general the Delaware Estuary is well mixed in the vertical dimension (HydroQual, 1998).

Source water assessment zone delineations for this water intake, and others located in the tidal portion of the river, were determined through application of the three dimensional, time variable hydrodynamic and water quality models developed for the Delaware River Basin Commission (HydroQual, 1998). The hydrodynamic model is a version of the Estuarine, Coast and Ocean Model (ECOM) developed by Blumberg and Mellor (1980, 1987). It is three-dimensional and time-dependent so that it can reproduce the complex physics present. Evolving water masses, plumes, fronts and eddies are accounted for by prognostic equations for the thermodynamic quantities, temperature and salinity. Free surface elevation is also calculated prognostically so that tides and storm surge events can be simulated.

The spatial domain and the computational grid of the model are shown on Figure 2.1.1-1. The model extends from Trenton at the upstream limit to Liston Point at the downstream limit. The grid includes one lateral segment in the upper 15 miles, from the upstream boundary at Trenton to Burlington. For the next 23 miles, between Burlington and the southern portion of Camden, the grid contains three lateral segments. Downstream of Camden the grid contains five lateral segments.

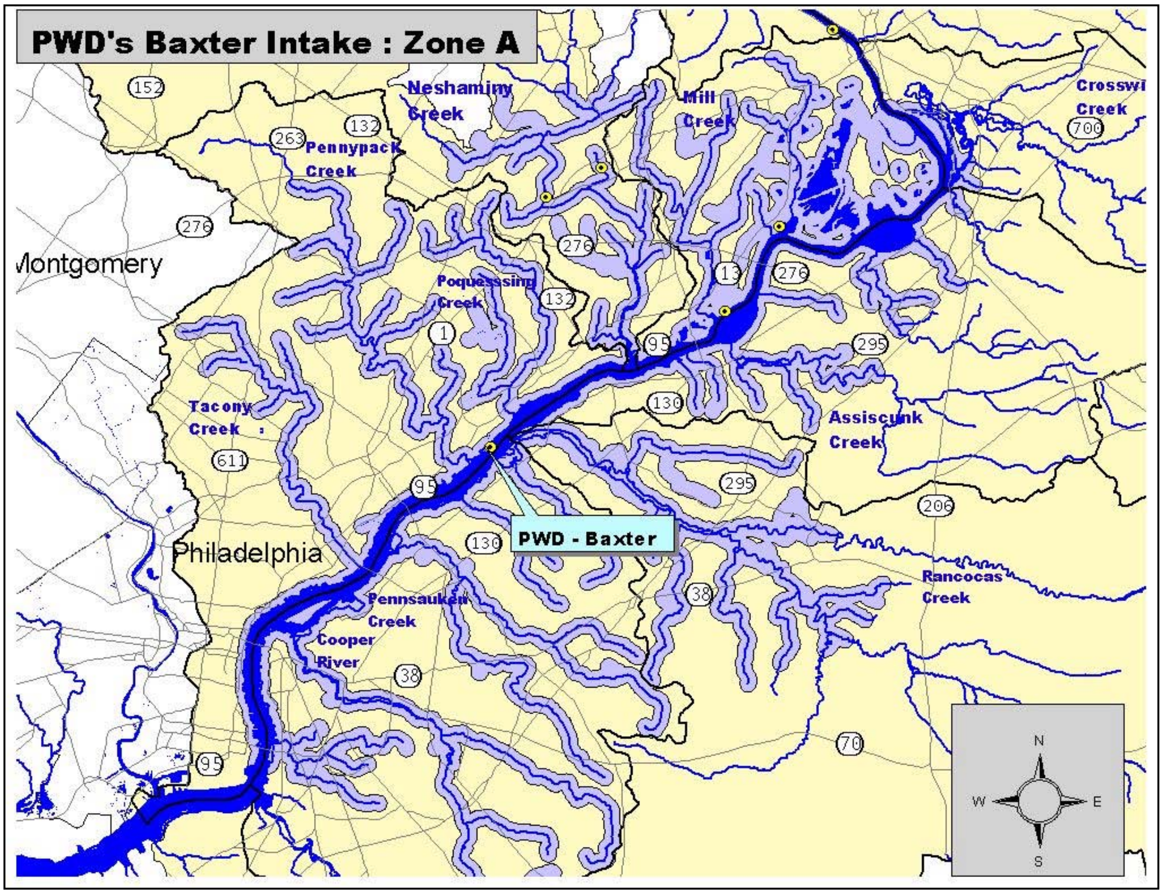
Figure 2.2.1-1 Model Grid

Two sets of river flows were used in the analysis to provide a conservative assessment of the zones within 5 or 25 hours travel time to the water intakes. The critical flow conditions with respect to maximizing the size of zones within 5 and 25 hour travel times are dependent on whether the contaminant source is upstream or downstream of the water intake. For contaminant sources located upstream of the water intake, high flow conditions represent the critical case because of the higher net downstream advective velocities produced by elevated freshwater inflows. For contaminant sources located downstream of the water intake, low flow conditions represent the critical case because of the reduced downstream net advective velocities.

2.2.1.4 Zone Delineation

The final zone delineation combined the tidal zone results from the hydrodynamic modeling with the upstream USGS zone delineation based on high flow conditions stream velocities. Zones were calculated on the Delaware River as well as along the main tributaries. Figure 2.2.1-2 displays the different zones delineated for the Baxter water supply intake for the Philadelphia Water Department. As shown, Zone A encompasses an area of 206 square miles and continues upstream of the intake to river mile 131 at Trenton, New Jersey. Zone A consists of the Tacony Creek Watershed, almost the entire Pennypack Creek Watershed, the entire Cooper River, Pennsauken Creek and large portions of the Rancocas Creek Watershed. Also included is the lower portion of the Neshaminy Creek Watershed , Mill Creek and Assiscunk Creek.

Figure 2.2.1-2 PWD’s Baxter Intake: Zone A

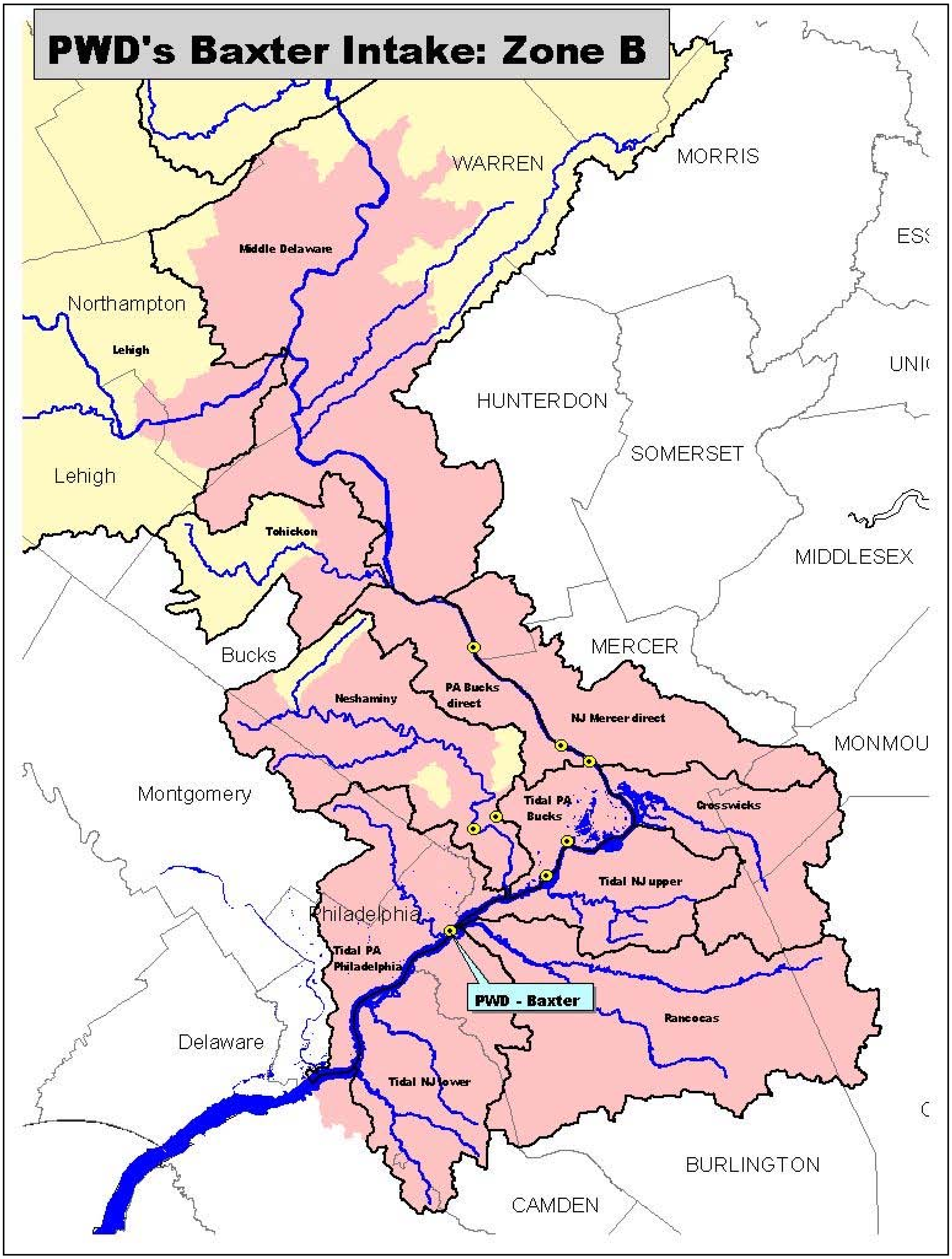


Zone B encompasses an area of 2,060 square miles and extends upstream to river mile 208 as shown by Figure 2.2.1-3. For the Baxter Intake, Zone B extends upstream from the intake to approximately 0.25 miles south of Portland, PA. Zone B also includes all the tributaries below the Lehigh River. Zone B includes portions of the Neshaminy and Tohickon Creeks, below the large reservoirs/lakes located in each watershed. Zone C consists of the remainder of the watershed, primarily the headwaters of the Delaware River, and the remainder of the Lehigh River. Also shown in Figure 2.2.1-3 are the locations of other water supply intakes within the zones delineated for the water supply. As shown in Figure 2.2.1-2 and 2.2.1-3, the Zone A or B from the Baxter Intake overlaps with the Zone A or B from numerous other intakes. This overlapping of zones allows for a more detailed assessment of potential sources for the whole watershed area.

As described above, the time of travel of a release from a potentially significant source of contamination combined with the characteristics of that source will determine whether it is included in the contaminant inventory.

All of the zones of delineation were determined and provided by the United States Geological Survey (USGS) and approved by PADEP for use in the Source Water Assessments. These zones of delineation were modified using the results of the tidal zone hydrodynamic modeling to include downstream areas as well. This modified zone delineation is considered the most accurate description available.

Figure 2.2.1-3 PWD's Baxter Intake: Zone B



2.2.2 Point Source Contaminant Inventory

Key Points

- **Almost 6,000 potential point sources were identified within the 2,060 square mile Baxter Intake.**
- **Most of these potential sources do not – and will never – discharge to the Delaware River. They have been identified so that water suppliers can assess their potential impacts upon the water supply, and identify appropriate protective measures.**
- **Over 1,700 RCRA facilities are located upstream of the Baxter Intake.**
- **Most of the RCRA facilities are not large quantity generators.**
- **Sewerage systems, dry cleaning plants (except rug cleaning), and gasoline service stations are the most common.**
- **VOCs, petroleum hydrocarbons, and SOCs were the most frequently reported contaminants.**

2.2.2.1 Method

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 drinking water supply for the intake, because it compiles potential contaminant sources within the 5-hour, 25-hour, and beyond 25-hour time of travel delineation zones. This inventory is a powerful list enabling the water supplier to better understand their source water. The inventory is also the stepping-stone to prioritizing potential contaminant sources. The prioritization or ranking of contaminant sources is discussed in the susceptibility analysis described in section 2.2.4 below.

The focus of this report section is the point source contaminant inventory. Non-point sources are discussed in the land use section 1.2.5 and within intake section 2.2.3. Point source data was compiled from various federal and state databases available on the Internet. 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.

Database Compilation

The following federal databases were accessed for point sources in the Delaware River study area:

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

Regulated aboveground storage tanks (ASTs) were also compiled from the PADEP Storage Tank Program. Combined with the aforementioned federal databases, the database compilation was complete.

The databases were queried for facility, process, and violation information. Facility information included items such as name, facility identification numbers, owner, and location (street address and/or latitude, longitude). GIS information was used to locate the Delaware SWAP study area sources within the Baxter delineation zones. Process information included data identifying on-site contaminants and the quantities and/or loading rates. Violation information was related to type (administrative versus operation or effluent violation) and frequency.

Database population for many of the facilities and certain pieces of information required for ranking, such as contaminants and quantities, were still missing upon compiling the source database. This data was simply unavailable through the federal databases for many of the minor dischargers and RCRA facilities. Consequently, missing information was populated based on educated assumptions using the known data. Data population of missing fields affects the susceptibility analysis more than the inventory. The inventory discussed in this section is based on actual downloaded data.

Note that individual site contaminants were downloaded, where available, for each facility. Each contaminant was associated with one of ten categories. These categories were generally based on contaminant groups described in the PADEP SWAP guidance document. The contaminant categories were subgrouped into non-conservative (total/fecal coliform, turbidity, nutrients, VOC/SOCs, metals) and conservative (*Cryptosporidium*/*Giardia*, nutrients, DBP precursors, petroleum hydrocarbons, and salts) categories. Nutrients were included in both the non-conservative and conservative categories, because phosphorous is mostly associated with particulates and nitrogen compounds are typically dissolved.

2.2.2.2 Results

Point Source Contaminant Inventory

After the database compilation and population were completed, inventories specific to each intake were developed. PWD's Baxter Intake was delineated into three zones based on travel time. Zones A and B consist of the area of the watershed within a 25-hour travel time of the intake. Zone C extends beyond 25 hours of travel time and essentially captures the remainder of the study area. Consequently, the inventory of sources throughout the three zones is quite extensive for the Baxter Intake.

The completed inventory for Baxter compiles almost 6,000 sources. The inventory is sorted into three sections for zones A, B, and C and subsorted by source type, PCS, RCRA, etc. The inventory indicates facility information such as name, city and county. The source of the data is also indicated, that is, RCRA, PCS, etc. Other pertinent information includes industry classification by SIC code, whether the facility is a large quantity generator for RCRA sites, and a major discharger for PCS sites. If information was available for a specific facility, such as on-site or discharged chemicals, quantities of chemicals, capacity of the site, and discharge flow rates, it is listed.

Inventory Characterization

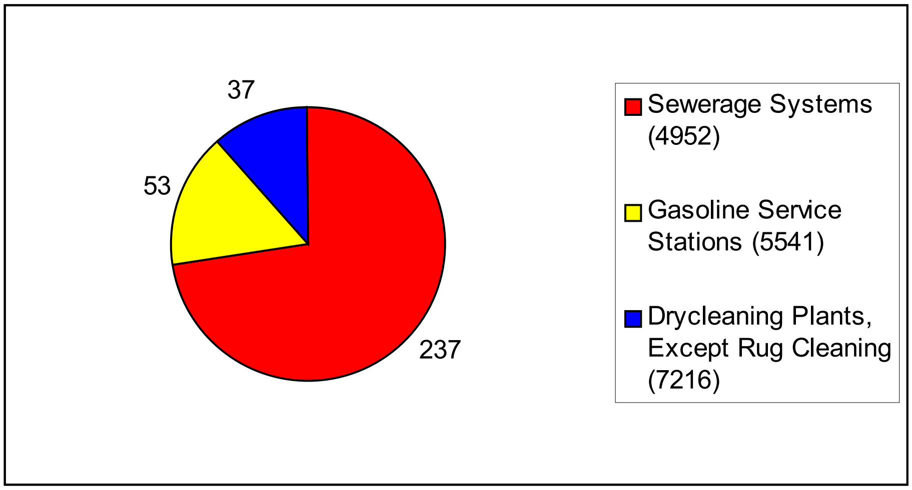
Data from the complete Baxter inventory summarized in Table 2.2.2-1 identifies the most common contaminant source types and the zones in which they are concentrated. The characterization also seeks to find common industries or dischargers and the most common contaminants by category. Source type (PCS, RCRA, etc…) and zone of delineation (A, B, or C) organize the table. Table 2.2.2-1 indicates that a number of sources are found upstream of the Baxter Intake. On a positive note, the least number of sources are found in the area of the watershed within Zone A, 5 hours of travel time. Most sources are found within Zone B, between 5 and 25 hours of travel time. RCRA facilities are the most numerous with greater than 1,700, followed by aboveground storage tanks, and NPDES. There are over 1,500 direct discharges in the watershed upstream of Baxter, however only 150 are within Zone A. These sources are ranked for significance with respect to other criteria, such as contaminant category, quantity, and violations, in section 2.2.4.

Table 2.2.2-1 Summary of Point Source Types Delineation Zone

Source Type	Zone A, < 5hr	Zone B, > 5hr, < 25hr	Zone C, > 25hr	Total Count
AST	149	666	711	1526
CERCLA	116	427	112	655
NP	55	162	313	530
NPDES	137	360	277	774
RCRA	167	760	793	1720
TRI	79	312	116	507
Total	703	2687	2322	5712

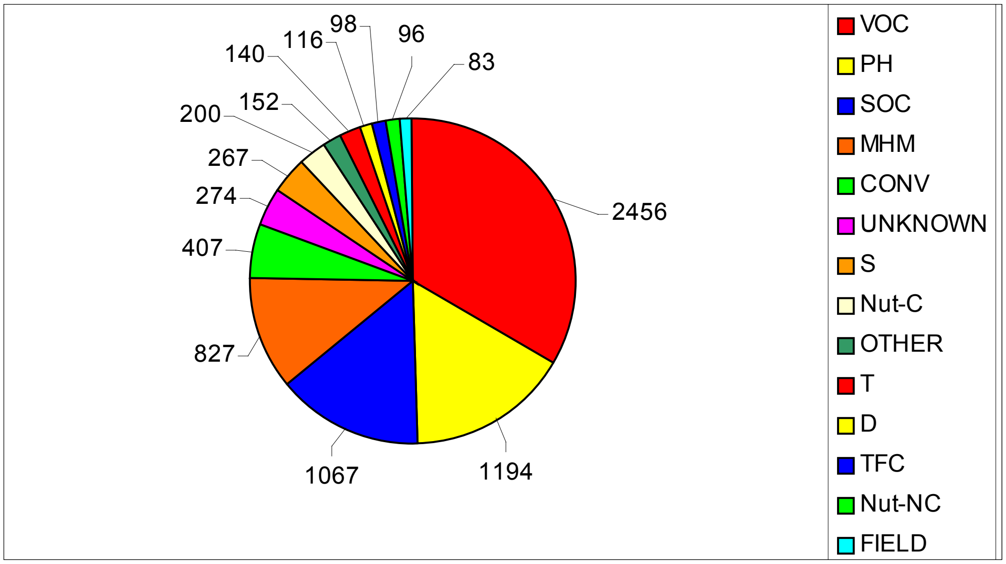
Figure 2.2.2-1 shows the most common industry types based on SIC code, throughout the Belmont delineation zones. The top three industry types are shown. The data is somewhat limited due to the amount of missing SIC codes, especially for the dischargers. Despite its limitations, the data provides an insightful overview of the prevalence of various industry types within the overall delineation zone. Sewerage systems were most numerous (SIC # 4952), followed by gasoline service stations (SIC # 5541), and dry cleaning plants-excluding rug cleaning (SIC # 7216).

Figure 2.2.2-1 Prevalent Industry Types for the Baxter Intake



Similar to Figure 2.2.2-2, parameter groups are summarized based on prevalence throughout the Baxter delineation zones in Figure 2.2.2-1. This is again based on a limited data set. Contaminant information was most complete for TRI sources. With this in mind, available data shows that VOCs are the most common contaminants reported by the sources, followed by petroleum hydrocarbons and SOCs. This is useful for water suppliers to keep in mind in monitoring efforts and surveillance of raw water.

Figure 2.2.2-2 Prevalent Contaminant Categories for the Baxter Intake



PCS Dischargers

A characterization of dischargers or PCS facilities within the Baxter Intake's delineation zone is examined in Table 2.2.2-2. Out of 774 dischargers, 124 are major (>one MGD). Wastewater treatment plants comprise the largest component, 236 of 774, for both major and minor dischargers. After sewerage systems, gasoline and water suppliers are the most common discharger types.

Table 2.2.2-2 PCS Discharger Summary

Total Dischargers	774
Major Dischargers	124
Major Sewerage Systems	81
Facilities with SIC Codes	702
Top 3 Discharge Types by SIC Code 4952 - Sewerage Systems 5541 - Gasoline Service Stations 4941 – Water Suppliers	 236 53 29
Dischargers with Available DMR Data	107
Most Common Parameters with DMR Data	Total Suspended Solids BOD5, Biological Oxygen Demand Flow Rate Carbonaceous BOD5 Ammonia-Nitrogen
Discharge Flow Rate Range (from DMRs)	0 – 40 MGD

Because so many of the dischargers are minor, Discharge Monitoring Report (DMR) data was available for 107 sites. The most common parameters found in the DMRs and effluent limits are indicated in Table 2.2.2-2. The common DMR parameters – TSS and BOD5 - correlate with turbidity and TOC (DBP precursor), which are of concern from a source water perspective. The flow rate poses some concern in drinking water supplies, but metals are much more toxic with respect to human health risks. The prevalence of nutrients is expected due to the number of wastewater plants.

Discharge Monitoring Report (DMR) data for Baxter sources are further summarized in Table 2.2.2-3 based on maximum reported quantities and parameter groups. This summary is quite similar to the entire study area summary presented in Section 1.5, because Baxter's delineation zone covers the majority of the Delaware River Study Area. The parameter groups generally follow those laid out in the PADEP SWAP guidance document. These groupings are used to rank potential contaminant sources in all of the intake report sections.

Since the ranking analysis is based on DMR maximum quantity data, this data is compiled in Table 2.2.2-3 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 releases. Note from Table 2.2.2-3 that this data was available for only 107 of the 702 dischargers in the delineation zone for Baxter. Available data was generally linked to major dischargers.

With that in mind, the data truly represents a worst-case estimate of individual loads being discharged in the study area within the delineation zones of the Baxter Intake.

Table 2.2.2-3 Summary of Available DMR Data

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
CONV	CARBONACEOUS BOD5	1.00000004749745E-03	-	11759	383.775104080529	1450
CONV	CHEMICAL OXYGEN DEMAND, COD	9.00000035762787E-02	-	1547.10205078125	189.457286648671	136
CONV	CHLORINE, TOTAL RESIDUAL	0	-	3191.80004882813	94.7602955698967	34
CONV	CYANIDE, TOTAL	0	-	795.767028808594	157.306528387546	25
CONV	pH	2.99999993294477E-02	-	2.99999993294477	2.99999993294477E-	1
CONV	SOLIDS, DISSOLVED TOTAL ,TDS	85	-	57304	17873.779838562	124
CONV	SULFATE as SO4	10499	-	30113	14105.88	50
CONV	SULFIDE as S	-0.331999987363815	-	0.58300000429153	1.42632910158025E-	79
CONV	TKN (TOT. KIELDAHL NITROGEN)	7.00000002980232E-02	-	131	24.0324657168495	73
D	BOD, CARBONACEOUS 5 DAY,5 C	28	-	51	39.6	5
D	BOD5, BIOLOGICAL OXYGEN DEMAND	-4.88100004196167	-	185656	1509.49896040956	3275
D	OXYGEN DEMAND, ULTIMATE	0.800000011920929	-	486	87.8884285151958	70
FIELD	FLOW RATE	7.00000018696301E-05	-	27984	70.4431161687595	2856
FIELD	TEMPERATURE	0	-	0	0	1
MHM	ALUMINUM, TOTAL	0.28999999165535	-	66	5.69205128153165	39
MHM	ALUMINUM, TOTAL RECOVERABLE	0.266460001468658	-	988	104.001528322697	13
MHM	ANTIMONY TOTAL RECOVERABLE	2.0000000949949E-03	-	0.23399999737739	9.39069761201566E-	43
MHM	ANTIMONY, TOTAL	3.80000006407499E-03	-	139.199996948242	17.5140997436078	31
MHM	ARSENIC, TOTAL	2.0000000949949E-03	-	58	11.1596713735988	7
MHM	ARSENIC, TOTAL RECOVERABLE	0	-	58.5999984741211	9.14406254002824	32
MHM	BARIUM, TOTAL	1.61999999545515E-03	-	151.300003051758	17.1145600409471	27
MHM	BERYLLIUM, TOTAL	3.32999997772276E-03	-	11.6999998092651	3.8083608833258	12
MHM	CADMIUM TOTAL RECOVERABLE	0	-	47.2999992370605	6.51294108041946	34
MHM	CADMIUM, TOTAL	1.9000000320375E-03	-	5.69999980926514	0.486641929905501	31
MHM	CHROMIUM TOTAL RECOVERABLE	9.08399969339371E-02	-	69.5999984741211	26.2245307894129	19
MHM	CHROMIUM, TOTAL	-0.123000003397465	-	68.0999984741211	1.09930142973199	138
MHM	CHROMIUM; HEXAVALENT	0.100000001490116	-	0.18899999558925	0.131333331267039	3
MHM	COPPER TOTAL RECOVERABLE	3.9999998989515E-04	-	2387	81.5398314254041	200
MHM	COPPER, TOTAL	-0.363000005483627	-	340	4.32366071704927	251
MHM	IRON TOTAL RECOVERABLE	9.60000038146973	-	2999	923.140000152588	5
MHM	IRON, TOTAL	9.00000035762787E-02	-	0.32600000500679	0.142999999721845	30
MHM	LEAD TOTAL RECOVERABLE	0	-	141.899993896484	6.98659912343884	55
MHM	LEAD, TOTAL	1.99999995529652E-02	-	22.7000007629395	1.92685759710995	33
MHM	MANGANESE, TOTAL	0.207000002264977	-	2396.97192382813	1300.75285633367	13
MHM	MERCURY TOTAL RECOVERABLE	2.0000000949949E-03	-	208	21.8133479978656	10
MHM	MERCURY, TOTAL	3.9999998989515E-04	-	1.79999995231628	0.550325000745943	8
MHM	NICKEL TOTAL RECOVERABLE	0	-	561	56.7314891499346	23
MHM	NICKEL, TOTAL	1.00000004749745E-03	-	1248	19.2085176412181	79
MHM	SELENIUM, TOTAL	2.0000000949949E-03	-	3.59999990463257	1.6260000000475	4
MHM	SELENIUM, TOTAL RECOVERABLE	0.025000000372529	-	34.7999992370605	18.496428203636	7
MHM	SILVER TOTAL RECOVERABLE	0	-	58.5999984741211	9.93665209728415	23
MHM	SILVER, TOTAL	0	-	69	3.06337056060917	34
MHM	THALLIUM, TOTAL	2.0000000949949E-03	-	58.5999984741211	19.3259993981467	9

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
MHM	ZINC TOTAL RECOVERABLE	-8.03000032901764E-02	-	991	59.1402115677993	256
MHM	ZINC, TOTAL	-2.30000000447035E-02	-	681	16.7642617248631	185
Nut-C	AMMONIA (AS N) + UNIONIZED AMMONIA	2.0000000949949E-03	-	60	16.4262631052039	38
Nut-C	AMMONIA-NITROGEN	0	-	1599	53.8965191134579	1362
Nut-C	NITRATE NITROGEN, TOTAL AS NO3	3.70000004768372	-	37.4000015258789	14.3670732393497	82
Nut-C	NITRATE-NITRITE, NITROGEN	15	-	505	210.25	20
Nut-C	NITRATE-NITROGEN as N	0.159999996423721	-	0.36000001430511	0.258888892001576	9
Nut-NC	PHOSPHORUS, TOTAL as P	-2.83599996566772	-	217	7.03795397646875	639
OTHER	DISSOLVED OXYGEN	0.017000000923872	-	0.01700000092387	0.017000000923872	2
PH	HYDROCARBONS,IN H2O,IR,CC14 EXT. CHROMAT	0	-	42.5	4.09123811516024	21
PH	OIL AND GREASE	0	-	3549	174.351865319046	118
PH	PETROL HYDROCARBONS TOTAL RECOVERABLE	0	-	6.73000001907349	0.54114084144969	71
PH	PETROLEUM HYDROCARBONS, TOTAL	0	-	42.5	4.09123811516024	21
SOC	(DIOXIN) 2,3,7,8-TCDD	0	-	3.46000008285046	1.15400002759998E-	3
SOC	1,2,4-TRICHLOROBENZENE	0	-	37.7999992370605	7.00619988481048	13
SOC	1,2-DICHLOROBENZENE	0	-	37.7999992370605	7.43257680495914	13
SOC	1,2-DIPHENYLHYDRAZINE	6.99999975040555E-04	-	37.7999992370605	10.4534442912878	9
SOC	1,3-DICHLOROBENZENE	0	-	29.2999992370605	5.99788454495585	13
SOC	1,4-DICHLOROBENZENE	0	-	29.2999992370605	5.65817849727214	14
SOC	2,4,6-TRICHLORO- PHENOL	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	2,4-DICHLOROPHENOL	0	-	37.7999992370605	9.55802206116884	9
SOC	2,4-DIMETHYLPHENOL	0	-	75.6999969482422	19.1280215440654	9
SOC	2,4-DINITROPHENOL	0	-	37.7999992370605	9.55842206114903	9
SOC	2,4-DINITROTOLUENE	0	-	37.7999992370605	7.06396415328657	14
SOC	2,6-DINITROTOLUENE	0	-	37.7999992370605	9.55802206116884	9
SOC	2-CHLORONAPHTHALENE	1.00000004749745E-03	-	37.7999992370605	17.2044397101039	5
SOC	2-CHLOROPHENOL	0	-	75.6999969482422	19.1282215440749	9
SOC	2-NITROPHENOL	0	-	37.7999992370605	9.55806650560246	9
SOC	3,3'-DICHLORO- BENZIDINE	1.00000004749745E-03	-	37.7999992370605	10.8337220673889	9
SOC	4,4'-DDD	4.99999987368938E-05	-	1.16999995708466	0.28793499426259	6
SOC	4,4'-DDE (P,P'-DDE)	9.99999974737875E-06	-	1.16999995708466	0.286254993989739	6
SOC	4,4'-DDT (P,P'-DDT)	1.99999994947575E-05	-	1.16999995708466	0.300594995097223	6
SOC	4,6-DINITRO-o-CRESOL	0	-	37.7999992370605	9.55806650560246	9
SOC	4-CHLORO-3-METHYL PHENOL	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	4-NITROPHENOL	0	-	37.7999992370605	9.55806650560246	9
SOC	A-BHC-ALPHA	0	-	0.57999998331069	0.17063999697566	5
SOC	A-ENDOSULFAN-ALPHA	2.99999992421363E-05	-	0.57999998331069	0.172376663813338	6
SOC	ACENAPHTHENE	0	-	15.1000003814697	4.2965000453114	8
SOC	ACENAPHTHYLENE	0	-	15.1000003814697	3.10153080151381	13
SOC	ALDRIN	0	-	0.57999998331069	0.181885710252183	7
SOC	ANTHRACENE	0	-	15.1000003814697	3.11806925680811	13
SOC	B-BHC-BETA	1.79999992251396E-02	-	0.57999998331069	0.234549993649125	4
SOC	B-ENDOSULFAN-BETA	2.99999992421363E-05	-	1.16999995708466	0.314926660388058	6
SOC	BENZIDINE	2.0000000949949E-03	-	151	41.2922776908769	9
SOC	BENZO (A) ANTHRACENE	0	-	15.1000003814697	3.16910772489008	13
SOC	BENZO (A) PYRENE	0	-	15.1000003814697	3.12661428504258	14
SOC	BENZO(B)FLUORANTHENE	0	-	15.1000003814697	3.76153848794862	13
SOC	BENZO(GHI)PERYLENE	6.99999975040555E-04	-	15.1000003814697	4.64319005531142	10

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
SOC	BENZO(K) FLUORANTHENE	0	-	15.1000003814697	3.58004616997026	13
SOC	BHC-DELTA	8.99999961256981E-03	-	0.57999998331069	0.213299996219575	4
SOC	BIS (2-CHLOROETHOXY) METHANE	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	BIS (2-ETHYLHEXYL) PHTHALATE	0	-	257.299987792969	31.4262570620049	19
SOC	BIS(2-CHLOROISOPROPYL)ETHER	1.00000004749745E-03	-	37.7999992370605	9.84386083135614	10
SOC	BUTYLBENZYL PHTHALATE	6.99999975040555E-04	-	37.7999992370605	10.3068887100542	9
SOC	CHLORDANE (TECH MIX. AND METABOLITES)	7.00000018696301E-05	-	5.80000019073486	1.41120502983176	6
SOC	CHRYSENE	0	-	276	22.4044214524121	14
SOC	DI-N-BUTYLPHTHALATE	0	-	37.7999992370605	8.57223828395721	13
SOC	DI-N-OCTYL PHTHALATE	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	DIBENZO (A,H) ANTHRACENE	1.00000004749745E-03	-	15.1000003814697	5.18434450900855	9
SOC	DIELDRIN	9.99999974737875E-06	-	1.16999995708466	0.279921661480936	6
SOC	DIETHYL PHTHALATE	0	-	75.6999969482422	13.892514910343	13
SOC	DIMETHYLPHTHALATE	0	-	75.6999969482422	12.3615929257901	15
SOC	ENDOSULFAN SULFATE	2.99999992421363E-05	-	1.16999995708466	0.313096659777026	6
SOC	ENDOSULFAN, TOTAL	2.99999992421363E-05	-	1.16999995708466	0.270546659104487	6
SOC	ENDRIN	1.99999994947575E-05	-	0.57999998331069	0.156373329099248	6
SOC	ENDRIN ALDEHYDE	1.99999994947575E-05	-	1.16999995708466	0.352761660070125	6
SOC	FLUORANTHENE	0	-	37.7999992370605	6.9352427324962	14
SOC	FLUORENE	0	-	15.1000003814697	3.21043078977471	13
SOC	GAMMA-BHC	1.00000004749745E-03	-	1.0900000333786	0.296025002593524	8
SOC	HEPTACHLOR	0	-	0.57999998331069	0.17063999697566	5
SOC	HEPTACHLOR EPOXIDE	0	-	1.50999999046326	0.457639994472265	5
SOC	HEXACHLOROBENZENE	0	-	37.7999992370605	7.12619990333377	13
SOC	HEXACHLOROBUTADIENE	0	-	37.7999992370605	7.13089989434677	13
SOC	HEXACHLOROCYCLO- PENTADIENE	2.0000000949949E-03	-	37.7999992370605	10.4974776208659	9
SOC	HEXACHLOROETHANE	0	-	37.7999992370605	7.22010757494718	13
SOC	ISOPHORONE	1.00000004749745E-03	-	37.7999992370605	10.3277331807573	9
SOC	N-NITROSODI-N- PROPYLAMINE	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	N-NITROSODIMETHYL- AMINE	1.00000004749745E-03	-	75.6999969482422	20.4058548519517	9
SOC	N-NITROSODIPHENYL- AMINE	3.9999998989515E-04	-	75.6999969482422	18.0851193953713	10
SOC	NAPHTHALENE	0	-	15.1000003814697	2.67493849005013	13
SOC	NITROBENZENE	0	-	37.7999992370605	7.64680760795286	13
SOC	PCB-1016 (AROCHLOR 1016)	7.999999797903E-05	-	5.80000019073486	1.6285466886596	6
SOC	PCB-1221 (AROCHLOR 1221)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1232 (AROCHLOR 1232)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1242 (AROCHLOR 1242)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1248 (AROCHLOR 1248)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1254 (AROCHLOR 1254)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1260 (AROCHLOR 1260)	0	-	5.80000019073486	1.62703335725382	6
SOC	PENTACHLOROPHENOL	1.00000004749745E-03	-	37.7999992370605	17.2044397101039	5
SOC	PHENANTHRENE	0	-	15.1000003814697	2.57865335498548	15
SOC	PHENOL	0	-	58.5999984741211	14.4246245706454	8
SOC	PHENOLS	-6.92000016570091E-02	-	0.87550002336502	8.80762957885626E-	54
SOC	PHENOLS, TOTAL	7.00000002980232E-02	-	25.9419994354248	1.44919116455404	68
SOC	PYRENE	0	-	37.7999992370605	7.36145372217288	13
SOC	TOTAL BASE/NEUTRAL PRIORITY POLLUTANTS	1.30000002682209E-02	-	2.40000009536743	0.620500023476779	4
SOC	TOTAL PCBS	7.00000018696301E-05	-	5.80000019073486	1.91645402727445	5
SOC	TOTAL TOXIC ORGANICS (TTO) (40CFR433)	0	-	0.354999989271164	0.118333329757055	3

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
SOC	TOXAPHENE	1.99999994947575E-04	-	5.80000019073486	1.91510002021338	6
T	SOLIDS,SUSPENDED TOTAL TSS	-40.0400009155273	-	22666	374.490762914408	4817
TFC	FECAL COLIFORM	0.090999998152256	-	0.09099999815225	0.090999998152256	1
VOC	1,1,1-TRICHLOROETHANE	0	-	5.80000019073486	1.89065713704414	14
VOC	1,1,2,2-TETRACHLORO-ETHANE	1.00000004749745E-03	-	6.6399998664856	3.29049001048552	10
VOC	1,1,2-TRICHLOROETHANE	0	-	11.6999998092651	2.86422143944947	14
VOC	1,1-DICHLOROETHANE	3.9999998989515E-04	-	29.2999992370605	8.29546654477276	9
VOC	1,1-DICHLOROETHYLENE	0	-	11.6999998092651	2.71394288404762	14
VOC	1,2-DICHLOROETHANE	0	-	253	26.062999984622	10
VOC	1,2-DICHLOROETHANE, TOTAL WEIGHT	0	-	11.6999998092651	2.96097274287868	11
VOC	1,2-DICHLOROPROPANE	0	-	5.80000019073486	1.29418572520288	14
VOC	1,2-TRANS-DICHLOROETHYLENE	0	-	11.6999998092651	2.79418215662996	14
VOC	1,3-DICHLOROPROPYLENE	0	-	0	0	4
VOC	2-CHLOROETHYLVINYL ETHER	1.00000004749745E-03	-	58.5999984741211	26.3086994278128	6
VOC	4-BROMOPHENYL PHENYL ETHER	2.0000000949949E-03	-	37.7999992370605	17.2048797101248	5
VOC	4-CHLOROPHENYL PHENYL ETHER	2.0000000949949E-03	-	37.7999992370605	17.2048797101248	5
VOC	ACROLEIN	9.99999977648258E-03	-	189.199996948242	59.7657263985073	11
VOC	ACRYLONITRILE	0	-	94.620002746582	25.4213999516486	15
VOC	BENZENE	0	-	5.80000019073486	1.60701430768157	14
VOC	BIS (2-CHLOROETHYL) ETHER	1.00000004749745E-03	-	45	14.0262498330907	10
VOC	BROMOFORM	3.00000014249235E-04	-	5.80000019073486	2.86043001526268	10
VOC	BROMOMETHANE	1.15999998524785E-02	-	58.5999984741211	24.3101597291417	10
VOC	CARBON TETRACHLORIDE	0	-	11.6999998092651	3.07013847874343	13
VOC	CHLOROBENZENE	0	-	11.6999998092651	2.54985715546146	14
VOC	CHLOROETHANE, Total Weight	0	-	58.5999984741211	14.3712196223554	10
VOC	CHLOROFORM	0	-	21.4400005340576	7.350373398792	15
VOC	CHLOROFORM, DISSOLVED	0.236000001430511	-	34.9799995422363	8.11259995102882	10
VOC	CHLOROMETHANE	1.37000000104308E-02	-	58.5999984741211	23.2003697386943	10
VOC	CIS-1,3-DICHLORO PROPENE	7.40000000223517E-03	-	29.2999992370605	7.65253990530036	10
VOC	DIBROMOCHLOROMETHANE	1.99999994947575E-04	-	5.80000019073486	2.37474166746082	12
VOC	DICHLOROBROMOMETHANE	1.00000004749745E-03	-	67.6971969604492	2.34894611380385	65
VOC	ETHYL BENZENE	0	-	0	0	4
VOC	ETHYLBENZENE	3.00000014249235E-04	-	29.2999992370605	7.90842988007935	10
VOC	METHYL BROMIDE (BROMOMTHANE)	6.99999975040555E-04	-	7.999999797903E-	7.49999977415428E-	2
VOC	METHYL CHLORIDE (CHLOROMETHANE))	0	-	2.30000005103648 E-03	5.42857143695333E-04	7
VOC	METHYLENE CHLORIDE	0	-	11.6999998092651	2.44481112163824	18
VOC	TETRACHLOROETHENE	0	-	5.80000019073486	1.54865001422004	20
VOC	TOLUENE	0	-	18.2000007629395	3.54428580829075	7
VOC	TOLUENE, DISSOLVED	3.00000014249235E-04	-	29.2999992370605	9.31272489801995	8
VOC	TOTAL VOLATILE POLLUTANTS	3.00000002607703E-03	-	0.03400000184774	1.20000005699694E-	4
VOC	TRANS-1,3-DICHLORO PROPENE	3.00000014249235E-04	-	29.2999992370605	7.85601989983406	10
VOC	TRICHLOROETHENE	0	-	2.90000009536743	0.657082121963245	19
VOC	TRICHLOROETHYLENE, DISSOLVED	3.00000014249235E-04	-	5.80000019073486	2.26242501903471	8
VOC	VINYL CHLORIDE	0	-	29.2999992370605	6.67649325321351	15
VOC	VOLATILE COMPOUNDS, (GC/MS)	19	-	77.1999969482422	45.3749995231628	4

[1] Quantities in lbs/day unless otherwise indicated

Table 2.2.2-3 shows that total suspended solids 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, such as TSS, of particulates in the water supply, but is a more meaningful measure of performance in drinking water treatment. Microbial data is very scarce, with only one reportable maximum quantities for fecal coliform. Maximum and average ammonia loads are greater than phosphorus loads. The table also indicates the various VOCs and SOCs discharged into the Delaware River. Vinyl chloride has the single largest discharged VOC quantity of 6.7 pounds per day. Relative to the other VOCs, Methylene Chlroide and Tetrachl Oroethene are also large average maximum discharge quantities. Total phenols are the largest discharged quantity of SOCs. Otherwise, quantities are similar across the many synthetic organic compounds. Of the metals, zinc is clearly the largest discharged quantity. High maximum quantities are also reported for aluminum, total chromium, total copper, total nickel, and total zinc. Chromium and lead pose the greatest risk in drinking water.

RCRA/AST Facilities

As summarized in Table 2.2.2-4, RCRA facilities comprise many of the point sources within the Baxter Intake's delineation zone. However, only 387 out of the 1 720 RCRA facilities are designated as "Large Quantity Generators". 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 chemicals and chemical preparations not elsewhere classified, automotive transmission repair shops, electroplating, plating, polishing, etc. facilities, and top, body, and upholstery repair shops and paint shops. A relatively low number of RCRA sites are cited as having violations. Capacity information for use in ranking sites is available for merely ten sites, and contaminant information is not available. A range of 2 to 25 million gallons gives an idea of the capacity for the RCRA sites with available data.

Table 2.2.2-4 RCRA Facility Summary

Total RCRA Facilities	1720
Large Quantity Generators	387
Facilities with SIC Codes	702
<u>Top 5 RCRA Industry Types by SIC Code</u>	
7216 – Drycleaning Plants, Except Rug Cleaning	37
2899– Chemicals And Chemical Preparations, Not Elsewhere Classified	10
7537 – Automotive Transmission Repair Shops	8
3471 – Electroplating, Plating, Polishing, etc.	7
7532 – Top, Body, And Upholstery Repair Shops and Paint Shops	7
RCRA Facilities with Violations	282
RCRA Facilities with Capacity/Volume Data	10
Range of Capacity	2 - 25,000,000 gallons 1 – 3,456,000 gal/day
Most Common Parameters/Contaminants	Not Applicable – no contaminants linked to RCRA downloads

RCRA data was supplemented with Aboveground Storage Tank (AST) information from PADEP. PADEP AST data included useful and detailed information as to tank age, contaminants and volumes. AST data is summarized in Table 2.2.2-5.

Table 2.2.2-5 AST Facility Summary

Total AST Facilities	1526
AST Facility Overlap with RCRA Facilities	73
Total Number of Tanks	4674 Total/1904 ASTs
Tank Capacity Range	200 gal – 8 MG
Tank Age Range (years)	1 – 75
Number of Different Parameters/Contaminants	103
Most Common Parameters and Quantities by Number of Tanks Misc. Hazardous Substance Diesel Fuel Gasoline	 609 tanks/5.1 MG 235 tanks/6.7 MG 192 tanks/18.1 MG
Most Common Parameters/Contaminants and Quantities by Total Volume Heating Oil Gasoline Diesel	 78 MG 18 MG 7 MG

Table 2.2.2-5 shows that 1526 facilities throughout Baxter's delineation zones have aboveground storage tanks. Of those facilities, only 73 overlap with the RCRA facilities. This may be due to RCRA sites also comprising underground storage tanks. The AST data is still useful for characterizing potential contaminant sources in the watershed. Tanks range in capacities from 200 gallons to 8 million gallons and range in age from 1 to 75 years old. Older tanks may pose a greater risk for spills. The tanks contain 103 different substances. The most common of these by volume, as labeled in the original PADEP data, is a non-specific hazardous substance. The specific chemical was not given. After miscellaneous hazardous substances, gasoline and diesel fuels are most common by volume. 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 intake. These factors are considered in the intake specific susceptibility ranking.

TRI Facilities

A summary of TRI sources is presented in Table 2.2.2-6. A facility is listed in the TRI if a chemical from the inventory is used or manufactured on site. These sites are not necessarily dischargers. Data on which chemicals are on–site, quantities of chemicals, and releases are available for the TRI sources. The range of quantities is how much is used or manufactured in a given year. Releases may be to air, water or land. Information on the amount of a given chemical and the chemical released is not provided.

With that in mind, Table 2.2.2-6 indicates that 507 TRI facilities are found in the delineation zone for Baxter. A SIC code is identified for 504 of these industries. SIC codes are linked to activities that PADEP identified in the state SWAP document. Based on activity, most TRI facilities are chemical manufacturers, machine/metalworking shops, or plastics manufacturers.

Chemical and quantity data is very complete for the TRI facilities, however quantities are presented as ranges. Ammonia, copper, toluene, phosphoric acid, and nitric acid are the most common chemicals listed by the various TRI sites. Quantity ranges for these chemicals are shown in Table 2.2.2-6. This amount of substance is not necessarily released into a water body. Limited information is available on the number of releases to water for 507 of the TRI facilities. Based on this, chemical manufacturers have had the most reported number of releases.

Table 2.2.2-6 TRI Facility Summary

Total TRI Facilities	507
Facilities with SIC Codes	504
Top 3 Industry Types by Activity	
Chemical Manufacturing	115
Machine/Metalworking Shops	83
Plastics Manufacturing	63
Top 3 TRI Industries by SIC Code	
2819	15
2899	15
2851	15
Facilities with Quantity Data	12
Most Common Parameters for Facilities with Quantity Data	
Ammonia	37
Copper	20
Toluene	17
Phosphoric Acid	16
Nitric Acid	14
Facilities with Release Data	312
Facilities with Greatest Number of Releases	
Horsehead Development Co. Inc.	168 releases to water
Zinc Corp. of America	168 releases to water
Ashland Chemical Inc.	105 releases to water

CERCLA Facilities

Although data for CERCLA facilities is limited, Table 2.2.2-7 summarizes the available information within 25-hour time of travel and beyond for the Baxter Intake. Six hundred and fifty-five CERCLA facilities are in the Baxter delineation zone, but only 34 are on the final National Priority List. Information for 35 of the CERCLA facilities is available through the RCRA and TRI databases, where those facilities are also listed. Only 63 sites are found in the flood plain.

Table 2.2.2-7 CERCLA Facility Summary

Total Number of CERCLA Facilities	655
Number on the NPL List	34
Number also listed as RCRA	29
Number also listed as TRI	6
Number in Flood Plain	63

2.2.3 Runoff Loading Summary

Key Points

- **The Delaware River Runoff Loading Model was developed to estimate contaminant loadings to the river from storm runoff.**
- **The model uses the physical characteristics of the subwatersheds, meteorological data, updated land use information, and event mean concentrations for the nine parameters of interest to estimate average daily contaminant loadings within each of the Baxter Intake's zones of contribution.**
- **The developed land areas associated with industrial/commercial land use and residential uses are estimated to contribute the highest per-acre loadings of most of the contaminants evaluated, including disinfection by-products, metals, nutrients, petroleum hydrocarbons, salts and coliforms.**
- **Unit *Cryptosporidium* and turbidity loadings are higher from agricultural areas.**

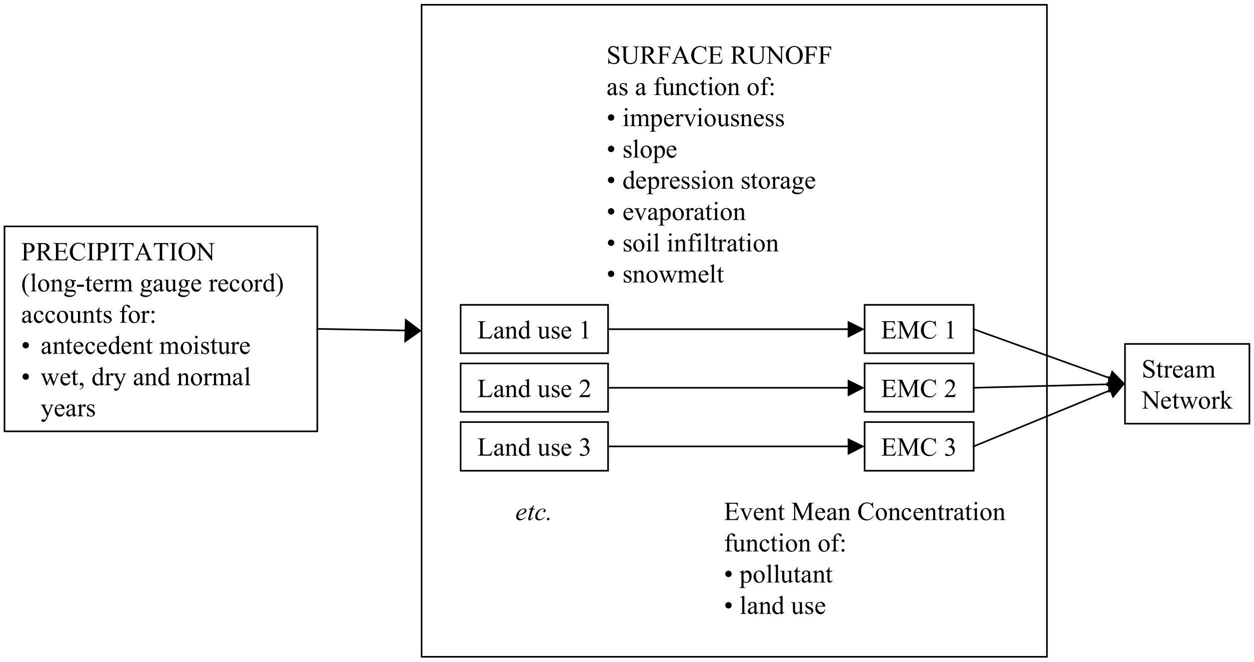
The Delaware River Source Water Assessment Partnership developed the Delaware Runoff Loading Model (DRLM) in an effort to estimate pollutant loads from rainfall runoff throughout the watershed. The DRLM results provide information on the relative contributions of surface runoff from various land use categories, as well as from different geographical areas. The procedure incorporates collection of data, model development and simulation, and post-processing of output data for further use in the susceptibility analysis. A database management system (DBMS) was created to assist with storing parameter data, creating the model, and post-processing model outputs.

2.2.3.1 Method

The RUNOFF Module of the U.S. EPA's Stormwater Management Model (SWMM) simulates rainfall-runoff quantities and quality at specified inlet locations. Figure 2.2.3-1 displays the structure of the SWMM RUNOFF Module. The model inputs subshed parameters, rainfall time-series, climatic data, and event mean concentrations (EMCs) for the land use categories, and outputs annual and monthly pollutant loads for the length of the simulation period. The model incorporates infiltration, depression storage, and roughness to estimate runoff flow and ultimately, runoff pollutant quantities.

The amount of a particular pollutant reaching the receiving stream is dependent on the volume of surface runoff and the concentration of that constituent in the runoff. An EMC is the total mass load of a pollutant yielded from a site during a storm divided by the total runoff water volume discharged during the storm. EMCs are related to the constituent of interest and the land use type. For a subshed, the surface runoff from a particular land use predicted by SWMM RUNOFF, is multiplied by the EMC for that land use type to yield a loading rate.

Figure 2.2.3-1 Watershed Loading Model Schematic Diagram



Subcatchments

The subcatchments of the Delaware River Watershed ultimately drain into the Chesapeake Bay. The Delaware Watershed Study area is composed of 391 subwatersheds and the area tributary to the PWD Baxter Intake includes 217 of the 391 subwatersheds, about 52% of the Delaware Watershed Study area. The subwatersheds were further divided into land use categories to track the contributing pollutant loads from each land use category. The land use categories were based on the USGS's NLCD dataset updated with 2000 Census data for residential and commercial areas, as detailed in Section 1.2.5.

The land use categories distinguish the amount of rainfall that runs off the surface of the subwatershed, as opposed to infiltrating into the subsurface or entering the atmosphere through evapotranspiration. For example, during a storm, more rainfall runs off from a residential area than from a forested area, since there are more impervious surfaces such as driveways, roads, and buildings in developed areas. The forested area retains more of the rainfall, which either infiltrates into the ground or evaporates. For modeling purposes, the land use categories were summed for each subwatershed in order to track individual land use loading contributions to the totals for each subwatershed. Figure 2.2.3-2 and Table 2.2.3-1 below summarize the land use characterization for the Delaware River Watershed Study area within the Zone B delineation for the PWD Baxter Intake and reflects modifications in residential development and increases in commercial areas based on increases in populations from the Census Bureau. For the defined area, 75% is characterized as agriculture, forests, and wetlands. Developed and urbanized areas account for about 23% of the Zone B delineated area for the PWD Baxter Intake.

Figure 2.2.3-2 Land Use Characterization for PWD Baxter Intake Zone B

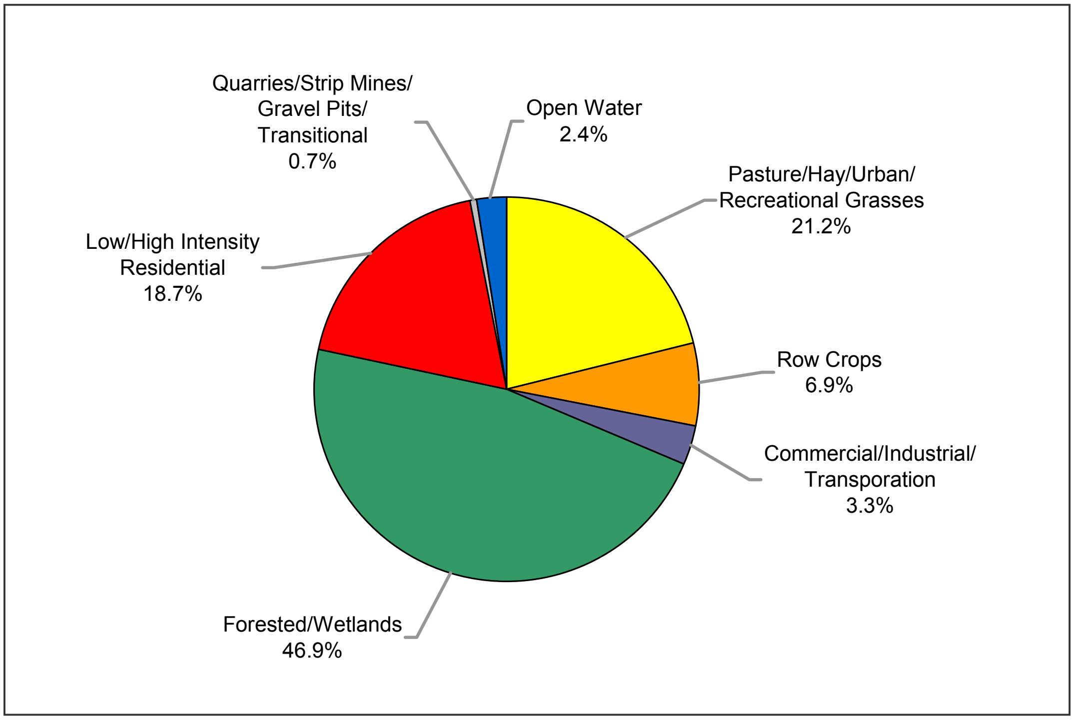


Table 2.2.3-1 Updated Land Use Categories

Land Use Subcategory	Area (acres)	Percentage of Zone B Delineated Area
Pasture/Hay/Urban/Recreational Grasses	439,302	21.2%
Row Crops	142,534	6.9%
Commercial/Industrial/Transporation	68,489	3.3%
Forested/Wetlands	972,877	46.9%
Low/High Intensity Residential	387,882	18.7%
Quarries/Strip Mines/Gravel Pits/Transitional	14,207	0.7%
Open Water	48,982	2.4%

The percentage of impervious area for all land use categories, excluding residential, were estimated according to values extracted from the Water Management Model (WMM) and adjusted during the calibration. The percentage of impervious area for residential areas was calculated using Hick's methodology, which calculates the percentage of total impervious area as a function of the population density.

For pervious areas, the portion of precipitation that runs off is affected by slope, depression storage, infiltration, vegetative cover, and evapotranspiration. Infiltration is determined primarily by the type of soil. The SWMM RUNOFF Module simulates infiltration using the Green-Ampt theory for both saturated and unsaturated soils. The Green-Ampt infiltration routine relates infiltration rate to the moisture conditions of the surface and the total volume of rainfall infiltrated. For the SLRM, the soil information was downloaded from the Natural Resources Conservation Service (NRCS) and the soils GIS coverage was intersected with subwatersheds to identify the soil types in each subwatershed.

Event Mean Concentrations (EMCs)

Applying EMCs to calculated runoff volumes provides reasonable estimates of runoff pollutant loadings. EMCs for the soluble pollutant categories were assigned according to the land use category. The SWMM RUNOFF Module allows the model to assume a constant concentration of a constituent for the duration of the storm event. The quantity of a constituent in surface runoff is a function of constant EMCs associated with the land use categories. The RUNOFF model water quality parameters included *Cryptosporidium*, disinfection by products, metals and heavy metals, conservative nutrients, non-conservative nutrients, petroleum hydrocarbons, salts, turbidity, and total/fecal coliform. For each of these contaminant types, a surrogate constituent was selected. For example, chloride was used as the surrogate for salts and the EMCs for chloride were used in the model. The complete list of EMCs can be found in Appendix .3.

Runoff volumes are computed for each land use category based on percent imperviousness of the land use, annual rainfall, slope of the subwatershed, evaporation, infiltration, and depression storage. This analysis was performed on a subwatershed-by-subwatershed basis and the results were used to determine load distributions according to the land use category. The pollutant mass load estimate is computed for each land use within each subwatershed as a product of the EMC and the surface runoff. By estimating the pollutant loading over the area of a land use type within a subwatershed and summing for all land uses, the total pollutant load from a subwatershed can be computed.

Meteorological Data

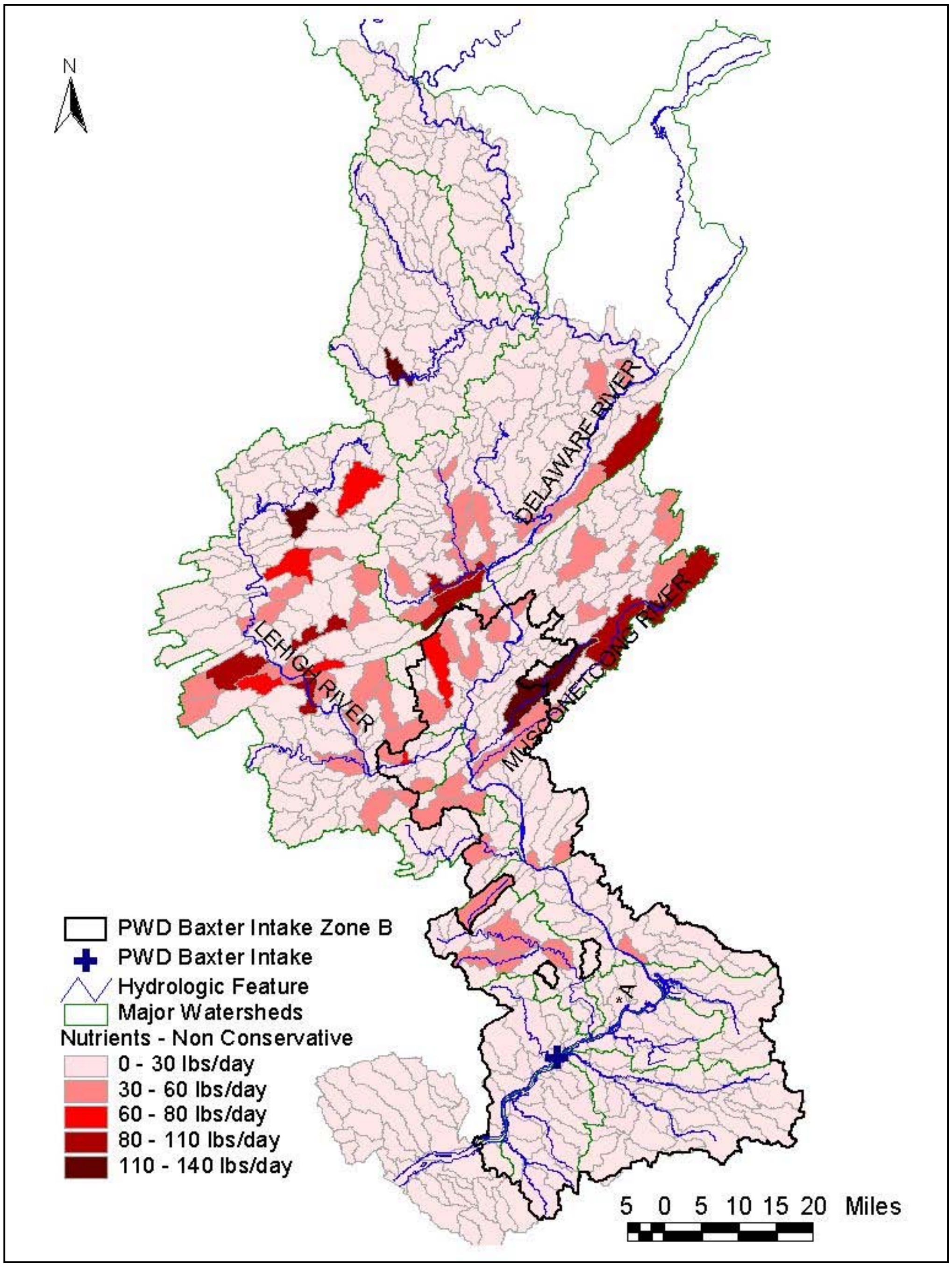
The amount of surface runoff is primarily driven by the precipitation. Long-term climate and precipitation records were used to drive the hydrology of the system. Using a long-term record represents a wide range of hydrologic conditions that occur in a given climate. Using a long-term record on a continuous basis accounts for antecedent moisture conditions and more accurately represents initial conditions at the beginnings of storm events. Snowfall and snowmelt affect the quantity and timing of surface runoff during the winter months and have been included in the long-term continuous simulation.

If available, rainfall, wind, and temperature data for a period of over ten years (1990-2000) were collected for RUNOFF model simulations. The hourly rainfall data were obtained from the National Weather Service (NWS) at stations in and surrounding the Delaware River Watershed. The hourly data was further discretized into 15-minute increments. To account for snowmelt, the daily minimum and maximum temperatures and average monthly wind speeds were obtained for the period of simulation.

2.2.3.2 Results

The DRLM was used to quantify contaminant loads for all pollutant categories included in the susceptibility analysis except for volatile organic compounds. Generally, the greater contaminant loads are found in the lower portion of the watershed. These areas tend to have more development, and thus greater impervious surfaces and runoff volumes. Figure 2.2.3-3 shows the results for the watershed for non-conservative nutrients for which the surrogate phosphorus was chosen. The darker areas, representing higher load estimates, are located closer to streams and rivers and are observed to be further downstream in the watershed. The lighter areas are less developed and less surface runoff results from rainfall events. The subwatersheds with greater pollutant loads tend to be distributed both within the Zone B delineation for the PWD Baxter Intake and along the major hydrologic features.

Figure 2.2.3-3 Non-Conservative Contaminant Runoff Loadings



The Zone A delineated area for an intake is defined as the area within a five-hour time of travel of the water supply intake, including one-quarter mile downstream and within a one-quarter mile wide area on either side of the stream from the intake. For the contaminant loads from rainfall-runoff, Zone A includes parts of the Neshaminy, tidal PA Bucks, Crosswicks, tidal PA Philadelphia, tidal NJ Upper, tidal NJ Lower and Rancocas subwatersheds.

Zone B for PWD’s Baxter Intake encompasses Zone A and area further upstream in the Delaware Watershed including the NJ Mercer direct, PA Bucks direct, Tohickon, Middle Delaware and Lehigh subwatersheds. Since Zone B encompasses a larger area, the pollutant loads are greater for Zone B than for Zone A. As previously described, the area contained in the Zone B delineation is about 23% impervious surfacesThe average daily contaminant loadings for each of the Baxter Intake zones are summarized below by Table 2.2.3-2.

Table 2.2.3-2 Calculated Average Daily Contaminant Loadings

Zone	Area	*Cryto-sporidium*	Disinfection by Products	Metals and Heavy Metals	Conservative Nutrients	Non-Conservative Nutrients	Petroleum Hydrocarbons	Salts	Turbidity	Total/Fecal Coliforms
	(acres)	(oocysts/day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(coliforms/day)
A	1,321,111	4.4E+08	24320	95	5744	742	8932	54801	7.4E+05	1.5E+13
B*	131,219	1.7E+09	88384	334	26851	3939	28858	185445	3.5E+06	5.0E+13
Total A&B	1,452,330	2.1E+09	112703	429	32595	4681	37789	240246	4.2E+06	6.5E+13

** Zone B values exclude Zone A*

On a smaller scale, the contributions from each of the major subwatersheds are summarized in Tables 2.2.3-3 and 2.2.3-4 below. Table 2.2.3-3 summarizes the total daily loads for each major subwatershed listed from upstream to downstream in the Delaware Watershed. Since only portions of some major subwatersheds are included in the Zone B delineation and the sizes of the subwatersheds vary, the values listed in Table 2.2.3-4 are the total daily loads divided by the contributing area of each major subwatershed. This provides a load per acre per day value.

Table 2.2.3-3 Daily Contaminant Loads for Major Subwatersheds

Majorshed*	Area (acres)	*Crytosporidium* (oocysts/day)	Disinfection by Products (lbs./day)	Metals/Heavy Metals (lbs./day)	Conservative Nutrients (lbs./day)	Non-Conservative Nutrients (lbs./day)	Petroleum Hydrocarbons (lbs./day)	Salts (lbs./day)	Turbidity (lbs./day)	Total/Fecal Coliforms (coliforms/day)
Crosswicks	92,066	7.2E+07	4,414	16	927	124	1,856	10,117	5.4E+04	2.9E+12
Lehigh	75,412	1.0E+09	55,630	227	17,252	2,461	17,975	123,595	2.7E+06	3.1E+13
Middle Delaware	379,996	1.4E+09	73,871	294	22,891	3,276	23,986	160,352	3.3E+06	4.2E+13
Neshaminy	135,263	3.1E+08	16,417	60	4,881	757	5,158	33,493	6.7E+05	9.1E+12
NJ Mercer direct	102,094	1.1E+08	5,510	17	1,529	238	1,838	9,993	1.0E+05	3.3E+12
PA Bucks direct	53,740	8.6E+07	3,913	11	1,500	244	1,042	6,023	1.2E+05	2.0E+12
Rancocas	225,815	1.7E+08	10,826	44	2,437	286	4,518	27,246	2.9E+05	6.9E+12
Tidal NJ lower	117,273	7.9E+07	4,697	18	1,094	134	1,949	10,866	7.5E+04	3.1E+12
Tidal NJ upper	69,183	6.1E+07	3,670	13	798	114	1,509	8,111	4.1E+04	2.4E+12
Tidal PA Bucks	36,423	5.0E+07	2,587	12	559	66	860	6,322	1.4E+05	1.4E+12
Tidal PA Philadelphia	101,377	1.5E+08	8,056	34	1,882	226	2,719	18,146	3.3E+05	4.8E+12
Tohickon	36,493	1.2E+08	5,205	13	2,239	387	1,219	6,884	1.7E+05	2.4E+12

** Areas reflect portions of the majorshed within the boundary of the Zone B delineation.*

Table 2.2.3-4 Daily Contaminant Loads per Acre for Major Subwatersheds

Majorshed*	Area (acres)	*Crytosporidium* (oocysts/day-acre)	Disinfection by Products (lbs./day-acre)	Metals/Heavy Metals (lbs./day-acre)	Conservative Nutrients (lbs./day-acre)	Non-Conservative Nutrients (lbs./day-acre)	Petroleum Hydrocarbons (lbs./day-acre)	Salts (lbs./day-acre)	Turbidity (lbs./day-acre)	Total/Fecal Coliforms (coliforms/day-acre)
Crosswicks	92,066	781	4.8E-02	1.7E-04	1.0E-02	1.3E-03	0.020	0.110	0.584	3.2E+07
Lehigh	75,412	954	5.9E-02	2.1E-04	1.2E-02	1.6E-03	0.025	0.134	0.713	3.9E+07
Middle Delaware	379,996	189	1.2E-02	4.1E-05	2.4E-03	3.3E-04	0.005	0.027	0.142	7.7E+06
Neshaminy	135,263	532	3.3E-02	1.2E-04	6.8E-03	9.2E-04	0.014	0.075	0.398	2.2E+07
NJ Mercer direct	102,094	705	4.3E-02	1.5E-04	9.1E-03	1.2E-03	0.018	0.099	0.527	2.9E+07
PA Bucks direct	53,740	1,339	8.2E-02	2.9E-04	1.7E-02	2.3E-03	0.035	0.188	1.001	5.4E+07
Rancocas	225,815	319	2.0E-02	7.0E-05	4.1E-03	5.5E-04	0.008	0.045	0.238	1.3E+07
Tidal NJ lower	117,273	613	3.8E-02	1.3E-04	7.9E-03	1.1E-03	0.016	0.086	0.459	2.5E+07
Tidal NJ upper	69,183	1,040	6.4E-02	2.3E-04	1.3E-02	1.8E-03	0.027	0.146	0.778	4.2E+07
Tidal PA Bucks	36,423	1,975	1.2E-01	4.3E-04	2.5E-02	3.4E-03	0.051	0.278	1.477	8.0E+07
Tidal PA Philadelphia	101,377	710	4.4E-02	1.6E-04	9.1E-03	1.2E-03	0.018	0.100	0.531	2.9E+07
Tohickon	36,493	1,971	1.2E-01	4.3E-04	2.5E-02	3.4E-03	0.051	0.277	1.474	8.0E+07

** Areas reflect portions of the majorshed within the boundary of the Zone B delineation.*

The contaminant loading results for the area within Zone B, including Zone A, for the Baxter Intake are summarized below:

Cryptosporidium: The areas of highest pollutant estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the highest load intensity occurs in the Tidal PA Bucks and Tohickon Subwatersheds.

Disinfection by-Products: The higher EMCs for disinfection by-products are associated with developed land use categories such as commercial/industrial/ transportation and residential. The areas of highest pollutant estimates are located in the Middle Delaware Subwatershed, with relatively high loading also occurring in the Lehigh and Neshaminy Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal PA Bucks and Tohickon Subwatersheds.

Metals/Heavy Metals: The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh subwatersheds. On a per acre basis, the most concentrated loading occurs in the Neshaminy Subwatershed followed by Tidal NJ Lower, NJ Mercer Direct, and Tidal PA Philadelphia.

Conservative Nutrients: The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh subwatersheds. On a per acre basis, the most concentrated loading occurs in the Crosswicks and Lehigh Subwatersheds.

Non-conservative Nutrients: The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal NJ Lower and Tidal PA Philadelphia Subwatersheds.

Petroleum Hydrocarbons: The highest EMCs for petroleum hydrocarbons are associated with commercial/industrial/transportation areas, followed by residential land use categories. The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. Other relatively high loading areas are noted in the Neshaminy and Rancocas Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal PA Bucks and Tohickon Subwatersheds.

Salts: The higher EMCs for salts are associated with developed land use categories such as commercial/industrial/transportation, mining, and residential. The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal PA Bucks, Tohickon, and PA Bucks Direct Subwatersheds.

Turbidity: The highest EMCs for turbidity are associated with agricultural and forested areas, followed by wetlands, then developed land use categories. The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis Tidal PA Bucks, Tohickon, and PA Bucks Direct Subwatersheds have the highest loading concentrations.

Total/Fecal Coliform: the areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Middle Delaware Subwatershed.

The summary of the results from the DRLM show the pollutant loads over the entire watershed from each of the smaller subwatershed. The contaminant loads are not only dependent on the land use type, but also on soil properties, subwatershed slopes, depression storage, and climate conditions. The estimates from the DRLM were further used in the qualitative loading analysis portion of the susceptibility analysis.

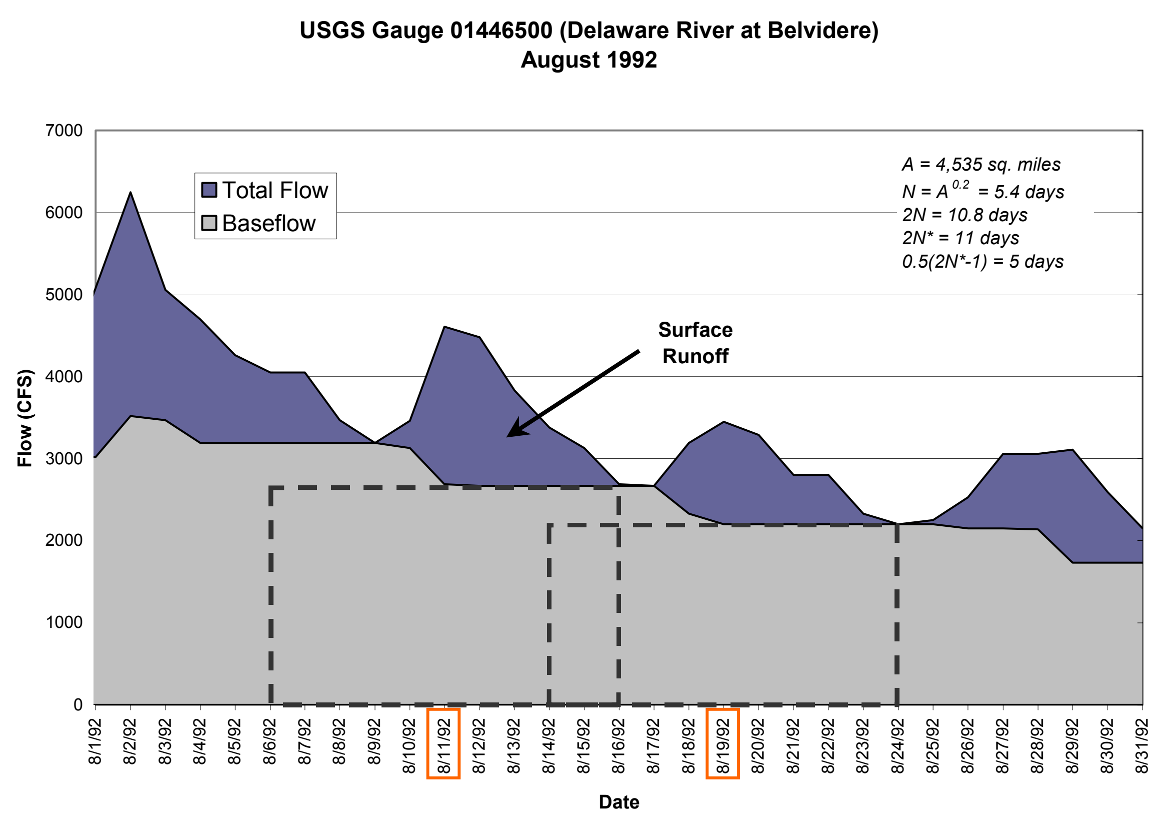
2.2.3.3 Hydrograph Separation for Baseflow and Runoff Calibration

In order to assess the reliability of the pollutant loads from SWMM, a hydrograph separation analysis was performed to compare with estimated runoff quantities and water quality loads from the DRLM. A hydrograph separation program was created in SAS® to divide the total flow into baseflow and surface runoff. This program was modeled after the USGS's HYSEP computer program, but assumes only one of its three hydrograph separation methods, the sliding-interval method. The hydrograph separation yields total flow, baseflow, and runoff values in daily, monthly, seasonal, and annual averages. The daily average flows were obtained from the USGS for gauges located in the Delaware River Basin.

The sliding-interval method associates a baseflow with a selected day by taking an equal interval before and after that day and assigning the lowest discharge to that day. The intervals are calculated based on the drainage area. For example, as shown in Figure 2.2.3-4, the drainage area for the USGS gauge located on the Delaware River at Belvidere is 4,535 square miles and the interval after surface runoff is 5.4 days. The interval for finding the baseflow is applied before and after a specified day. Thus, total duration is twice the calculated interval (10.8 days) and then rounded to the nearest odd number greater than that value (11 days) to include the interval before and after that day as well. Three is the minimum duration used in the sliding interval method. The selected day should be the median with equal duration before and after to associate the lowest discharge within the entire interval. For the Delaware River at Belvidere, the total interval is eleven days and the "windows" for August 11th, 1992 and August 19th, 1992 are displayed in Figure 2.2.3-4. The baseflow designated to August 11th, 1992 is 2,690 cubic feet per second (cfs) and August 19th, 1992 is 2,200 cfs.

The surface runoff is the difference between the total streamflow and the baseflow, as described above. In Figure 2.2.3-4 the area shaded blue is the remainder of the total flow that is designated as surface runoff.

Figure 2.2.3-4 Hydrograph Separation Analysis for the Delaware River at Belvidere for August 1992



The hydrograph separation was conducted for the active USGS gauges in the Delaware River Watershed. The values are average annual flows in cubic feet per second and inches per year for the period of record available for each gauge. The percent runoff is the amount of total flow that is assumed to be surface runoff. The total flow, baseflow, and runoff values were converted to inches per year by dividing the flows by the drainage area.

Since there is seasonal variation in the flows, the average baseflow and surface runoff values were also calculated by season. Generally, the average seasonal baseflow was highest in the spring, winter, summer, then fall (in descending order). Often the average seasonal baseflow was two to three times greater in the spring than the summer. Seasonal surface runoff for the winter, spring, summer, and fall averaged 9.9, 9.5, 4.7, 6.1 inches per year, respectively.

The USGS streamflow hydrograph separation results were used to calibrate the results from the DRLM. Since there is evidence of seasonal variability, the calibration of the DRLM was done on a seasonal basis. Comparing the simulated values with the hydrograph separation results, parameters in the DRLM were further refined.

2.2.4 Susceptibility Analysis

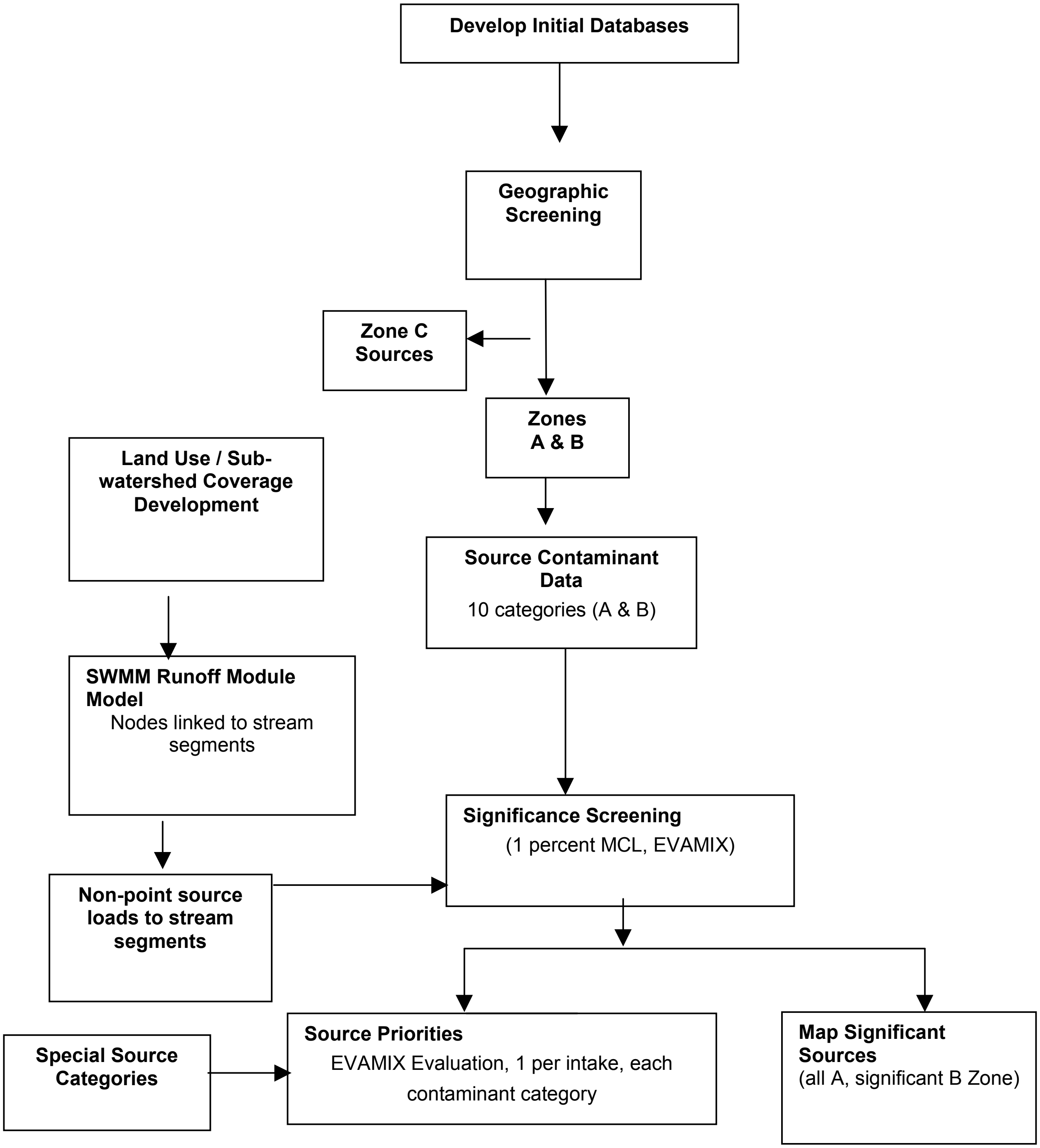
Key Points

- **A series of screenings was used to identify those sources that have the greatest potential to affect water quality at the Baxter Intake.**
- **Five non-conservative contaminant categories and five conservative contaminant categories were selected to represent all potential contaminants.**
- **For each category, a threshold value indicative of the significance of the concentrations of contaminants that could result from a potential spill or discharge was defined.**
- **EVAMIX, a multi-criteria software package was used along with information from the Technical Advisory Group, to prioritize the potential significance of each of the potential point sources within Baxter's Zone A and Zone B, and to evaluate the potential significance of non-point sources estimated by the Delaware River Runoff Loading Model.**
- **NPDES and non-point source discharges within the Baxter Intake's Zone A and Zone B were determined to have the highest protection priorities in the watershed.**
- **The potential significance of each source of contamination was designated A (potentially significant source of highest protection priority) through F (potential source of lowest protection priority). Those sources ranked A through C are potentially significant sources of contamination to the Baxter Intake.**
- **All of the highest ranked sources are either NPDES sites or storm water loadings from specific sub-watersheds.**
- **Contaminant sources actually discharging to the river (e.g., NPDES permitted point sources, or stormwater runoff) are estimated to have greater potential significance than those with only the potential to release contaminants to the River (e.g., a spill or leak).**
- **EVAMIX was also used to rank potential sources for each contaminant category.**

2.2.4.1 Method

Because of the large number of potential sources of contamination that have been identified, the method behind the susceptibility analysis relies on a process of successive screenings. These screenings help focus the efforts of source water protection on those sources that have the greatest potential to affect the water quality of the source water at the intake. The process of screening is shown in Figure 2.2.4-1, and described in this section. The section starts with an introduction to the ten contaminant categories being considered.

Figure 2.2.4-1 Source Prioritization Flow Diagram



Contaminant Categories

There are two difficulties faced in trying to prioritize potential sources of contamination of the drinking water. Because the Delaware River Watershed is very large, there are thousands of potential sources to be assessed. In addition, the assessments must also cover a full range of contaminant types. The PADEP guidance indicates that the best approach is to try to group all potential contaminants into a limited number of contaminant groups, and then assess all sources for each of the contaminant categories. For this study, ten contaminant categories have been developed. For each category, a planning level threshold concentration based either on ambient water quality in the river, or on regulatory standards such as the drinking water standard has been developed. This threshold value is used as a relative measure of the significance of contaminant concentrations that could potentially occur due to a spill or discharge from each of the sources. Each category is summarized below.

Non-Conservative Contaminants

There are five contaminant categories that can be considered "non-conservative" contaminants. Once spilled or discharged into the river, the concentration that results will decrease as the spill moves downstream, either because the contaminant dies off, evaporates into the air, or attaches itself to silt particles and settles to the bottom of the river. The non-conservative contaminant categories are:

1. Total/Fecal Coliform: Fecal coliform is used as the indicator contaminant for this category. The suggested threshold value is the recreational water standard of 200 count/100 ml. Fecal coliform tends to die off over time within the river.

2. Turbidity: Turbidity can be measured directly, but most existing data relates to Total Suspended Solids (TSS), and this is used as an indicator for turbidity. The suggested threshold comes from median ambient conditions in the river, of approximately 10 mg/l. TSS tends to settle to the bottom of the river over time.

3. Nutrients: There are several contaminants in the nutrient category. Phosphorous was selected as one indicator for this category. The suggested threshold value comes from the median ambient conditions in the river, of approximately 0.12 mg/l. Some portion of the total phosphorus concentration is associated with phosphorus adhering to silt particles, which tend to settle to the bottom of the river over time.

4. VOC/SOC: This category is particularly challenging because it includes hundreds of compounds. To meet this challenge, it was decided that the total amount of VOC/SOC present at a site would be used as an indicator for this category. Because there are so many different potential threshold values for this large and diverse category, a very conservative threshold of 5 ug/l is used. This is the drinking water standard for benzene, as well as many other toxic solvents. By comparing the total VOC/SOC concentration generated by a spill or discharge with this conservative threshold, even small spills or discharges will be deemed significant. VOCs and some SOCs can evaporate or "volatilize" from the river, others can attach themselves to silt and settle to the bottom of the river. Both have the effect of reducing concentrations in the river over time.

5. Metals: This category is also challenging because numerous metals are included. The total amount of metals present at a site is used as an indicator. Because there are many different potential threshold values for various metals, a conservative threshold of 0.015 mg/l was selected. This is the regulatory standard for lead in drinking water, and is lower than for most metals. Most metals tend to attach themselves to silt and settle to the bottom of the river, reducing concentrations in the river over time.

Conservative Contaminants

Five contaminant categories can be considered to be "conservative". Concentrations of conservative contaminants are only affected by dilution, and do not decrease through other means. The five categories are:

6. *Cryptosporidium/Giardia*: A potential threshold value is difficult to define for this important potential contaminant category for surface water sources. A value of only 1 oocyst per liter has been selected for a screening threshold based on potential health impacts.

7. Nutrients: Nitrate, a second, common nutrient was also selected for analysis because of its prevalence in the watershed. The drinking water standard of 10 mg/l was used for the threshold value.

8. DBP Precursors: Disinfection by-products are a concern for drinking water systems that disinfect with chlorination. A good indicator for this contaminant category is Total Organic Carbon (TOC). The threshold value was set based on the median ambient concentration in the river of approximately 2.7 mg/l.

9. Petroleum Hydrocarbons: Oil and oil-based products are common contaminants. This category contains a large variety of individual contaminants, and Total Petroleum Hydrocarbons (TPH) was chosen as the indicator contaminant. A threshold value of 5 mg/l was selected, based primarily on standards applied at hazardous waste site remediation.

10. Salts: For this category, chloride was selected as the indicator contaminant. The drinking water standard of 250 mg/l was selected as the threshold value.

Zone Based Screening

The first screen applied to eliminate less important potential sources makes use of the zone concept recommended by PADEP for use in the SWAP:

- Zone A: the critical segment covering ¼ mile on either side of the stream upstream of the intake within a 5-hour travel time to the intake. All potential sources within this zone are included in the subsequent steps.

- Zone B: a second segment located within 2 miles of either side of the stream upstream of the intake, within a 25-hour travel time to the intake. All potential sources within this zone are also included in the subsequent steps.

- Zone C: the rest of the upstream watershed. These sources remain listed in the database, but are eliminated from further analysis because they are deemed less significant than sources in zones A and B.

The PADEP zone concept is used to narrow the list of sources down to include only those with higher priority. Potential sources within Zone C sources are dropped from further analysis within this preliminary assessment, leaving those sources within zone A or B for the intake.

Multi-Criteria Evaluation (EVAMIX)

Following the zone based screening, the most important screening and evaluation method used for most of the analysis relied on a multi-criteria evaluation software package called EVAMIX. EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation, regardless of the units of measure. The algorithm behind EVAMIX is unique in that it maintains the essential characteristics of quantitative and qualitative criteria, yet is designed to eventually combine the results into a single appraisal score. This critical feature gives the program much greater flexibility than most other matrix based evaluation programs, and allows the evaluation team to make use of all data available to them in its original form.

EVAMIX makes a pair by pair comparison of all contaminant sites under evaluation across all evaluation criteria, resulting in thousands of computations. The computations eventually result in an overall appraisal score. This is a single number, attached to a single alternative, and represents the overall worth of that alternative relative to the other alternatives based on the criteria selected, and the weights attached to the criteria. This number is used to determine the final ranking of alternatives from best to worst, or most important to least important.

EVAMIX offers several important advantages when used in planning studies:

- The alternatives under consideration are clearly defined

- The criteria used in evaluating the alternatives are explicit and measurable

- The algorithm can handle both quantitative and qualitative data, utilizing all available data to the highest degree of measurability possible

- The priorities underlying the evaluation are made explicit, and can be flexibly applied to highlight the effect that weighting has on the final ranking

- The technique is flexible enough to handle new data as it becomes available

- The technique is applied using widely available software (Excel spreadsheets)

The use of EVAMIX requires the development of a two dimensional matrix consisting of the options to be evaluated (columns) and a set of evaluation criteria (rows). For every combination of options and criteria, a score is assigned. The choice of the criteria is governed, in part, by the need for the scoring to be as objective as possible. By objective, we mean that the scores should represent impartial data and information useful in making decisions. The criteria must be clear and unambiguously defined, and can be set up as either quantitative criteria (e.g. threshold concentration in percent, time of travel in hours), or qualitative criteria (e.g. discharge frequency, location etc.).

The other input variable required for the evaluation procedure is the selection of weighting factors for each of the criteria. While the scoring process strives to be as objective as possible and is carried out by the project team, the selection of weights is inherently subjective and should be done by the decision-makers, planners, or stakeholders. Unlike the matrix of scores, numerous possible weight sets are possible, and all are equally "valid".

A workshop was held in June 2001 at which members of the Technical Advisory Group for the Schuylkill River participated in an exercise designed to develop a representative set of criteria weights. Since the TAG representation for the Schuylkill River consisted of a good cross-section of stakeholders, the same weights were applied for evaluation on the Delaware River. These weights formed the basis for the evaluation.

Time of Travel Calculation Method
One of the criteria used in the screening evaluation, as well as in the final prioritization process using EVAMIX (described below), required an estimate of the time of travel from the point source to the intake. To do this, an estimate of velocity of the river under high flow conditions was needed. This estimate was made for two portions of the river: the Delaware River and all tributaries upstream of Trenton, and the Delaware River downstream of Trenton in the tidal zone.

Upstream of Trenton, the zone delineation was carried out by the USGS, based on extreme high flow conditions. The underlying, average flow velocity behind the Zone B and Zone A delineations is about 5.5 feet per second, which was determined on a gage by gage basis by correlating flows with measured velocities. This value of 5.5 feet per second flow velocity was used for transport of contaminants from sources upstream of Trenton on the Delaware River and all Tributaries.

Below Trenton, the tidal influences make the estimate of time of travel much more complex. Time of travel could only be estimated by using the three dimensional, time variable hydrodynamic and water quality models developed for the Delaware River Basin Commission (HydroQual, 1998). (see section 2.2.1) The hydrodynamic model is a version of the Estuarine, Coast and Ocean Model (ECOM) developed by Blumberg and Mellor (1980, 1987). This model shows that transport of contaminants within the tidal zone is a combination of advective transport (flow with the river water), and diffusion of the contaminant. The advective transport actually reverses direction with each tidal cycle, and net movement downstream is very slow. Diffusion is the primary mechanism that moves the contaminants from the point of entry to the intake. Based on a series of model simulations where contaminants were inserted at different sections of the river, the simulated time of arrival of the contaminants were plotted. In general, the net "velocity" of the contaminant based on the initial time of arrival at the intake divided by the distance from the insertion point and the intake was usually between 7 and 10 feet per second. This occurred whether the contaminant was moving upstream from below the intake, or downstream from above the intake. Most of this movement in the tidal zone was the result of diffusion.

Based on these results, the velocity of contaminants moving along the river in the tidal zone was assumed to be an average of 8 feet per second, and all time of travel calculations used this average velocity for extreme or worst case conditions.

Estimated Concentration at Intake Method

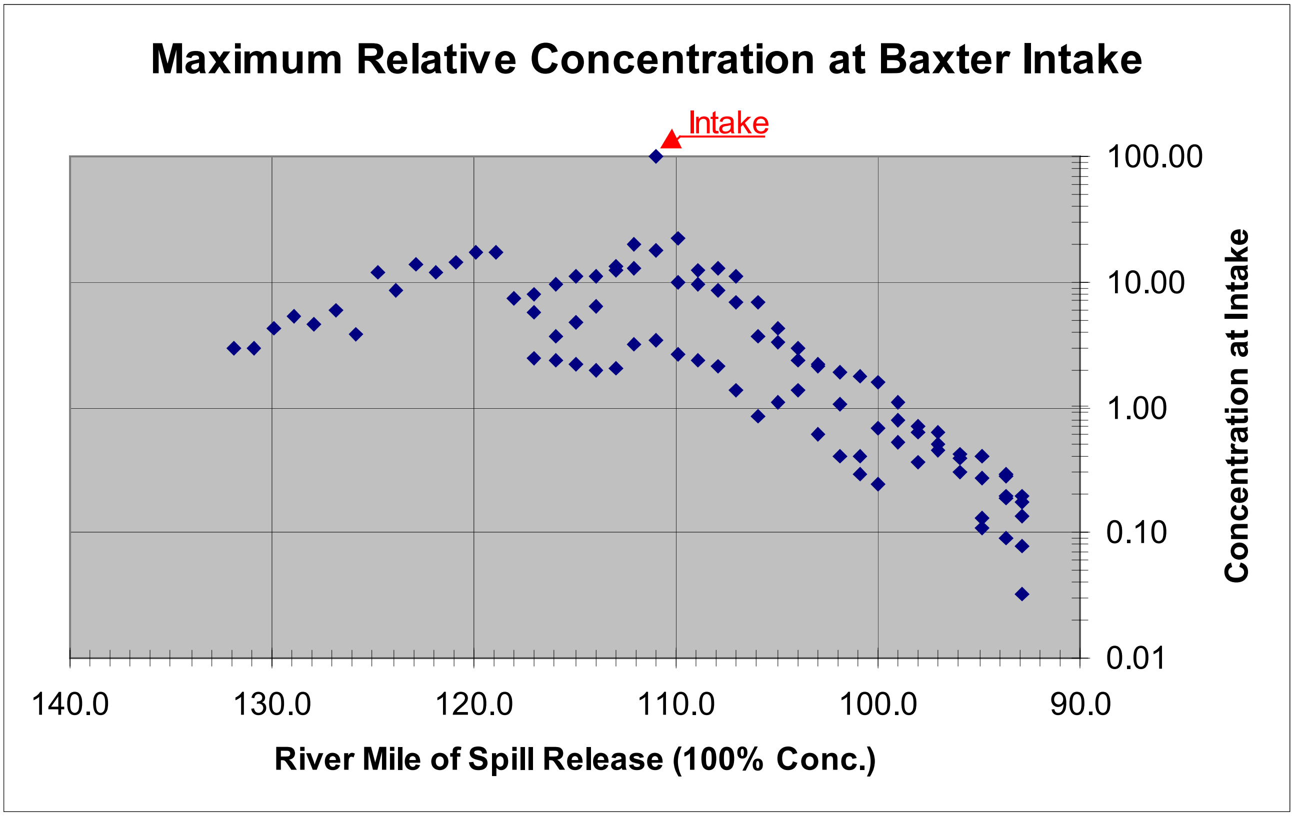
Another of the criteria used in the screening evaluation, as well as in the final prioritization process using EVAMIX (described below), required an estimate of the concentration of the contaminant once it reached the intake. Because the intake is located in the tidal zone, two distinct reductions in concentration will occur. The first is due to the mixing of the contaminant with river water. The second occurs in the tidal zone as the contaminant diffuses due to the back and forth tidal motion. To estimate this, the following approach was used.

The contaminant mass was assumed to enter the river at the nearest point to the potential point source, or at the downstream end of a subwatershed for non-point sources. River dilution was calculated by dividing the mass of contaminant assumed to have entered the river by the median flow at the intake. In this case, this is based on the median flow at the Trenton gage. This provides the first dilution.

Because the intake is in the tidal zone, a second reduction in concentration occurs, this time based on the diffusion occurring in the tidal zone, as well as additional dilution as tidal water moves in and out of the tidal zone. To calculate this, the hydrodynamic model results were analyzed. Figure 2.2.4-2 shows the results of placing a contaminant at "100%" concentration at various points along the river. Figure 2.2.4-2 plots the location of the contamination insertion against the simulated relative concentration at the intake.

Based on the results in the figure, a reasonably conservative estimate of the tidal dilution effect is that the concentration at the intake will be only 10% of the concentration in the river for all spills or discharges occurring upstream of the intake. For spills or discharges occurring downstream of the river, the concentration of the contaminant at the intake will be only about 1% of the concentration in the river.

Figure 2.2.4-2 Maximum Relative Concentration at the Baxter Intake



Point Source Screening

Point source data comes from a number of data sources, and each database can contain hundreds of potential sources. Less significant point sources needed to be screened out, leaving only the most important sources for final ranking. A slightly different screening approach was needed for each type of source because of the data available and the structure of the databases.

The point source screening approaches for each of the main data sources are summarized in this section.

1. PCS Database

This database contained almost 800 individual facilities, over 200 of which are wastewater or sewage disposal facilities. These can be divided into major facilities with discharges of more than 1 million gallons per day (mgd) and minor facilities with discharges of less than 1 mgd. Default flows of 1 mgd for large facilities and 0.1 mgd for small facilities were used along with assumed concentrations based on the site SIC code and existing median concentrations for similar facilities where data were unavailable. The screening approach consisted of calculating potential concentrations of contaminants resulting from each source at the intake, and comparing against threshold values for each contaminant category. The estimated concentration at the intake for each site included in the PCS data was calculated including dilution at the intake but not including decay, volatilization, or die off. If the impact was more than 1 percent of the threshold, it passed the screen, otherwise it was screened out.

2. CERCLA

There were over 650 CERCLA sites representing hazardous waste sites of all kinds. These are known sites that have contamination, but cannot easily be fit into our point source screening because there is no discharge data or concentration data. For this reason, they must be handled separately in a narrative analysis that considers such characteristics as whether or not the site was on the National Priority List, if the site was in Zone A for the intake, if the site was in the flood plain, and if the site was identified within the self-assessment zone of the intake. The process and results are discussed in greater detail in Section 2.2.4.3.

3. RCRA

There are more than 1700 RCRA facilities in the study area with little actual data on quantities stored or used at the sites. To address this problem, default quantities were assigned. Chemicals used at each facility were estimated based on SIC codes. Where such codes were unavailable, the State Guidance categories were used.

The screening approach for RCRA sites contained several steps.

1. RCRA sites with only Underground Storage Tanks (USTs) were screened out because they pose little threat to the surface waters.

2. RCRA sites that are not UST or Aboveground Storage Tanks (ASTs) were screened using the following guidelines:

    - Floodplain: if the site is not in the floodplain, it is screened out, and

    - If there are no reported spills, violations, or releases according to the Right to Know data, it is screened out.

3. Those sites with ASTs required a separate EVAMIX screening. There were over 1500 of such sites with listed ASTs. The procedure for performing the impact screening relied on EVAMIX and the following screening criteria:

Total Tank Volume: in gallons of total tank volume. Larger tank volume meant a higher priority.

Volume Weighted Chemical Ranking: an additive score representing the types of chemicals stored onsite, each weighted by the percent of total tank volume used to store that category of contaminant. In this case, the chemicals are rated according to their impact on the treatment system and the ease with which the current treatment can handle the contaminant in the raw water. This results in a ranking of contaminant categories in order of decreasing importance to the treatment process with points assigned as follows: VOCs/SOCs (10), *Crytosporidium* (9), Metals (8), Petroleum Hydrocarbon (7), Nitrate (6), TSS (5), Chloride (4), TOC/DBP precursors (3), Phosphorus (2), Fecal Coliform (1). Each contaminant category gets a score (10 for VOCs, 9 for *Cryptosporidium* etc. down to 1 for Fecal Coliform.) For each category, the rank number is multiplied by the fraction of total tank volume of that contaminant to the total tank volume onsite. The weighted categories are then added up. For example, a site with VOCs (10,000 gal tank) and salts (90,000 gal) would score 10 x 0.1 + 4 x 0.9 = 4.6.

Leaks Reported: a qualitative score of 1 for a leak, a score of 0 for no leak.

Tank Age: a quantitative score in years after date of installation.

Location: a qualitative score that checks if the site is within floodplain or not (score of 3), in Zone A (score of 2), or in Zone B (score of 1).

Travel Time: a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

The criteria were weighted, based on the results of the Technical Advisory Group and discussions with the project team. The weights are:

- Tank Age: 12 percent
- Total Tank Volume: 36 percent
- Vol. Weighted Chemical Ranking: 15 percent
- Leak History: 10 percent
- Location: 21 percent
- Travel Time: 5 percent

The screening of RCRA sites resulted in two lists of sites moving through the screen: non-AST sites that reported spills and are within the floodplain, and ASTs that pass the EVAMIX screening.

4. TRI Sites

There are over 500 TRI sites that manufacture or use toxic chemicals. These sites, however, do not discharge contaminants. The database lists the contaminants onsite, including: VOCs, metals, nutrients, and chloride. To focus on the high priority sites, an EVAMIX screening was required, base on the following criteria:

Location: if in flood plain (3 points), zone A (2 points) or zone B (1 point):

Chemicals Listed: a score was given based on the acute effects on health of each contaminant category, resulting in the following scores: VOCs/SOCs (10), *Cryptosporidium* (9), Metals (8), Petroleum Hydrocarbon (7), Nitrate (6), TSS (5), Chloride (4), TOC, /DBP precursors (3), Phosphorus (2), Fecal Coliform (1). For sites with more than one category, the scores were the sum of the rank of chemicals listed (e.g. a site with VOCs and Metals would score 10+8 = 18)

Amount Stored: based on the range listed in the database, in kg per year

Number of releases to water: total number of releases in database

Travel Time: a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

Criteria weights were applied within the EVAMIX screening as follows:

- Location: 15 percent
- Chemicals Listed: 20 percent
- Amount Stored: 35 percent
- Number of releases to water: 25 percent
- Travel Time: 5 percent

Non-point Source Runoff Screening

Potential non-point sources were identified using the SWMM model and Event Mean Concentrations (EMCs) to calculate total annual pollutant loading for each subwatershed.

Because there are over 500 subwatersheds, EVAMIX screening was applied using three criteria. These were:

1. Relative Impact at Intake (weight 60 percent):

This criterion is based on the concentration of a contaminant caused by the potential source at the intake as a percent of the contaminant category threshold value. Since there are potentially 10 values, one for each contaminant category, only the highest ranked category or greatest relative impact chemical category was used for this criterion.

2. Time of Travel (weight 20 percent):

This is a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

3. Location (weight 20 percent)

This criterion scored watersheds as 2 if in Zone A, and 1 if in Zone B.

The highest ranked subwatersheds passed through to the full ranking of sources.

Source Priorities: Full EVAMIX Ranking of All Sites
Finally, all the significant (those that passed the screening) point sources and runoff loads (entered as pseudo point sources) were prioritized, accomplishing the main goal of the assessment. There were two types of final rankings. The first ranking was a combined ranking of sites from all categories, compared against each other. The second ranking was by contaminant type, with all significant sources contributing to a particular contaminant category included.

Multi-criteria Ranking using EVAMIX: Combined Sources
EVAMIX was used to rank all sources over the entire range of contaminant categories. Full ranking allowed us to compile a final list of sources, independent of contaminant class. The following criteria were used:

Relative Impact at Intake (weight 12 percent):

This criterion is based on the concentration of contamination potentially caused by the source at the intake as a percent of the contaminant category threshold value. Since there are potentially 10 values, one for each contaminant category, only the highest ranked category or greatest relative impact chemical category was used for this criterion.

Time of Travel (weight 5 percent):

This is a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

Potential for Release/Controls (weight 14 percent):

This was developed using the qualitative categories taken from the State SWAP guidelines.

High: no control practices, or a regulated discharge not in compliance with regulations (4 points)

Medium/High: a non-point source with no BMP in place, or regulated discharge and in compliance with regulations (3 points)

Medium: a non-point source with BMP in place, or a point source not regulated but contained in some way (retaining wall, double walled tank etc.) with no emergency response plan (2 points)

Low: a regulated point source by the State, containment, and/or emergency response plan (1 point)

Potential Release Frequency (weight 14 percent):

A qualitative criterion based on the following scores:

Very High: a continuous discharger, 5 points

High: an intermittent or rainfall related (CSO, SSO, NPS) discharger, 4 points

Medium: a discharge with roughly a monthly frequency, 3 points

Low: a discharge with roughly an annual frequency, 2 points

Very Low: a discharge that occurs only as a catastrophic spill, or a storm related discharge with about a 100-year occurrence frequency, 1 point

Violation Type/Frequency (weight 10 percent):

A qualitative criterion based on the following scoring:

High: Operation or Effluent Violations, 3 points

Medium: Management Violations, 2 points

Low: Administrative Violations or none, 1 point

In this case, points are cumulative for each violation within the last 3 years in each category. For example two violations for not filing paperwork (2x1) plus an effluent violation (3 points) would result in a score of 5 points.

Location (weight 5 percent):

A qualitative criterion based on GIS analysis according to the following categories:

In the Floodplain: 3 points

In Zone A: 2 points

In Zone B: 1 point

Existing Removal Capacity (weight 10 percent):

A criterion with qualitative scoring based on the chemical released and the ability of the existing treatment to remove it. Scoring was according to the following system:

Not removed (salts, radionuclides, nitrates): 3 points

Limited removal (Cryptosporidium, SOCs, VOCs, Petroleum Hydrocarbons, Phosphorus, TOC): 2 points

High removal (fecal coliform, TSS, metals): 1 point.

Scores were cumulative for each category present at the site.

Impact on Treatment Operation (weight 10 percent):

A criterion with qualitative scoring based on the contaminant released and its impact on the operation of the treatment systems in place. Scoring was according to the following system.

High (TSS, VOCs, Petroleum Hydrocarbon): 4 points

Medium/High (metals, TOC): 3 points

Medium (*Cryptosporidium*, nitrate, phosphorus): 2 points

Low (fecal coliform, chloride, radionuclides): 1 point

The score is cumulative over all categories present.

Potential Health Impacts (weight 20 percent):

A criterion with qualitative scoring based on the contaminant released and its potential acute impact on health if not removed. Scoring was according to the following system:

High (*Cryptosporidium*, SOCs, VOCs, radionuclides, fecal coliform): 3 points

Medium (TOC, metals, nutrients, nitrate): 2 points

Low (salts, TSS, phosphorus): 1 point

The score is cumulative over all categories present.

This ranking resulted in a single list of sources for the intake showing high, medium, and low priority sources from all categories.

EVAMIX Ranking by Contaminant Category

Ranking by contaminant category was completed using six criteria and the multi-criteria evaluation program EVAMIX. Criteria (with weights from the June 2001 Task Force Meeting) are given below.

Relative Impact at Intake (weight 40 percent):

This criterion is based on the concentration of contamination potentially caused by the source at the intake as a percent of the contaminant category threshold value.

Time of Travel (weight 5 percent):

This is a criterion calculated as the time of travel from source to intake, based on high flow velocity and the tidal zone velocities.

Potential for Release/Controls (weight 20 percent):

This was developed using the qualitative categories taken from the State SWAP guidelines.

High: no control practices, or a regulated discharge not in compliance with regulations (4 points)

Medium/High: a non-point source with no BMP in place, or regulated discharge and in compliance with regulations (3 points)

Medium: a non-point source with BMP in place, or a point source not regulated but contained in some way (retaining wall, double walled tank etc.) with no emergency response plan (2 points)

Low: a regulated point source by the State, containment, and/or emergency response plan (1 point)

Potential Release Frequency (weight 15 percent):

A qualitative criterion based on following scores:

Very High: a continuous discharger, 5 points

High: an intermittent or rainfall related (CSO, SSO, NPS) discharger, 4 points

Medium: a discharge with roughly a monthly frequency, 3 points

Low: a discharge with roughly an annual frequency: 2 points

Very Low: a discharge that occurs only as a catastrophic spill, or a storm related discharge with about a 100-year occurrence frequency, 1 point

Violation Type/Frequency (weight 15 percent):

A qualitative criterion based on the following scoring:

High: Operation or Effluent Violations, 3 points

Medium: Management Violations, 2 points

Low: Administrative Violations or none, 1 point

In this case, points are cumulative for each violation within the last 3 years in each category. For example two violations for not filing paperwork (2x1) plus an effluent violation (3 points) would result in a score of 5 points.

Location (weight 5 percent):

A qualitative criterion based on GIS analysis according to the following categories:

In the Floodplain: 3 points

In Zone A: 2 points

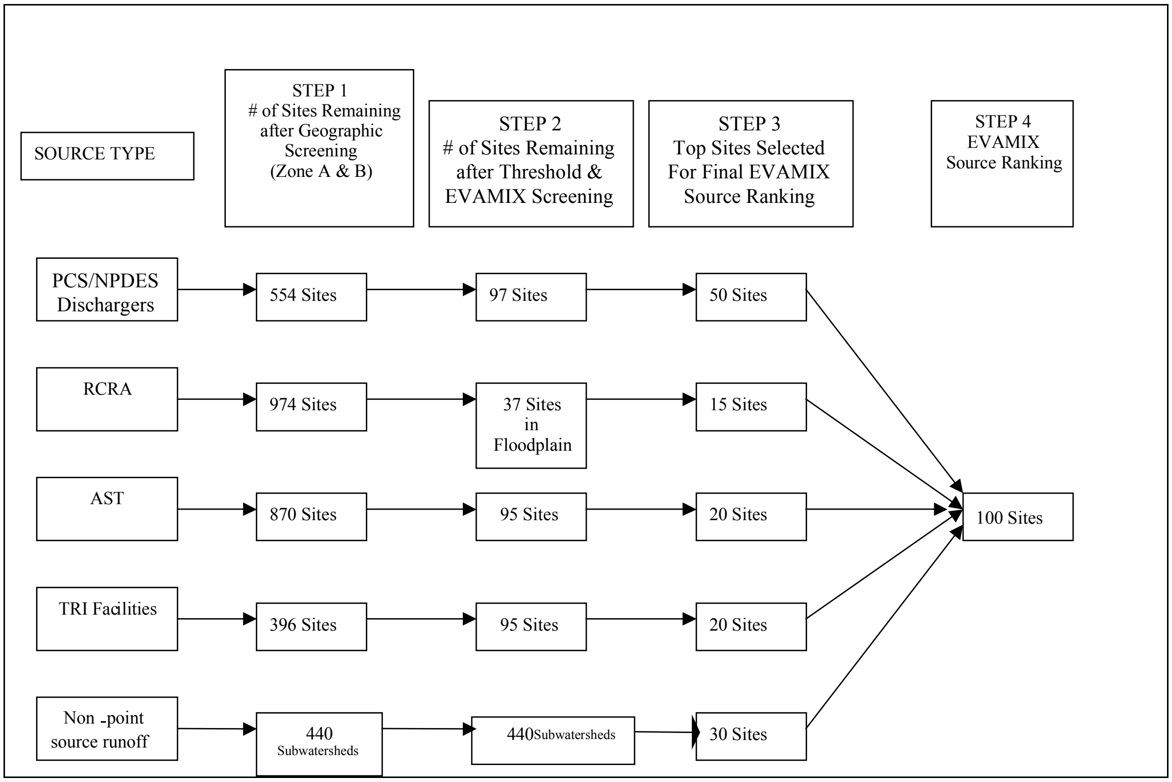
In Zone B: 1 point

Results from each of the ten contaminant categories based evaluations resulted in a listing of high, medium, and low priority sites for that contaminant category.

2.2.4.2 Results

Figure 2.2.4-2 is a flow diagram of the screening and ranking process that was used to successively select the most important sites from each of the databases available, and combine them in an organized manner to produce a final list of high priority sites. The process can be compared to a playoff elimination process, with various divisions providing a set number of teams to the overall playoff. Like such playoff structures, it can occur that a site will not be included in the final list because it was eliminated in competition with other sites within its categories. (To follow the analogy, the 4th best team in a division is not invited to the playoffs, even if it is better than the 3rd best team from another, weaker division, because only the top three teams are invited from each division.) Despite this fact, the process does provide the top sites from each database category, and provides valuable insight into the relative importance of each category of sites. Enough sites were included from each category to make sure that no highly ranked sites would be overlooked.

Figure 2.2.4-3 Screening and Ranking Process



The diagram shows that there were several screening steps (or elimination rounds) leading to the final ranking. These are described briefly below.

Zone Based Screening

The inventory of potential sources of contamination started with all of the sites included in the PCS, RCRA, AST, and TRI databases. After all had been located and coordinates assigned, those in Zone C were eliminated from consideration. This left 554 sites from the PCS database (essentially those with a surface water discharge permit), 870 sites listed with above ground storage tanks (ASTs), and 396 facilities from the TRI database (sites that generate or handle toxic chemicals). In addition, all of the subwatersheds that are within the travel times of the Baxter Intake's Zones A or B were also included (440 subwatersheds). RCRA sites that had underground storage tanks were eliminated. It was decided that only RCRA sites located within the flood plain were of concern in this round of analysis, and the 37 sites that met this condition were included in the analysis.

Database Based Screening

The zone based screening still left over 3200 sites that needed to be screened further to a manageable number. This was done either by simple threshold screening, based on the amount of contaminants stored or used, or by a more complex evaluation using several criteria.

Threshold Based Screening

For one of the categories, (PCS) simple threshold screening was an effective approach for screening.

PCS Sites: As described in section 2.2.4.1, the percent change in the concentration of a chemical at the intake due to releases from each site could be roughly estimated, and this was used to screen the 554 PCS (NPDES) sites. This threshold screening was performed to select the largest dischargers. A cutoff of a 1 percent change in concentration at the intake was established, based on the percent increase by the discharged mass loading. Of the 554 sites, only 97 discharges could potentially affect concentrations by more than 1 percent. Most of the others were much too small to have a measurable impact and were eliminated from further analysis. The top 50 were used in the final ranking.

Criteria Based Screening

For the AST sites, TRI sites, and the subwatersheds (stormwater pollutant loading), a more sophisticated approach was required to adequately select the most important sites from each category. Several criteria were used with the multi-criteria evaluation program EVAMIX to perform each of these screening analyses. EVAMIX output was used to complete the screening by ranking the sites in descending order of importance and then selecting the top sites based on the results of the ranking.

AST Sites: EVAMIX screening resulted in a ranking of all the sites based on six criteria. The criteria were age of the tank, storage volume of the tank, chemical ranking based on the mix of chemicals onsite, whether there had been leaks in the past, the location relative to the river, and the travel time to the intake (see section 2.2.4.1 for details). From the 870 sites, the 95 highest ranked sites passed the screen into the final ranking. Of these, the top ranked 20 sites were used in the final screening evaluation. The results of the final ranking (Table 2.2.4-1) confirmed that most AST sites had very low rankings, with only 2 sites making it into the top 100 sites.

TRI Sites: EVAMIX screening resulted in a ranking of all the TRI sites based on five criteria. The criteria were amount of chemical stored, chemical ranking based on the mix of chemicals onsite, whether or not releases to water have been reported, the location relative to the river, and the travel time to the intake (see section 2.2.4.1 for details). From the 396 sites, the 95 highest ranked sites passed the screen into the final ranking. Of these, the top 20 sites were used in the final ranking analysis.

NPS Subwatersheds: There were 440 subwatersheds that could be considered to be in the Baxter Intake's zone A or B. A screening of these subwatersheds for their potential impact due to stormwater pollutant loading was performed using EVAMIX and three criteria. The first criterion was the relative impact, measured as the expected concentration from the pollutant runoff at the intake, divided by the threshold number for that contaminant category. Because there were 9 contaminant categories relevant to stormwater runoff, the highest relative impact was used. The other two criteria were location and time of travel to the intake. The subwatersheds or NPS sources were relatively important, and the 30 highest ranked subwatersheds were included in the final ranking.

Source Priorities: Full EVAMIX Ranking of All Potential Sources

All of the significant point sources and runoff loads (entered as pseudo-point sources) that passed the screening process were lumped together for a final ranking, once again using EVAMIX. There were 135 mixed sites evaluated, eventually producing a list of the top 100 sites for the intake. This important, final ranking of the mixed group of sites used the nine criteria described above in section 2.2.4.1. The criteria weights were those established during the Technical Advisory Group workshop.

1. Relative Impact at Intake (weight 12 percent)

2. Time of Travel (weight 5 percent):

3. Potential for Release/Controls (weight 14 percent):

4. Potential Release Frequency (weight 14 percent):

5. Violation Type/Frequency (weight 10 percent):

6. Location (weight 5 percent):

7. Existing Removal Capacity (weight 10 percent):

8. Impact on Treatment Operation (weight 10 percent):

9. Potential Health Impacts (weight 20 percent):

Table 2.2.4-1 lists the 96 point sources and non-point sources that passed the screening. The table is organized into roughly three groups of sites in descending order of priority as calculated by EVAMIX. The table has eight columns.

Column 1: Source ID code: a unique database source code

Column 2: Source Name, the name as listed in the database

Column 3: Primary database containing information about the source used in the analysis

Column 4: Point Source subwatershed (NPS)

Column 5: Zone (either A or B)

Column 6: Estimated time of travel to the intake under high flow conditions

Column 7: Relative impact at the intake

Column 8: High, Medium, or Low Ranking based on EVAMIX numerical ranking output, nine criteria and selected criteria weights

Table 2.2.4-1 Final Ranking of Sources for Combined Contaminant Categories

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	1.7500	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	94.3671	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0270	Highest-A
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	9.7827	Highest-A
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	3.2347	Highest-A
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	25.4051	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.8249	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.0822	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.0822	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.0082	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.0082	Highest-A
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.0822	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.0822	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.0822	Highest-A
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0822	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.0822	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.0082	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0822	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.0822	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.0082	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.0082	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.0822	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.0082	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.0822	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.0822	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.0822	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.0480	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.0082	Highest-A
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.0522	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.0082	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.0822	Moderately High-B
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.0822	Moderately High-B
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.0082	Moderately High-B
2850	Rockledge Branch-645	NP	Rockledge Branch - 645	Zone A	0.4	0.2094	Moderately High-B
2866	Delaware River-666	NP	Delaware River - 666	Zone A	0.4	0.1861	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.0082	Moderately High-B
2849	Byberry Creek-641	NP	Byberry Creek - 641	Zone A	0.6	0.6254	Moderately High-B
2857	Walton Run-656	NP	Walton Run - 656	Zone A	0.6	0.3530	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.0082	Moderately High-B
2858	NESHAMINY R-657	NP	NESHAMINY R - 657	Zone A	1.1	0.2702	Moderately High-B
2854	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	1.0168	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.0082	Moderately High-B
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.0082	Moderately High-B
2847	NESHAMINY R-637	NP	NESHAMINY R - 637	Zone A	1.6	0.5232	Moderately High-B
2853	Mill Creek-648	NP	Mill Creek - 648	Zone A	1.6	0.3055	Moderately High-B
2852	Unknown-647	NP	Unknown - 647	Zone A	1.6	0.2329	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.0822	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
2833	Martins Creek-616	NP	Martins Creek - 616	Zone A	2.4	0.2217	Moderately High-B
2839	Mill Creek-626	NP	Mill Creek - 626	Zone A	2.6	0.3242	Moderately High-B
2840	Queen Anne Creek-627	NP	Queen Anne Creek - 627	Zone A	2.6	0.2825	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.0822	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Moderately High-B
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.2875	Moderately High-B
2911	RANCOCAS CR-743	NP	RANCOCAS CR - 743	Zone A	3.1	0.3537	Moderately High-B
2836	Mill Creek-619	NP	Mill Creek - 619	Zone A	3.3	0.2389	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.0822	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.0822	Moderately High-B
2819	NESHAMINY R-601	NP	NESHAMINY R - 601	Zone B	4.0	0.7623	Moderately High-B
2825	Little Neshaminy Creek-610	NP	Little Neshaminy Creek - 610	Zone B	4.2	0.7108	Moderately High-B
2916	RANCOCAS CR-752	NP	RANCOCAS CR - 752	Zone B	4.4	0.4870	Moderately High-B
2808	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	1.6627	Moderately High-B
2834	Little Neshaminy Creek-617	NP	Little Neshaminy Creek - 617	Zone B	5.1	0.9317	Moderately High-B
2896	RANCOCAS CR, N BR-716	NP	RANCOCAS CR, N BR - 716	Zone B	5.1	0.4041	Moderate-C
2823	Little Neshaminy Creek-606	NP	Little Neshaminy Creek - 606	Zone B	5.5	0.8733	Moderate-C
2803	Mill Creek-576	NP	Mill Creek - 576	Zone B	5.5	0.7337	Moderate-C
2801	Mill Creek-573	NP	Mill Creek - 573	Zone B	6.4	0.6328	Moderate-C
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	39777.3404	Moderate-C
2806	NESHAMINY R-580	NP	NESHAMINY R - 580	Zone B	7.7	0.4776	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.0822	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.0822	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.2865	Moderate-C
1198	BETHLEHEM STEEL – BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	1.1285	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
2767	Gallows Run-523	NP	Gallows Run - 523	Zone B	14.7	0.7392	Moderate-C
2723	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	1.5915	Moderate-C
948	ALUMINUM SHAPES INC.	TRI	Delaware River - 931	Zone B	1.1	1.1812	Moderate-C
5091	WILLOW GROVE AIR FORCE RESERVE STA	AST	Little Neshaminy Creek - 617	Zone B	5.1	55688.2765	Moderate-C
2685	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	2.3733	Moderate-C
2719	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	1.1215	Moderate-C
2713	Unknown-444	NP	Unknown - 444	Zone B	19.5	1.7868	Moderate-C
2697	Unknown-415	NP	Unknown - 415	Zone B	19.8	1.2608	Moderate-C
703	ROHM & HAAS DVI PHILADELPHIA PLANT	TRI	Mill Run - 675	Zone A	1.3	15.4160	Moderate-C
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	800.4507	Moderate-C
594	SPS TECHS. INC.	TRI	Rockledge Branch - 645	Zone A	2.8	0.9065	Moderate-C
700	PRE FINISH METALS INC.	TRI	Delaware River - 649	Zone B	3.9	29.6055	Moderate-C
519	COASTAL EAGLE POINT OIL CO.	TRI	BIG TIMBER CR - 769	Zone B	3.3	1291.8568	Moderate-C
957	U.S. PIPE & FNDY. CO.	TRI	ASSISCUNK CR - 662	Zone A	1.6	7.8302	Moderate-C
5726	G R O W S INC LANDFILL	RCRA	Delaware River - 649	Floodplain	2.8	0.1591	Moderate-C
543	OCCIDENTAL CHEMICAL CORP. BURLINGTON N. PLANT	TRI	Delaware River - 927	Zone A	2.0	246.4136	Moderate-C
5452	YATES FOIL USA INC	RCRA	Delaware River - 927	Floodplain	3.1	0.2829	Moderate-C
5951	AMSPEC CHEMICAL CORP	RCRA	Delaware River - 932	Floodplain	2.9	0.0016	Moderate-C
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	173.7606	Moderate-C
6482	COASTAL EAGLE POINT OIL CO	RCRA	BIG TIMBER CR - 769	Floodplain	3.3	0.4420	Moderate-C
5940	RHODIA INC	RCRA	Delaware River - 649	Floodplain	3.9	0.0078	Moderate-C
5839	MSC PRE FINISH METALS INC	RCRA	Delaware River - 649	Floodplain	3.9	0.0014	Moderate-C
926	AMSPEC CHEMICAL CORP.	TRI	Newton Creek - 753	Zone B	3.1	24.4227	Moderate-C
574	COURTAULDS AEROSPACE INC. & CHEMICAL CORP.	TRI	Delaware River - 932	Floodplain	2.8	7.8344	Moderate-C
904	ROCHE VITAMINS & FINE CHEMICALS	TRI	PEQUEST R - 405	Zone B	21.9	576.4406	Moderate-C

The final results of the rankings are broken down into six major categories according to PADEP's SWA Plan. These are represented by designations A through F, with A representing sources of highest protection priority and gradually decreasing to F for sources of lowest protection priority. This designation process was initially designed for intakes with a limited number of sources where the whole inventory could be ranked. However, given the large number of sources and the ranking process, sources that are represented by designations D through F were screened out in the significance screening process. Therefore, the sources ranked in the document are considered potentially significant sources of contamination and fall into categories A through C. They are described in Table 2.2.4-2.

Table 2.2.4-2 Contaminant Source Ranking Designations

Designation	Description
Potentially Significant Sources of Contamination to Water Supply	
A	Potentially Significant Source of Highest Protection Priority
B	Potentially Significant Source of Moderately High Protection Priority
C	Potentially Significant Source of Moderate Protection Priority
Remaining Sources From Inventory Screened Out By Significance Screening Criteria	
D	Potential Source of Moderately Low Protection Priority
E	Potential Source of Low Protection Priority
F	Potential Source of Lowest Protection Priority

As shown, the sources in categories A through C may require additional "ground-truthing" in order to provide a more accurate designation of their significance. Although not considered to be potentially significant, sources in category D may need to be evaluated, as more information becomes available.

The results provide significant insight into the relative threat that various types of sources might have on the water quality at the intake. The key results are:

- All of the highest ranked sites are either NPDES sites from the PCS database or stormwater pollutant loading represented by various subwatersheds. The top 22 ranked sources are NPDES, as well as 28 of the top 30 sites included as priorities in this combined rankings.

- Stormwater or NPS loading appears to also represent a high priority. There are 2 subwatersheds with stormwater related loading in the top priority sites.

- TRI sites are generally ranked lower. There are no TRI sites as high priority sites, and all TRI sites are found in the "moderate" priority category.

- RCRA sites, with or without ASTs, are generally ranked the lowest of all of the types of sites. Only 9 of these sites made it into the top priority sites.

- Results indicate that with a balanced assessment, those contaminant sources that are actually discharging to the river (NPDES permitted point sources or stormwater runoff) represent the greatest concern. Those with only the potential to release contaminants through spills or leaks (TRI, RCRA, AST) are generally given a lower priority.

- Despite the low overall rankings, the highest potential relative impacts appear to occur with the TRI and AST sites. The relative impact numbers show that, were a catastrophic spill or leak to occur at these highly ranked sites, concentrations at the intake could potentially be very high.

- Health Impacts, as scored in the assessment, had a large influence on the resulting rankings, with those sites ranked high on potential health impacts ranking as important sites.

- Treatment Impacts were also important in the final rankings, with those sites scoring high on potential impact to the treatment process also ending up highly ranked in the overall assessment.

- The geographic distribution of significant sources showed that most of the category A sources were from point sources in drainage areas of the Delaware River below Trenton and stormwater runoff sources in the upper Delaware River Watershed.

- A comparison of the types of sources indicated by the ranking process with the sources, indicated by water quality analysis and impaired stream information, (see section 2.1.5) corroborates that NPDES discharges and polluted runoff (non-point sources) from developed areas are the most important influences on water quality at the PWD Baxter Intake.

The rankings provided in Table 2.2.4-1 are based on a careful evaluation of existing data in the databases described in section 2.2.2. They are only as accurate as the data provided, and serve as a good starting point for data collection and field "ground-truthing" of these sites.

Figure 2.2.4-4 is a map of the site locations for point sources and subwatersheds in the Lower Delaware Watershed that scored highest in the ranking process. Figure 2.2.4-5 denotes the Middle Delaware Watershed and figure 2.2.4-6 shows the point sources and subwatersheds in the upper part of the watershed that scored the highest in the ranking process. The numbers indicated on the map correspond to identification numbers of the various sources in the tables.

Figure 2.2.4-4 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Lower Delaware Watershed

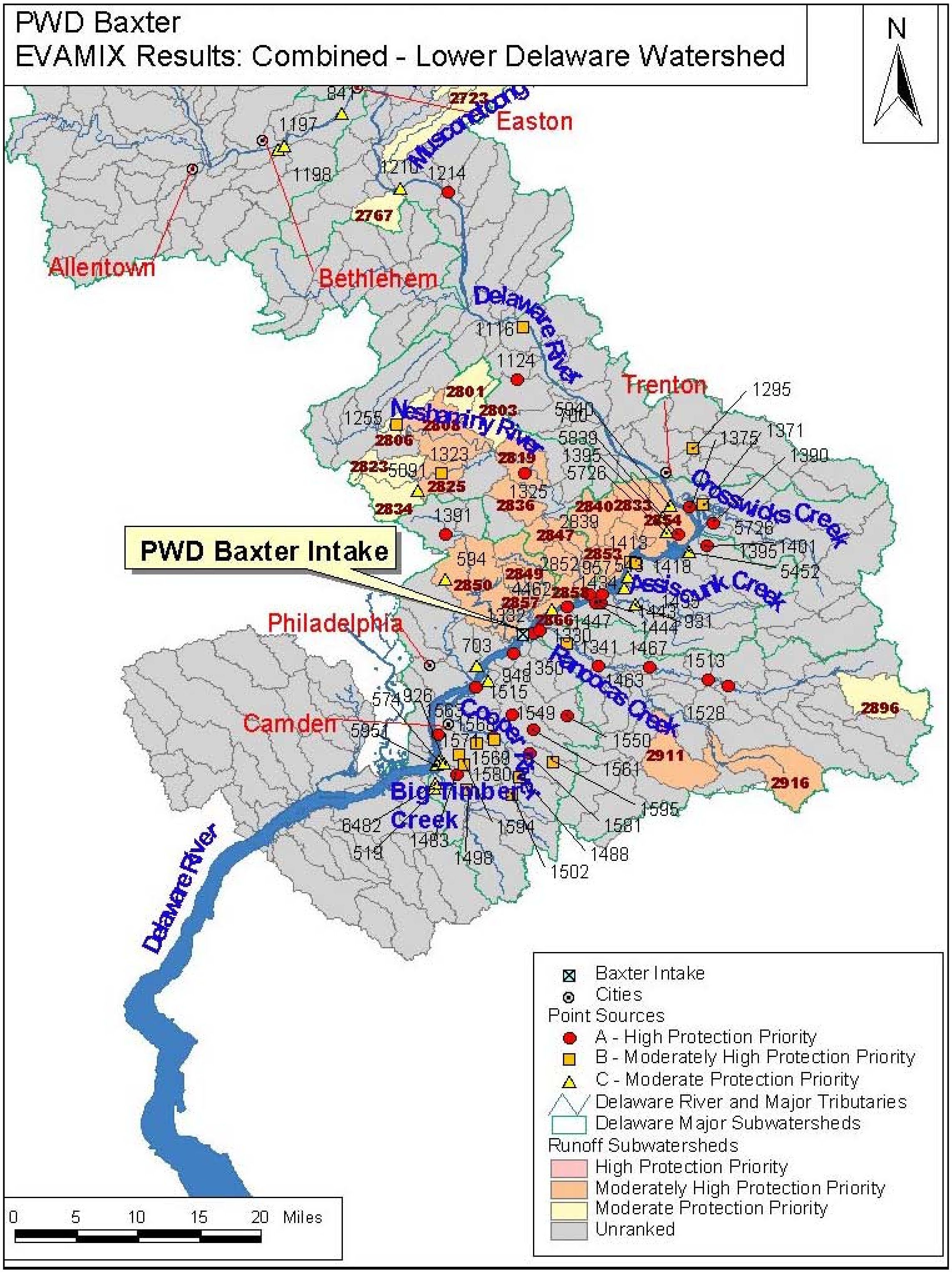


Figure 2.2.4-5 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Middle Delaware Watershed

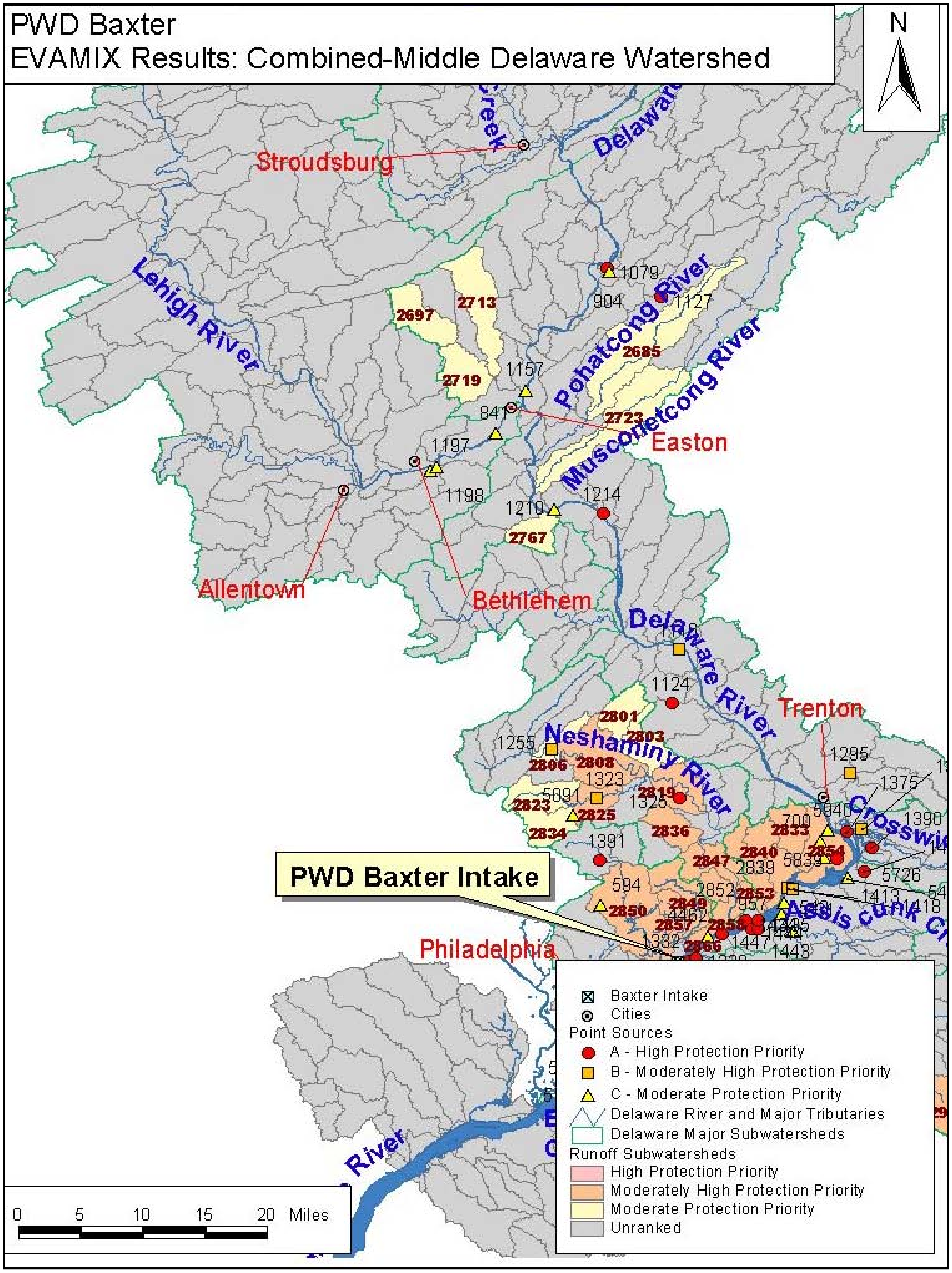
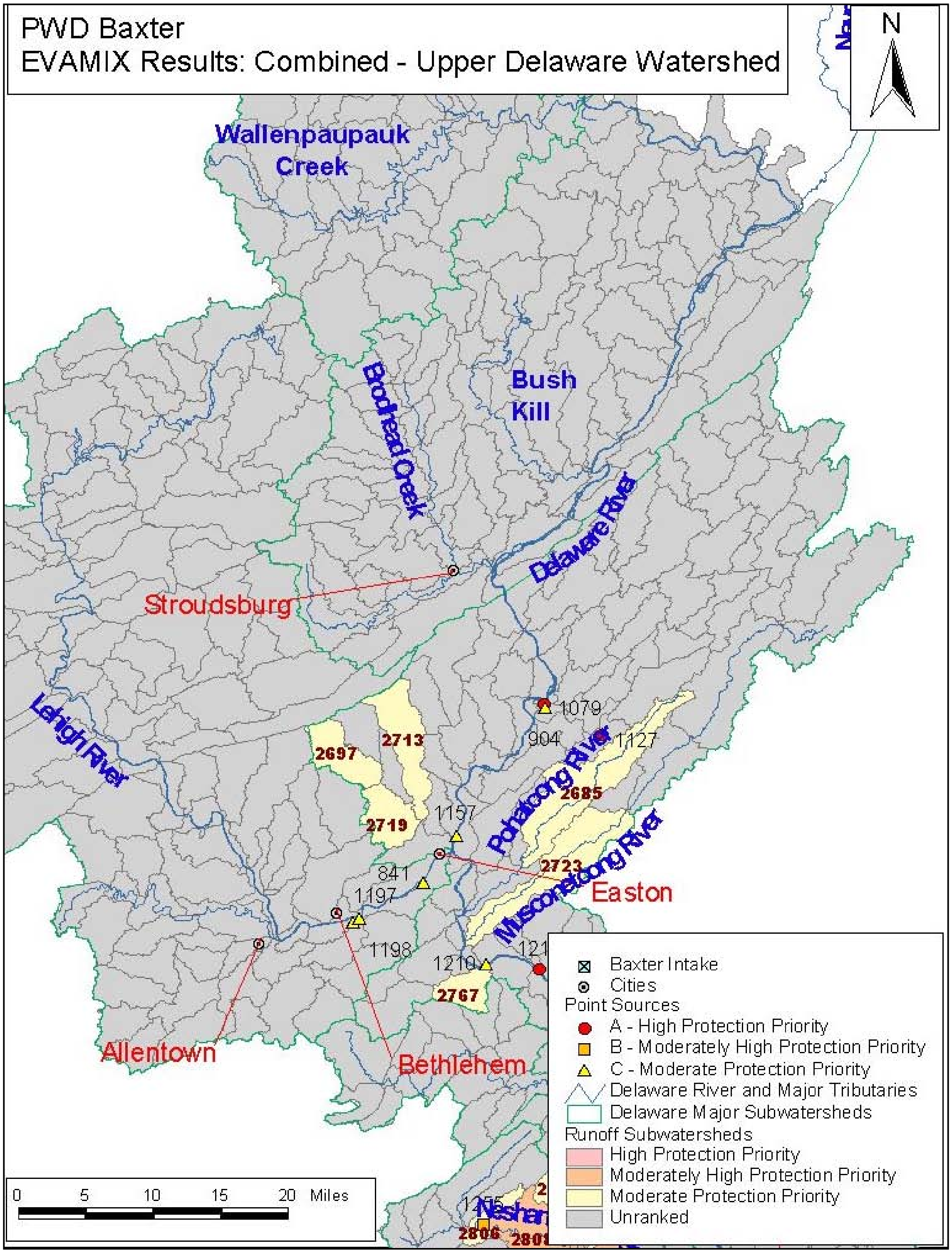


Figure 2.2.4-6 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Upper Delaware Watershed



EVAMIX Ranking by Contaminant Category

The extensive screening of sites done for the combined ranking was not suitable for use in the contaminant-by-contaminant evaluation. The combined ranking screening was done in part based on the types of chemicals stored, and thus could conceivably screen out numerous sites for a given contaminant, simply because that contaminant is less critical than another contaminant. For those contaminant categories where the number of sites was too large, a simple threshold screening was performed based on the impact of that contaminant source on the potential concentration at the intake. In general, the following approach was used for selecting sites from each category for final ranking by contaminant category:

- 50 sites from the PCS database were included (including all the major dischargers);
- The top ranked 20 RCRA sites in the floodplain were included; and
- The top ranked 20 sites from the TRI database, the top 20 sites from the AST database, and the top 20 sites from the NPS database were included.

Ranking by contaminant category was completed using EVAMIX and six criteria (weights were provided by the technical advisory committee at the June 2001 workshop):

1. Relative Impact at Intake (weight 40 percent)

2. Time of Travel (weight 5 percent)

3. Potential for Release/Controls (weight 20 percent)

4. Potential Release Frequency (weight 15 percent)

5. Violation Type/Frequency (weight 15 percent)

6. Location (weight 5percent)

Tables 2.2.4-3 through 2.2.4-12 provide the rankings of the primary potential sources of each contaminant group. Each Table has 8 columns:

Column 1: Source ID code: a unique database source code

Column 2: Source Name, the name as listed in the database

Column 3: Primary database containing information about the source used in the analysis

Column 4: Point Source subwatershed (NPS)

Column 5: Zone (either A or B)

Column 6: Estimated time of travel to the intake under high flow conditions

Column 7: relative impact at the intake

Column 8: Final rank category based on nine criteria and selected criteria weights

Salts

Table 2.2.4-3 shows the results of the ranking for salts, as represented by estimated sources of chloride. The table indicates that the highest priority sources of chlorides are either stormwater runoff from urbanized watersheds, or potential releases of industrial salts from industrial sites as represented by sites listed in the TRI database. It should be noted that neither type of source individually appears to provide sufficient loading to cause water quality impairments at the intake, but combined, especially during winter periods, the runoff may result in some impacts. Geographically, most of the highest priority sources were located in the area near Easton, PA, along the Delaware downstream of Trenton, and along the Lehigh River, as shown by Figures 2.2.4-7 through 2.2.4-9.

Table 2.2.4-3 Contaminant Category Ranking for Salts (Chlorides)

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
640	DIAL CORP.	TRI	Delaware River - 649	Zone A	1.6	0.0364	Highest-A
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	0.0313	Highest-A
904	ROCHE VITAMINS & FINE CHEMICALS	TRI	PEQUEST R - 405	Zone B	21.9	0.0131	Highest-A
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	0.0066	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.0018	Highest-A
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.0012	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.0025	Highest-A
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.0045	Highest-A
90752	RANCOCAS CR-752	NP	RANCOCAS CR - 752	Zone B	4.4	0.0014	Highest-A
90601	NESHAMINY R-601	NP	NESHAMINY R - 601	Zone B	4.0	0.0013	Highest-A
90617	Little Neshaminy Creek-617	NP	Little Neshaminy Creek - 617	Zone B	5.1	0.0014	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.0033	Highest-A
90606	Little Neshaminy Creek-606	NP	Little Neshaminy Creek - 606	Zone B	5.5	0.0013	Highest-A
956	CIRCUIT FOIL USA INC. (FORMERLY YATES IND.)	TRI	Delaware River - 927	Zone B	3.1	0.0007	Highest-A
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.0030	Highest-A
90496	Nishisakawick Creek-496	NP	Nishisakawick Creek - 496	Zone B	12.8	0.0014	Highest-A
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	0.0027	Highest-A
90523	Gallows Run-523	NP	Gallows Run - 523	Zone B	14.7	0.0013	Moderately High-B
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	0.0021	Moderately High-B
90443	Lopatcong Creek-443	NP	Lopatcong Creek - 443	Zone B	17.6	0.0016	Moderately High-B
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	0.0019	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	0.0023	Moderately High-B
90525	Cooks Creek-525	NP	Cooks Creek - 525	Zone B	16.8	0.0012	Moderately High-B
90512	Saucon Creek-512	NP	Saucon Creek - 512	Zone B	17.9	0.0013	Moderately High-B
90393	Martins Creek-393	NP	Martins Creek - 393	Zone B	19.8	0.0015	Moderately High-B
90389	Oughoughton Creek-389	NP	Oughoughton Creek - 389	Zone B	20.6	0.0016	Moderately High-B
90406	Unknown-406	NP	Unknown - 406	Zone B	19.8	0.0013	Moderately High-B
90378	Waltz Creek-378	NP	Waltz Creek - 378	Zone B	20.8	0.0014	Moderately High-B
90371	PEQUEST R-371	NP	PEQUEST R - 371	Zone B	23.5	0.0018	Moderately High-B
578	LACLEDE FAIRLESS	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.0023	Moderately High-B
90358	Jacoby Creek-358	NP	Jacoby Creek - 358	Zone B	24.3	0.0012	Moderately High-B
493	NATIONAL MEDICAL CARE INC.	TRI	Unknown - 691	Zone A	0.4	0.0015	Moderately High-B
641	CORCO CHEMICAL CORP.	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.0006	Moderately High-B
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	0.0005	Moderately High-B
607	WONDER CHEMICAL CORP.	TRI	Delaware River - 649	Zone A	3.9	0.0002	Moderate-C
644	USS FAIRLESS WORKS	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.0086	Moderate-C
909	WITCO CORP. BRAINARDS FACILITY	TRI	Delaware River - 914	Floodplain	18.4	0.0015	Moderate-C
757	SOLVAY AUTOMOTIVE INC.	TRI	Mill Creek - 648	Zone B	2.0	0.0008	Moderate-C
510	CONSOLIDATED CHEMEX CORP.	TRI	Delaware River - 930	Zone B	0.0	0.0003	Moderate-C
550	COLONIAL CHEMICAL CO.	TRI	RANCOCAS CR - 743	Zone B	3.1	0.0007	Moderate-C
870	PFIZER PIGMENTS INC.	TRI	Shoeneck Creek - 462	Zone B	18.4	0.0026	Moderate-C
796	HI-PURE CHEMICALS INC.	TRI	Unknown - 444	Zone B	21.1	0.0029	Moderate-C
805	HARCROS PIGMENTS INC.	TRI	Shoeneck Creek - 462	Zone B	18.4	0.0010	Moderate-C
917	MAGNESIUM ELEKTRON INC.	TRI	Lockatong Creek - 522	Zone B	23.0	0.0018	Moderate-C
914	GULCO INC.	TRI	Lopatcong Creek - 443	Zone B	18.7	0.0009	Moderate-C
833	CABOT CORP.	TRI	Gallows Run - 523	Zone B	15.2	0.0002	Moderate-C
890	VICTAULIC CO. OF AMERICA APEX FACILITY	TRI	Merrill Creek - 446	Zone B	18.2	0.0004	Moderate-C
806	APOLLO METALS LTD.	TRI	Monocacy Creek - 470	Zone B	21.9	0.0003	Moderate-C
598	RHONE-POULENC AG CO.	TRI	Little Neshaminy Creek - 617	Zone B	5.1	0.0007	Moderate-C
950	SYBRON CHEMICALS INC.	TRI	RANCOCAS CR, N BR - 740	Zone B	5.3	0.0004	Moderate-C
891	J. T. BAKER INC.	TRI	Lopatcong Creek - 443	Zone B	18.7	0.0015	Moderate-C

Figure 2.2.4-7 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Lower Delaware River Watershed

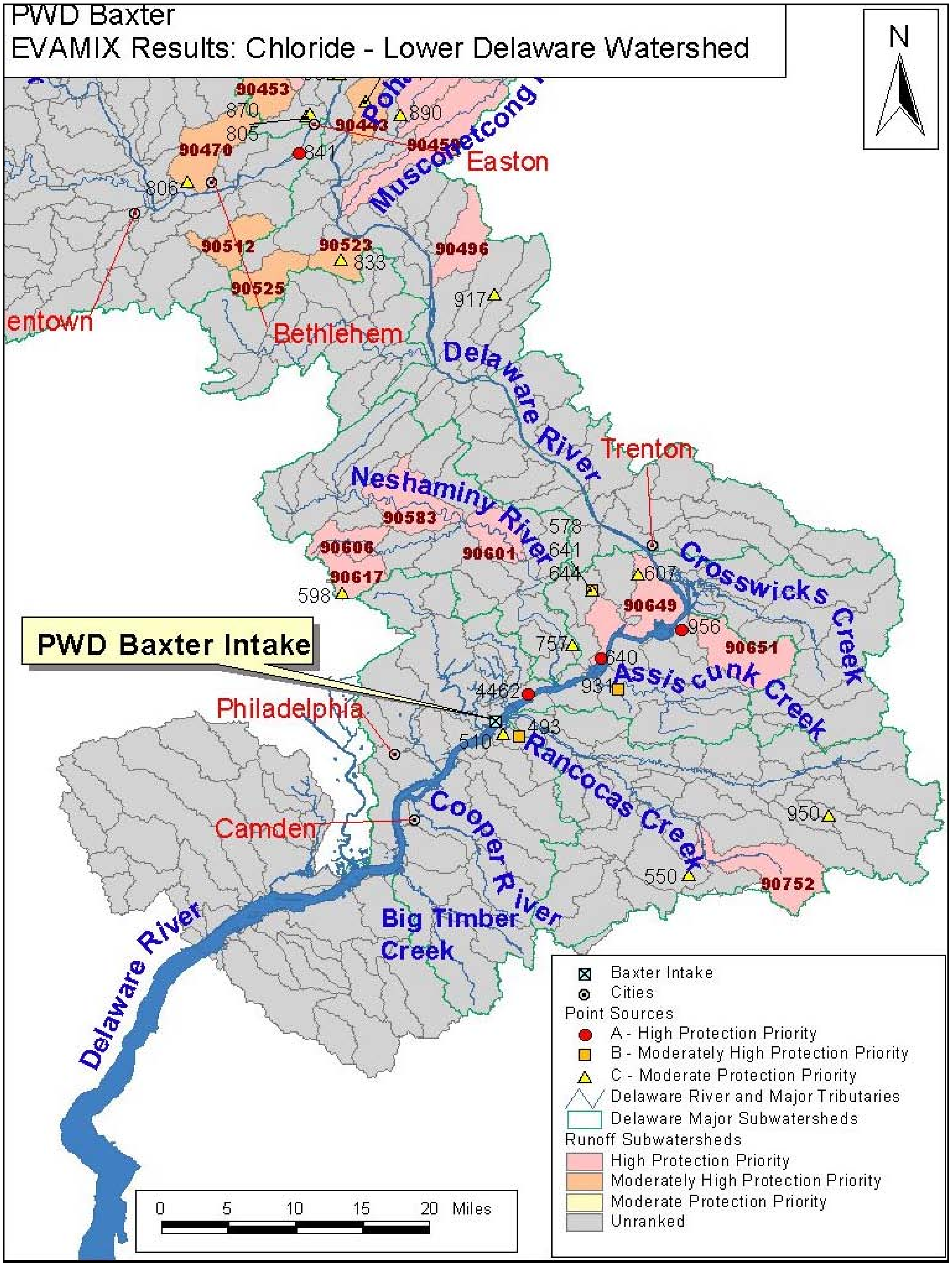


Figure 2.2.4-8 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Middle Delaware River Watershed

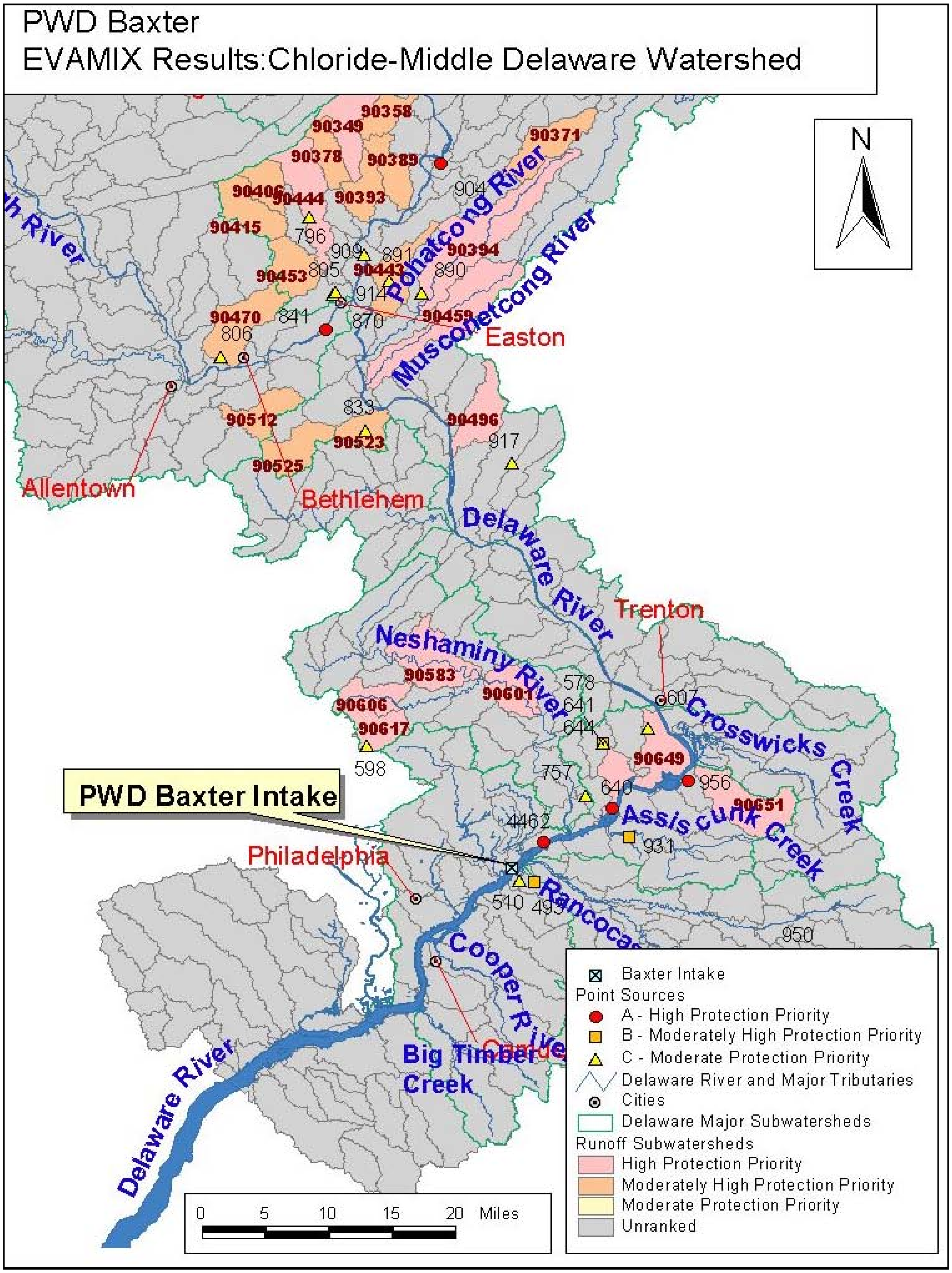
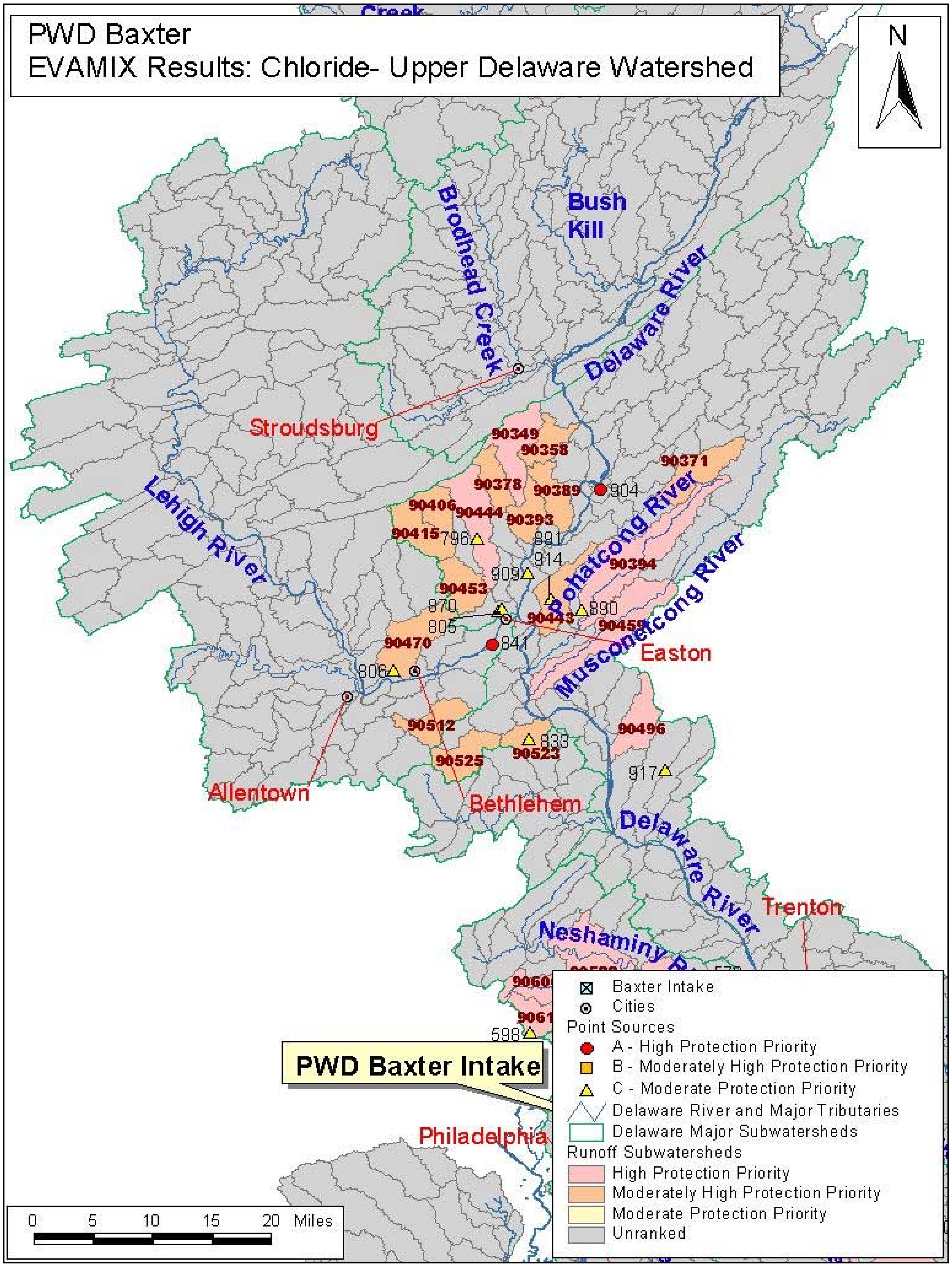


Figure 2.2.4-9 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Upper Delaware River Watershed



Cryptosporidium

Table 2.2.4–4 shows the results of the ranking for pathogens, as represented by estimated sources of *Cryptosporidium*. The table indicates that sources of pathogens are either stormwater runoff from agricultural or urbanized watersheds, and permitted discharges from wastewater treatment plants. NPDES sources are represented in the high priority category (category A). Most sources appear to be relatively minor contributors. However, there are some sources that could provide sufficient loads to have a cumulative impact on the water quality. Geographically, high priority sources were located along the mainstem Delaware River, Rancocas Creek, Neshaminy Creek and the Lehigh River. Figures 2.2.4-10 through 2.2.4-12 illustrate the priority point sources and subwatersheds for *Cryptosporidium* in the lower and upper Delaware River Watershed.

Table 2.2.4-4 Contaminant Category Ranking for *Cryptosporidium*

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.00013	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.00013	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.00013	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.00013	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.00013	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.00013	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.00013	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.00013	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.00013	Highest-A
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.00013	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.00013	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.00013	Highest-A
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.00013	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.00013	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.00013	Highest-A
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.00013	Highest-A
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.00013	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.00013	Highest-A
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.00013	Highest-A
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.00013	Highest-A
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.00013	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.00013	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00013	Highest-A
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.00013	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.00013	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.00013	Highest-A
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.00013	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.00013	Highest-A
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.00013	Highest-A
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.00013	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.00013	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.00013	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.00013	Moderately High-B
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.00013	Moderately High-B
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.00013	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.00013	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.00013	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.00013	Moderately High-B
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.00013	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.00013	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.00013	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.00013	Moderately High-B
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.00013	Moderately High-B
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.00013	Moderately High-B
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.00013	Moderately High-B
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.00013	Moderately High-B
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.00013	Moderately High-B
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00013	Moderately High-B
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.00013	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.00013	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.00013	Moderately High-B
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.00013	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.00013	Moderately High-B
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.00013	Moderately High-B
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.00013	Moderately High-B
1198	BETHLEHEM STEEL - BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	0.00013	Moderately High-B
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.00013	Moderately High-B
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.00020	Moderately High-B
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00001	Moderately High-B
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.00001	Moderately High-B
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.00001	Moderately High-B
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.00013	Moderate-C
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.00013	Moderate-C
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.00001	Moderate-C
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.00001	Moderate-C
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.00001	Moderate-C
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.00001	Moderate-C
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.00001	Moderate-C
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.00001	Moderate-C
1263	FERMENTA ANIMAL HEALTH CO	NPDES	*C - 590	Zone B	6.4	0.00013	Moderate-C
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.00001	Moderate-C
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.00001	Moderate-C
1211	JERSEY CENTRAL POWER & LIGHT	NPDES	Delaware River - 918	Zone B	14.4	0.00013	Moderate-C
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.00001	Moderate-C
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderate-C
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.00001	Moderate-C
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.00001	Moderate-C
1133	PP&L (MARTINS CREEK UNIT)	NPDES	Delaware River - 399	Zone B	20.6	0.00013	Moderate-C
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderate-C
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.00001	Moderate-C
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.00001	Moderate-C
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.00015	Moderate-C
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.00001	Moderate-C
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.00001	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.00001	Moderate-C
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.00001	Moderate-C
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.00014	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.00001	Moderate-C
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.00012	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.00001	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.00001	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.00001	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.00001	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.00001	Moderate-C

Figure 2.2.4-10 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Lower Delaware River Watershed

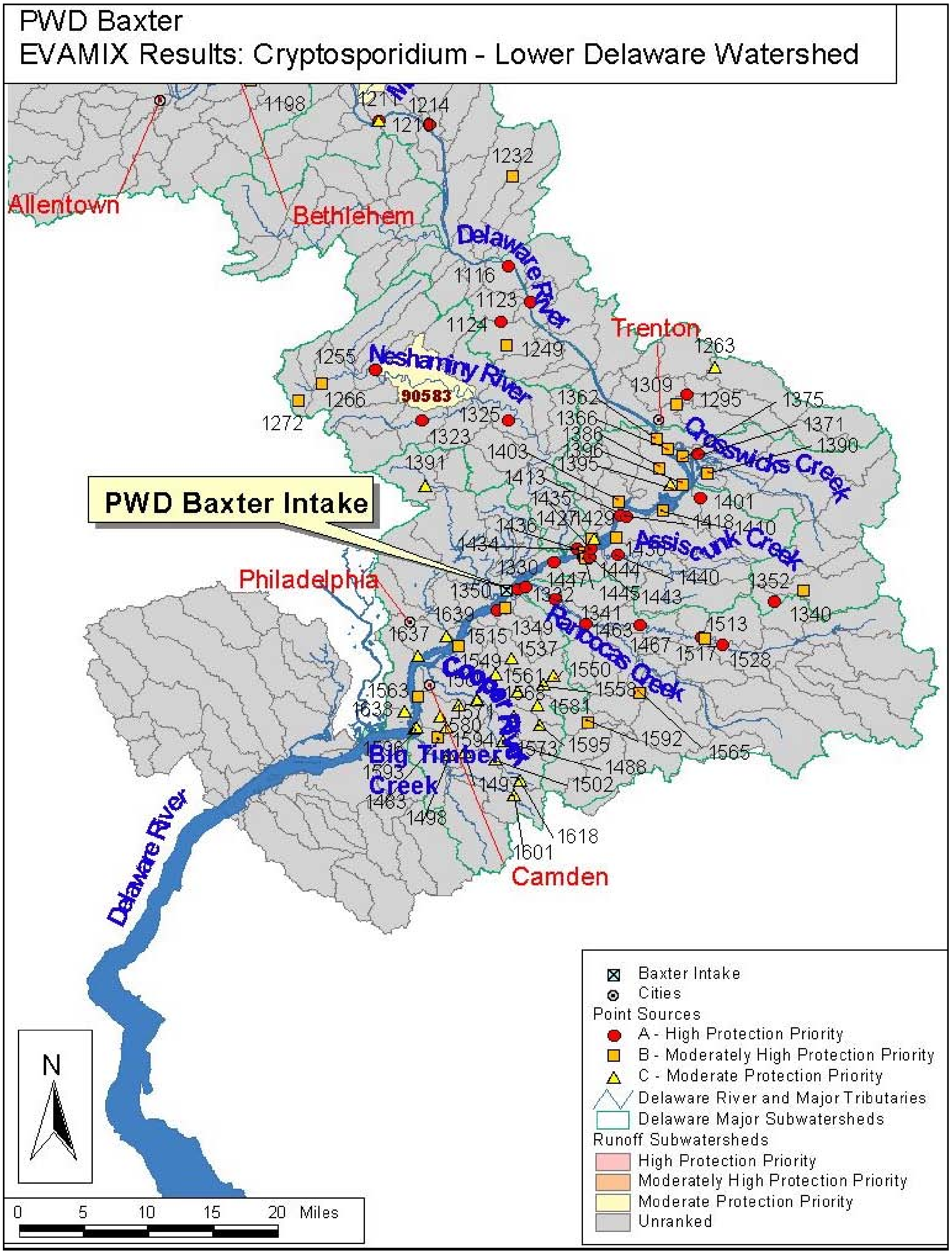


Figure 2.2.4-11 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Middle Delaware River Watershed

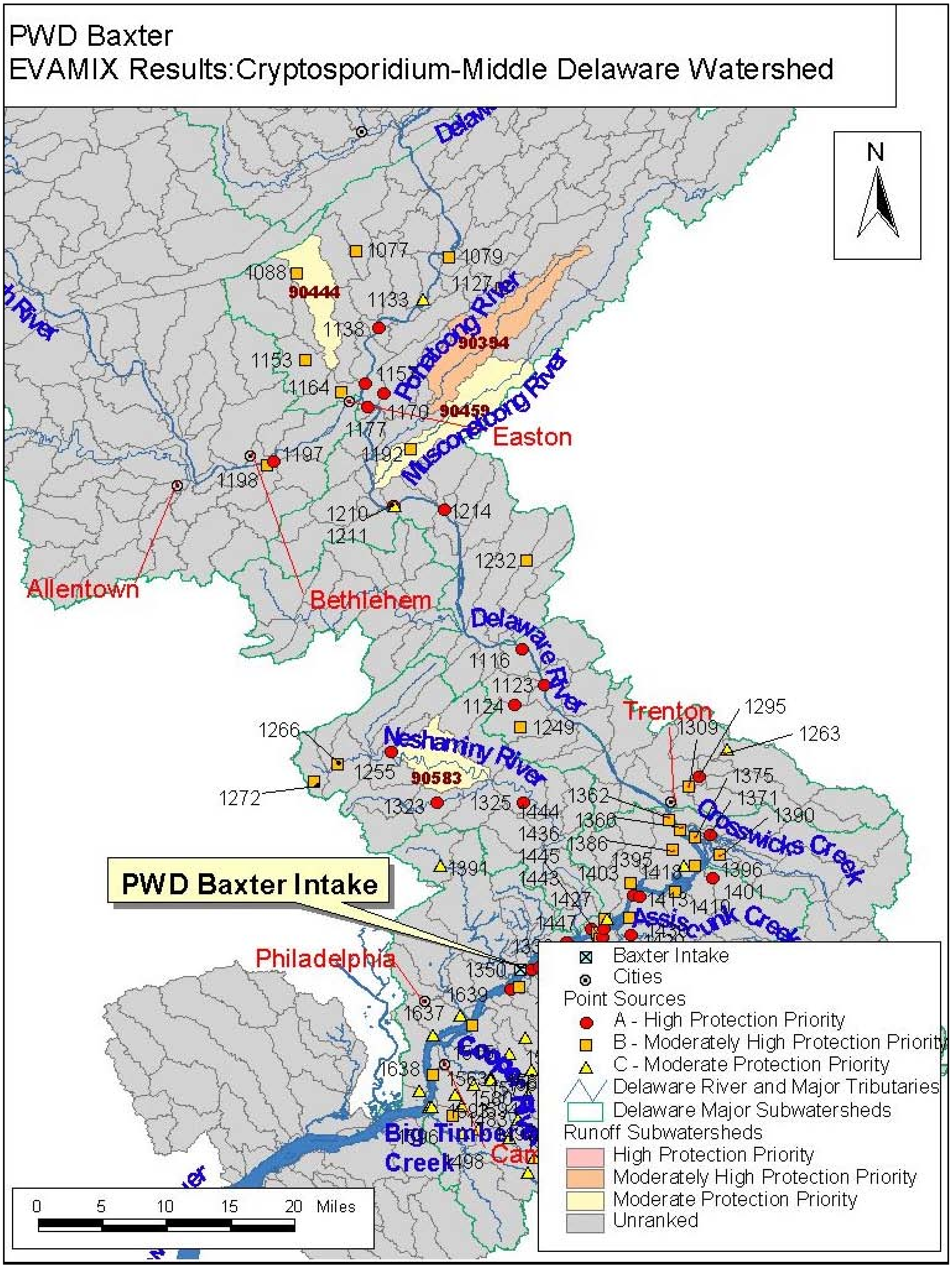
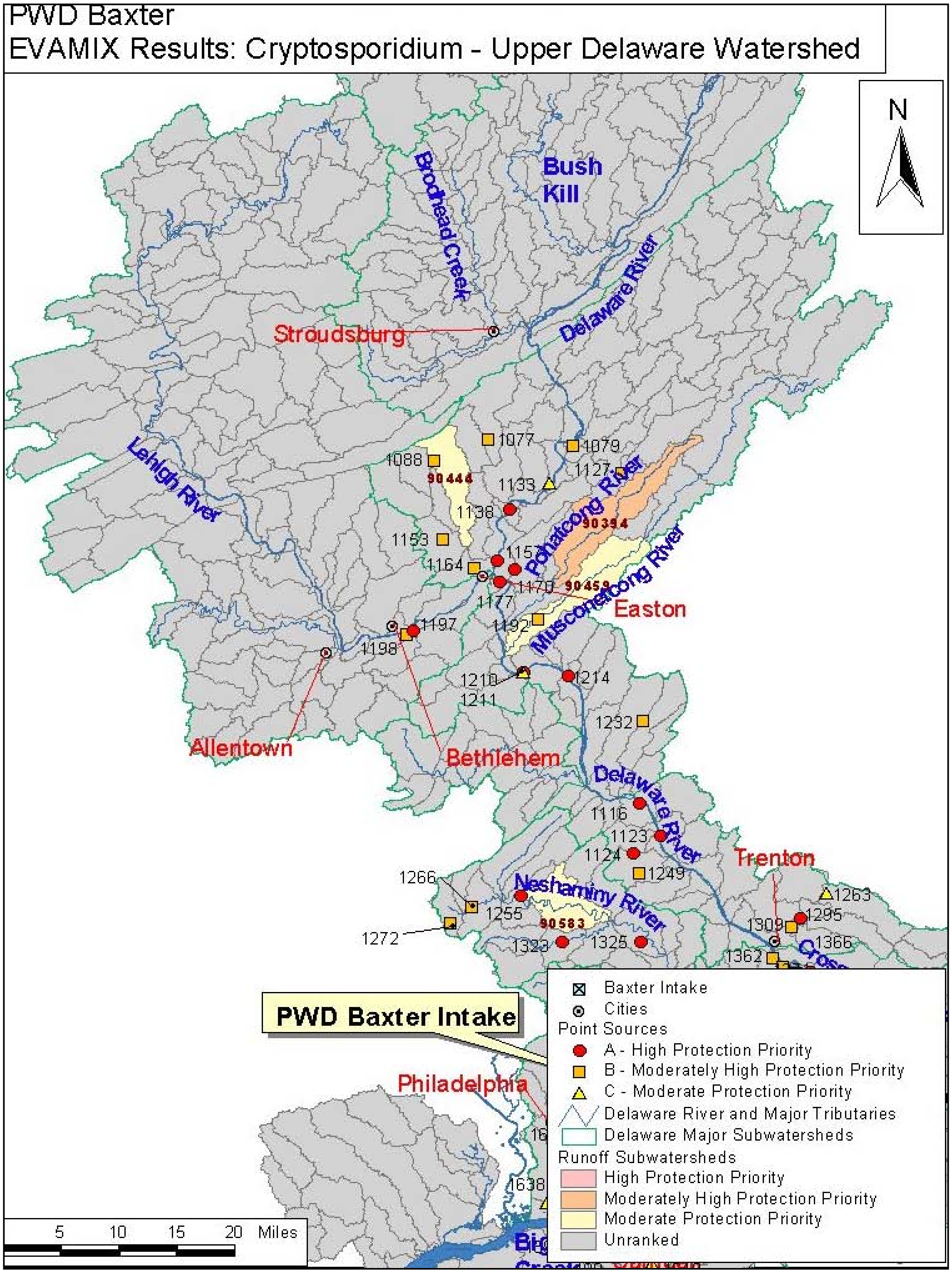


Figure 2.2.4-12 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Upper Delaware River Watershed



Fecal Coliform

Table 2.2.4-5 shows the results of the ranking for fecal coliform. The table indicates that sources are either stormwater runoff from agricultural or urbanized watersheds, and permitted discharges from wastewater treatment plants. Although both sources are represented in the high priority category (category A), the results suggest that periodic loading from stormwater is orders of magnitude higher than the loading from wastewater treatment plants. The table shows that during dry weather flows, wastewater loading is insignificant at the Baxter Intake, but that during storm events, fecal coliform would be expected to increase by orders of magnitude. Geographically, priority point sources are located in the lower portion of the Delaware Watershed, while the priority stormwater runoff subwatersheds are in the upper Delaware Watershed. Figures 2.2.4-13 through 2.2.4-15 illustrate the priority point sources and subwatersheds for coliform in the upper and lower Delaware River Watershed.

Table 2.2.4-5 Contaminant Ranking for Fecal Coliform

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.31010	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.23143	Highest-A
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.21318	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.16836	Highest-A
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	0.17971	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00001	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.00001	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.00013	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.00001	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.00013	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.00001	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.00013	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.00001	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.00013	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.00013	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.00001	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.00001	Highest-A
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	0.15862	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.00001	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.00013	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.00013	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.00013	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.00001	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.00013	Highest-A
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	0.15042	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.11159	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.00013	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.00013	Highest-A
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.00001	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.00013	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.00001	Highest-A
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.00013	Moderately High-B
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.00013	Moderately High-B
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.00013	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.00001	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.00013	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.00013	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderately High-B
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.00001	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.00001	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.00013	Moderately High-B
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.10314	Moderately High-B
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.00013	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderately High-B
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.00013	Moderately High-B
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.00013	Moderately High-B
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.00013	Moderately High-B
90496	Nishisakawick Creek-496	NP	Nishisakawick Creek - 496	Zone B	12.8	0.12478	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.00013	Moderately High-B
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.00001	Moderately High-B
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	0.13380	Moderately High-B
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00013	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.00001	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Moderately High-B
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.00013	Moderately High-B
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.00013	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.00013	Moderately High-B
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.00013	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.00001	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.00001	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.00013	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.00013	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.00001	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.00013	Moderate-C
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.00013	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.00001	Moderate-C
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.00013	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.00013	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.00013	Moderate-C
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.00013	Moderate-C
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.00001	Moderate-C
90672	Barkers Brook-672	NP	Barkers Brook - 672	Zone B	3.5	0.09818	Moderate-C
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Moderate-C
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.00013	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.00013	Moderate-C
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.00013	Moderate-C
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.00013	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.00013	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.00001	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.00001	Moderate-C
90525	Cooks Creek-525	NP	Cooks Creek - 525	Zone B	16.8	0.11448	Moderate-C
90371	PEQUEST R-371	NP	PEQUEST R - 371	Zone B	23.5	0.12480	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.00001	Moderate-C
90623	DOCTORS CR-623	NP	DOCTORS CR - 623	Zone B	4.4	0.09282	Moderate-C
90443	Lopatcong Creek-443	NP	Lopatcong Creek - 443	Zone B	17.6	0.11408	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.00001	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.00001	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.00013	Moderate-C

Source ID	**Source Name**	**Database Used**	**Subwatershed**	**Zone**	**Time of Travel**	**Relative Impact (%)**	**Priority**
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.00013	Moderate-C
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.00013	Moderate-C
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.00013	Moderate-C
90484	Hakihokake Creek-484	NP	Hakihokake Creek - 484	Zone B	13.4	0.10490	Moderate-C
90572	Delaware River-572	NP	Delaware River - 572	Zone B	5.9	0.09226	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.00013	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.00013	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.00013	Moderate-C

Figure 2.2.4-13 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Lower Delaware River Watershed

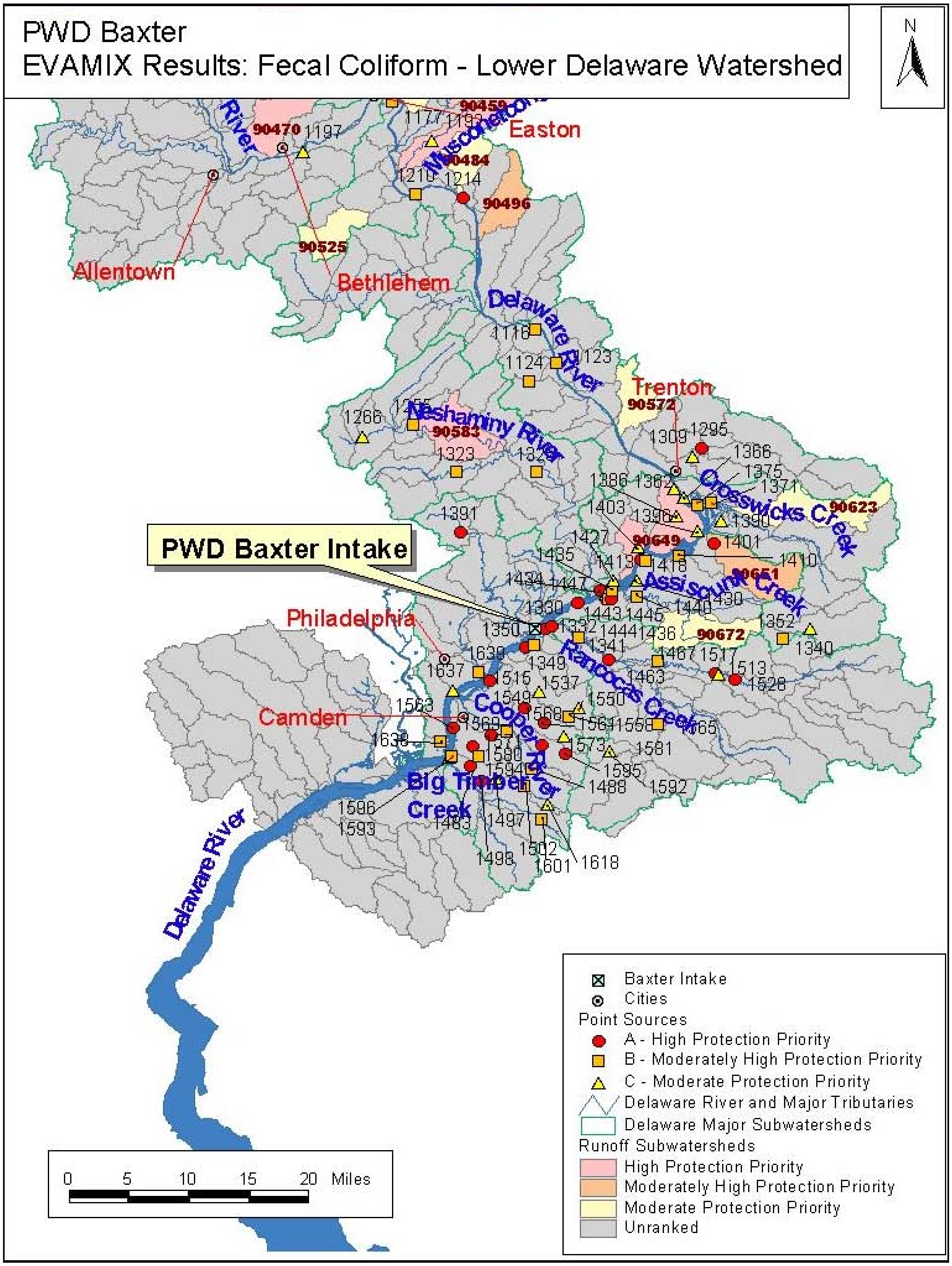


Figure 2.2.4-14 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Middle Delaware River Watershed

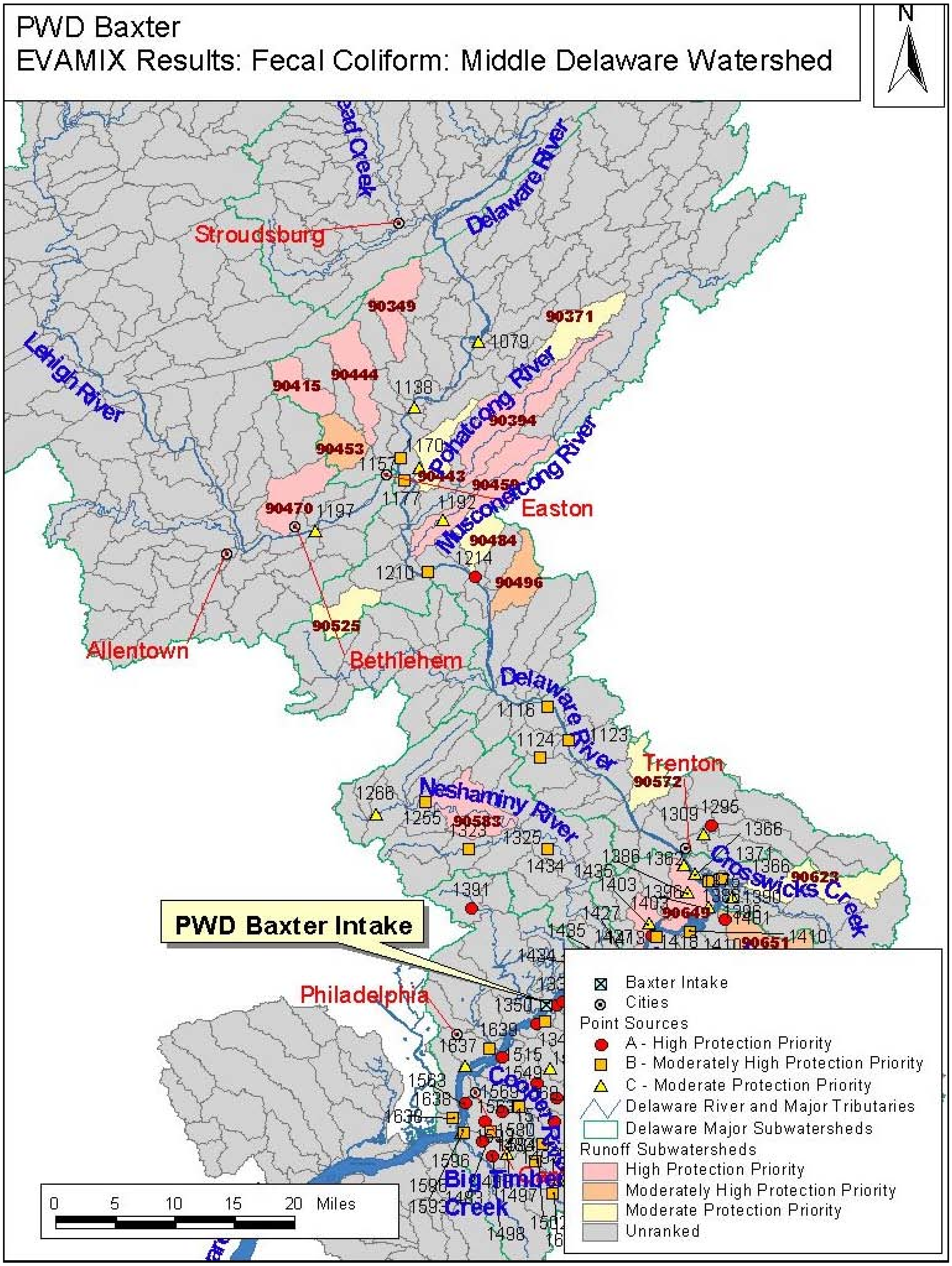
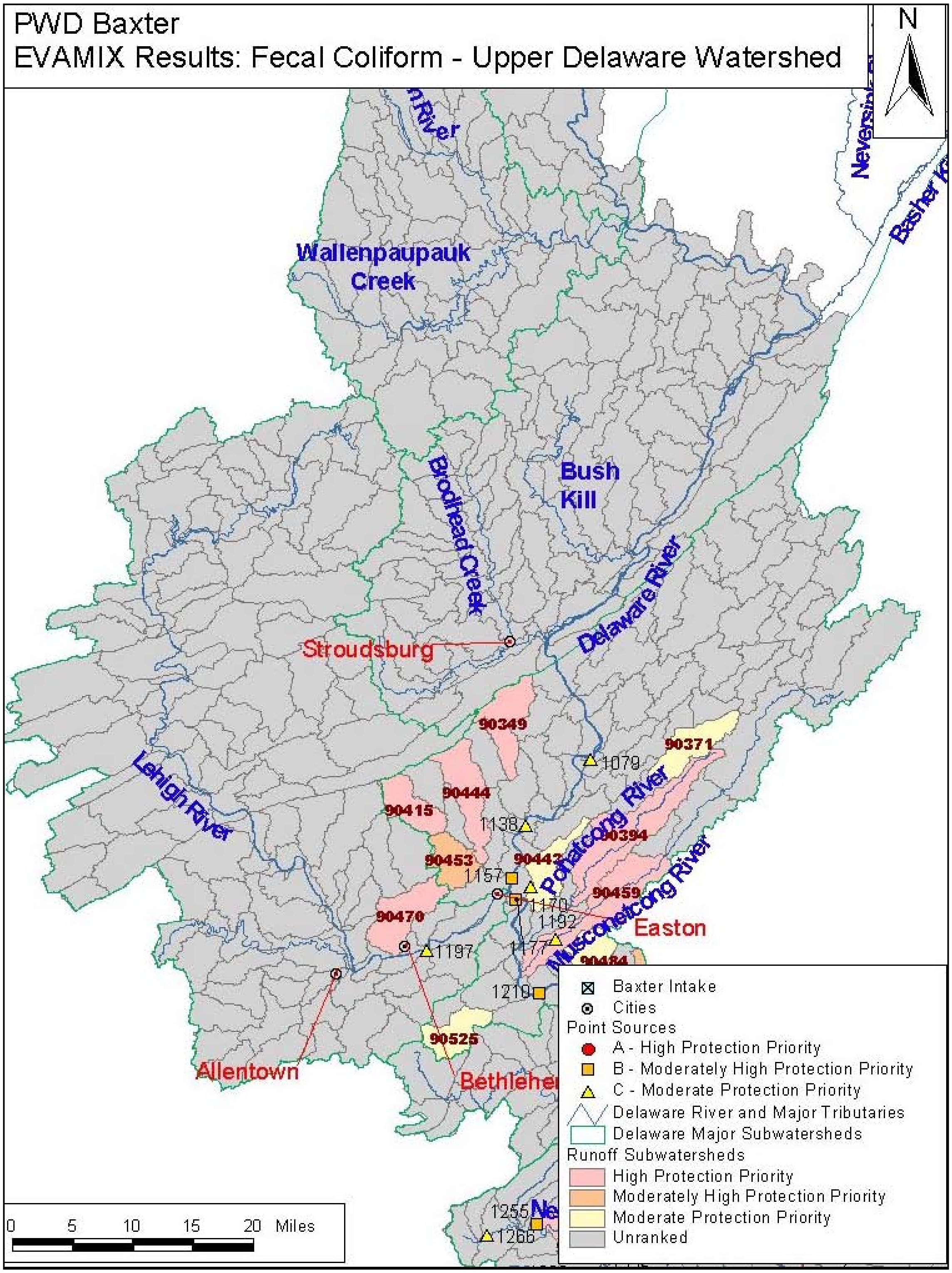


Figure 2.2.4-15 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Upper Delaware River Watershed



Metals

Table 2.2.4-6 provides the results of the heavy metal source ranking. Results generally show that NPDES permitted discharges are the primary sources. Some TRI sites with significant storage or use of metals are also rated as high priority sources, primarily because a catastrophic leak or spill would result in extremely high concentrations. Most of the TRI sites fall into the high protection priority category (category A). Only one AST site is listed as a high priority. It is important to note that acid mine drainage could not be included in this analysis and may be a more significant source than any of the other source categories (see section 2.1.5.4). Most sites were located in the watershed below Trenton. However, a few sites were in Upper Delaware areas. Figures 2.2.4-16 through 2.2.4-18 identify the priority point sources for metals in the lower and upper parts of the Delaware River Watershed.

Table 2.2.4-6 Contaminant Category Ranking for Metals

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
956	CIRCUIT FOIL USA INC. (FORMERLY YATES IND.)	TRI	Delaware River - 927	Zone B	3.1	2368.223	Highest-A
731	HARSCO CORP. HECKETT DIV. PLANT 15	TRI	Queen Anne Creek - 627	Floodplain	2.9	1392.510	Highest-A
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	1325.911	Highest-A
644	USS FAIRLESS WORKS	TRI	Queen Anne Creek - 627	Floodplain	2.9	1055.986	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.000	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.017	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.017	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.017	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.017	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.002	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.002	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	12.672	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.017	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.017	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.002	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.002	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.002	Highest-A
804	BETHLEHEM APPARATUS CO. INC.	TRI	Saucon Creek - 512	Zone B	17.9	607.134	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.002	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.017	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.017	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.002	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.017	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.017	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.017	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.017	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.002	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.017	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.017	Highest-A
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.002	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.002	Highest-A
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.002	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.004	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.002	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.017	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.002	Moderately High-B
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.017	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.002	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	9.783	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.017	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.017	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.017	Moderately High-B
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.162	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.002	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.002	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.002	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.017	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.017	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.002	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.002	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.017	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.017	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.017	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.017	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.017	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.017	Moderately High-B
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.002	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.017	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.002	Moderately High-B
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	25.405	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.017	Moderately High-B
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.002	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.002	Moderately High-B
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.002	Moderately High-B
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.017	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.005	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.017	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.017	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	3.235	Moderate-C
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	4.843	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.002	Moderate-C
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.017	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.002	Moderate-C
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.017	Moderate-C
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.017	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.017	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.017	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.017	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.017	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.017	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.017	Moderate-C
578	LACLEDE FAIRLESS	TRI	Queen Anne Creek - 627	Floodplain	2.9	148.765	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.017	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.017	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.017	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.017	Moderate-C
515	EASTMAN WIRE & CABLE CO.	TRI	PENNSAUKEN CR - 706	Zone A	1.3	107.636	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.017	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.017	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.026	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.017	Moderate-C
859	WILDON IND. INC.	TRI	Delaware River - 345	Zone B	24.3	403.626	Moderate-C
5726	G R O W S INC LANDFILL	RCRA	Delaware River - 649	Floodplain	2.8	0.159	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.002	Moderate-C
5951	AMSPEC CHEMICAL CORP	RCRA	Delaware River - 932	Floodplain	2.9	0.002	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.017	Moderate-C
498	HOEGANAES CORP.	TRI	Delaware River - 930	Zone A	0.0	46.659	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.017	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.017	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.017	Moderate-C

Figure 2.2.4-16 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Lower Delaware River Watershed

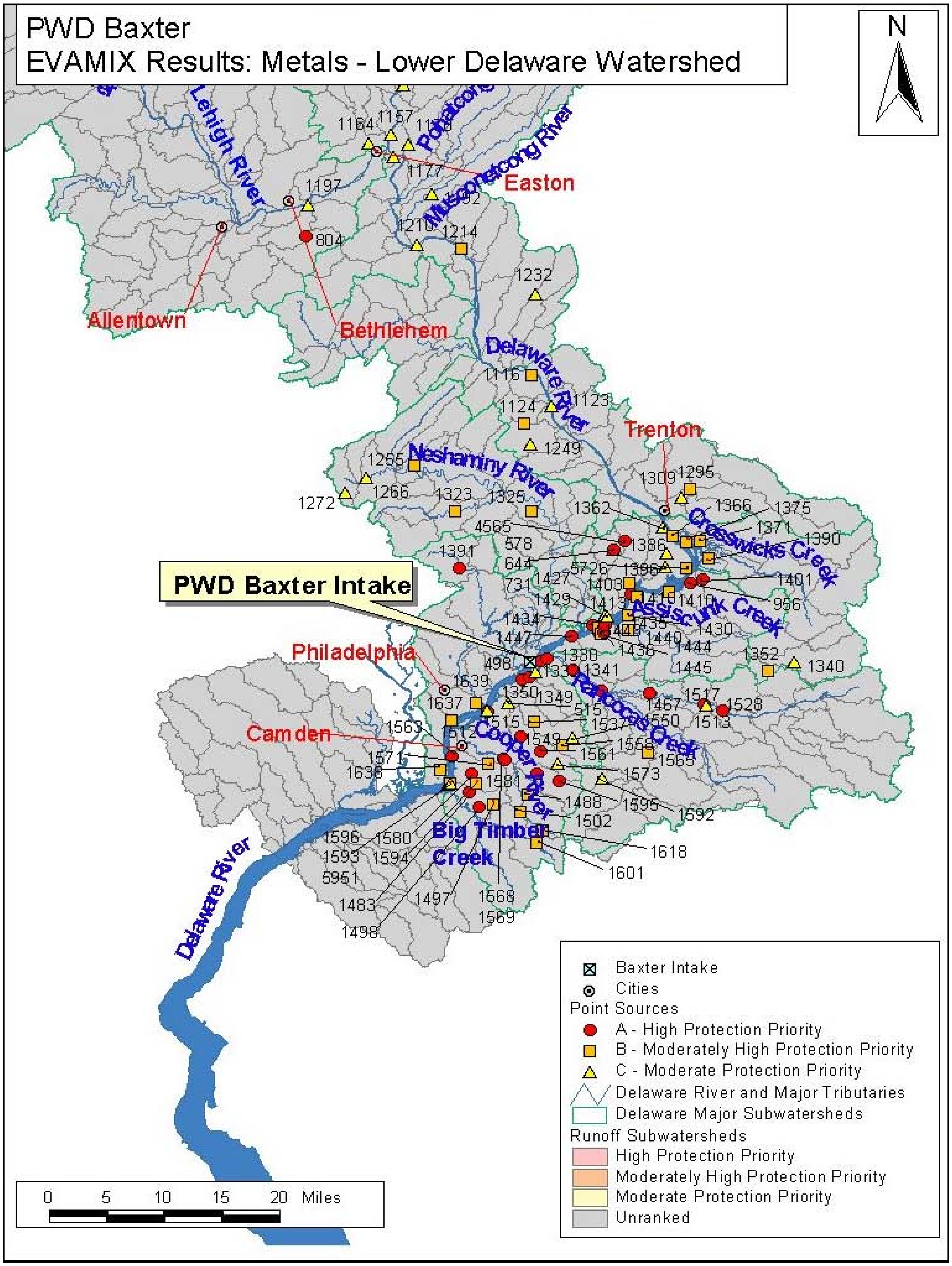


Figure 2.2.4-17 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Middle Delaware Watershed

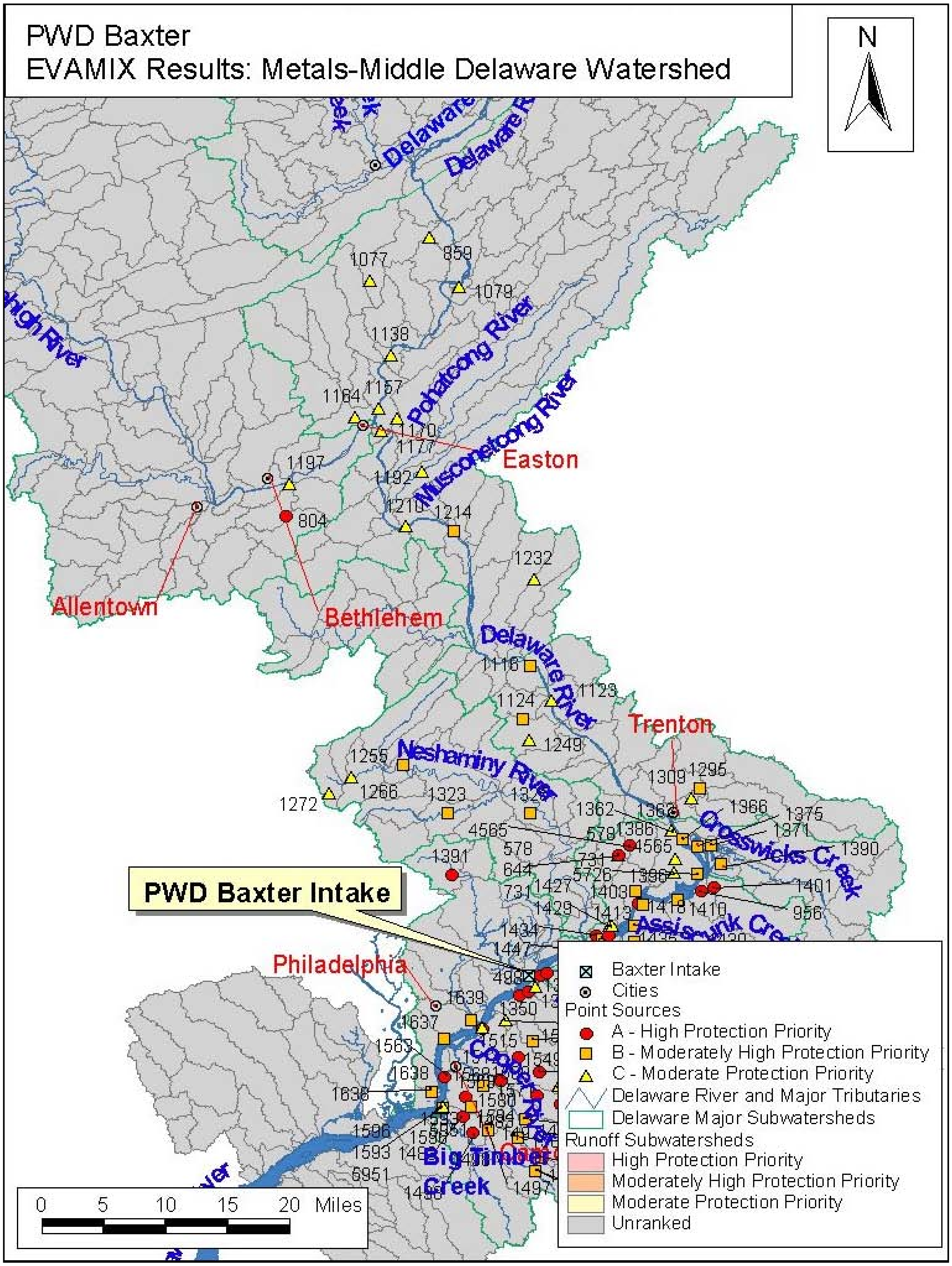
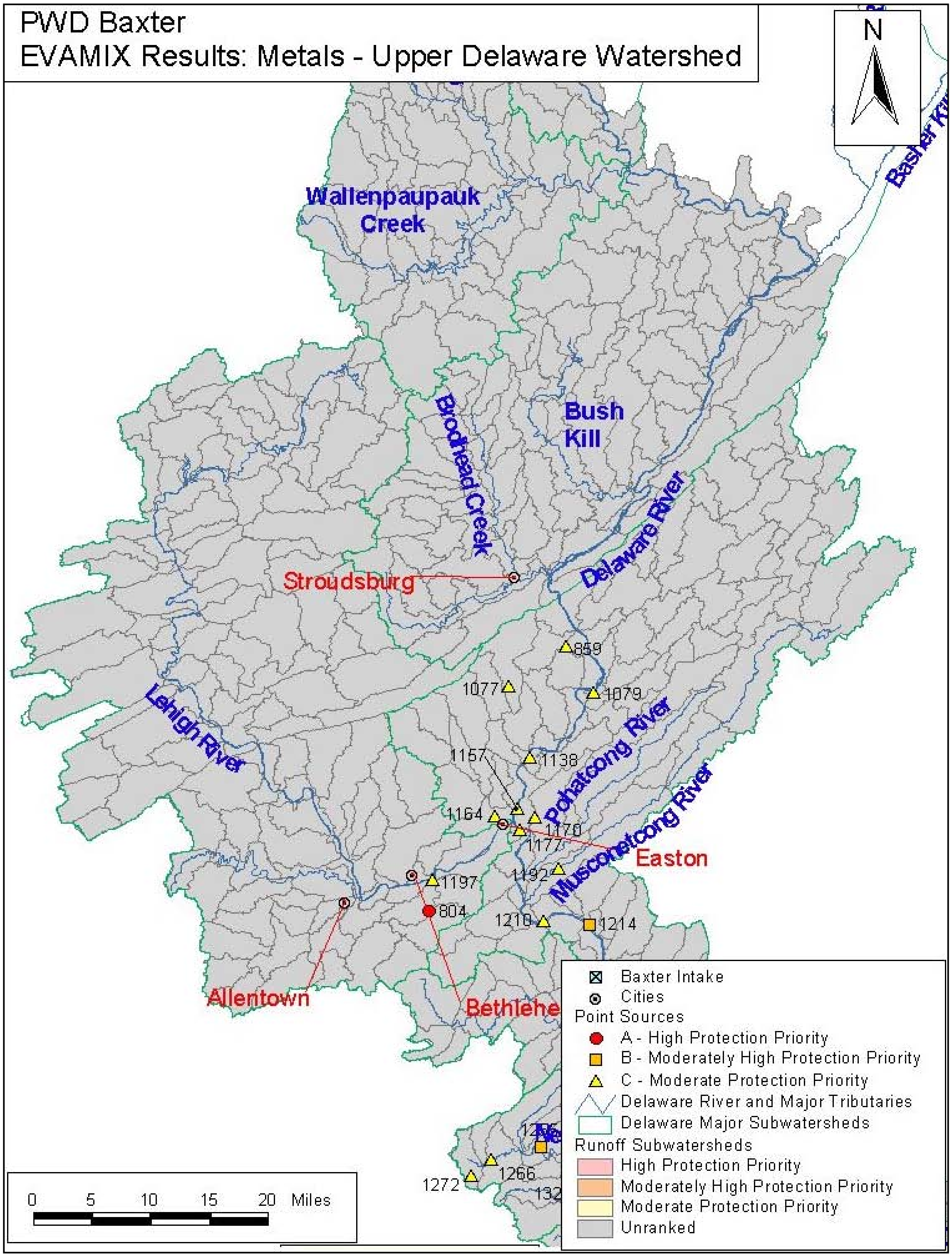


Figure 2.2.4-18 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Upper Delaware Watershed



Nitrates

Table 2.2.4-7 shows the ranking of sites for nitrate loading. The high category (category A) is dominated by NPDES dischargers, primarily wastewater treatment plants. Most of the loading from these sites appears to be relatively low, and is not likely to cause a cumulative impact that would cause an exceedance of the nitrate standard at the intake. Moderate priority sites (category C) are a mixture of NPDES sites and TRI sites. The potentially significant sources were located in the floodplain of the Delaware River and Zones A and B for the Baxter Intake. Therefore, efforts to reduce nitrate impacts will be necessary watershed wide. Figures 2.2.4-19 through 2.2.4-21 illustrate the priority point sources and subwatersheds for nitrates in the lower and upper Delaware River watersheds.

Table 2.2.4-7 Contaminant Category Ranking for Nitrates

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	0.99443	Highest-A
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.09152	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.01811	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00009	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.00094	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.00094	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.00094	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.00094	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.03144	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.00094	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.00009	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.01000	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.00009	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.00094	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.00009	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.00009	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.00009	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.00009	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.00094	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.00094	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.00094	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.00009	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.00094	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.00094	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.00009	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.00094	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.00094	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.00009	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.00154	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.00009	Highest-A
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.00009	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.00094	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.00009	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.00094	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.00009	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.00094	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.00009	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00094	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.00009	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.00094	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.00009	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.00094	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.00094	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.00009	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.00094	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.00009	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.00009	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.00094	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.00094	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.00094	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.00094	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.00773	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.00094	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.00094	Moderately High-B
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.00009	Moderately High-B
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.00009	Moderately High-B
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.00009	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.00009	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00094	Moderately High-B
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.00009	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.00094	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.00094	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.00094	Moderately High-B
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.00050	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.00094	Moderately High-B
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.00009	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.00094	Moderately High-B
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.00094	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.00009	Moderate-C
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.00094	Moderate-C
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00094	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.00094	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.00094	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.00094	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.00094	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.00094	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00094	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.00094	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.00094	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.00094	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.00094	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.00094	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00009	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.00094	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.00094	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.00094	Moderate-C
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.00094	Moderate-C
498	HOEGANAES CORP.	TRI	Delaware River - 930	Zone A	0.0	0.01211	Moderate-C
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.00094	Moderate-C
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	0.08991	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.00094	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.00094	Moderate-C
644	USS FAIRLESS WORKS	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.03028	Moderate-C
757	SOLVAY AUTOMOTIVE INC.	TRI	Mill Creek - 648	Zone B	2.0	0.02099	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.00094	Moderate-C
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.00094	Moderate-C
641	CORCO CHEMICAL CORP.	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.00462	Moderate-C
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.00175	Moderate-C
528	WILLING B WIRE CORP.	TRI	RANCOCAS CR - 676	Zone A	1.5	0.00154	Moderate-C
569	CUMBERLAND FARMS INC.	TRI	ASSISCUNK CR - 662	Zone A	2.2	0.00323	Moderate-C

Figure 2.2.4-19 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Lower Delaware Watershed

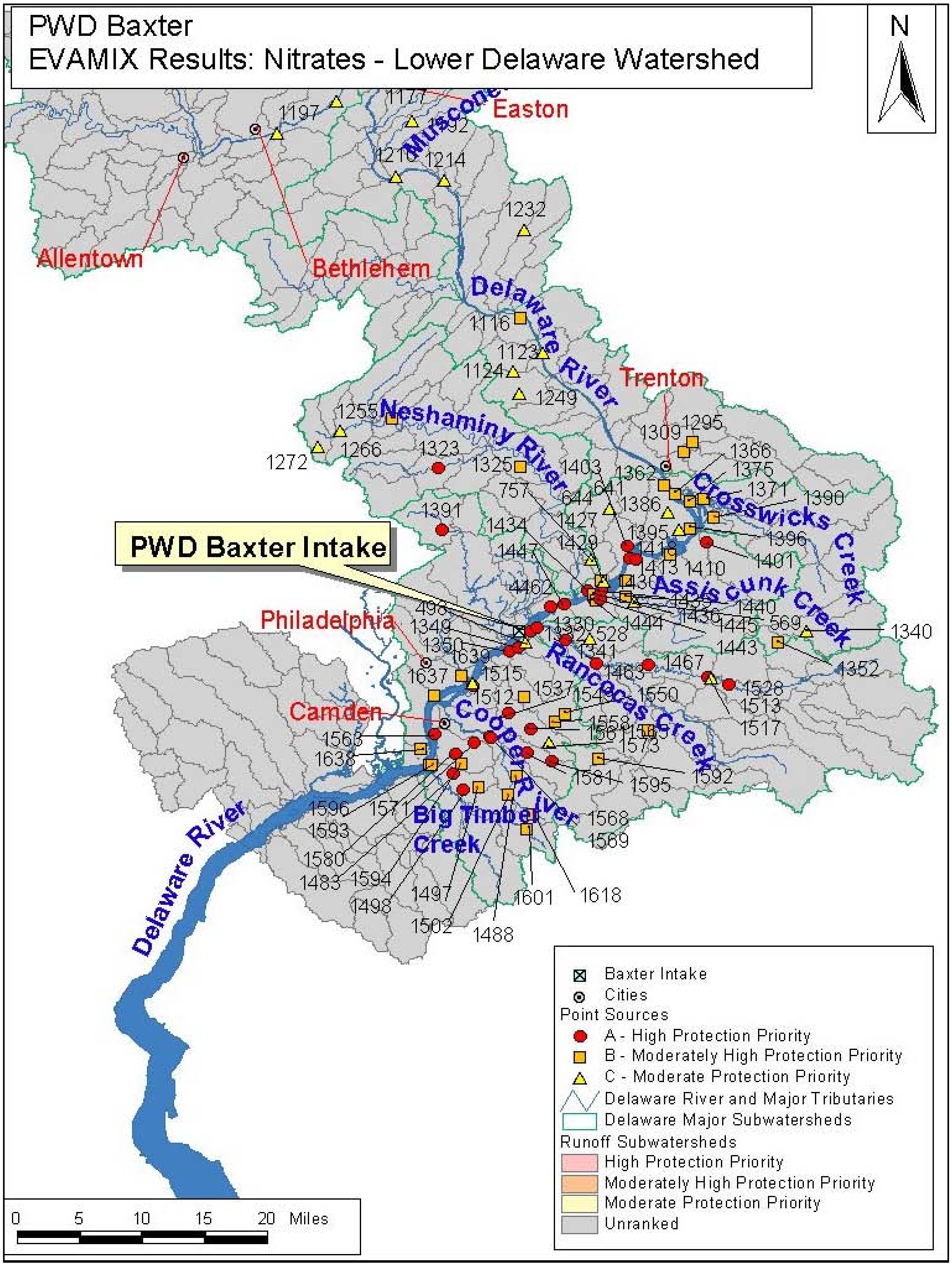


Figure 2.2.4-20 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Middle Delaware Watershed

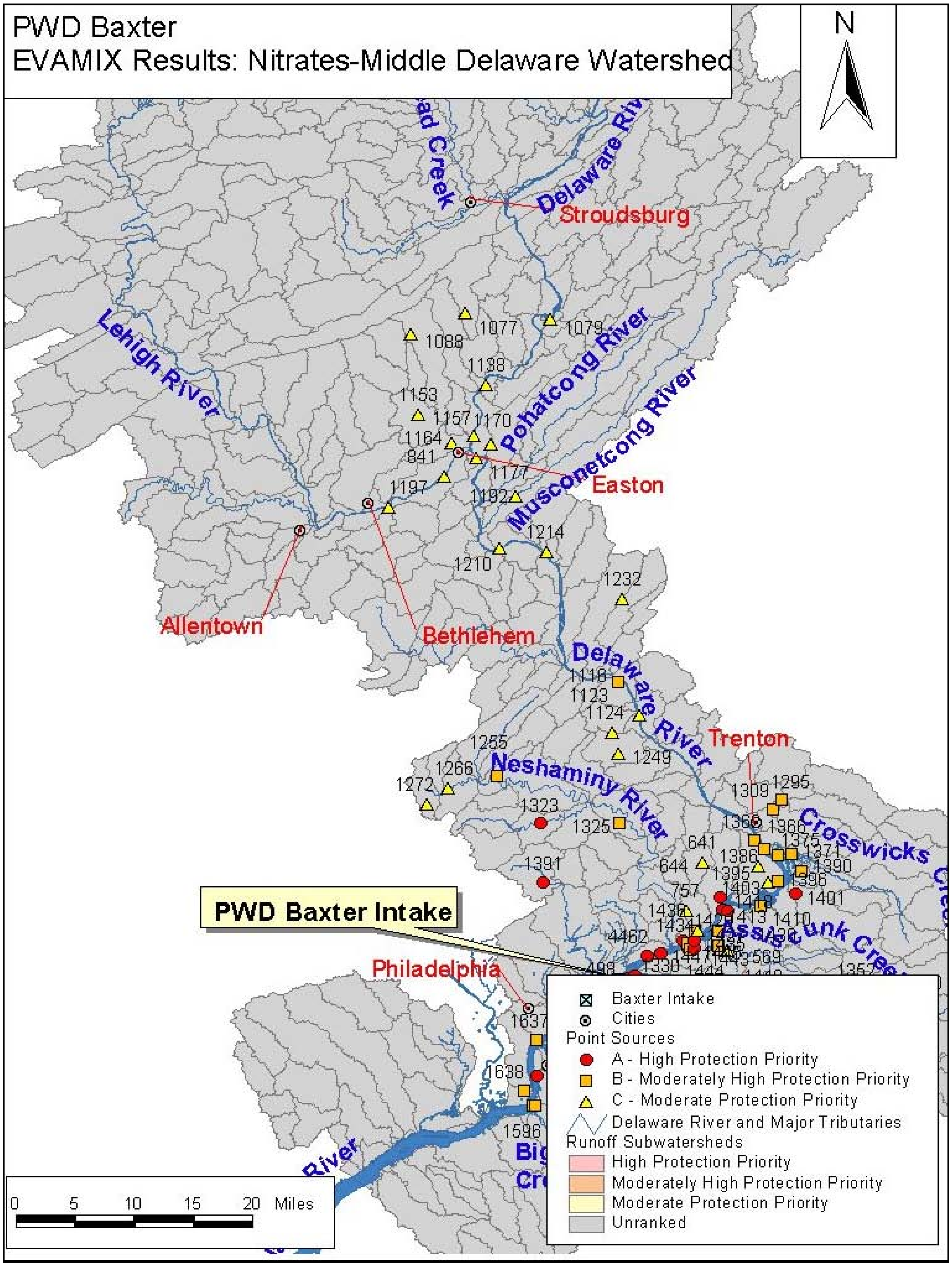
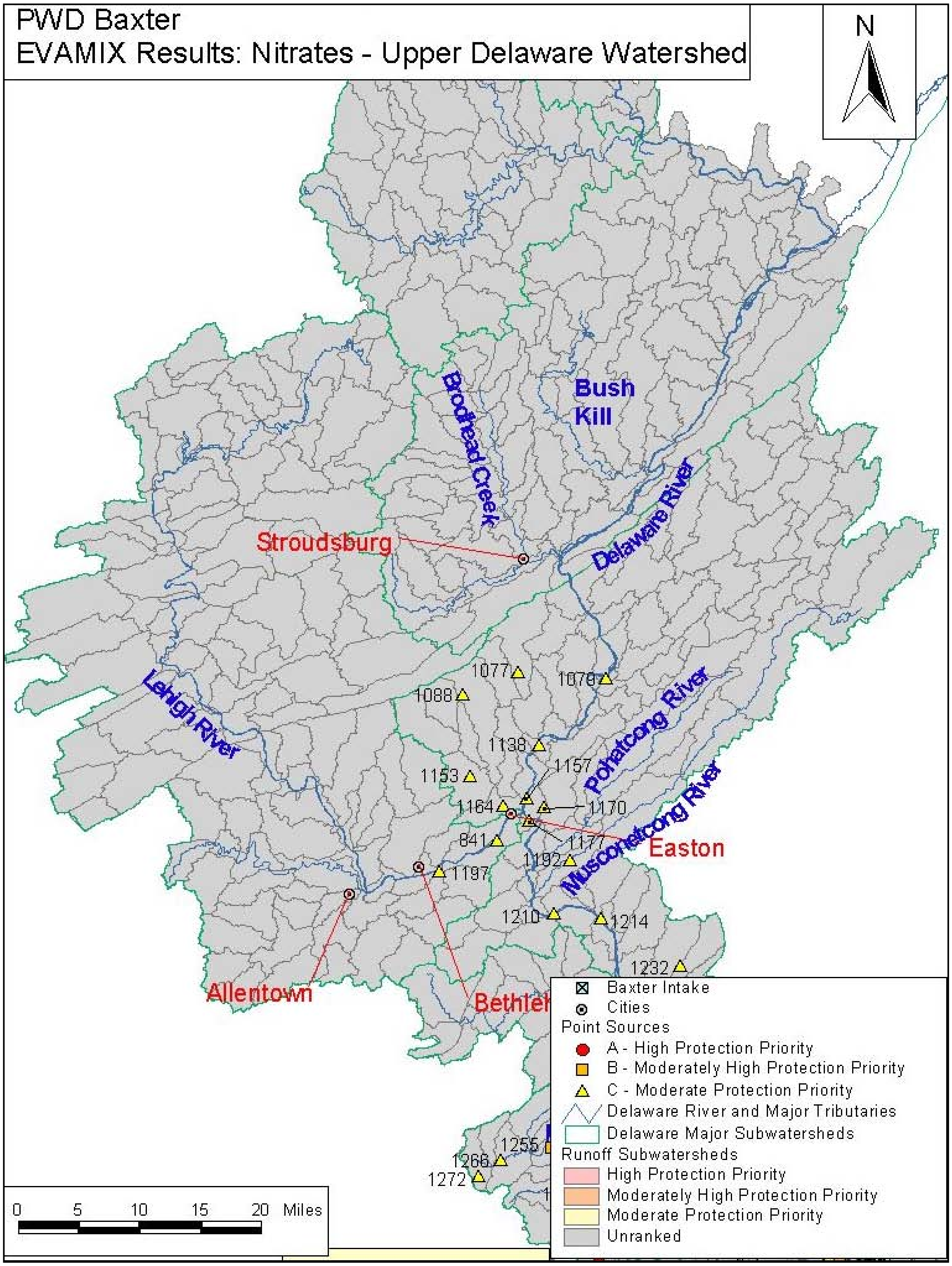


Figure 2.2.4-21 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Upper Delaware Watershed



Petroleum Hydrocarbons

The number of significant sources of petroleum hydrocarbons are shown in Table 2.2.4-8. Above ground storage tanks containing fuel, NPDES sites or stormwater runoff were identified as significant potential sources of petroleum hydrocarbon loading. Most of the high priority sites are either fuel storage facilities (with a low probability of release but potentially very high concentrations), NPDES sites with relatively low loadings, or stormwater runoff with lower concentrations but frequent occurrence. All of the potentially significant sources of AST identified were a geographic mixture of locations in the Zone A and Zone B. Fourteen non-point source runoff subwatersheds were identified as potentially significant sources of high protection priority and 11 as moderately high priorities. Figures 2.2.4-22 through 2.2.4-24 illustrate the priority point sources and subwatersheds for petroleum hydrocarbons in the Delaware River watershed. Most of the high priority subwatersheds are located in the upper portion of the watershed, including Lehigh and Musconetcong Creeks.

Table 2.2.4-8 Contaminant Category Ranking for Petroleum Hydrocarbons

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4654	GILBERT TERM	AST	Saucon Creek - 494	Zone B	17.1	21551.363	Highest-A
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	17236.847	Highest-A
4459	CROYDON GENERATING STA	AST	Delaware River - 666	Zone A	0.6	16706.483	Highest-A
5036	MEENAN OIL LP	AST	Delaware River - 597	Zone B	5.4	14570.286	Highest-A
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	9.539E-05	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0037304	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.027027	Highest-A
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0002544	Highest-A
1198	BETHLEHEM STEEL - BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	1.1284555	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.1196412	Highest-A
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.1153142	Highest-A
5055	WARMINSTER BULK PLT	AST	Little Neshaminy Creek - 613	Zone B	4.2	6364.3745	Highest-A
90672	Barkers Brook-672	NP	Barkers Brook - 672	Zone B	3.5	0.1073159	Highest-A
90623	DOCTORS CR-623	NP	DOCTORS CR - 623	Zone B	4.4	0.1089153	Highest-A
90752	RANCOCAS CR-752	NP	RANCOCAS CR - 752	Zone B	4.4	0.1074457	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.1715621	Highest-A
90572	Delaware River-572	NP	Delaware River - 572	Zone B	5.9	0.0941263	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.4340213	Highest-A
90496	Nishisakawick Creek-496	NP	Nishisakawick Creek - 496	Zone B	12.8	0.1288676	Highest-A
90484	Hakihokake Creek-484	NP	Hakihokake Creek - 484	Zone B	13.4	0.1083365	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.2466218	Highest-A
90525	Cooks Creek-525	NP	Cooks Creek - 525	Zone B	16.8	0.1143867	Highest-A
90443	Lopatcong Creek-443	NP	Lopatcong Creek - 443	Zone B	17.6	0.1184753	Highest-A
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.3220462	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90512	Saucon Creek-512	NP	Saucon Creek - 512	Zone B	17.9	0.093902	Highest-A
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	0.1341673	Moderately High-B
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.2137611	Moderately High-B
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	0.1508291	Moderately High-B
90393	Martins Creek-393	NP	Martins Creek - 393	Zone B	19.8	0.106943	Moderately High-B
90406	Unknown-406	NP	Unknown - 406	Zone B	19.8	0.0933621	Moderately High-B
90422	Buckhorn Creek-422	NP	Buckhorn Creek - 422	Zone B	20.3	0.0992126	Moderately High-B
90389	Oughoughton Creek-389	NP	Oughoughton Creek - 389	Zone B	20.6	0.1146208	Moderately High-B
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	0.1853983	Moderately High-B
90378	Waltz Creek-378	NP	Waltz Creek - 378	Zone B	20.8	0.1003107	Moderately High-B
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	0.160758	Moderately High-B
90371	PEQUEST R-371	NP	PEQUEST R - 371	Zone B	23.5	0.1322657	Moderately High-B
4446	COLMAR TERM	AST	West Branch Neshaminy Creek - 586	Zone B	9.0	3977.734	Moderately High-B
3666	TORRESDALE FUEL CO INC	AST	Delaware River - 690	Zone A	0.4	53.036454	Moderately High-B
4449	YELLOW FREIGHT SYS	AST	Delaware River - 666	Zone A	0.7	53.036454	Moderately High-B
4333	PENSKE TRUCK LEASING	AST	NESHAMINY R - 657	Zone A	1.5	53.036454	Moderately High-B
4396	EGGERT FUELS	AST	Mill Creek - 648	Zone A	1.6	53.036454	Moderately High-B
4403	DIAL	AST	Delaware River - 649	Zone A	1.8	63.643745	Moderately High-B
4576	SAFETY KLEEN CORP FAIRLESS HILLS BRANCH	AST	Queen Anne Creek - 627	Zone A	2.9	53.036454	Moderately High-B
4817	CHEMCENTRAL PHILA	AST	Delaware River - 649	Zone A	3.9	53.036454	Moderately High-B
4389	3M CO	AST	Mill Creek - 648	Zone B	2.4	530.36454	Moderately High-B
4856	SKILLMAN OIL	AST	Delaware River - 567	Floodplain	8.3	79.554681	Moderately High-B
4317	ATKINSON FREIGHT LINES CORP	AST	Delaware River - 666	Zone B	0.6	53.036454	Moderately High-B
4314	PENSKE TRUCK LEASING CO LP	AST	Delaware River - 666	Zone B	0.7	53.036454	Moderately High-B
4633	WILLOW GROVE TERM	AST	Robinhood Brook - 628	Zone B	2.8	278.44138	Moderately High-B
4870	WILLIAM W FABIAN & SON INC	AST	Newtown Creek - 600	Zone B	4.0	418.98799	Moderately High-B
4991	SINKLER INC	AST	Robinhood Brook - 633	Zone B	2.8	265.18227	Moderate-C
5050	DRYDEN OIL CO OF PA INC	AST	Little Neshaminy Creek - 613	Zone B	4.2	79.554681	Moderate-C
4962	DALE WOOD CO	AST	Delaware River - 808	Floodplain	15.0	265.18227	Moderate-C
4812	AMER TRANS FREIGHT	AST	Delaware River - 649	Zone B	4.3	53.036454	Moderate-C
4442	AEP COLMAR	AST	West Branch Neshaminy Creek - 586	Zone B	9.2	106.07291	Moderate-C
4130	NORTHAMPTON FARM BUR COOP	AST	Unknown - 444	Floodplain	19.8	53.036454	Moderate-C
4916	HAROLD MYERS	AST	Cabin Run - 558	Zone B	12.8	53.036454	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4050	WIND GAP OIL STORAGE	AST	Unknown - 444	Zone B	22.2	556.88277	Moderate-C
4521	AERNI & HITZEL FUEL INC	AST	LEHIGH R - 474	Zone B	17.9	53.036454	Moderate-C
4063	UNION FUEL CO	AST	Shoeneck Creek - 462	Zone B	17.9	53.036454	Moderate-C
4074	DEITER BROS FUEL CO INC	AST	LEHIGH R - 934	Zone B	21.1	212.14582	Moderate-C
4601	FRITCH INC	AST	Unknown - 477	Zone B	20.6	79.554681	Moderate-C
4048	FOGELS FUEL SVC	AST	Shoeneck Creek - 453	Zone B	20.6	53.036454	Moderate-C
4289	MARTINS CREEK STEAM ELEC STA	AST	Delaware River - 399	Zone B	20.8	53.036454	Moderate-C
4342	LEHIGH HEAVY FORGE CORP	AST	LEHIGH R - 485	Zone B	21.4	78.228769	Moderate-C
4046	REIMER BROS	AST	Waltz Creek - 378	Zone B	22.2	159.10936	Moderate-C
3874	ALLENTOWN CTL OFC	AST	LEHIGH R - 934	Zone B	21.4	53.036454	Moderate-C
4128	SZILAGYI FUEL	AST	LEHIGH R - 485	Zone B	21.4	53.036454	Moderate-C
4092	WS REICHENBACH & SON INC	AST	LEHIGH R - 485	Zone B	21.4	53.036454	Moderate-C
4172	PENSKE TRUCK LEASING CO LP	AST	Unknown - 477	Zone B	21.6	53.036454	Moderate-C
4290	HOWER & SON	AST	Waltz Creek - 378	Zone B	21.9	53.036454	Moderate-C
4186	JOHN GOFFREDO & SONS INC	AST	Waltz Creek - 378	Zone B	21.9	53.036454	Moderate-C
4190	R R CORTAZZO	AST	Unknown - 444	Zone B	22.2	53.036454	Moderate-C
3849	TRANS BRIDGE LINES INC	AST	Monocacy Creek - 470	Zone B	22.4	53.036454	Moderate-C

Figure 2.2.4-22 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Lower Delaware River Watershed

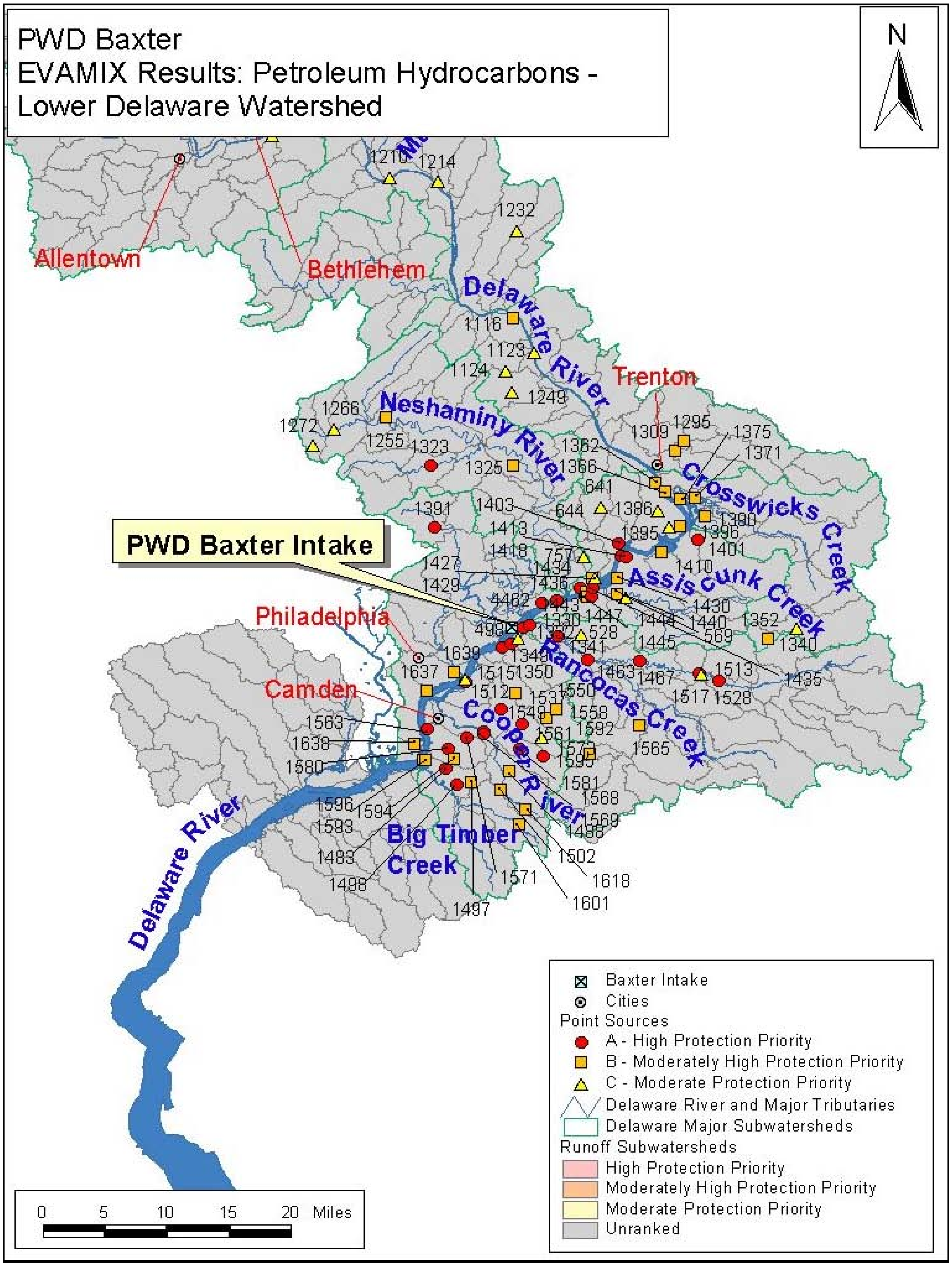


Figure 2.2.4-23 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Middle Delaware River Watershed

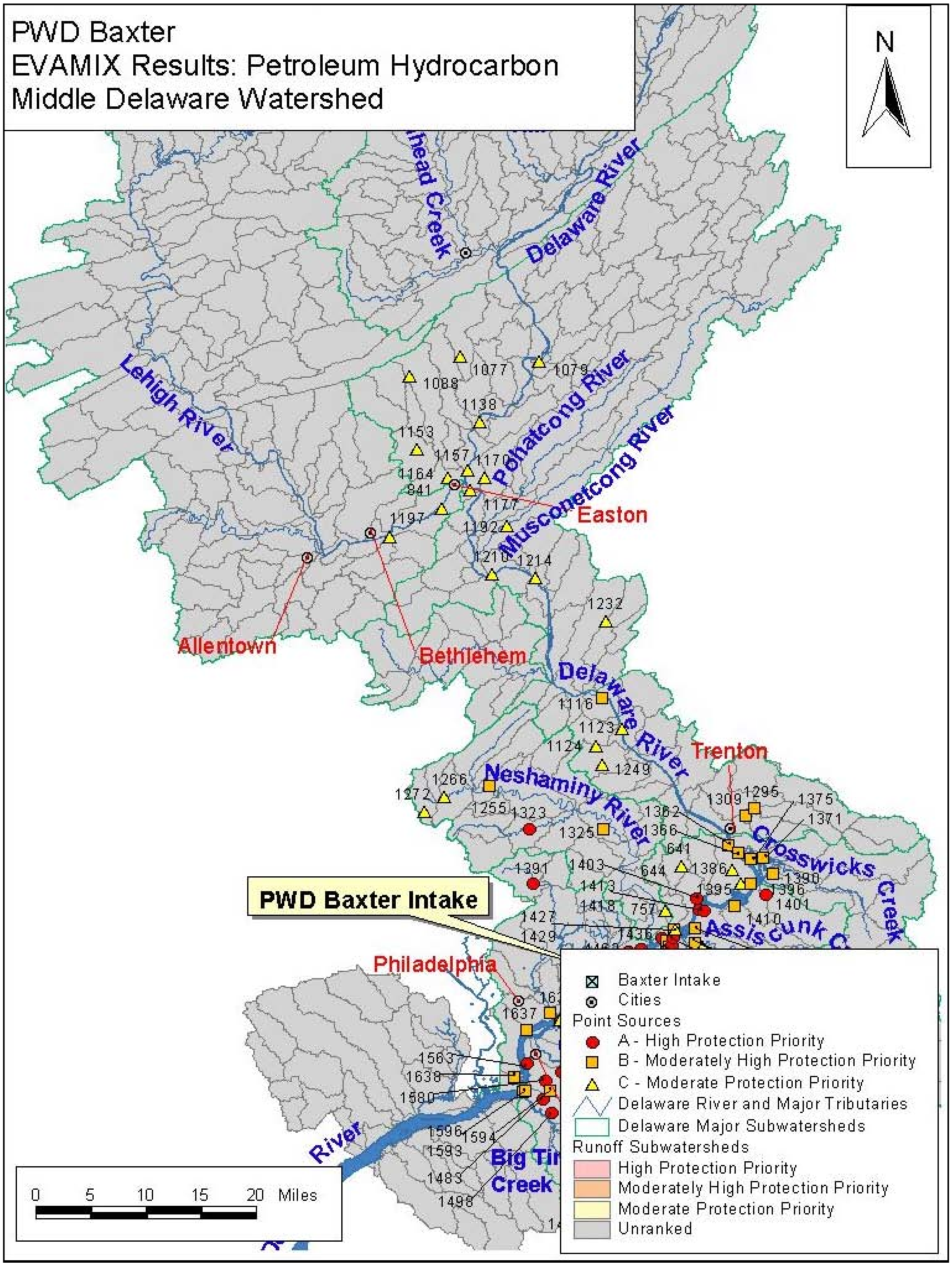
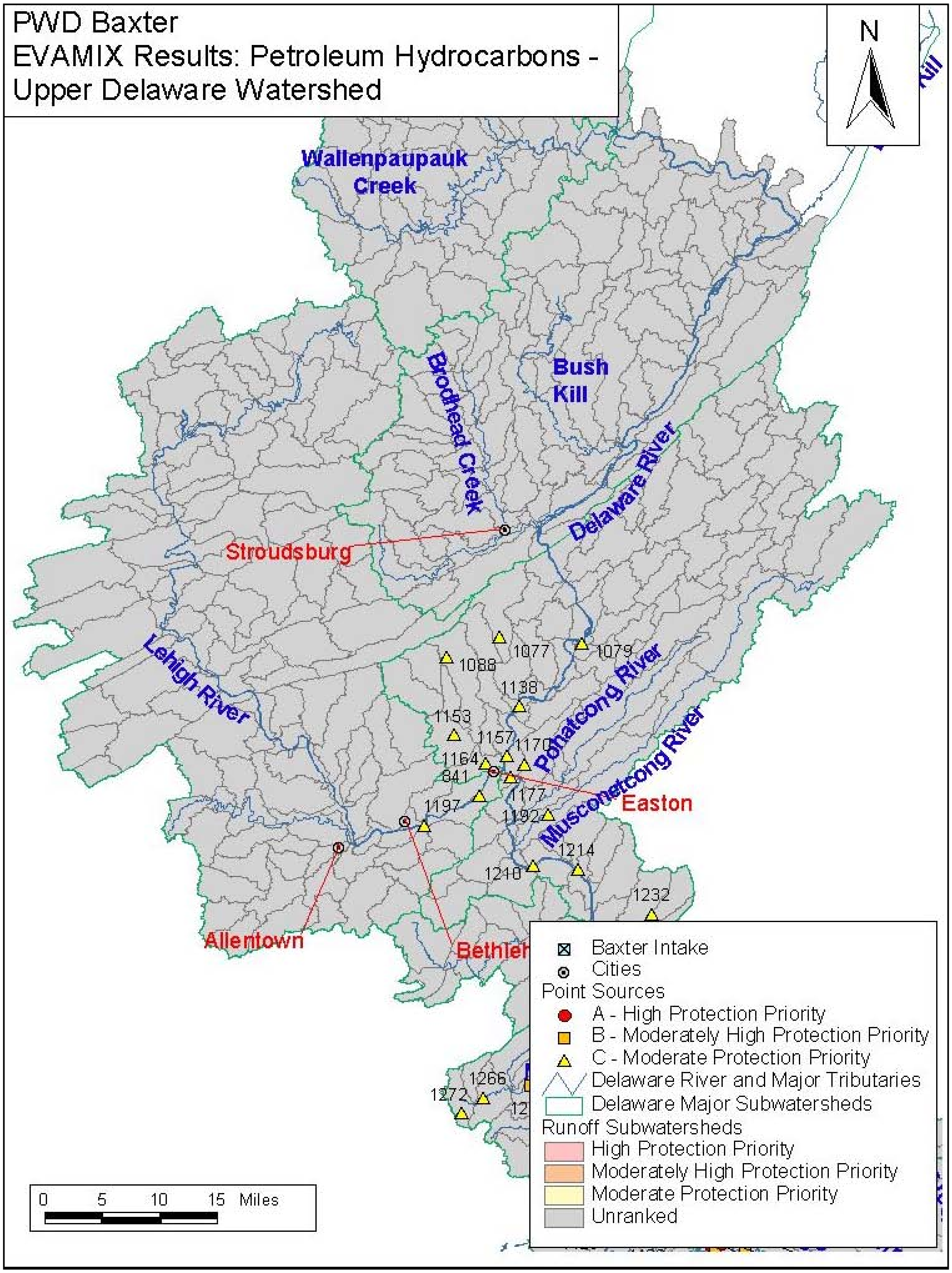


Figure 2.2.4-24 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Upper Delaware River Watershed



Phosphorus

Table 2.2.4-9 shows the ranking of sites for phosphorus loading. Like nitrates, the high protection priority category (category A) is dominated by NPDES dischargers, primarily wastewater treatment plants. Most of the loading from these sites appears to be relatively low, and is not likely to cause a cumulative impact that would cause significant water quality impairment at the intake. There is one AST site that is also included in the high category, primarily due to the high potential concentrations should a spill occur. Moderate priority sites are mainly NPDES and one TRI site. A large majority of the potentially significant sources were located in the drainage areas along the mainstem Delaware River. Figures 2.2.4-25 through 2.2.4-27 illustrate the priority point sources and subwatersheds for phosphorous in the lower and upper Delaware River Watersheds.

Table 2.2.4-9 Contaminant Category Ranking for Phosphorus

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	23.369	Highest-A
637	RHONE-POULENC BASIC CHEMICALS DIV. OF RHONE-POULEN	TRI	Delaware River - 649	Zone B	3.9	4.667	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.001	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.011	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.011	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.011	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.011	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.011	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.001	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.001	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.011	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.011	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.001	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.001	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.011	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.001	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.001	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.011	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.011	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.011	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.287	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.001	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.011	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.011	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.001	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.011	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.011	Highest-A
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.001	Highest-A
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.001	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.001	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.011	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.001	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.011	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.011	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.001	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.011	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.001	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.011	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.001	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.011	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.001	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.011	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.001	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.011	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.001	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.011	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.001	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.011	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.011	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.011	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.011	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.011	Moderately High-B
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.001	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.011	Moderately High-B
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.001	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.011	Moderately High-B
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.001	Moderately High-B
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.001	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.001	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.011	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.011	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.081	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.011	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.011	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.011	Moderately High-B
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.004	Moderately High-B
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.001	Moderately High-B
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.011	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.001	Moderate-C
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.011	Moderate-C
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.011	Moderate-C
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.011	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.011	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.011	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.011	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.011	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.011	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.011	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.011	Moderate-C
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	2.573	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.011	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.011	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.001	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.011	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.011	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.011	Moderate-C
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.011	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.011	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.011	Moderate-C
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.011	Moderate-C
624	ELF ATOCHEM N.A. INC.	TRI	Delaware River - 666	Zone A	0.6	0.202	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.011	Moderate-C
641	CORCO CHEMICAL CORP.	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.193	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.011	Moderate-C
948	ALUMINUM SHAPES INC.	TRI	Delaware River - 931	Zone B	1.1	0.009	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.011	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.011	Moderate-C
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	0.134	Moderate-C
956	CIRCUIT FOIL USA INC. (FORMERLY YATES IND.)	TRI	Delaware River - 927	Zone B	3.1	0.073	Moderate-C
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.011	Moderate-C

Figure 2.2.4-25 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Lower Delaware River Watershed

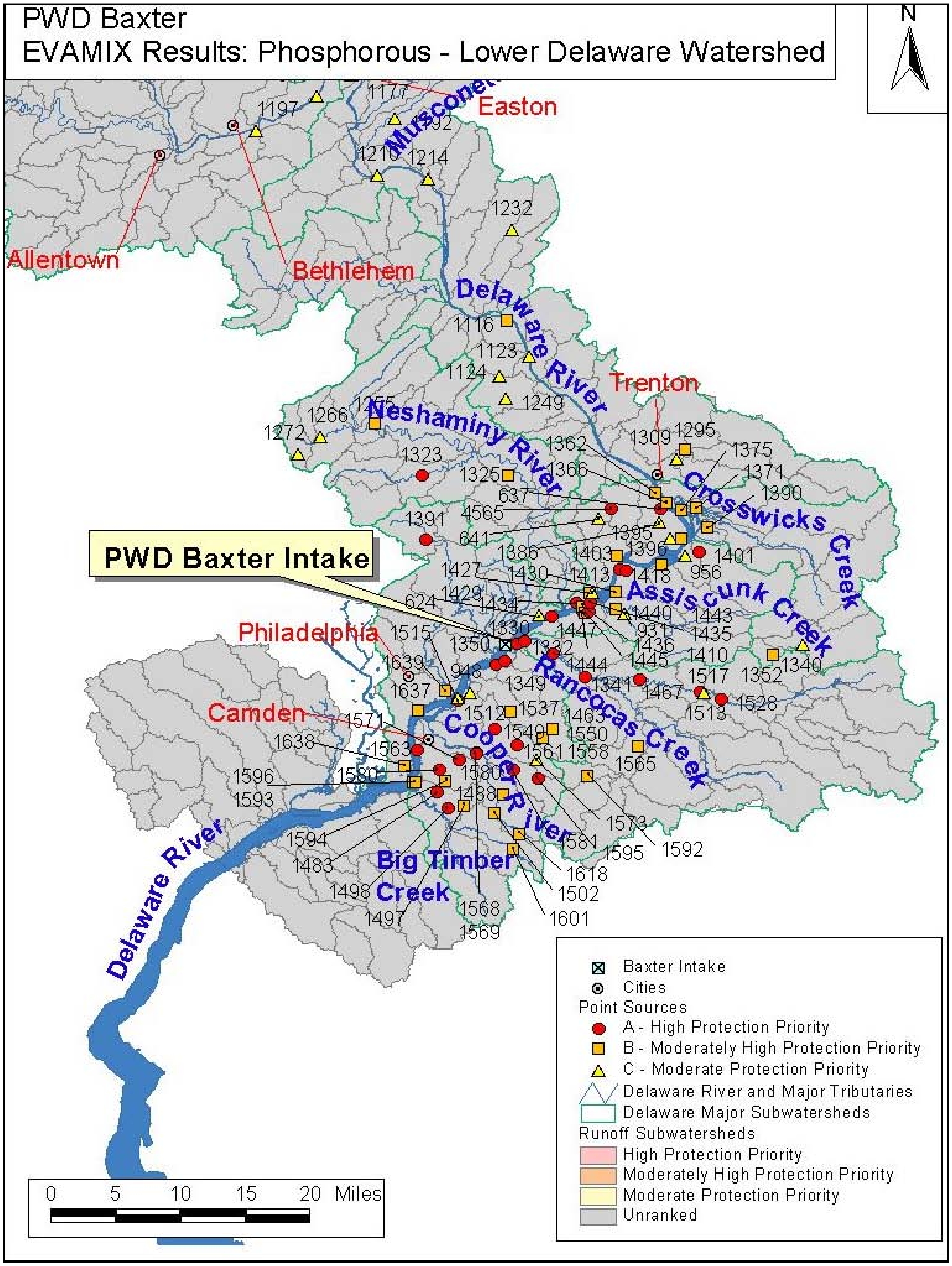


Figure 2.2.4-26 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Middle Delaware River Watershed

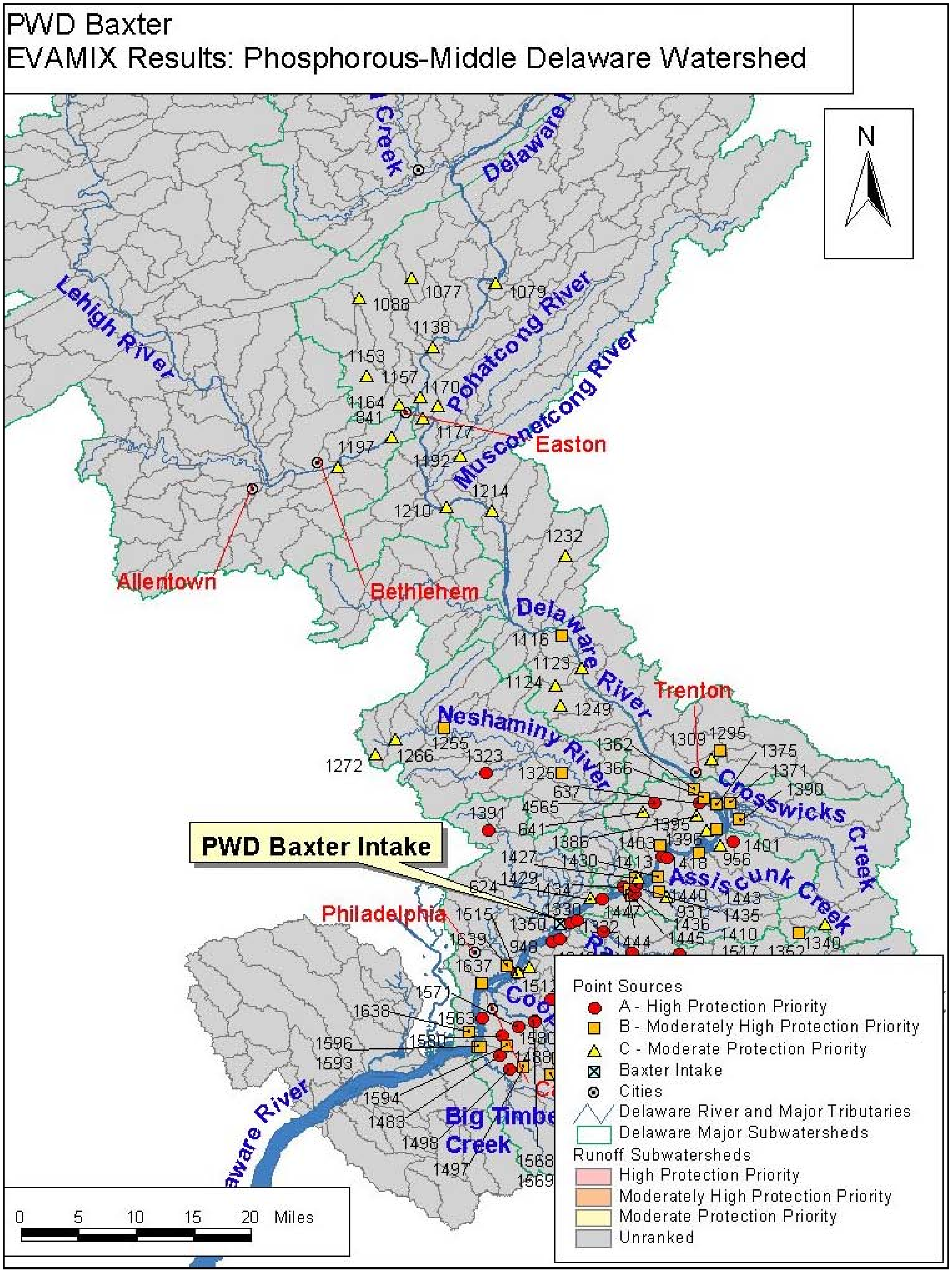
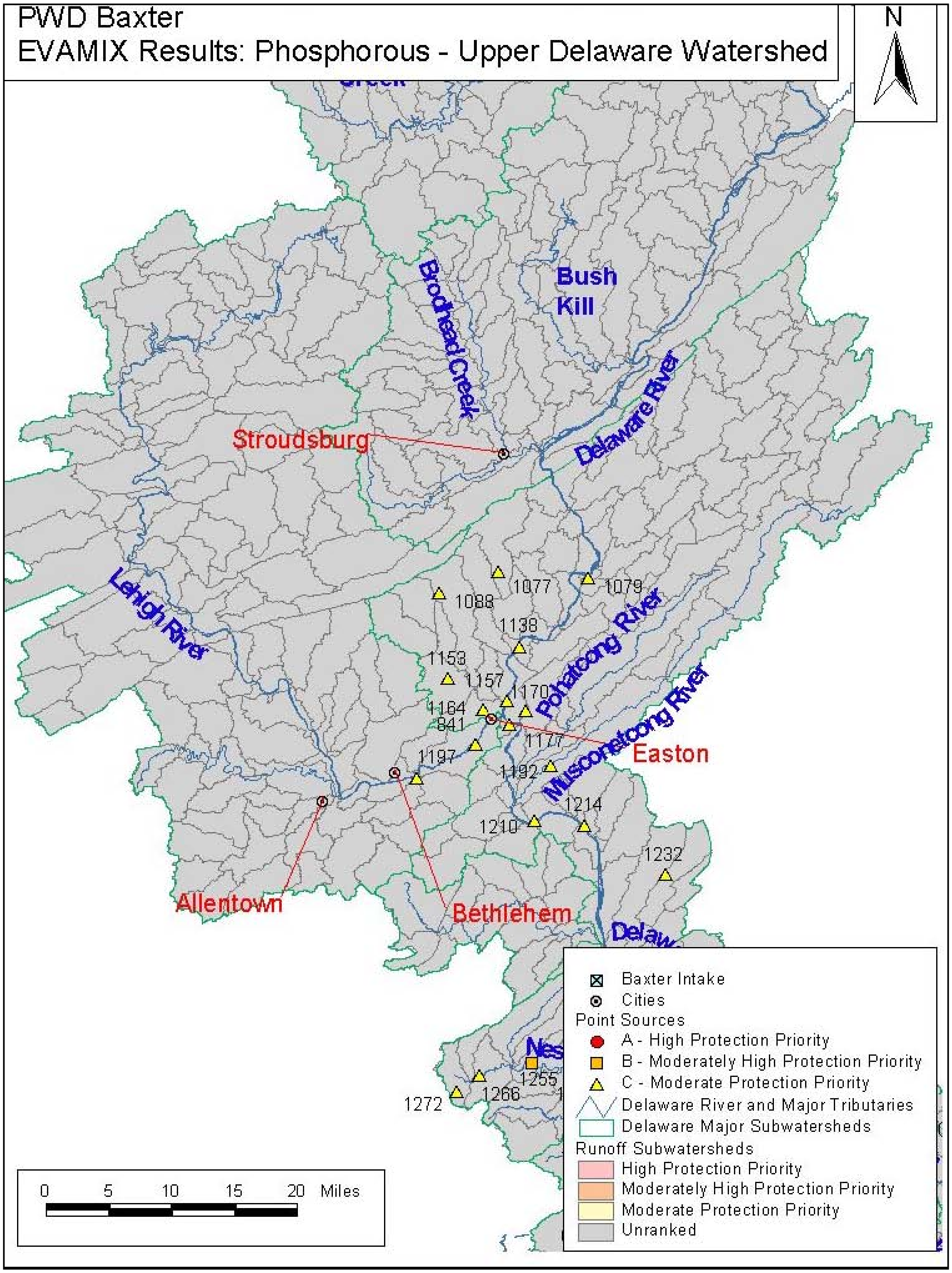


Figure 2.2.4-27 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Upper Delaware River Watershed



Disinfection By-Product (Total Organic Carbon)

Table 2.2.4-10 provides the results of the ranking of potential sources of total organic carbon (TOC). In this case, all of the high protection priority sites (category A) are NPDES discharges from wastewater treatment plants and industries and one TRI facility. In general, nonpoint source locations appear to have a lower total load and impact on water quality than do the NPDES sites. Nonpoint sources are all found in the low priority category. Figures 2.2.4-28 through 2.2.4-30 illustrate the priority point sources and subwatersheds for total organic carbon in the lower and upper Delaware River watersheds.

Table 2.2.4-10 Contaminant Category Ranking for Total Organic Carbon (Disinfection By-product Surrogate)

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	1.7500	Highest-A
909	WITCO CORP. BRAINARDS FACILITY	TRI	Delaware River - 914	Floodplain	18.4	1.3454	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.6086	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.7357	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.3801	Highest-A
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.2610	Highest-A
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.1925	Highest-A
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.2865	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.0822	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.0822	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.0822	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.0822	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.0822	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.0822	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.0822	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.0822	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.0822	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.0822	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.0822	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.0822	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.0822	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.0822	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.0822	Highest-A
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.0822	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.0822	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.0480	Highest-A
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.0822	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.0082	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.0082	Highest-A
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.0822	Highest-A
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.0822	Highest-A
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.0822	Highest-A
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.0822	Moderately High-B
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0822	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.0822	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.0822	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.0822	Moderately High-B
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.0082	Moderately High-B
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.0082	Moderately High-B
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.0082	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.0822	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.0822	Moderately High-B
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.0082	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.0822	Moderately High-B
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0822	Moderately High-B
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.0082	Moderately High-B
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.0822	Moderately High-B
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.0822	Moderately High-B
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.0082	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.0822	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.0822	Moderately High-B
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.0082	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.0082	Moderately High-B
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.0082	Moderately High-B
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0042	Moderately High-B
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.0082	Moderately High-B
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.0822	Moderately High-B
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.0822	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.0082	Moderately

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
							High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.0822	Moderately High-B
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.0822	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.0082	Moderately High-B
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.0525	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.0082	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.0822	Moderate-C
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.0082	Moderate-C
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.0082	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0822	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.0822	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.0822	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.0082	Moderate-C
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.0082	Moderate-C
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.0082	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.0082	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.0822	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.0822	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.0082	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.0082	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.0822	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.0082	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.0822	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.0822	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0822	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.0822	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.0822	Moderate-C
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.0822	Moderate-C
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.0962	Moderate-C
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.0822	Moderate-C
1198	BETHLEHEM STEEL - BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	0.0822	Moderate-C
607	WONDER CHEMICAL CORP.	TRI	Delaware River - 649	Zone A	3.9	0.1345	Moderate-C
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.0703	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.0082	Moderate-C
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.1076	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1263	FERMENTA ANIMAL HEALTH CO	NPDES	*C - 590	Zone B	6.4	0.0822	Moderate-C
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.0538	Moderate-C
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.0157	Moderate-C

Figure 2.2.4-28 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Lower Delaware River Watershed

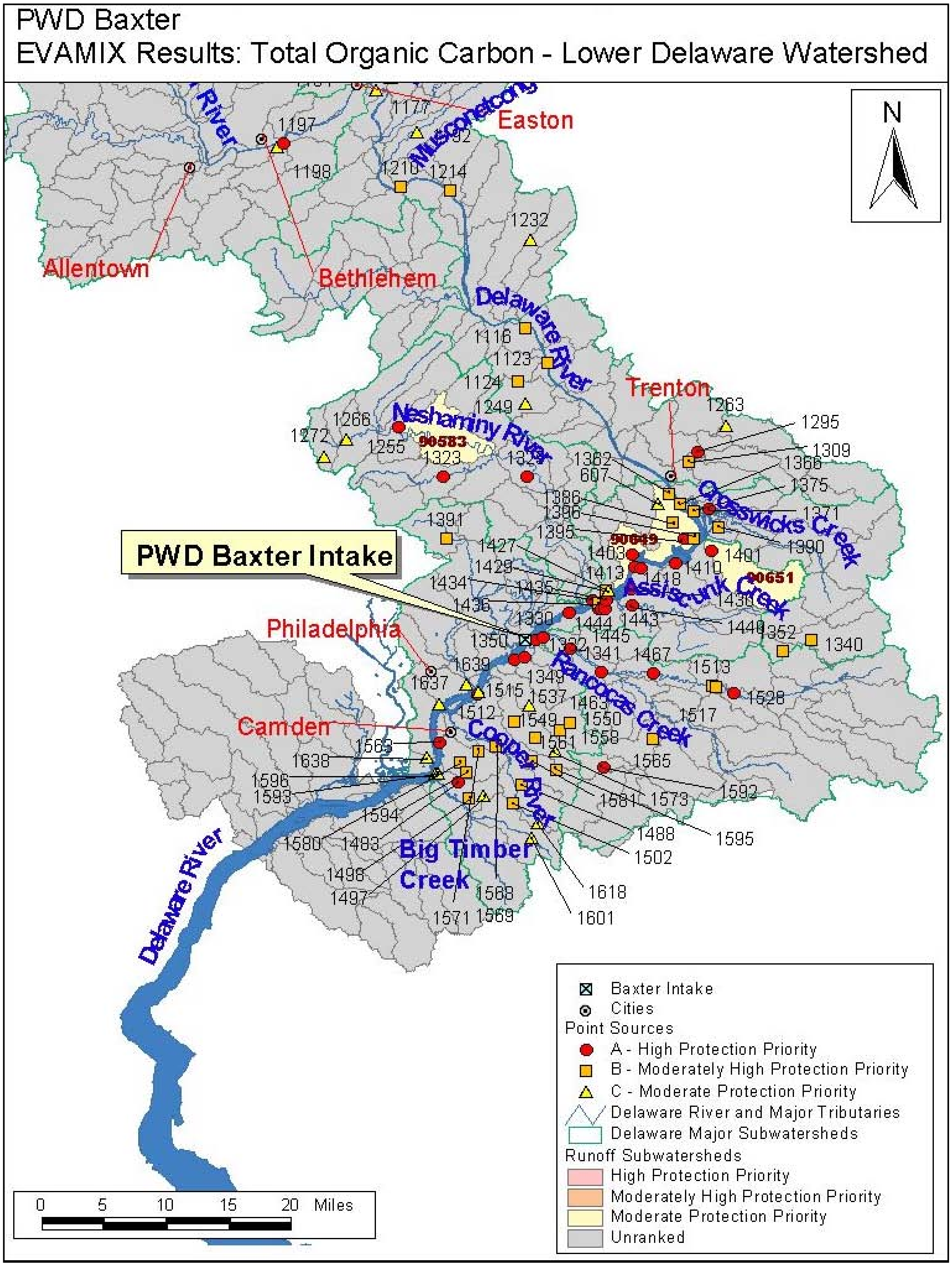


Figure 2.2.4-29 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Middle Delaware River Watershed

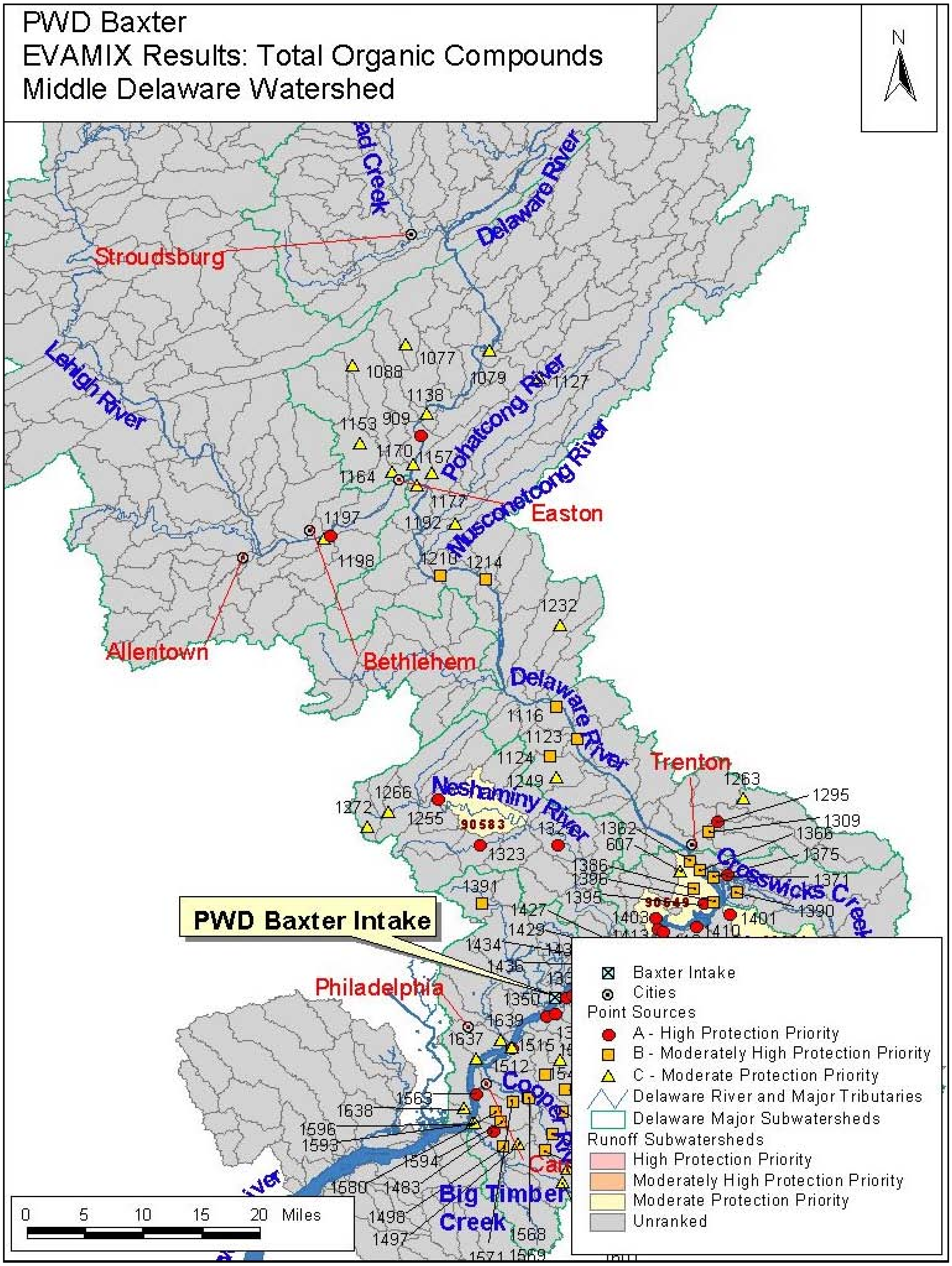
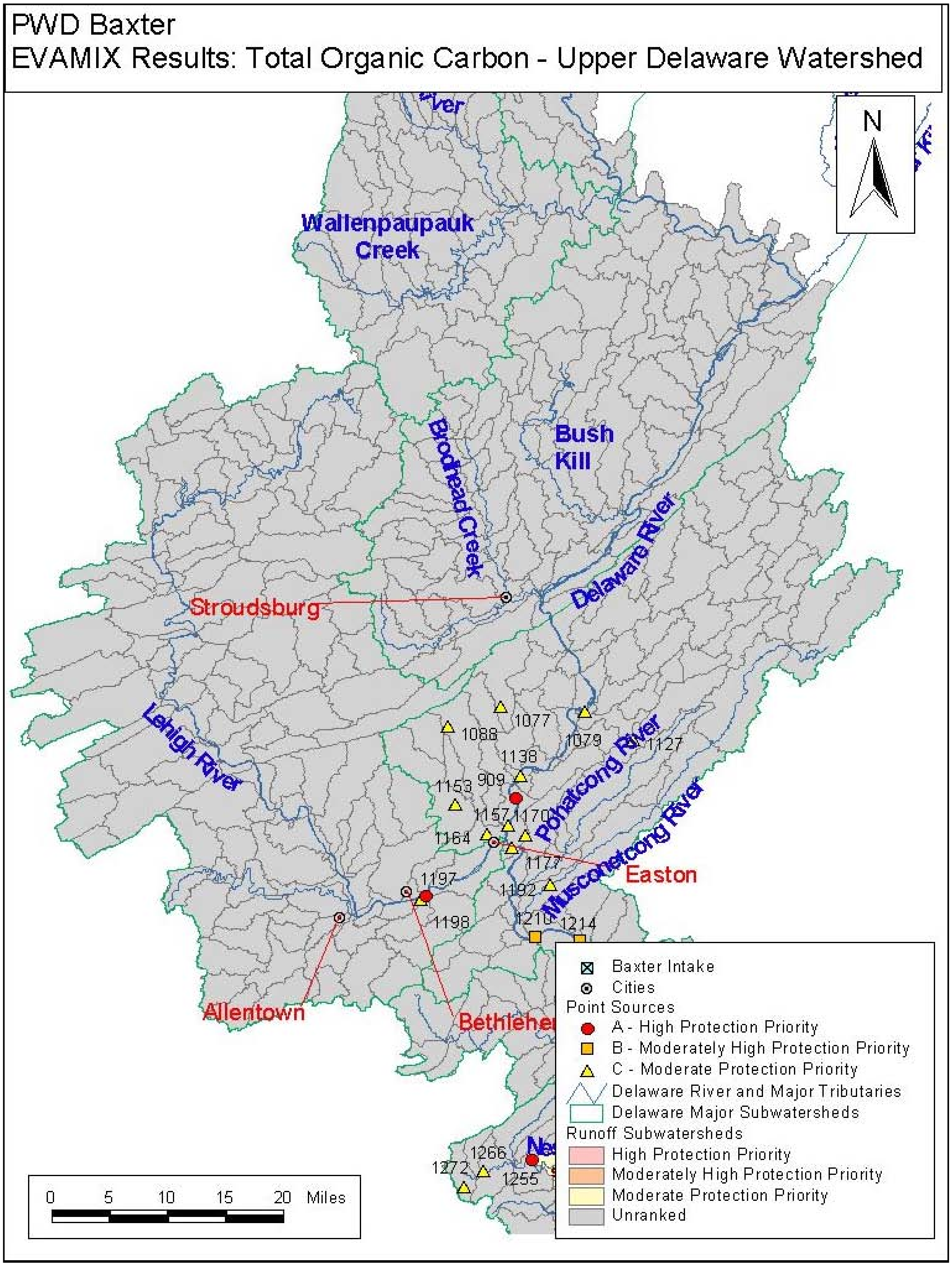


Figure 2.2.4-30 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Upper Delaware River Watershed



Turbidity (Total Suspended Solids)

Turbidity was analyzed using total suspended solids (TSS) as a surrogate. Table 2.2.4 – 11 provides the results of the final ranking of turbidity sources. Stormwater runoff and NPDES discharges were primarily identified as potentially significant sources of TSS. Only one AST site was identified as a high priority. The stormwater runoff (NPS sites) tends to show much higher loading with less frequency. The NPDES sites have lower rates of TSS loading, however, they are more constant discharges. Loading rates from non-point sources appear high enough to cause concern for cumulative impacts at the intake during storm events. Figures 2.2.4-31 through 2.2.4-33 illustrate the priority point sources and subwatersheds for total suspended solids in the lower and upper Delaware River watersheds.

Table 2.2.4-11 Contaminant Category Ranking for Total Suspended Solids

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	2.3733	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	1.6627	Highest-A
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	1.7868	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	1.5915	Highest-A
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	1.5884	Highest-A
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.3632	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.0002	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.0003	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.2008	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.0030	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.0003	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.0030	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.0030	Highest-A
5113	AMER WTP	AST	Delaware River - 597	Zone B	5.6	1.3259	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.0003	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.0030	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	1.0168	Highest-A
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	1.3218	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.0003	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.0030	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.0030	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.0003	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.0003	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0056	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.1054	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.0341	Highest-A
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	1.2608	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.0003	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.0030	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.0030	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.0003	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0021	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.0073	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.0030	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.0321	Moderately High-B
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.0030	Moderately High-B
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.0003	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.0030	Moderately High-B
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.0003	Moderately High-B
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.0030	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.0003	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0030	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.0003	Moderately High-B
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.0003	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.0003	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.0030	Moderately High-B
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	1.1215	Moderately High-B
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.0030	Moderately High-B
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.0030	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.0003	Moderately High-B
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.0030	Moderately High-B
90617	Little Neshaminy Creek-617	NP	Little Neshaminy Creek - 617	Zone B	5.1	0.9317	Moderately High-B
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.0030	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.0030	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.0003	Moderately High-B
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.0030	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.0003	Moderately High-B
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.0483	Moderately High-B
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.0030	Moderately High-B
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.0030	Moderately High-B
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.0030	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.0030	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.0739	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.0030	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.0348	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.0003	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.0003	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.0030	Moderate-C
90606	Little Neshaminy Creek-606	NP	Little Neshaminy Creek - 606	Zone B	5.5	0.8733	Moderate-C
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.0030	Moderate-C
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.0030	Moderate-C
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.0003	Moderate-C
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.0030	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.0003	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.0030	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.0030	Moderate-C
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.0030	Moderate-C
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.0003	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.0030	Moderate-C
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0000	Moderate-C
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.0030	Moderate-C
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.0030	Moderate-C
90389	Oughoughton Creek-389	NP	Oughoughton Creek - 389	Zone B	20.6	0.9820	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.0003	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.0003	Moderate-C
90601	NESHAMINY R-601	NP	NESHAMINY R - 601	Zone B	4.0	0.7623	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0118	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.0003	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.0065	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.0030	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.0003	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.0030	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.0030	Moderate-C
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.0030	Moderate-C
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.0030	Moderate-C
90393	Martins Creek-393	NP	Martins Creek - 393	Zone B	19.8	0.9162	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0030	Moderate-C
90576	Mill Creek-576	NP	Mill Creek - 576	Zone B	5.5	0.7337	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.0030	Moderate-C
90610	Little Neshaminy Creek-610	NP	Little Neshaminy Creek - 610	Zone B	4.2	0.7108	Moderate-C

Figure 2.2.4-31 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Lower Delaware River Watershed

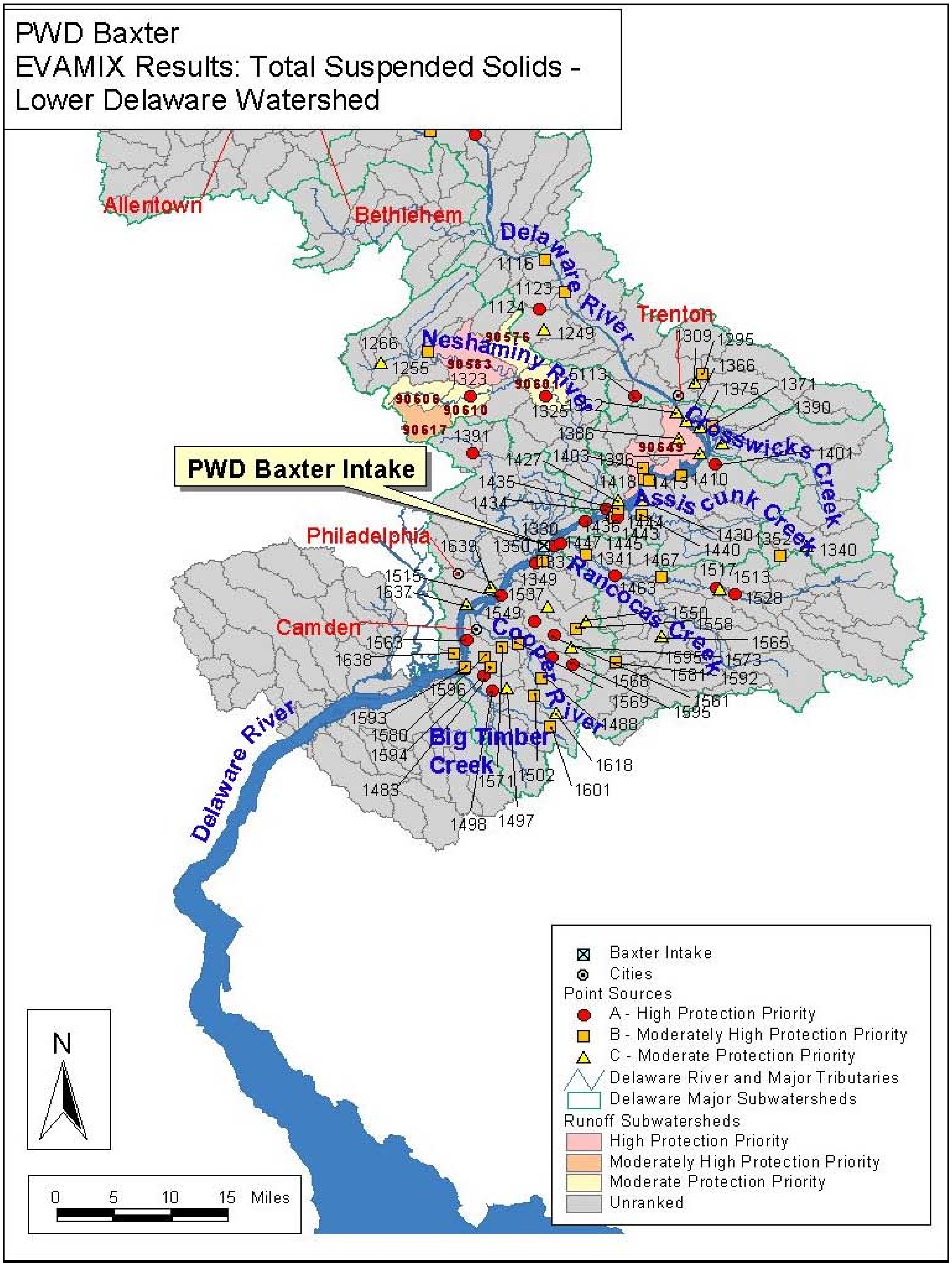


Figure 2.2.4-32 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Middle Delaware River Watershed

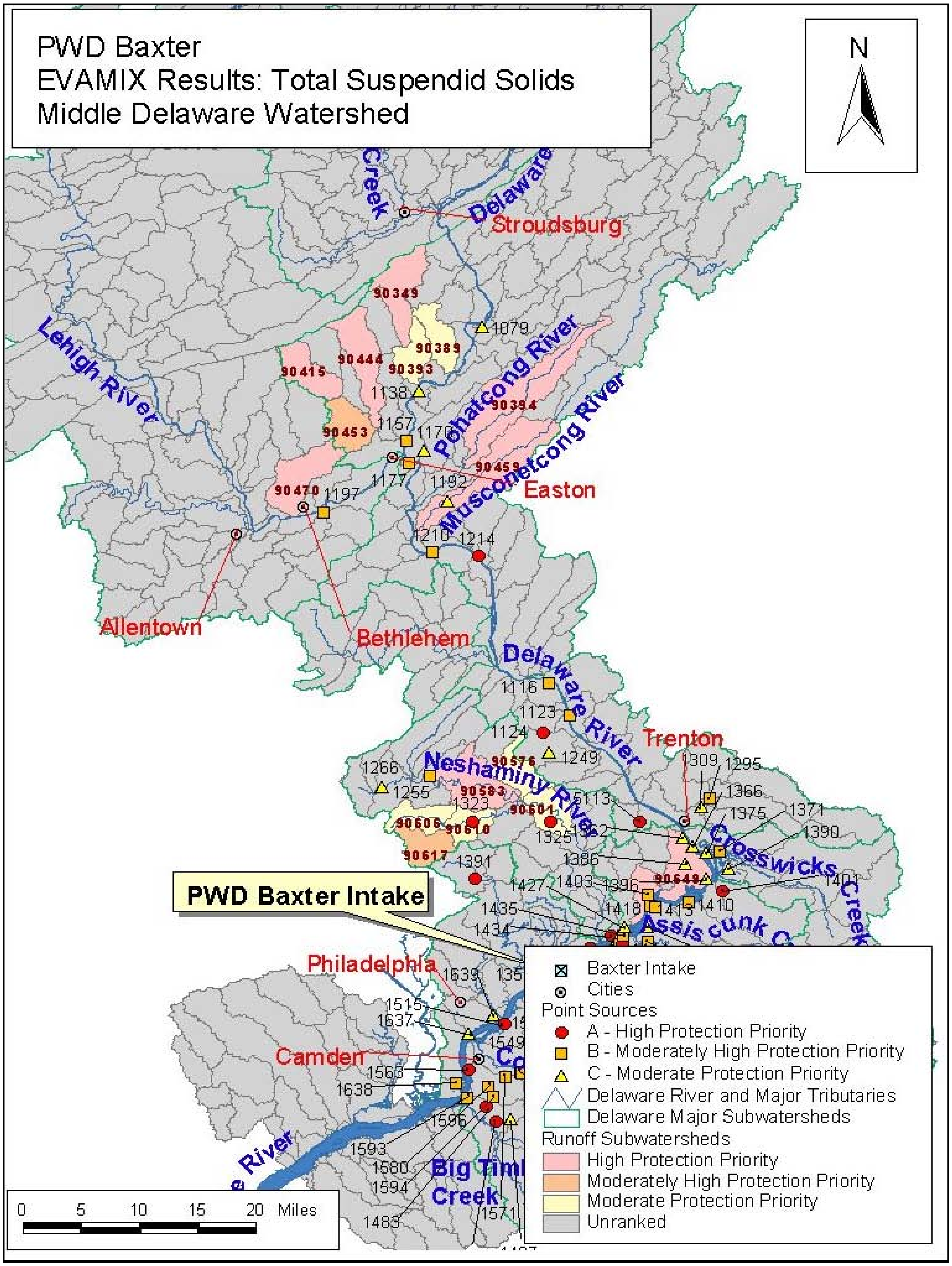
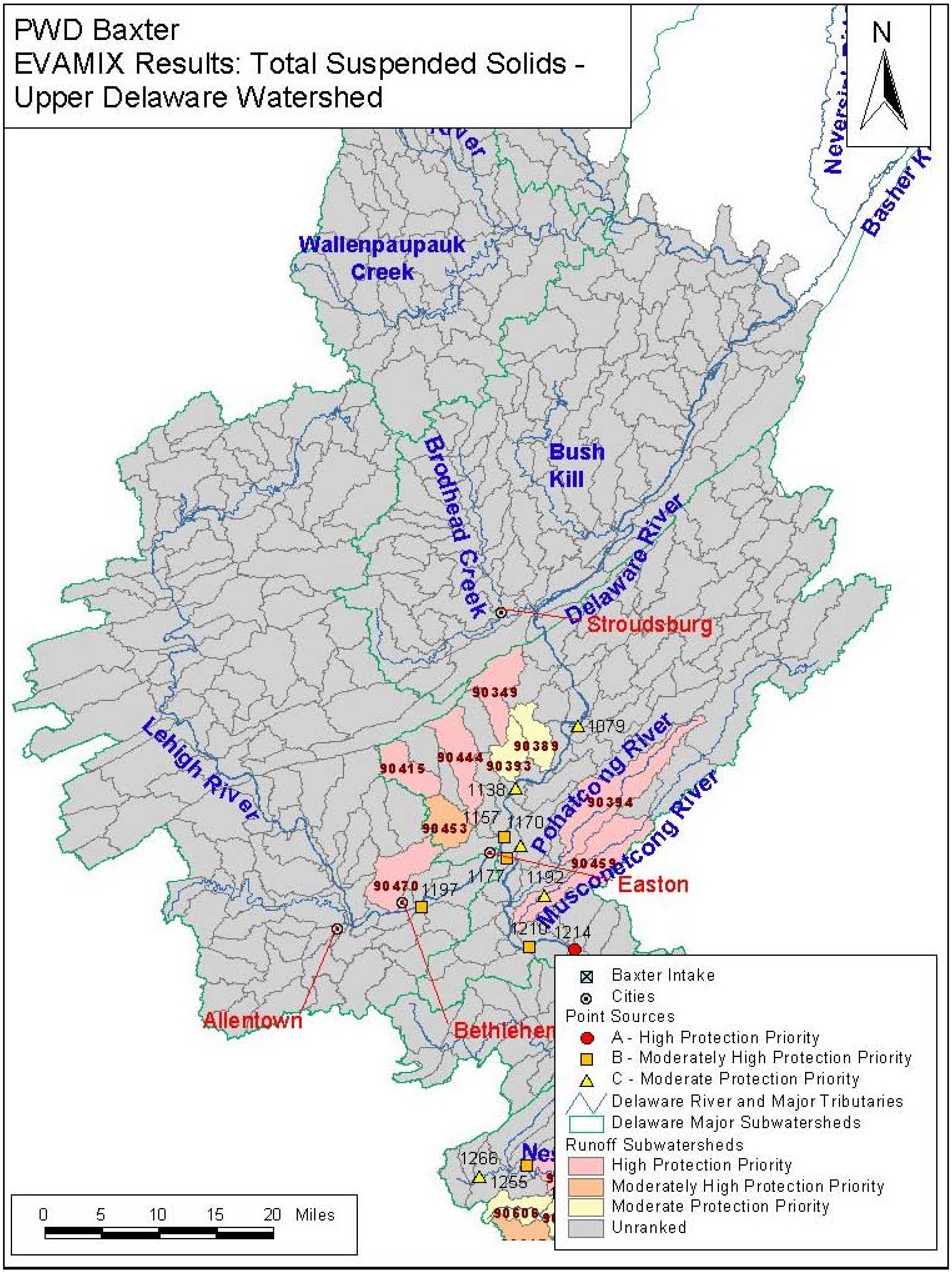


Figure 2.2.4-33 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Upper Delaware River Watershed



VOCs

Table 2.2.4-12 shows the results of the ranking of volatile organic compound (VOC) sites. In this case, the only significant potential sources of VOCs are storage tanks (ASTs), industrial sites from the TRI database, or wastewater treatment plants. The high protection priority category (category A) is a mixture of AST, RCRA, TRI, and NPDES sites. The moderately high and moderate protection priority categories are primarily AST, RCRA, and TRI sites. The NPDES sites appear to load VOCs at a low rate, and are not likely to cause water quality impairment at the intake. The AST and TRI sites would require a spill to cause water quality impairment, but resulting concentrations would be very high. RCRA sites were difficult to assess for potential loading. Figures 2.2.4-34 through 2.2.4-36 illustrate the priority point sources for volatile organic compounds in the lower and upper Delaware River watersheds.

Table 2.2.4-12 Contaminant Category Ranking for Volatile Organic Compounds

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	64174.1091390	Highest-A
5091	WILLOW GROVE AIR FORCE RESERVE STA	AST	Little Neshaminy Creek - 617	Zone B	5.1	55688.2765256	Highest-A
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	39777.3403754	Highest-A
881	CRAIN IND. EASTON DIV.	TRI	LEHIGH R - 474	Zone B	18.2	24270.4800489	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.0056916	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	94.3671436	Highest-A
476	SAN JUAN INTL. INC.	TRI	Pond Run - 612	Zone B	5.4	13526.8903623	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0027027	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	3.9205004	Highest-A
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.2256911	Highest-A
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0000000	Highest-A
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0056598	Highest-A
4633	WILLOW GROVE TERM	AST	Robinhood Brook - 628	Zone B	2.8	16706.4829577	Highest-A
698	CRC IND. INC.	TRI	Little Neshaminy Creek - 613	Zone B	4.2	1553.9212787	Highest-A
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0032114	Highest-A
5726	G R O W S INC LANDFILL	RCRA	Delaware River - 649	Floodplain	2.8	0.1193320	Highest-A
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.0278378	Highest-A
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	800.4506997	Highest-A
5951	AMSPEC CHEMICAL CORP	RCRA	Delaware River - 932	Floodplain	2.9	0.0011933	Highest-A
624	ELF ATOCHEM N.A. INC.	TRI	Delaware River - 666	Zone A	0.6	89.8589735	Highest-A
599	CARTEX CORP.	TRI	Martins Creek - 616	Floodplain	3.3	81.2496859	Highest-A
543	OCCIDENTAL CHEMICAL CORP. BURLINGTON N. PLANT	TRI	Delaware River - 927	Zone A	2.0	246.4135945	Highest-A
534	HERCULES INC. BURLINGTON PLANT	TRI	Delaware River - 927	Zone A	2.0	106.5570651	Highest-A
4801	RHODIA INC	AST	Delaware River - 649	Zone A	3.9	10395.1449514	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.8248631	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
5452	YATES FOIL USA INC	RCRA	Delaware River - 927	Zone B	3.1	0.2121458	Highest-A
597	3M	TRI	Mill Creek - 648	Zone B	2.4	107.4226854	Highest-A
6482	COASTAL EAGLE POINT OIL CO	RCRA	BIG TIMBER CR - 769	Zone B	3.3	0.3314778	Highest-A
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	173.7606092	Highest-A
5940	RHODIA INC	RCRA	Delaware River - 649	Zone B	3.9	0.0058340	Highest-A
5839	MSC PRE FINISH METALS INC	RCRA	Delaware River - 649	Zone B	3.9	0.0010607	Highest-A
531	RHEIN CHEMIE CORP.	TRI	*C - 587	Zone B	5.4	315.1974130	Highest-A
955	CONGOLEUM CORP. AMTICO FLOORING DIV.	TRI	Branch of Pond Run - 609	Zone B	5.1	101.7136563	Highest-A
940	HOMASOTE CO.	TRI	Delaware River - 926	Zone B	5.6	165.2847119	Moderately High-B
923	U.S. NAVY NAVAL AIR WARFARE CENTER AIRCRAFT DIV.	TRI	Delaware River - 926	Zone B	5.6	110.7952045	Moderately High-B
566	CONGOLEUM CORP. PLANT 1	TRI	Pond Run - 603	Zone B	5.6	104.6196907	Moderately High-B
570	FINA OIL & CHEMICAL CO.	TRI	Pond Run - 603	Zone B	7.2	491.6163231	Moderately High-B
904	ROCHE VITAMINS & FINE CHEMICALS	TRI	PEQUEST R - 405	Zone B	21.9	576.4405752	Moderately High-B
912	BASF CORP.	TRI	Pophandusing Brook - 409	Zone B	22.2	545.2093146	Moderately High-B
625	ROHM & HAAS DELAWARE VALLEY INC.	TRI	Mill Creek - 648	Zone A	2.0	311.5104592	Moderately High-B
6057	ASHLAND CHEMICAL CO	RCRA	LEHIGH R - 474	Floodplain	18.7	0.0003646	Moderately High-B
4561	WONDER CHEM	AST	Delaware River - 649	Zone B	3.9	6894.7389984	Moderately High-B
4817	CHEMCENTRAL PHILA	AST	Delaware River - 649	Zone A	3.9	5303.6453834	Moderately High-B
5198	3M BRISTOL PACKAGING SYSTEMS PLANT	RCRA	Mill Creek - 648	Floodplain	1.8	0.0000001	Moderately High-B
5483	SITHE NJ HOLDINGS - GILBERT	RCRA	Delaware River - 918	Zone B	14.4	0.0795547	Moderately High-B
5368	SUPERPAC INC	RCRA	Mill Creek - 632	Floodplain	4.0	0.0000001	Moderately High-B
3674	SUNOCO 0002 6617	AST	Martins Creek - 616	Floodplain	2.8	3977.7340375	Moderately High-B
519	COASTAL EAGLE POINT OIL CO.	TRI	BIG TIMBER CR - 769	Zone B	3.3	1291.8568009	Moderately High-B
4828	BASIC CHEM SOLUTIONS	AST	Delaware River - 649	Zone A	3.9	4773.2808451	Moderately High-B
5036	MEENAN OIL LP	AST	Delaware River - 597	Zone B	5.4	6656.0749562	Moderately High-B
633	ALLIED-SIGNAL INC. FRANKFORD PLANT	TRI	Delaware River - 704	Zone B	1.3	478.5856464	Moderately High-B
792	TOWER PRODS. INC.	TRI	LEHIGH R - 933	Zone B	18.4	923.1245805	Moderately High-B
6198	FREDRICKS CO THE	RCRA	Rockledge Branch - 645	Floodplain	2.6	0.0000000	Moderately High-B
6448	J T BAKER CHEMICAL CO	RCRA	Delaware River - 914	Zone B	17.9	0.2651823	Moderately High-B
604	ALDAN RUBBER CO.	TRI	Delaware River - 704	Zone B	1.3	195.7101592	Moderately High-B
5865	PARAMOUNT PKG CORP	RCRA	West Branch Neshaminy Creek - 586	Floodplain	8.4	0.0000001	Moderately High-B
4312	SUNOCO 0014 3305	AST	Byberry Creek - 641	Zone B	1.3	3977.7340375	Moderately High-B
5028	TREVOSE GAS & CO	AST	Byberry Creek - 641	Zone B	1.3	3977.7340375	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
5742	GRAVCO INC	RCRA	West Branch Neshaminy Creek - 586	Floodplain	8.4	0.0000001	Moderately High-B
4330	SUNOCO 0012 8959	AST	NESHAMINY R - 657	Zone B	1.8	3977.7340375	Moderately High-B
4389	3M CO	AST	Mill Creek - 648	Zone B	2.4	3977.7340375	Moderately High-B
4523	ELEMENTIS PIGMENTS INC	AST	Shoeneck Creek - 462	Zone B	18.4	9281.3794209	Moderately High-B
4725	EXXON RS 2 0336	AST	NESHAMINY R - 637	Zone B	2.6	3977.7340375	Moderately High-B
4315	WAWA FOOD MKT 277	AST	NESHAMINY R - 637	Zone B	2.8	3977.7340375	Moderately High-B
4898	7 ELEVEN 32639	AST	Queen Anne Creek - 627	Zone B	2.9	3977.7340375	Moderately High-B
4816	WHEELABRATOR FALLS INC	AST	Delaware River - 649	Zone B	3.9	3977.7340375	Moderately High-B
5058	CASTROL IND EAST	AST	Little Neshaminy Creek - 613	Zone B	4.2	3977.7340375	Moderately High-B
5049	CRC IND INC	AST	Little Neshaminy Creek - 613	Zone B	4.2	3977.7340375	Moderate-C
4904	WAWA 288	AST	Geddes Run - 561	Zone B	12.3	5303.6453834	Moderate-C
4130	NORTHAMPTON FARM BUR COOP	AST	Unknown - 444	Floodplain	19.8	5303.6453834	Moderate-C
4198	CRAIN IND	AST	LEHIGH R - 474	Zone B	18.2	6364.3744601	Moderate-C
6449	JAMES RIVER RIEGELSVILLE MILL	RCRA	MUSCONETCONG R - 459	Floodplain	16.0	0.0000001	Moderate-C
785	BETHLEHEM STRUCTURAL PRODS. CORP. COKE OPS.	TRI	Saucon Creek - 510	Zone B	17.4	169.4922362	Moderate-C
4128	SZILAGYI FUEL	AST	LEHIGH R - 485	Zone B	21.4	5303.6453834	Moderate-C
4177	HELLERTOWN STA	AST	Saucon Creek - 510	Zone B	17.6	3977.7340375	Moderate-C
3949	LOUBUC INC	AST	LEHIGH R - 936	Zone B	21.9	5303.6453834	Moderate-C
4190	R R CORTAZZO	AST	Unknown - 444	Zone B	22.2	5303.6453834	Moderate-C
4046	REIMER BROS	AST	Waltz Creek - 378	Zone B	22.2	5303.6453834	Moderate-C
4347	SQUARE ONE MINI MKT	AST	Unknown - 477	Zone B	20.8	4773.2808451	Moderate-C
767	BETHLEHEM STEEL CORP. STRUCTUAL PRODS. DIV.	TRI	LEHIGH R - 485	Zone B	21.4	169.9200798	Moderate-C
4112	G & JS PIT STOP II	AST	Shoeneck Creek - 445	Zone B	19.2	3977.7340375	Moderate-C
4279	AIR PROD & CHEM HANGER 2	AST	LEHIGH R - 935	Zone B	23.5	5303.6453834	Moderate-C
4164	B & C MINI MART	AST	Unknown - 420	Zone B	20.0	3977.7340375	Moderate-C
4601	FRITCH INC	AST	Unknown - 477	Zone B	20.6	3977.7340375	Moderate-C
5457	UNDERWATER TECHNICS INC	RCRA	Delaware River - 931	Floodplain	1.3	0.0004707	Moderate-C
5434	COLORITE POLYMERS	RCRA	Delaware River - 663	Floodplain	1.5	0.0530365	Moderate-C
5305	KEYSTONE LIGHTING USI LIGHTING	RCRA	Mill Creek - 648	Floodplain	1.8	0.0000000	Moderate-C
5329	LOWER BUCKS HOSP	RCRA	Mill Creek - 648	Floodplain	1.8	0.0000000	Moderate-C
3763	HESS 38406	AST	LEHIGH R - 936	Zone B	21.6	3977.7340375	Moderate-C
5439	GRIFFIN PIPE PRODUCTS	RCRA	Delaware River - 927	Floodplain	2.0	0.0013259	Moderate-C
4057	ALBRIGHTS SVC CTR	AST	Monocacy Creek - 470	Zone B	21.9	3977.7340375	Moderate-C
4052	SHOP QUIK 1	AST	Unknown - 444	Zone B	22.2	3977.7340375	Moderate-C
5440	HERCULES INC	RCRA	Delaware River - 927	Zone A	2.0	0.3646256	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
5667	FBF INC	RCRA	Mill Creek - 632	Floodplain	4.0	0.0000000	Moderate-C
5921	Q C INC	RCRA	Mill Creek - 632	Floodplain	4.0	0.0000000	Moderate-C
5438	ELECTRONIC PARTS SPECIALTY CO	RCRA	Unknown - 722	Zone A	2.9	0.0013259	Moderate-C
5694	PSE & G - MERCER GENERATING STA	RCRA	Delaware River - 927	Zone A	3.7	0.0477328	Moderate-C
5686	AMERICAN STANDARD INC	RCRA	Pond Run - 612	Zone B	5.6	0.0733627	Moderate-C
6452	PEARSALL CHEMICAL DIV WITCO	RCRA	Delaware River - 915	Zone B	17.1	0.0198887	Moderate-C
6070	BETHLEHEM STRUCTURAL PRODS CORP	RCRA	LEHIGH R - 485	Zone B	21.4	0.1856276	Moderate-C

Figure 2.2.4-34 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Lower Delaware River Watershed

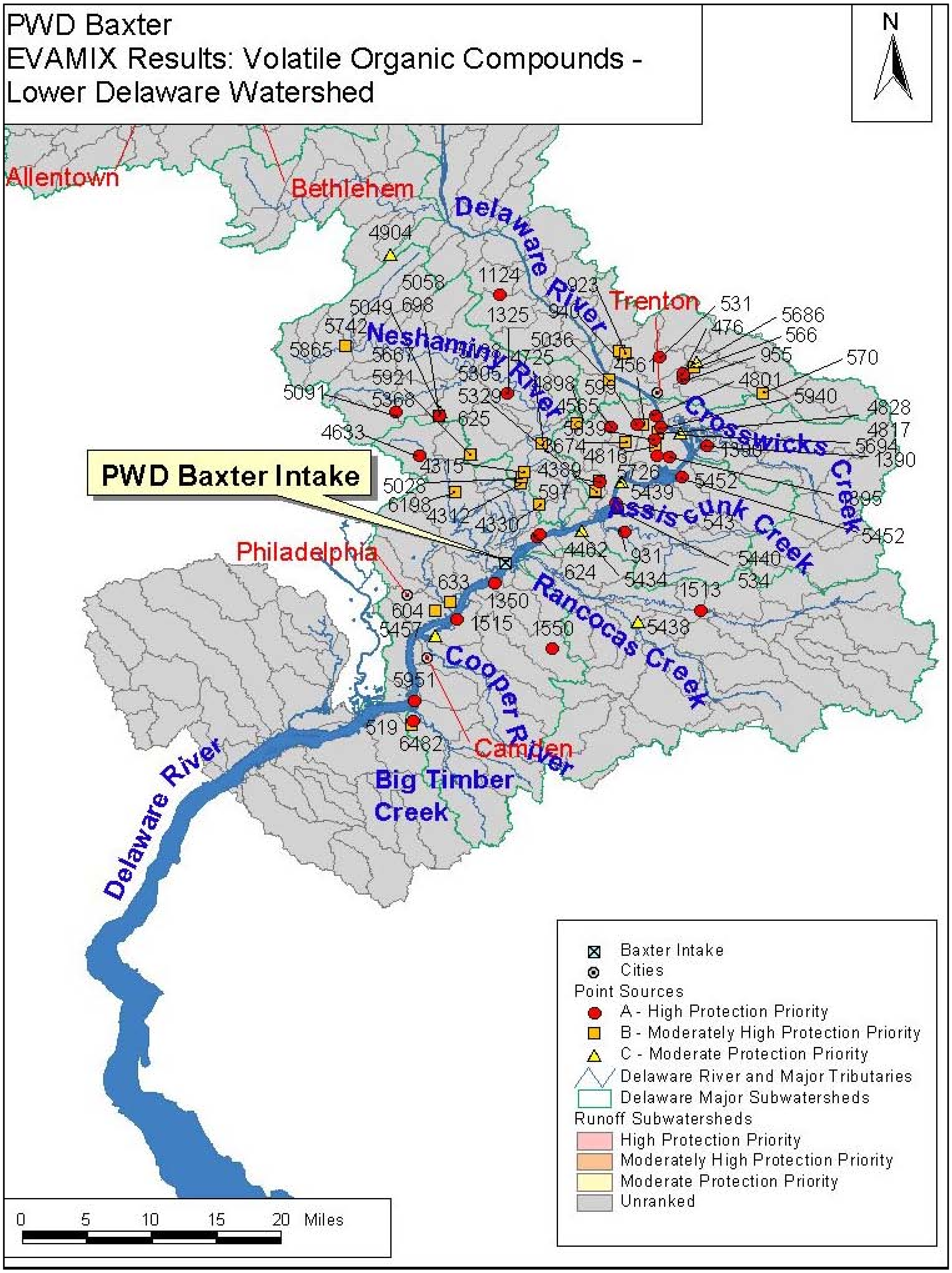


Figure 2.2.4-35 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Middle Delaware River Watershed

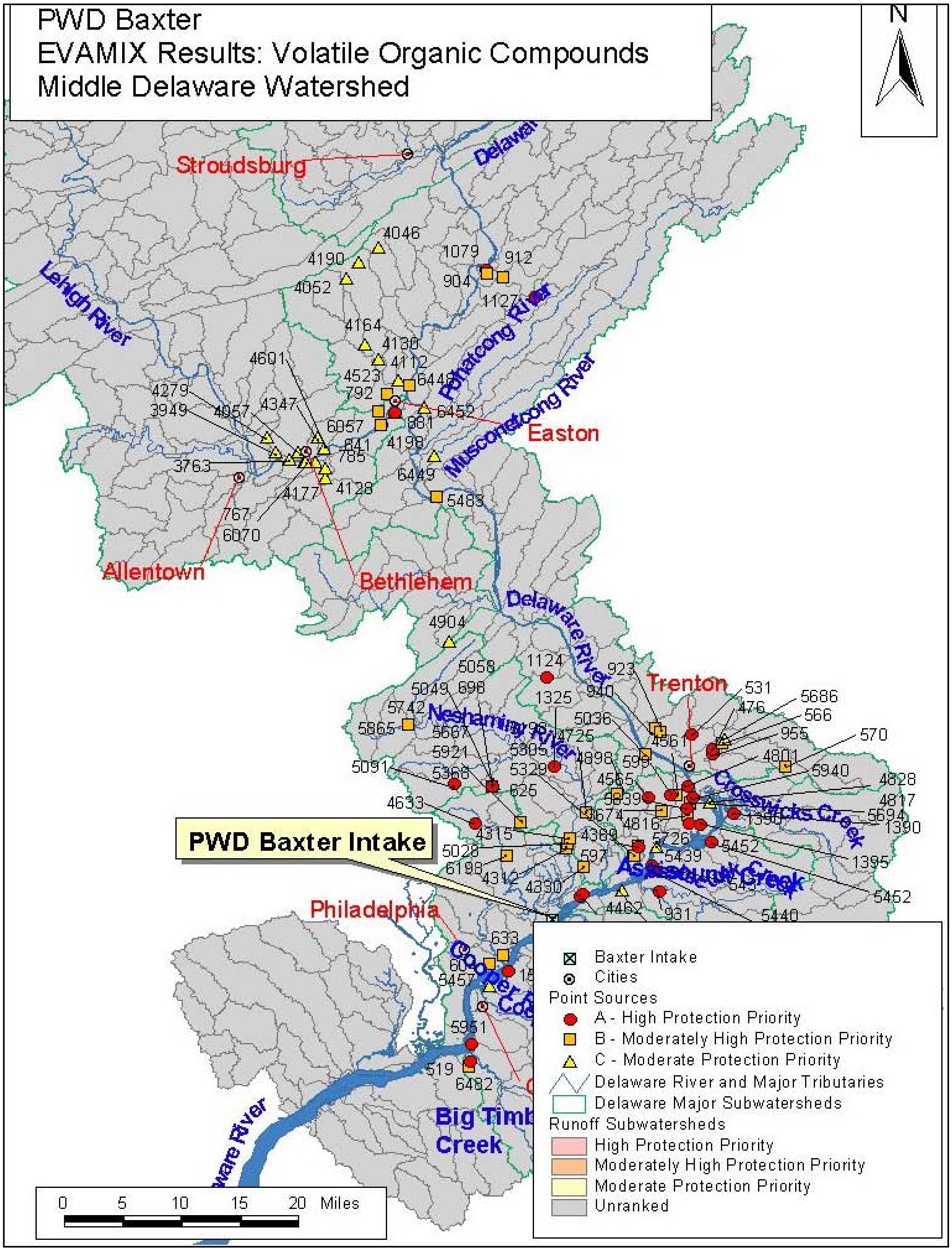
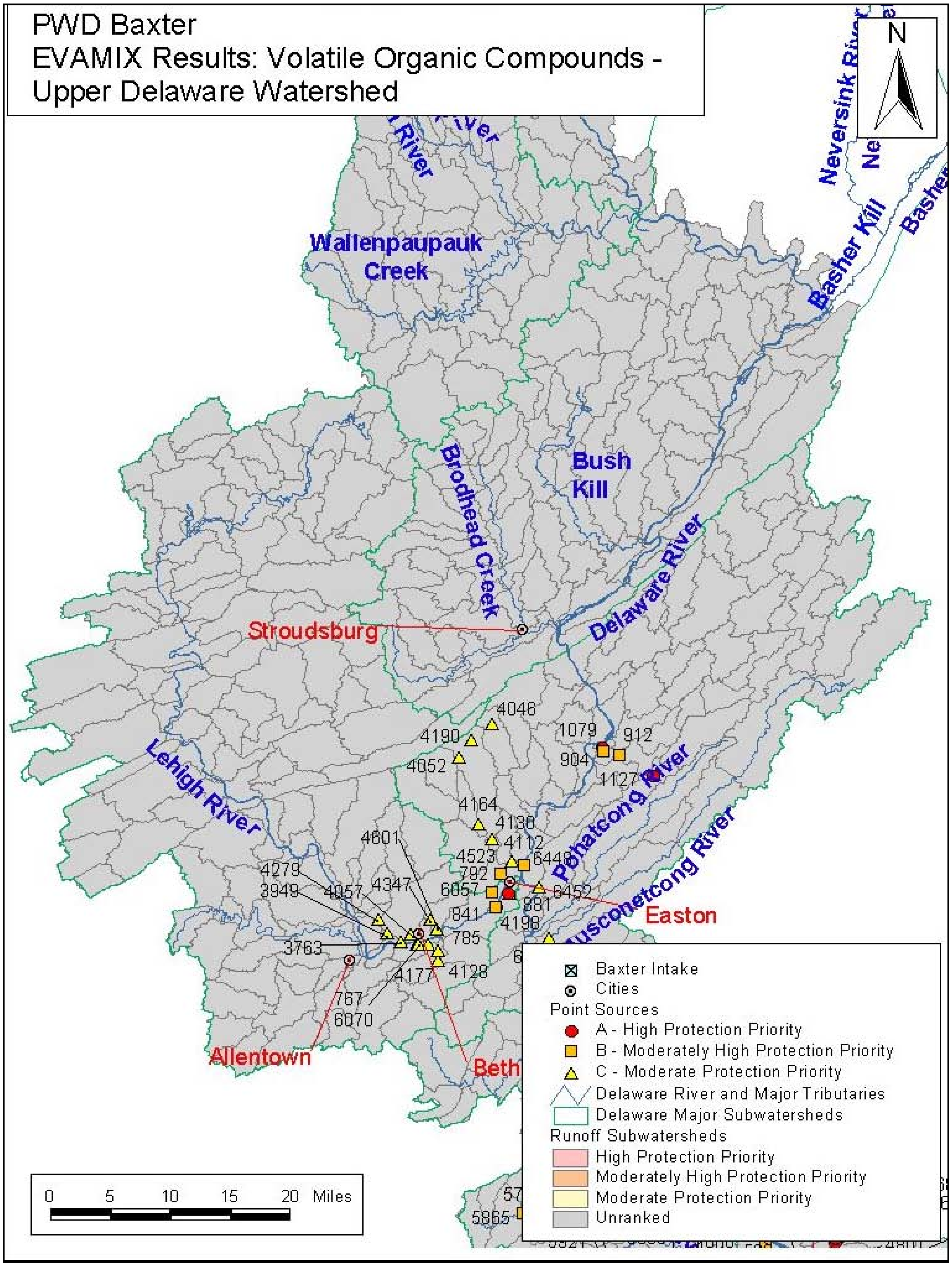


Figure 2.2.4-36 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Upper Delaware River Watershed



2.2.4.3 Narrative Results

Potentially Significant CERCLA Sources

There are 655 CERCLA sites in the watershed; 34 of these sites are on the National Priority List (NPL) for clean up by the USEPA. Approximately 543 of those CERCLA sites fall within the Zone A and B (5 to 25-hour times of travel) from the Baxter Intake during extreme high flow conditions. Only 116 of those 543 sites are within the Zone A (5-hour time of travel) from the Baxter Intake.

Of those 116 sites in Zone A, 63 are within the floodplain. It is very difficult to quantify the types and extent of contamination at a CERCLA site as well as the contaminant's ability to migrate and impact a surface water supply. Therefore, a simple screening process was developed to determine which CERCLA sites may be a potentially significant source of contamination to the water supply. Sites that were considered to be significant met one or several of the following characteristics:

- The site is a National Priority List Site and considered to be contaminated and of concern by the USEPA;
- The site is within Zone A of the Baxter Intake;
- The site is within the floodplain;
- The site is not currently being cleaned up by USEPA; and
- The site is identified by stakeholders as contaminated and of concern to the local community.

The priority ranking of the sites used the following criteria:

- A site met multiple criteria from above;
- A site was closer to the intake than another; and
- A site had a higher surface water migration score than another site or overall migration score according to rankings provided at www.scorecard.org.

Using these criteria, 34 NPL sites were identified within the watershed. Two of the NPL sites reside within the floodplain, 24 fall within the Zone A and B of PWD's Baxter Intake. NPL sites are considered to be significant due to their history of contamination and local environmental impacts that require cleanup by the USEPA. As shown in Table 2.2.4-13, Montgomery, Chester, Berks, and Bucks Counties are the top four counties in Pennsylvania when ranked by the number of NPL sites within them. Table 2.2.4-14 has a summary list of the most frequently detected chemicals at NPL sites in several counties within the Delaware River Watershed. As shown, the most common contaminants at these sites are volatile organic compounds and metal compounds.

Table 2.2.4-13 County Rankings in PA for Number of NPL Sites

Rank	County	Number of Superfund Sites
1	MONTGOMERY	16
2	CHESTER	12
3	BERKS	8
4	BUCKS	7
5	ADAMS	4
	ALLEGHENY	4
	LANCASTER	4
	LEHIGH	4
	MERCER	4
	MONROE	4
	YORK	4
6	DELAWARE	3
	SCHUYLKILL	3

Source www.scorecard.org

Table 2.2.4-14 Most Frequently Detected Chemicals at NPL Sites in Various Counties Draining into the Delaware River Watershed

Contaminant	County
TCE	Berks
Diethanolamine	Berks
1,1,1-Trichlorethane	Bucks
Zinc	Bucks
Trichlorethylene	Chester
Nickel Compounds	Chester
Vinyl Chloride	Lehigh
Copper	Lehigh
TCE	Montgomery
Copper	Montgomery
Methyl Isobutyl Ketone	Philadelphia
Nickel Compounds	Philadelphia
Mercury	Schuylkill
Barium Compounds	Schuylkill

Source www.scorecard.org

In addition to NPL sites there were another 69 CERCLA sites in the floodplain upstream of the Baxter Intake. These sites were examined for potential significance along with the other CERCLA sites identified by stakeholders as potentially significant sources of concern.

The final ranking of the NPL sites is provided in Table 2.2.4-15. The rankings identified four NPL sites that are considered to be potentially significant sources of contamination. All four of the sites were located within the Zone A (5 hour) travel time to the Baxter Intake. All other sites are located in Zone B (<25 hour) or C. The sites of protection priority C are sites that have been cleaned up, contained, or are being utilized by businesses again and should represent little threat to the environment.

There is no way to adequately quantify all of these sites for proper comparison in the overall EVAMIX prioritization rankings. However, based on the limited information available, it appears that the CERCLA sites would potentially rank very low compared to other potentially significant sources in the watershed from the combined ranking.

Spills and Accidents

The Delaware River Watershed is a major transportation corridor for railroads and trucking. In addition, there are several major petroleum pipelines located within the watershed. The volumes of chemicals transported by these means are quite significant. A tanker truck can normally hold about 5,000 gallons of a chemical. A railroad tanker car can normally hold about 14,000 gallons of a chemical. A pipeline, if it breaks and spills contaminants for an hour or more can spill between 1,000 to 10,000 gallons of a chemical depending on its size.

Hypothesizing that an accident were to spill the partial or entire contents of these sources into the river, estimates show that the impacts on downstream local water supplies could be severe, even up to 100 miles downriver of the spill. Assuming that a pipeline, railroad tanker car, or even tanker truck spilled benzene even 10 miles upriver from the water supply intake, only 10 gallons of benzene would need to make it to the river during a normal flow day for concentrations in the river to cause significant impacts on water quality. This would either require the water treatment plant to stop withdrawing water from the river or require special treatment of the water with carbon.

Table 2.2.4-15 Potentially Significant CERCLA Sources for the Baxter WTP Intake

Rank	Zone	Name	Chemicals	Floodplain	NPL Status
C	A	WELSBACH & GENERAL GAS MANTLE CONTAMINATION		No	Yes
C	A	FLORENCE LAND RECONTOURING LANDFILL		No	Yes
C	A	ROEBLING STEEL CO		No	Yes
C	A	SWOPE OIL & CHEMICAL CO		No	Yes

Under more extreme conditions, up to 100 gallons of benzene would need to be spilled for a similar impact. These estimates do not take into account the potential loss of benzene due to holding in pockets in the river or binding to sediments and other material as it flows downstream. Therefore, higher concentrations of 1,000 gallons of benzene spilled from an accident would most likely have a severe impact on water quality at the intake even if it were spilled during a rain event 100 miles upriver.

In terms of their overall priority compared to the other sources provided in the combined ranking, spills and accidents can have one of the greatest relative impacts on water quality and require some moderate level of protection priority. An early warning system on the Schuylkill River such as the system present on the Ohio River would help to prevent such severe impacts in the event of a spill.

Radionuclides

The presence of the Nuclear Generating Station in the region requires monitoring for the presence of radionuclides in the finished drinking water. To date, special monitoring has only detected Gross Beta radionuclides at levels far below the regulated limits in the finished water from Delaware River sources. All other types of radionuclides have not been detected.

Given that current water quality data does not suggest any radionuclide issues with these sources and the current controls and monitoring in place to protect against them, these sources would be considered a medium protection priority and would tend to fare lower than other sources identified in the combined ranking.

2.2.5 Qualitative Loading Analysis

Key Points

- **Quantitative contaminant loading analyses are difficult to implement as it is not possible to accurately characterize all of the factors affecting potential contaminant releases and transport.**
- **Qualitative contaminant loading analyses can provide order-of-magnitude assessments that will help to identify potentially significant major loads**
- **Non-point sources associated with stormwater runoff were identified as significant sources of fecal coliform, total suspended solids, and petroleum hydrocarbons.**

2.2.5.1 Method

Performing a quantitative pollutant loading analysis requires a substantial investment in data collection. For example, for sites that actually discharge wastewater to the river on a continuous or intermittent basis, accurate data on discharge rates and concentrations of contaminants in the discharge water are required. For sites that store chemicals, accurate data on the amount and type of chemical stored are required, and a series of assumptions must be made about the probability of leaks or spills occurring. The analysis must also account for natural sources of certain contaminants and a calibrated non-point source or runoff-loading model is needed to add stormwater-related pollutant loading to the calculations. For this reason, a quantitative contaminant loading analysis goes well beyond the scope of this study, and the data collected is not sufficiently accurate to allow a quantitative analysis to be performed.

Despite the limitations that the data impose, a more qualitative analysis of contaminant loading is still valuable, and can provide important insight into the relative magnitude of the impacts that the major contaminant sources might have on the water quality within the watershed. The approach to performing the analysis is summarized by the following steps.

Step 1: Loading Estimates

- For sites that have continuous or intermittent discharges, estimates of annual contaminant loading for each contaminant category are calculated by multiplying median discharge concentration by average annual discharge rate.

- For sites that simply store or use chemicals onsite, there is no logical way to estimate point loading because contaminants are only released through spills or leaks. An extreme estimate of potential loading can be made by assuming stored chemicals in the largest tank onsite are released through a catastrophic tank failure and are all spilled to the surface water.

- For non-point source pollutant loading, estimates for each contaminant category were provided by the SWMM model results on an annual basis.

Step 2: Loading Magnitude Comparisons

The loading estimates produced in step one are of widely varying accuracy. The SWMM model stormwater loads may be generally accurate, however, they are based on Event Mean Concentrations that may or may not be representative of local conditions within the watershed. The loading estimates for point source dischargers range from accurate for dischargers who regularly monitor their discharges and report results (usually the larger sources), to highly speculative where data had to be filled in for both concentration and discharge rate (many of the smaller dischargers). The loading estimates for sites that store or use chemicals are not based on data, and represent a speculation on potential leaking or spilling that probably overestimates loading by a considerable margin.

Despite the disparity in accuracy, the total annual loads can be contrasted with each other, and general conclusions about the magnitude of each type of source drawn. These estimates will also be compared to estimates of contaminant loads from natural or more regional sources (e.g. acid mine drainage) where information or data are available. The intent is not to calculate actual estimates of loading rates, but to better understand which sources are most likely to be major sources, and which appear to be minor sources.

Step 3: Reality Check

Because of the highly speculative nature of the loading estimates, annual average contaminant loads for each source are estimated and divided by annual average flow rates in the river. These concentrations are then diluted by the tidal effects of the lower Delaware River based on the tidal river model, and used to estimate an in-stream concentration. The calculated concentration can be compared to in-stream sampling data and conclusions drawn about the degree of overestimation or underestimation that the loading estimates appear to represent.

2.2.5.2 Results

Only a general, qualitative analysis of contaminant loading can be made with the sketchy data available for this analysis. A cumulative loading analysis goes well beyond the scope of this analysis and is not attempted here. The qualitative loading analysis is based on the loading estimates produced by the database in support of the evaluation of sites, and only provides an indication of the relative importance of each potential source.

Loading Estimates

Using the database, order of magnitude estimates of loads from each type of source can be made. These are discussed here in a general sense for the sites in the major databases.

Each source is rated according to the relative impact that the source might have on ambient river concentrations.

- Low: if the sites do not appear to contribute enough pollutant to even register as a portion of the ambient concentration. Generally, each of these sites if discharging or spilling to the river, would only change the concentration at the intake by less than 0.1%.

- Medium: if the sites could be contributing a low percentage of the actual ambient concentrations. Generally, each of these sites, if discharging or spilling to the river, would change the concentration at the intake 0.1 to 25%.

- High: if the sites could or are one of the major contributors of this contaminant. Generally, each of these sites, if discharging or spilling to the river, would change concentrations at the intake by more than 25%.

A distinction is made between sources that are contributing and those that could, but only if spills or leaks occur.

Table 2.2.5-1 provides a summary of the estimated combined contributions by the various source types under either normal or abnormal (such as the primary storage tank spilling all its contents) conditions. The table also provides comments on whether the indicated, cumulative sources appear to drive or influence water quality when compared to water quality data. "Yes" indicates that current water quality day corroborates the indicated source contributions. "Partial" indicates that current water quality data only partially corroborates the source contributions. "No" indicates that no real correspondence exists between the source contributions and water quality data.

Table 2.2.5-1 Qualitative Combined Contributions to River Water Quality

Contaminant	NPDES (dischargers)	NPS (runoff)	TRI (toxic facilities)	AST (storage tanks)	Matches with Reality?
Salts	Low	Low	Low	Low	Yes
Cryptosporidium	Low	Low	Low	Low	No
Fecal coliforms	Low	Medium	Low	Low	Yes
Nitrate	Low-Medium	Low	Medium*	Medium*	Yes
Metals	Medium-High	Low	High*	High*	Yes
Phosphorus	Medium	Medium	Medium*	Medium-High*	Partial
Petroleum Hydrocarbons	Low-Medium	Medium	Low	High*	Yes
Disinfection-by-Products	Medium	Low-Medium	Medium*	Low	Partial
Turbidity	Medium	Medium	Low	Medium*	Yes
Volatile Organic Compounds	Medium-High	Low	High*	High*	Yes

** Abnormal and highly unlikely situation would require the simultaneous release of contaminants from storage tanks.*

As shown, estimates for salts, fecal coliforms, nitrate, metals, petroleum hydrocarbons, turbidity, and volatile organic compounds appear to match well with current water quality data observations. However, the estimate for *cryptosporidium* does not match. Some categories, such as phosphorus and disinfection-by-products, only show partial matches. Source contributions for metals, such as lead and copper, do generally match water quality. However, source contributions do not correlate with iron and manganese intake levels, which are greatly influenced by acid mine drainage. Therefore, the qualitative loading analysis, which is based on conservative assumptions, only provides some very general indications about the impacts of various sources. This analysis requires further refinement as part of a true cumulative analysis for a TMDL in order to provide more accurate predictions.

Salts

NPDES (permitted dischargers): Low

Permanent discharges, but at very low concentrations.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a source of salts during the winter, but does not appear to be a concern.

TRI (generators/handlers): Low

Sites could contribute minor amounts, but only do so through spill or leaks.

AST (above ground tanks): Low

A few potential sites could affect water quality, but only through a catastrophic spill.

Comparison of the loading results to actual seasonal trends in water quality data (section 2.1.5) shows that the results of both analyses indicate that NPS (stormwater) runoff is the main source of salts in the watershed. The qualitative loading results further indicate that the cumulative impact of these sources from developed areas is probably not significant, however, long term trends appear to suggest that the cumulative impacts could become more significant and the source of the increasing concentrations in the river.

Cryptosporidium

NPDES (permitted dischargers): Low

These are majority of the sources, however, the loading rate is relatively low, and does not result in significant concentrations in the ambient water under normal circumstances.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a source of *Cryptosporidium* from certain land uses, and is probably responsible for almost all the background levels found in the river.

TRI (generators/handlers): Low

AST (above ground tanks): Low

Not a source. Comparison of the qualitative loading data with actual water quality data from research studies conducted by PWD, suggest that the elevated concentrations observed during storm events are most likely due to stormwater runoff from developed areas and pasture lands. However, during non-rainfall periods, it appears that NPDES discharges in particular from wastewater treatment plants are the main source of daily concentrations observed in the Delaware River. Therefore, efforts to reduce mean daily concentrations of *Cryptosporidium* in the river should focus on reducing the impacts from wastewater discharge, while efforts to reduce peak concentrations should focus on mitigating stormwater runoff from pastures and developed areas.

Fecal Coliform
NPDES (permitted dischargers): Low

These sites are one of only two sources, however, the loading rate is relatively low, and does not result in significant concentrations in the ambient water under normal circumstances.

NPS (stormwater runoff loading): Medium

Stormwater runoff is the primary source and is probably responsible for almost all the background levels found in the river. This is usually seen in the extreme variability of fecal counts responding to rainfall events.

TRI (generators/handlers): Low

Not a source

AST (above ground tanks): Low

Not a source

Comparison of the qualitative loading data with actual water quality data suggests that the elevated concentrations observed during storm events are most likely due to stormwater runoff from developed areas and pasture lands. However, during non-rainfall periods, it appears that coliforms can originate from a number of sources including wastewater discharges, leaking septic tanks, leaking sewers, “wildcat” or illegal sewage discharges, geese, and livestock.

Metals

NPDES (permitted dischargers): Medium-High

NPDES discharges may account for some of the metal concentration found at the intake. The amounts, cumulatively, could represent a low but significant percent of total metal loading for certain metals.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a significant source of metals during storm events, with runoff often contributing copper, zinc, cadmium, and other metals at relatively low concentrations to the water.

TRI (generators/handlers): High (potential only)

Sites could contribute major amounts of metal to the river, but only do so through spill or leaks. The amounts stored, if spilled, could cause order of magnitude exceedences of the drinking water standards at the intake for short periods of time.

AST (above ground tanks): High (potential only)

Sites could contribute major amounts of metal to the river, but only do so through spill or leaks. The amounts stored, if spilled, could cause order of magnitude exceedences of the drinking water standards at the intake for short periods of time.

Though the qualitative analysis suggests that TRI and AST sites have the potential for the greatest cumulative impacts, it would require numerous simultaneous catastrophes in the watershed for this to occur. Based on analysis of long-term trends, it appears that concentrations of metals are increasing in the river. Also water quality data suggests most metals increase during storm events. The only metal that does not always increase during rain events is manganese. In section 1.4.6.1, it was shown that concentrations measured from acid mine drainage discharges can actually be responsible for everyday concentrations of iron and manganese observed in the Delaware River. Also, spatial analyses in section 2.1.5 also observed a decrease in metals concentrations with distance downriver. Therefore, though it is estimated qualitatively that NPDES discharges appear to have a medium impact on metal concentrations in the river, it is more likely that stormwater runoff and acid mine drainage are the driving factors cumulatively influencing water quality trends in the river.

Nitrates

NPDES (permitted dischargers): Low-Medium

Permitted discharges of wastewater contribute a steady load of nitrates to the river, but in general do not result in concentrations that approach the drinking water standard.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a source of nitrate, especially runoff from agricultural lands. Overall loading, however, appears to be low.

TRI (generators/handlers): Medium (potential only)

Generally not a source, although a few sites appear to have the potential to be a temporary source if a spill were to occur.

AST (above ground tanks): Medium (potential only)

Generally not a source, although one site appears to have the potential to be a temporary source impacting concentrations through a spill or leak.

Analysis of observed nitrate concentrations in sections 2.1.5 show that nitrate and ammonia concentrations are decreasing in the river. Also, seasonal fluctuations in nitrate concentrations appear to be dominated by biological activity in the river. However, analysis of impairment data in section 2.1.5.4 suggests that nutrients are one of the top five leading causes of impairments in the tidal portion of the Delaware River Watershed in Pennyslvania. Upon further examination, these impairments may be more related to phosphorus than nitrate. Overall, the combined information suggests that improvements by wastewater discharge and reduced agricultural runoff have benefited the watershed, but the cumulative impacts of nitrate from both point and non-point sources combined may still play a significant role in determining stream health.

Petroleum Hydrocarbons
NPDES (permitted dischargers): Low-Medium

Generally not a source, although a number sites appear to contribute to concentrations. However, the loading rate is relatively low, and does not result in significant concentrations in the ambient water under normal circumstances.

NPS (stormwater runoff loading): Medium

Stormwater runoff is a source of petroleum hydrocarbons during storm events, particularly from urban areas. Measurable concentrations at the intake are likely to be the result from stormwater runoff.

TRI (generators/handlers): Low

Not a source

AST (above ground tanks): High (potential only)

This is only a source if spilled or leaked. The amounts stored at many sites, however, mean that a spill could have significant impact, with very high concentrations occurring following a spill.

As observed, petroleum hydrocarbons from non-point source runoff and aboveground storage tanks were considered to have the greatest potential qualitative impacts. Petroleum hydrocarbon impacts are typically observed from spills caused by accidents or releases. The impacts of hydrocarbons from stormwater runoff have not been observed in either water quality data or stream impairment descriptions to date. Therefore, the observed cumulative impact of various sources on hydrocarbons is low, but the observed impact from an individual source during an accident can be significant.

Phosphorus
NPDES (permitted dischargers): Medium

Wastewater discharges are a source of phosphorus, but at amounts that are not likely to have a large effect on ambient concentrations at the intake.

NPS (stormwater runoff loading): Medium

Stormwater runoff can be a source of phosphorus in runoff from residential and agricultural areas. Overall loading, however, appears to be relatively low.

TRI (generators/handlers): Medium (potential only)

Some sites could contribute significant amounts, but only do so through spill or leaks.

AST (above ground tanks): Medium-High (potential only)

In general, not a source, however one or two sites noted as storing phosphorus.

Analysis of observed orthophosphate concentrations in sections 2.1.5 and 1.4 show that orthophosphate concentrations are increasing in the river. Seasonally, orthophosphate concentrations also appear their greatest during spring when runoff and rainfall occurs. In addition, analysis of impairment data in section 2.1.5.4 suggests that nutrients are one of the top three leading causes of impairments in the lower half of the Schuylkill River Watershed. These impairments may be related mainly to phosphorus and not to nitrate. Overall, the combined information suggests that the cumulative release of phosphorus from non-point sources may be the most significant contribution for control.

Disinfection By-Product (Total Organic Carbon)
NPDES (permitted dischargers): Medium

Wastewater discharges are one of the major sources of TOC, and can be having a measurable impact on concentrations at the intake.

NPS (stormwater runoff loading): Low-Medium

Stormwater runoff can be a significant source of metals during storm events, at relatively low to medium concentrations to the water.

TRI (generators/handlers): Medium (potential only)

Sites could contribute significant amounts, but only do so through spill or leaks.

AST (above ground tanks): Low

Not a significant source

Total organic carbon can come from many sources including agriculture, decaying leaves and algae, and sewage discharge. However, the nature of the organic matter from those sources can be significantly different and have significantly different impacts on the formation of disinfection by-products when they react with chlorine. Water quality data in section 1.4 suggests that TOC has increased in the river over the past decade. Since the population in the watershed has not changed significantly in the past decade, it is doubtful that NPDES discharges are the influencing cumulative source related to this increase. However, during this period, developed land throughout the watershed has increased. These observations suggest that the combined impact from the many non-point sources in the watershed may be driving the increasing concentrations observed in the river.

Turbidity (Total Suspended Solids)
NPDES (permitted dischargers): Medium

Wastewater discharges are a major source of TSS, and probably have a measurable impact at the intake.

NPS (stormwater runoff loading): Medium

Stormwater runoff is the major source of TSS during storm events, and can cause large increases in concentration for periods of time during and after a storm.

TRI (generators/handlers): Low

Not a source

AST (above ground tanks): Medium (potential only)

Only a source if major spill occurs.

The qualitative analysis suggests that both NPDES discharges and non-point sources are the controlling sources of turbidity. Water quality data suggests that non-point source runoff tends to control turbidity due to its increased values during the wetter seasons. NPDES discharges may contribute to the daily non-rain event turbidity levels, but water quality data to date does not clearly suggest any impact on turbidity from dry weather discharges.

VOCs

NPDES (permitted dischargers): Medium-High

Generally not a significant source of VOCs, however can discharge measurable amounts.

NPS (stormwater runoff loading): Low

Not a significant source

TRI (generators/handlers): High (potential only)

Sites could contribute significant amounts, but only do so through spill or leaks. A spill would result in orders of magnitude increase above drinking water standards.

AST (above ground tanks): High (potential only)

Sites could contribute significant amounts, but only do so through spill or leaks. A spill would result in orders of magnitude increase above drinking water standards.

As observed, volatile organic compounds toxic release facilities and aboveground storage tanks were considered to have the greatest potential qualitative impacts. Analysis of the limited VOC data does not suggest any impacts from particular point sources or facilities. Past experiences tend to suggest that individual sources such as accidents and spills that release benzene or toluene are most likely to impact the water supply. Therefore, the observed cumulative impact and likelihood from various sources of VOCs is low, but the observed impact from an individual source during an accident can be significant.

2.2.6 Watershed Protection and Restoration Activities

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 from 1995 to 2001.

These programs include the Pennsylvania Department of Environmental Protection's (PA-DEP) 319 Non-Point Source Program and the Growing Greener Program, the Pennsylvania Department of Conservation and Natural Resources (PA-DCNR) Rivers Conservation Plan Program, and Pennsylvania's Coastal Zone Management Program. Also included were Pennsylvania's Natural Resource and 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). Additional sources include monies from the New York State DEP, New York City DEP, and New Jersey DEP funds. 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).

Restoration activities within the lower portion of the Delaware River Watershed are generally within the Zone A limit of PWD's Baxter Intake. The lower portion of the Delaware River includes the following source water assessment study areas: Tidal PA-Philadelphia, Tidal PA Bucks, Neshaminy, Tohickon, NJ Mercer Direct, PA Bucks Direct, Crosswicks, Tidal NJ Upper, Rancocas, and Tidal NJ Lower. The combined grant funding for these study areas from 1995-2002 was $7,673,676.

The middle portion of the Delaware River Watershed is made up of the following source water assessment study areas: Lehigh and Middle Delaware. The combined funding level for the middle portion was $1,662,166.

The upper portion of the Delaware River Watershed is made up of the Upper Delaware, East Branch Delaware, Mongaup, and the Lackawaxen. The combined funding level for the upper portion was $9,781,960. Figure 2.2.6-1 summarizes the distribution of grant dollars by project type. Over 18% of the grant funds were allocated for restoration projects in the watershed.

Figure 2.2.6-1 Distribution of Tidal PA Philly Grants by Project Type

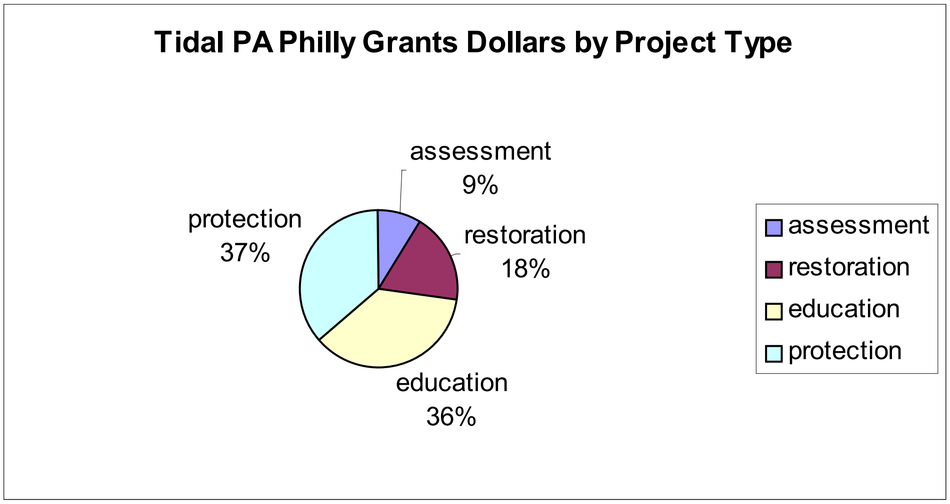


Table 2.2.6-1 lists the grants received within the Lower Delaware River Watershed from 1995-2001. The largest project funded was the Fairmount Water Works, receiving approximately 33% of the total funding for the watershed. The Fairmount Water Works will serve as the educational center for the region in terms of water resources and the connection between anthropogenic activities and environmental sustainability.

Table 2.2.6-1 Projects Receiving Grants in the Lower Delaware River Watershed (several SWAP Study areas)

Study Area	Grant	Awardee	Project Description	Year
Neshaminy	$250,000	Bucks County	Park Development for Peace Valley	2001
Neshaminy	$40,000	Bucks County	Churchville Reservoir Nature Center	2001
Neshaminy	$80,000	Heritage Conservancy	Rivers Conservation Plan - Lower Neshaminy	2001
Neshaminy	$200,000	Heritage Conservancy	90 acres preserved Durham Mine Bat Cave	2001
Neshaminy	$130,000	Heritage Conservancy	51 acres preserved of Quakertown Swamp	2001
Neshaminy	$63,850	Bucks County Audubon Society	Honey Hollow Watershed Conservation Plan	2001
Neshaminy	$60,000	Buckingham Township	Stormwater basin retrofit into wetland	2000
Neshaminy	$6,530	N.B. Neshaminy Creek Watershed Assc.	Start-up of a watershed association - Lake Galena	2000
Neshaminy	$112,535	American Littoral Society	Comprehensive watershed assessment	2000
Neshaminy	$60,000	Bucks County Conservation District	Warrington Lake & Neshaminy Creek Assessment	2001
Neshaminy		Doylestown Twp. Env. Advisory Council	Restoration at Bridge Point Park	2001
Neshaminy	$10,000	Horsham Township	Update comprehensive recreation & park plan	2001
Neshaminy	$60,000	Buckingham Township	Elementary School stormwater restoration & education	

Study Area	Grant	Awardee	Project Description	Year
Neshaminy	$6,530	N.B. Neshaminy Creek Watershed Assc.	Organizing a watershed group	
Neshaminy	$46,420	Pennridge Area Coordinating Committee	Watershed assessment	2000
Neshaminy	$50,000	Plumstead Township	Stormwater basin retrofit	2000
Neshaminy	$10,645	Senior Adult Activity Center of Lansdale	North Penn S.E.C. groundwater education	
NJ Mercer Direct	$564,900	Delaware River Basin Commission	2002 DRBC 106 Water Pollution Control Program	2002
NJ Mercer Direct	$95,000	Delaware River Basin Commission	PCBs Trackdown	2001
NJ Mercer Direct	$75,000	Delaware River Basin Commission	Municipal STP PCB Trackdown	2001
NJ Mercer Direct	$185,571	Delaware River Basin Commission	National Estuary Program	2001
PA Bucks Direct	$31,000	Upper Makefield Township	Develop township wide trail system	2001
PA Bucks Direct	$5,000	Upper Makefield Township	Riparian buffer along Jericho Creek	2001
PA Bucks Direct	$60,000	Delaware Riverkeeper	Paunacussing Creek Hydrogeomorphic survey	2001
PA Bucks Direct	$5,000	Upper Makefield Township	Riparian buffer restoration	2001
PA Bucks Direct	$60,000	Makefield Lakes Community Association	Community environmental education, restoration	2000
PA Bucks Direct	$48,000	Partnership for Land Use Management	Develop a NPS management plan for Paunnacussing Creek	2000
PA Bucks Direct	$4,875	Partnership for Land Use Management	Environmental awareness program	2000
PA Bucks Direct	$25,000	Delaware River Greenway Partnership	Streambank stabilization along Del Canal State Park	2000
PA Bucks Direct	$75,000	American Littoral Society	Educational materials for stream restoration monitoring	2001
Rancocas	$160,000	NJ DEP	Regional Geographic Initiative (RGI) Project	1998
Rancocas	$50,000	Partnership for the Delaware Estuary	Rancocas Delaware Estuary Program Watershed Initiative	2000
Tidal NJ Lower	$20,000	Partnership for the Delaware Estuary	Estuary Corporate Environmental Stewardship Program	2001
Tidal NJ Lower	$50,000	Partnership for the Delaware Estuary	Lower Tributaries Subwatershed Initiative	2000
Tidal NJ Lower	$34,560	Partnership for the Delaware Estuary	15 minute video and distribution about watersheds	2000
Tidal NJ Lower	$72,283	Partnership for the Delaware Estuary	Clean Water Partners Program	2001
Tidal PA Bucks	$1,200,000	Middletown Township	Otter Creek Watershed restoration phase II	2001
Tidal PA Bucks	$30,000	Bucks County Planning Commission	Otter Creek watershed assessment & protection plan	
Tidal PA Bucks	$60,000	American Littoral Society	Hydrogeomorphic survey of Paunacussing CR	2000
Tidal PA Bucks	$30,000	Bucks County Planning Commission	Watershed assessment, restoration & protection plan	
Tidal PA Philly	$75,000	Environmental Fund for Pennsylvania	Greenworks Project	2001
Tidal PA Philly	$190,000	Fairmount Park Commission	What's in Our Watershed?	2001

Study Area	Grant	Awardee	Project Description	Year
Tidal PA Philly	$15,867	Philadelphia City Sail Inc.	Environmental education program	2001
Tidal PA Philly	$65,000	Resources for Human Development Inc.	Protection Of Children From Environmental Threats	2000
Tidal PA Philly	$3,735	School District of Philadelphia	Environmental Education - Hunter Elementary	2001
Tidal PA Philly	$5,000	Temple University	Environmental Education - Delaware Canal State Park	2001
Tidal PA Philly	$698,500	The Academy of Natural Sciences	Urban Rivers Awareness	2001
Tidal PA Philly	$10,000	The Village Of Arts and Humanities	Teen Environmental Leadership Internship Program	2001
Tidal PA Philly	$15,000	The Village Of Arts and Humanities	Environmental Justice Small Grants - Camac	2001
Tidal PA Philly	$18,000	Milford Township	Develop Comprehensive recreation and park plan	2001
Tidal PA Philly	$175,000	Natural Lands Trust	Conservation easement along 100 acres	2001
Tidal PA Philly	$11,000	Horsham Township	Educational outreach program Kohler Park	2000
Tidal PA Philly	$30,000	Horsham Township	Stabilize streambanks and revegetate Kohler Park	2001
Tidal PA Philly	$99,968	Towamencin Township	Riparian buffers for NPS & stormwater BMP retrofits	2001
Tidal PA Philly	$350,000	Fairmount Park Commission	Acquire 16 acres of rail line property for trail	2001
Tidal PA Philly	$100,000	Philadelphia Water Department	Rivers-conservation plan for Tacony	2001
Tidal PA Philly	$3,000	Awbury Arboretum	Watershed education program	1999
Tidal PA Philly	$98,000	Upper Southampton Township	Southampton Creek watershed restoration	2000
Tidal PA Philly	$9,640	Upper Southampton Township	Creation of Southampton Creek Watershed Association	2000
Tidal PA Philly	$1,104,483	Fairmount Park Commission	Wetlands and tidal flats access & interpretation	2000
Tidal PA Philly	$150,000	Pennsylvania Environmental Council	Delaware River Basin Initiative	2001
Tidal PA Philly	$148,610	Philadelphia Earth Force	Earth Force Delaware Watershed Green Initiative	2001
Tidal PA Philly	$24,174	Environmental Fund for PA	Video Green Works: "The Value of Water"	2001
Tidal PA Philly	$60,000	Environmental Fund for PA	Video Green Works: "Life on the Delaware River"	2001
Tohickon	$12,000	Bridgeton-Nockamixon Tinicum	GIS Mapping of Tinicum Headwaters	2001
Tohickon	$20,000	Tinicum Township	Stream buffer and headwater protection	2001
Tohickon	$29,750	SE-PA RC&D Council	Livestock farm BMP	2000
Tohickon	$14,250	Bedminster Land Conservancy	Implementation of WQ monitoring for Deep Run	
Tohickon	$10,000	Heritage Conservancy	Quakertown Swamp Partnership	

2.2.7 Public Participation Process

Key Points

- **Public kick-off meetings, Technical Advisory Group meetings, media articles and a web site are some of the methods used to involve the public in the SWAP.**
- **An open Technical Advisory Group (TAG) has been 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.**
- **Thirty - four people attended the first of several public kick-off meetings being conducted to introduce the SWAP.**
- **SWAP project information is available through the project website, www.phillywater.org/delaware.**

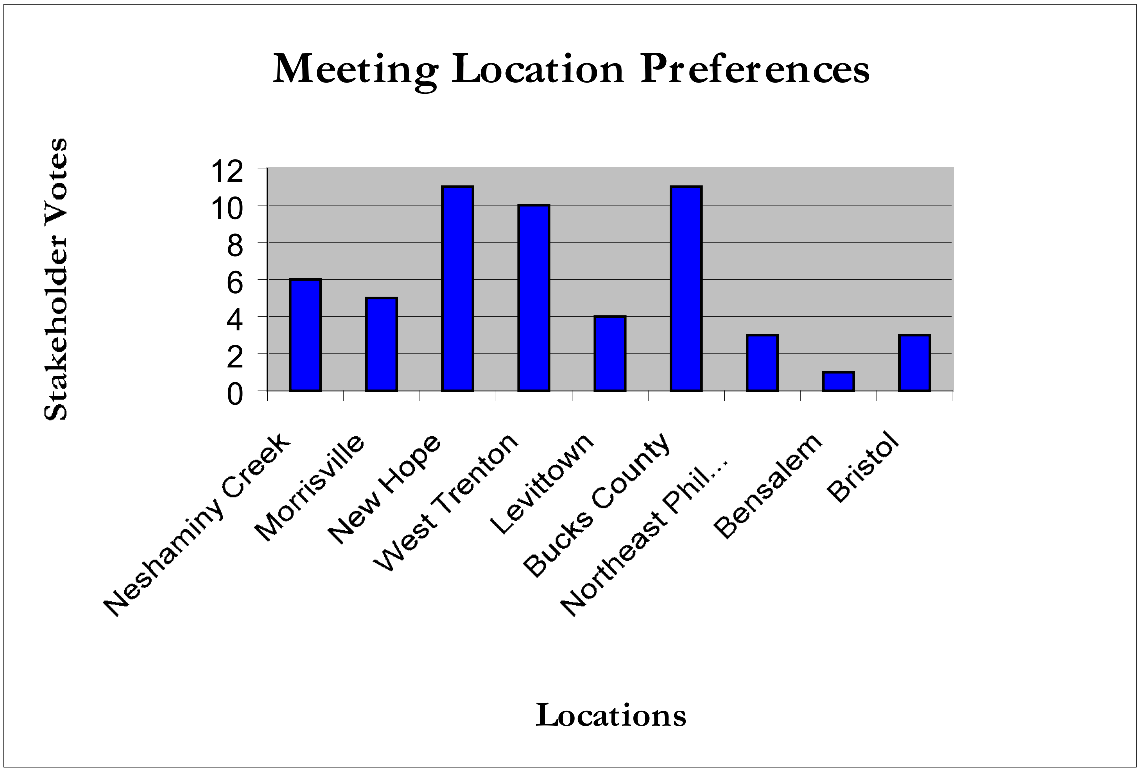
Several avenues will be available for stakeholder and public involvement throughout the Delaware Source Water Assessment Program. These include:

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

This multi-faceted approach provides 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. In the past, these avenues appear to have been moderately successful at reaching interested public and stakeholders. One public meeting has resulted in 34 attendees, two advisory group meetings resulted in 23 attendees, 12 legal notices have been published, two newspaper articles have been published about the project, and the web site has been accessed 146 times to date. More public meetings discussing the ongoing assessment will take place in the near future

One of the important goals of gathering stakeholder input during the initial stages of the public participation process is to develop a framework for the meetings to ensure that they are optimally effective. According to the results of the first round of surveys distributed to gather stakeholder input, the best time for the stakeholders to meet is during the day (either morning or afternoon) and most would prefer to meet in the New Hope, West Trenton, or Bucks County areas. The following figure illustrates the amount of stakeholder votes each location received.

Figure 2.2.7-1 Meeting Location Preferences



2.2.7.1 Advisory Groups

To better facilitate communication among the Source Water Assessment Partnership and the regions of the Delaware River Watershed to be assessed, an open Technical Advisory Group (TAG) has been 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 Delaware River Watershed. All of the stakeholders have been invited by the partnership to participate. Meeting quarterly, it is the primary responsibility of the TAG to inject public interest into the SWA process. Other duties of this group include:

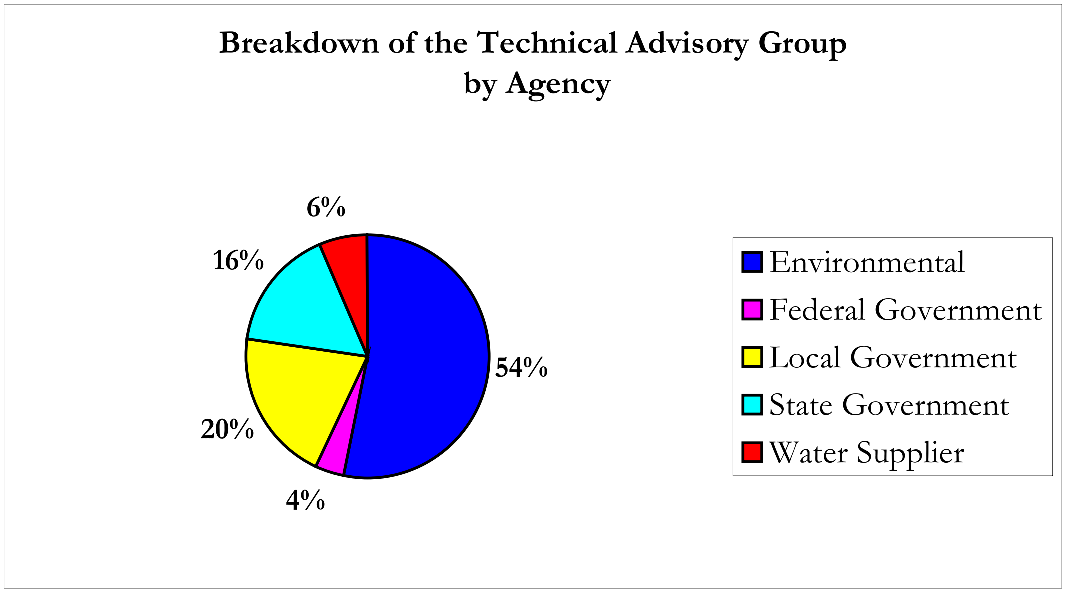
- Sharing information with stakeholders
- Verifying the information put forth by the partnership
- Providing input on the assessment techniques and criteria used by the partnership
- Offering general information regarding the areas local to each TAG
- Participating in public outreach and education
- 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 2.2.7-2).

Figure 2.2.7-2 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 drinking water is safe; protecting water quality in Pennsylvania rivers and streams; making sure waste is handled properly; managing the Commonwealth's recycling programs and helping citizens to 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.

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.

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.

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.

Founded in 1989, The ***Delaware River Greenway Partnership*** (DRG) promotes awareness and protection of the river and other natural resources by encouraging both public and private stewardship of the Delaware River and the greenway that surrounds it. Among the DRG's current projects are: *Bridging Our Lower Delaware*, *Delaware River Heritage Trail*, and *Annual Education Reform*. The DRG also publishes a quarterly newsletter, the *Delaware River Greenway News*. The DRG can be contacted by telephone at (908) 996-0230.

The ***Bucks County Sierra Club*** is an organization that works to protect the county's land, air, and water resources by encouraging Bucks County residents to take an active role in making elected officials recognize the importance of these resources and prevent further damage to them.

The mission of the ***Bucks County Water and Sewer Authority*** is to provide quality service in an environmentally safe manner at an affordable rate, and to educate their current and future customers on water conservation. The authorities' ongoing goals include: maintenance of their commitment to affordable rates and excellent service levels, meeting or exceeding all environmental and public health standards, continual seeking and identification of cost saving procedures without the sacrifice of quality, and the education of customers, neighbors, and the communities' children in that water is a limited resource and should be treated as one of our most valuable commodities. The *Bucks County Water and Sewer Authority* was founded by the Bucks County Commissioners in 1962 to support local municipalities with the installation of water and sewer service. As a non-profit agency carrying out an enterprise role, no tax money is involved in the operation of this (or any) authority; all income is derived by billing the people who utilize their services. Consequently, those not making use of the service do not pay towards it; also known as "user pays." The good news is, as an "Authority", it only charges its customers the cost to operate the service.

The ***Stroud Research Center*** uses its advanced knowledge of stream and river ecosystems to provide solutions for water resource problems around the world. The center uses extensive education programs, conservation leadership, and its professional services to promote public understanding of freshwater ecology and to develop new ideas and hypotheses to improve the environment. Included in Stroud's mission statement are: the advancement of knowledge of stream and river ecosystems through interdisciplinary research, the development and communication of new ecological ideas, hypotheses or theories, the provision of solutions for water resource problems worldwide, and the promotion of public understanding of freshwater ecology through education programs, conservation leadership and professional service. The Stroud Center can be contacted via telephone at (610) 268-2153 or fax at (610) 268-0490. The mailing address for the center is 970 Spencer Road, Avondale, PA, 19311. Comments and concerns may also be voiced via e-mail at Webmaster@Stroudcenter.org.

Since it's beginning in 1969, the ***Catskill Center for Conservation and Development*** has worked as a non-profit organization to inform the public of issues concerning the conservation of the resources of their area. Public forums are used to encourage the public to get involved with these issues, and to help foster a deep appreciation for the environment in which they live. Centering on environmental protection and sustainable economic development has helped the organization to protect the cultural, historic, and natural resources of the Catskill Mountains. Merging both environmental protection and sustainable economic development, the organization is a campaigner for the region's vital main streets, valuable natural resources, artistic and historic assets, and working landscapes. They achieve this through four main program areas; *Natural Resources and Land Conservation, Education, Community Planning and Development, and Regional Culture and Arts.* The Catskill Center can be reached via telephone at (845) 586-2611. It is located in Arkville, New York.

Funded in 1959, ***Trout Unlimited's*** mission statement is "to conserve, protect and restore North America's trout and salmon fisheries and their watersheds." The organization accomplishes this mission through an extensive volunteer network. With 125, 000 volunteers in 500 chapters nationwide, the organization works directly through professionals who testify before congress and intervene in federal legal proceedings to ensure they are involved in conservation issues. The drive of the organization is to protect our rivers and fisheries for generations to come. Trout Unlimited can be reach by telephone at (703) 522-0200 and by fax at (703) 284-9400. The mailing address is 1500 Wilson Blvd., #310, Arlington, VA, 22209-2404. Questions and comments can also be sent via e-mail at trout@tu.org.

The ***Heritage Conservancy***, formerly known as the Bucks County Park Foundation, was founded in 1958 when concerns about the rapid loss of open space in Bucks County started to arise. Since that time, the conservancy has been dedicating its time and efforts to protecting the counties natural and historic heritage. By partnering with citizens, businesses, and government agencies, the conservancy has become a leader in land conservation and historic preservation. The organization achieves these environmental goals through a process of assessing potential sites, educating the public, and implementing actions to improve our natural habitats. The Heritage Conservancy can be contacted by phone at (215) 345-7020 and by fax at (215) 345-4328. The mailing address is 85 Old Dublin Pike, Doylestown, PA, 18901.

Created as a chapter of the National Audubon Society in 1969, the ***Bucks County Audubon Society*** has set out to create a sense of need for environmental change. Since their start, the BCAS has been protecting the environment, educating the public on ways to better conserve their natural resources, and promoting the wise use of land, water, and air. With over 2300 members, BCAS is one of the chief citizen membership groups representing environmental and ecological interests in Bucks County. The mailing address for the Bucks County Audubon Society is 6234 Upper York Road, New Hope, PA, 18938. BCAS can also be reached by phone at (215) 297-5880 or by fax at (215) 297-0835. All e-mail can be directed to bcas@bcas.org.

The ***New Jersey Audubon Society*** works to instill a sense of environmental conservation in New Jersey's citizens to protect the plants, animals, and natural resources of their state. Though not associated with The National Audubon Society, the NJAS has set forth to conserve the natural environment through education programs and information services, as well as to increase the public's knowledge of New Jersey's flora and fauna through extensive field work. As one of the oldest independent audubon societies, the NJAS has made every effort to protect threatened and endangered species and has also established and maintained wildlife sanctuaries and education centers. The mailing address for the NJAS is: New Jersey Audubon Society Headquarters, 9 Hardscrabble Road, PO Box 126, Bernardsville, NJ 07924. Questions and concerns can also be direct via telephone at (908) 204-8998 and through e-mail at hq@njaudubon.org.

The ***National Audubon Society of New York State*** works on local, state, and national levels to provide protection for birds, forests, wetlands, and wildlife. The statewide council advocates and educates the proper management of wildlife and their habitats to help improve the environment. The National Audubon Society of New York has, since its foundation, significantly increased its financial and staff commitments to centers and education. They are looking at the broadest possible range of opportunities to meet their goals of continued growth in the area, under the principle that realistic center growth must provide results that are fiscally advantageous, operationally practical and educationally sound. The society can be reached via telephone at (518) 869-9731, fax at (518) 869-0737, and by means of e-mail at nasnys@audubon.org. The mailing address is 200 Trillium Lane, Albany, NY 12203.

The ***New Jersey Farm Bureau*** represents the agricultural producers and enterprises of New Jersey. Their goal is to create positive public relations, influence laws and regulations, and to seek out activities and ventures that benefit the welfare of the producer members. In their mission, the New Jersey Farm Bureau states that their mission is to represent the agricultural producers and enterprises of New Jersey at all levels of government – local, county, state, federal, and international. The bureau's mailing address is 168 West State Street, Trenton, New Jersey, 08608. They can also be reached by phone at (609) 393-7163 and by fax at (609) 599-1209.

Pennsylvania-American Water Company is committed to providing quality water, services, and products to their customers while trying to maintain the environment in which we live. The company works hard to focus on personal solutions and to exceed the expectations of their clients in the services they provide. In their mission they state that they will "continually build ever-increasing value for their shareholders and their customers in the business of water resource management." The PAWC can be reached via their toll-free number at (800) 565-7292.

It is the mission of the ***Wildlands Conservancy*** to protect vital open spaces, watersheds, wildlife, and farmlands in Pennsylvania. The organization is dedicated to the preservation of rivers, land, and trails through public education programs. The efforts of this member-supported organization have produced over 31, 000 acres of permanently protected open spaces in eastern Pennsylvania. The Conservancy is also working to protect Pennsylvania's waterways and care for injured or orphaned wildlife. Questions and concerns can be voiced through phone at (610) 965-4397 or fax at (610) 965-7223. The mailing address for the conservancy is 3701 Orchid Place, Emmaus, PA 18049.

Established in 1996, the ***Partnership for the Delaware Estuary*** was created to coordinate the protection and enhancement of the Delaware River Estuary. The partnership has taken a leadership role in promoting the conservation of this natural resource to help contribute to the usefulness of the estuary for environmentally friendly recreational purposes. By increasing the publics awareness and understanding of this important natural resource, the partnership is encouraging enhancement and protection throughout the Delaware Estuary. Comments, questions and concerns can be directed to Kathy Klein via e-mail at partners@udel.edu. The Partnership for the Delaware Estuary may also be reached through its toll-free number at 1-800-445-4935.

New Jersey Futures was formed in 1987 to serve as the watchdog over the state's development and redevelopment plans. This nationally recognized promoter of open space protection has become a leader in the fight for smarter land use. NJF is also working with the state of New Jersey on a plan to become the nations first "sustainable state:" a plan that incorporates the balance of economic, environmental, and social goals of the state. The organization is working hard to develop a strong economy, and a healthy natural environment. The mailing address for NJF is New Jersey Future, 114 West State Street, Trenton, NJ, 08608. Questions and concerns can be voiced via e-mail to njfuture@njfuture.org. The organization can also be reached by telephone at (609) 393-1189 and by fax at (609) 393-1189.

Technical Advisory Group Meetings

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

Table 2.2.7-1 Summary of Technical Advisory Group Meeting Dates and Locations

Meeting	Date	Location	Number of Attendees
1	May 16, 2001	Delaware River Basin Commission Offices West Trenton, NJ	14
2	November 8, 2001	Bucks County Water & Sewer Authority Offices Warrington, PA	9
3	May 14, 2002	Bucks County Water & Sewer Authority Offices Warrington, PA	
			Total Attendees 23

Summarization of Technical Advisory Group Meeting Minutes

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

MEETING 1

This meeting acted as an introduction to the Delaware River Watershed as well as to the Source Water Assessment Program. The meeting both summarized the Delaware River and its intrinsic values as well as reviewed the operation and challenges of a water treatment plant. The watershed of the Delaware River was said to be a home to over seven million people, composed of 1,450 industrial and municipal dischargers in which wastewater treatment accounts for 98% of the total discharge to the estuary. It was also stated that 17.5 million people rely on the estuary’s surface water intakes for drinking water; most of the water being distributed throughout New York City. The estuary was cited as a source of heritage, history, culture and recreation for the region. In evaluating the operation and challenges of a water treatment plant, the Baxter WTP was broken down and analyzed. The plant was undergoing capitol construction; therefore, a review of its current and future conditions took place.

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

- It is comprised of eight large surface water intakes.
- Over 600,000 MGD is withdrawn on average from the river and its tributaries (not allocated)
- It serves over 17.5 million people

The Source Water Assessment (SWA) was explained to be an iterative, continuous, and multi-phase process. The process aids in the identification of "potential" and/or existing sources of contamination, evaluates the vulnerability/susceptibility of the water supply to contaminant sources, and determines protection priorities and activities for the water supply. The ultimate goal of the SWA was specified as developing local sources of water protection initiatives involving both water suppliers and the public and educating the public about the source of their drinking water as well as its pertinent challenges.

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 for communities and watershed groups by incorporating projects into approved SWA plans

The point was made that source water advisory group participation is an integral piece in determining the success of the project. This group meets quarterly throughout the length of the project, provides public input into the process, and helps determine public outreach. A number of tasks that the stakeholders can do in order to assist in the source water assessments were also listed. These tasks, such as listing water source issues, providing pictures or tours of areas of concern, and providing input on ranking criteria were summarized. Final products and purposes of the project were also reviewed. The following table illustrates these specific final products.

Table 2.2.7-2 Final Products and Purposes

Product	*Type*	*Audience*
SWA Report	Technical	Water Supplier & Public Agencies
Summary Report	Educational/Motivational	Public
Maps/Coverages	Technical	Water Supplier & Public Agencies Watershed
Source Water Partnership	Educational/Motivational/Technical	All Stakeholders

It was also stated at the meeting that due to an inaccuracy in the federal databases, source issues must be "groundtruthed". In doing so, many things will be looked at including:

- Thousands of point sources and regulated facilities
- Dozens of wastewater plants
- Hundreds of farms
- Non-point source potential
- Numerous other sources typically identified

Another topic of consideration is source water protection issues. The following table outlines various issues as well as their possible sources:

Table 2.2.7-3 Source Water Protection Issues

Issues	*Possible Sources*
Pathogens-*Giardia/Cryptosporidium*	Sewage, livestock, & wildlife
Algal Blooms/Nutrients	Sewage, agriculture, lawncare, golf courses
Metals-Manganese	Acid mine drainage
Chloride & Sodium	Road salts/highways
Pesticides/Herbicides	Lawn care, right of ways, agriculture
MTBE/Bromide/DBP Precursors	Cars & recreational watercraft

Operation and challenges of a water treatment plant were also discussed at the meeting. Specifically, the challenges of optimized water treatment during capitol construction and increased regulatory requirements. The Baxter WTP was broken down in order to assess the challenges it faces. Its current condition and historical treatment were outlined in detail and the areas for improvement were identified. Baxter, scheduled to undergo capitol construction for seven months, finished in June 2001.

The meeting finished with a series of questions and answers in which the stakeholders were able to voice their concerns and comments as well as inquire about the assessment.

A schedule and timeline were presented. The deadlines for the draft reports, which begin in April 2002, are marked for completion by January 2003. The following figure displays the breakdowns of the assessment and the schedule.

Figure 2.2.7-3 Assessment Schedule

Intakes Assessed

Water Supply	Draft Reports
PWD – Baxter	April 2002
PSWC – Bristol	October 2002
Morrisville	October 2002
Lower Bucks JMA	October 2002

Non-tidal/Tributary Intakes

Water Supply	Draft Reports
PSWC – Neshaminy	July 2002
Middletown – Chubb Run	July 2002
PA American – Yardley	January 2003
Bucks County Water	January 2003

MEETING 2

Meeting two was broken up into three main sections. They were:

1. *Delaware River Source Water Assessments*

2. *Contaminant Source Inventory*

3. *Susceptibility Analysis*

Zone Delineation's for tidal and non-tidal areas were covered under the Delaware River SWAs. Determining the zone delineation for the intakes is a difficult task due to their considerably large size. The zone delineation was therefore broken down into several sections for simplification. These sections that compose the breakdown are:

- Intakes (the eight intakes were broken down into tidal and non-tidal influence and by intakes on tributaries)

- Zone definitions (Zones A, B, and C)

- Time of travel for tidal, non-tidal, and tributary intakes

- A further breakdown of tidal intakes

- Additional incorporation of tributaries in tidal zone, non-tidal river intakes, tributary delineation, and water quality data were also present in the analysis

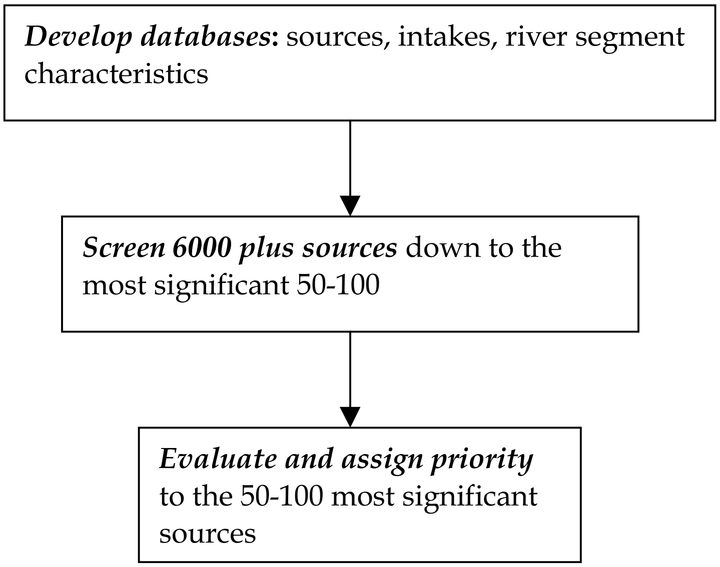
The next steps to take in the delineations were also discussed and include:

- Cleanup and refinement of the zones
- Beginning of data analysis
- Searching for electronic data or water quality studies to "groundtruth" suspected potential sources
- Working on stream impairment GIS and data for NJ

A contaminant inventory database compilation had been completed and was discussed at the meeting. Main web sites such as the "Right To Know Network" (RTK) and "Envirofacts" were utilized in the contaminant source compilation. Federal databases were accessed and data was downloaded. The data was downloaded by county, the data sites were then "clipped" in GIS to eliminate those outside of the watershed boundaries, missing "x-y" coordinates were filled in, facility data was cross-referenced, and quantity/contaminant data was populated.

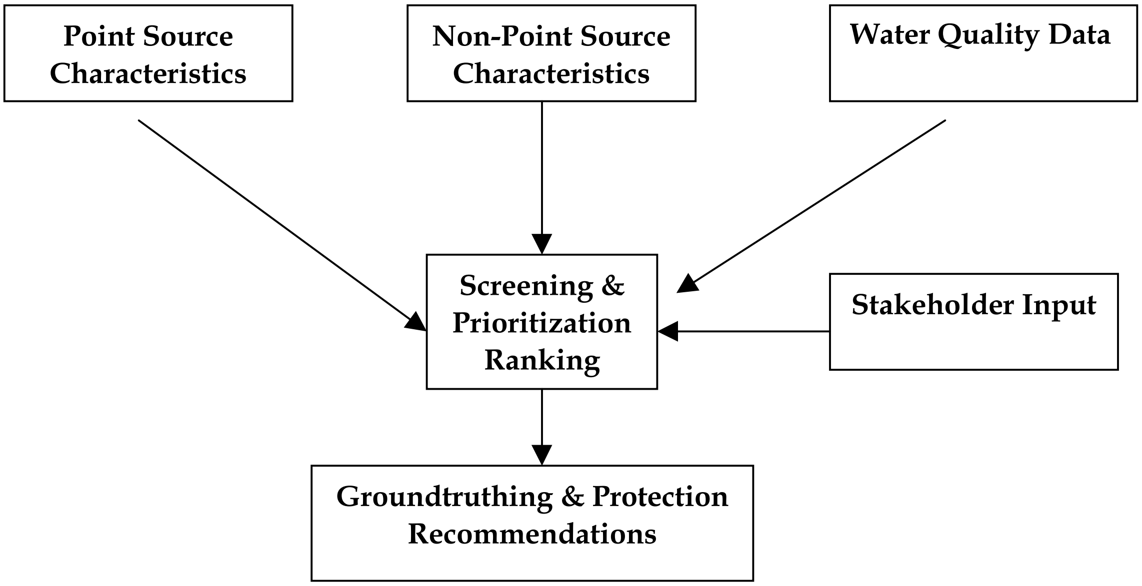
A susceptibility analysis overview was also presented at the meeting. The Delaware River Source Water Assessment proved to be a complex undertaking with the watershed covering 300 miles of river, as well as a 13,000 square mile watershed with more than 6,000 potential sources. The overall goal of the project is to understand which sources are most critical and which are less serious, understand present water quality concerns, focus energy on important sources, and result in a limited number of high priority sites. The general approach is comprised of three main steps, which are illustrated in the following figure (Figure 2.2.7-4):

Figure 2.2.7-4 Main Steps in the General Approach



This approach is based on and includes the approach of the Source Water Assessment and Protection Program of PADEP. It has been modified and formalized into the process that includes point sources, non-point sources, and "special categories" such as acid mine drainage, spills from railroads, and pipeline breaks. A technical approach or state approach was presented at the meeting and includes surface water and zone delineation, water quality analysis, a susceptibility analysis for the state which includes qualitative measures as well as available qualitative data. The Delaware River approach is inclusive of all the elements of the state approach but is more extensive. For example, the Delaware River approach is more quantitative than the state approach and is designed to handle thousands of potential sources. An illustration of the source water assessment simplified approach follows (see Figure 2.2.7-5). In this approach, stakeholder input is included in the "Screening and Prioritization Ranking" along with "Point and Non-Point Source Characteristics" and "Water Quality Data". After all four go through the "Screening and Prioritization Ranking", "Groundtruthing and Protection Recommendations" are then developed.

Figure 2.2.7-5 Source Water Assessment: Simplified Approach



A source priority ranking was completed utilizing the Evamix Evaluation Criteria Groups. The groups are comprised of:

- River Flow Related Criteria (2)
  - Location
  - Time of Travel
- User Related (1)
  - Potential Health Impact (combined ranking only)
- Intake Criteria (3)
  - Relative Impact (both intake and source related)
  - Removal Capacity (combined ranking only)
  - Impact on Treatment Operations (combined ranking only)
- Source Related (3)
  - Potential for Release/Presence of Controls
  - Potential Release Frequency
  - Violation Type/Frequency

Based on these, the stakeholders' criteria weightings are illustrated in the following table (Table 2.2.7-4):

Table 2.2.7-4 Stakeholder Criteria Weightings

Criteria	Min	Max	Average	Agreed
Relative Impact at Intake	5%	25%	13%	12
Time of Travel	2%	15%	7%	5
Existing Removal Capacity	3%	30%	13%	10
Impact on Treatment Operation	2%	30%	10%	10
Potential Health Impacts	10%	30%	20%	20
Potential for Release/Controls	3%	20%	10%	14
Potential Release Frequency	3%	20%	9%	14
Violation Type/Frequency	3%	20%	9%	10
Location	2%	20%	8%	5

The Delaware River approach employed four linked databases. In regards to the intake; location, stream segment, withdrawal data, and a list of contaminants where 50% MCL exceeded were included. In the stream segment were segment ID, position in stream, flow, and velocity. Lastly, the source included ID, location, stream segment, zone, quantity, concentration, contaminants, and likelihood of release.

Within the Delaware River approach it was necessary to assign pollutant categories. These categories are essential because the approach used cannot deal with thousands of sources, 42 intakes, and try to do this for all types of pollutants. The purpose of this approach is to assign one or more 10-pollutant categories to each source. This may be done using data from Federal or State Databases or through the use of SIC code and standard assumptions of pollutants related to SIC codes.

Advantages to the Evamix approach are that it helps to clearly define the alternatives under consideration, it requires a clear set of evaluation criteria, and it does not lose information because it accepts quantitative and qualitative data. Additionally, it organizes objective information into a clear set of scores, it segregates the subjective part of the evaluation into criteria weights, and it is flexible and simple in that it handles new data easily. Finally, the process is clear, defensible, and reproducible.

For this Delaware River approach, the Evamix results will be reviewed and "reality checked." Results for high-ranking sources will be added to other sources outside of the analysis (e.g., highway spills, pipelines, etc.). Furthermore, high-ranking sources will be flagged for follow-up data collection in a later phase to verify results.

The meeting again closed with questions and answers in which the stakeholders were able to present their concerns and provide input on the assessments.

2.2.7.2 Public Meetings

In an attempt to better educate the public about the importance of the Source Water Assessment Program (SWAP), several public meetings will be conducted throughout the study area; two for each intake. There have been no public meetings for the Baxter Intake thus far, however, a kick-off meeting is being scheduled for the Fall of 2002. The following general approach will be utilized in order to achieve the goal of generating public interest:

- Press releases will be produced by the Philadelphia Water Department and the local stakeholders, which will be sent to the local media and newspapers
- Legal notices will be sent to the local media and newspapers
- Advertisements will be 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 are, in essence, informational forums where members of the public are enabled to voice their concerns as well as share their visions for the project. Information about the assessments and the treatment plants for each intake is distributed along with a list of phone numbers to call to report violations. Tips on how to help improve source water quality ranging from better gardening practices to coordinating watershed groups is also included in the packet.

Standard meeting agendas have been developed and will be followed at each meeting. The agenda generally consists of an introduction, an explanation of the purpose of the meeting and an overview of Source Water Assessments, which includes a brief yet thorough description of the SWAP as well as the areas to be assessed, i.e., the SWAP study area's Bristol Intake. In addition, a discussion of contaminant source issues and water quality concerns is a keynote feature of the agenda. Finally, each meeting is concluded with an exercise in identification of potential contaminant sources, in which the attendees are asked to identify local sites that may impact the water supply. Examples are presented of what some of the source water assessment issues are and photos of these examples are shown to aid the public in identification. Questions, concerns, and comments are addressed as they are raised.

Prior to these kick-off meetings, several avenues are pursued in an attempt to notify the public. Letters produced by the Philadelphia Water Department, local stakeholders, and watershed groups specifying the location and directions, date, time and nature of the meetings are mailed to numerous stakeholders, including many of the businesses, government agencies, and environmental organizations located within or affected by the Delaware River Watershed. The information contained in these letters is also posted on the SWAP website, www.phillywater.org/delaware. In order to further generate public interest, various watershed groups and local stakeholders post flyers throughout their respective areas and send press releases to their local newspapers. Additionally, many of the local newspapers feature articles describing the nature of the meetings as well as the outcome, when applicable. Legal notices detailing the location, time, and date of each meeting are printed in the newspapers local to each area with which the SWAP is affiliated for the purpose of opening the meetings to everyone within the watershed.

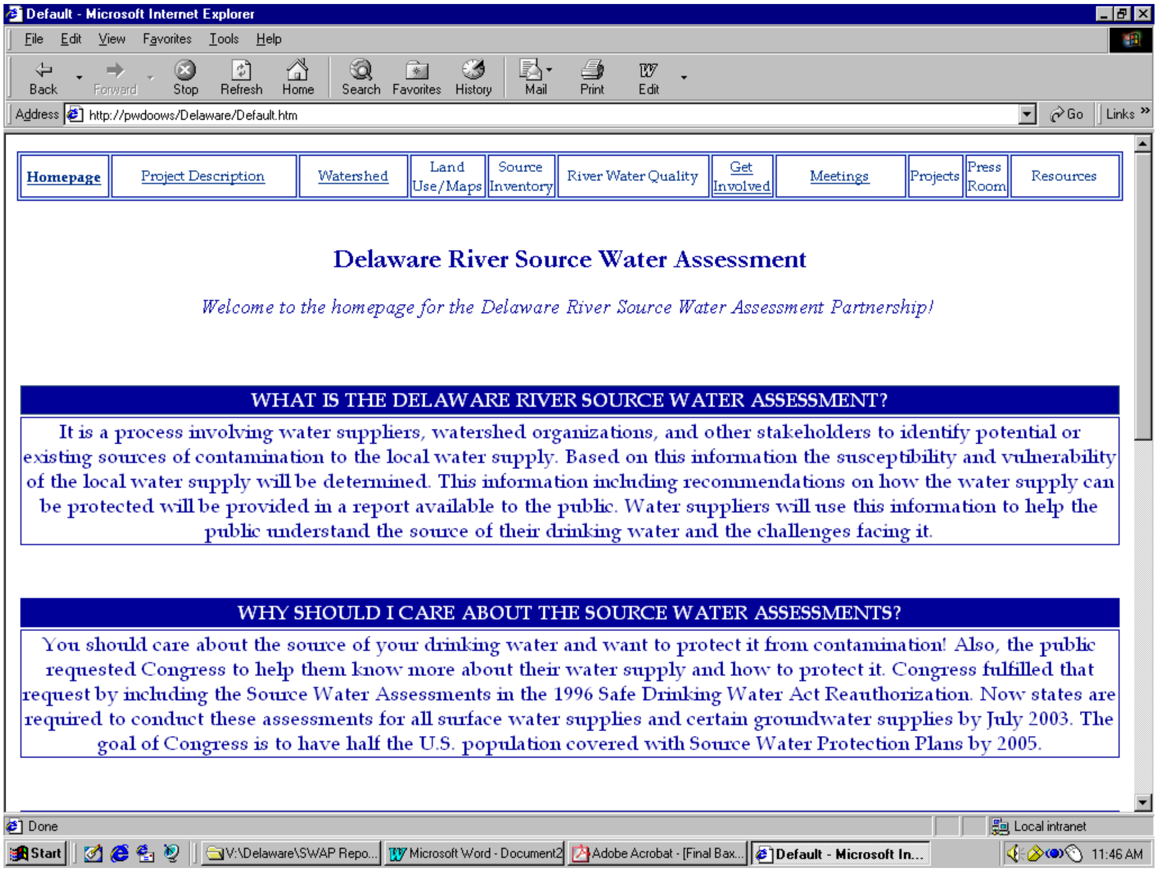
Newspaper articles will also be published in the Bristol Intake area by local newspapers that are highly distributed throughout the community talking about the source water assessments. The articles featured will clearly state the purpose of the meeting as well as the date and location of each of them. The function of the SWAP is described as well as its derivation. The articles invite the public to share their visions of the project and give the people an opportunity to contribute what they would like to see develop throughout the duration of the assessment. A contact number is also provided in the event that anyone might want to pursue more information on the Source Water Assessments.

2.2.7.3 Website

A website has been developed for the project (www.phillywater.org/delaware*)* to provide a location where information about the project can be easily accessed by the public and stakeholders (see Figure 2.2.7-6). Although, this is a task beyond the scope of the contract, it is considered a necessary form of information delivery. Most importantly, the website is 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 many stakeholders to whom information must be mailed on at least a quarterly basis.

The website has been set up to provide general information about the purpose of the SWAP as well as contact information. It also provides 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 is an on-line stakeholder survey that stakeholders can fill out to provide information about their water quality issues.

Figure 2.2.7-6 Delaware River SWAP Website (www.phillywater.org/delaware)



Delaware River Source Water Assessment

Welcome to the homepage for the Delaware River Source Water Assessment Partnership!

WHAT IS THE DELAWARE RIVER SOURCE WATER ASSESSMENT?

It is a process involving water suppliers, watershed organizations, and other stakeholders to identify potential or existing sources of contamination to the local water supply. Based on this information the susceptibility and vulnerability of the local water supply will be determined. This information including recommendations on how the water supply can be protected will be provided in a report available to the public. Water suppliers will use this information to help the public understand the source of their drinking water and the challenges facing it.

WHY SHOULD I CARE ABOUT THE SOURCE WATER ASSESSMENTS?

You should care about the source of your drinking water and want to protect it from contamination! Also, the public requested Congress to help them know more about their water supply and how to protect it. Congress fulfilled that request by including the Source Water Assessments in the 1996 Safe Drinking Water Act Reauthorization. Now states are required to conduct these assessments for all surface water supplies and certain groundwater supplies by July 2003. The goal of Congress is to have half the U.S. population covered with Source Water Protection Plans by 2005.

2.2.8 Baxter Intake Conclusions and Recommendations

The following section discusses the findings of the assessment, and provides recommendations for projects and initiatives that are general (for the entire watershed), regional, and intake specific. It also attempts to provide some specific examples of the best management practices that could be employed on some of the recommended projects.

Overall, the following activities were identified as having high priority for protection efforts to address:

- Sanitary sewer overflows of raw sewage from sewer collection systems, sewage lift stations, and manholes from upstream communities
- Discharges from municipal and industrial sources such as sewage treatment plants and chemical manufacturing facilities between Camden and Trenton
- Urban, residential, and agricultural runoff from various areas of the watershed, mostly located in tributaries such as the Pennypack Creek, Poquessing/Byberry Creek, Neshaminy Creek, and Rancocas Creek.
- Spill and accidents from cars, tanker trucks, railroad cars, pipelines, tire piles, and fires at industrial facilities near the river and its tributaries

Table 2.2.8-1 summarizes the protection priorities assigned to the various types of sources overall and for each contaminant category that could be quantified. As described above, runoff/non-point sources and municipal or industrial discharges had the greatest overall priority compared to other sources.

It is important to note that just because an activity is given a high priority that does not mean that any individual site is in violation of current environmental laws and regulations or impacts on the water quality at the facility. An activity with a high ranking means that it could possibly have a high potential to negatively impact the water supply quality under certain conditions.

Table 2.2.8.1 Summary of Protection Priority of Various Types of Potential Contaminant Sources

(A-C = significant protection priority, D-F = lower protection priority)

Contaminant Group	Permitted Municipal and Industrial Dischargers (NPDES)	Urban, Residential, and Agricultural Runoff	Industrial Facilities with Toxic Releases (TRI)	Hazardous Waste Facilities (RCRA)	AST (storage tanks)	CERCLA (landfills)	CSOs, SSOs, Defective Laterals	Acid Mine Drainage	Spills & Accidents
Overall (combined)	A-C*	B-C	C	C	C	C	A-C	C	A
Chloride	D-F	A-B	A-C*	D-F	A	D-F	D-F	D-F	A
Cryptosporidium	A-C*	B-C	D-F	D-F	D-F	D-F	A	D-F	A
Fecal Coliforms	A-C*	A-C	D-F	D-F	D-F	D-F	A	D-F	A
Metals	A-C*	D-F	A-C	C	C	C	N/A	A	A
Nitrate	A-C*	C	C	D-F	A	D-F	C	D-F	A
Petroleum Hydrocarbons	A-B	A-B*	D-F	D-F	A-C*	C	D-F	D-F	A
Phosphorus	A-C*	D-F	A-C	D-F	A	D-F	C	D-F	A
Disinfection By Products	A-C*	C	A-C	D-F	D-F	C	D-F	D-F	C
Turbidity	A-C	A-C*	D-F	D-F	D-F	D-F	D-F	D-F	C
Volatile Organic Compounds	A	D-F	A-C	A-C	A-C*	C	D-F	D-F	A
Herbicides/Pesticides	N/A	A	N/A	B-C	D-F	C	N/A	D-F	A
Radionuclides	A*	D-F	D-F	D-F	D-F	D-F	D-F	D-F	C

**dominant source type in listings*
Note: if only one source fell into a protection priority, that rank was given to the type of source for a given contaminant group
Just because an activity is given a high priority does not mean that any individual site is in violation of current environmental laws and regulations. An activity with a high ranking means that it could possibly have a high potential to negatively impact the quality of the water supply under certain conditions.

Geographically, most of the priority point sources for the Baxter Intake are located within priority non-point source watersheds. Therefore, it appears that, in general, protection and restoration efforts for non-point sources should be focused in similar areas as point sources.

Tables 2.2.8-2 and 2.2.8-3 provide summaries of the protection priorities for point and non-point sources in various watershed areas. Overall, the primary focus of PWD's protection efforts to protect and improve their water supply should include continued support of efforts for the ongoing improvements of the industrial and municipal discharges the tidal areas of the Delaware River between Trenton and Philadelphia/Camden. Non-point source protection should be focused in the Pennypack Creek, Poquessing/Byberry Creek, Neshaminy Creek, and Rancocas Creek area as well as portions of the Muscentong, Pohatcong, and Lehigh Rivers. However other parts of the watershed may need special attention for contaminant specific issues that do not match with the general overall priority areas or sources.

Table 2.2.8-2 Summary of Protection Priority Ranking of Various Main Stem Delaware River Areas for Point and Non-point Sources

	Protection Priority			
River Segment	**A High**	**B Moderately High**	**C Moderate**	**D-F Low**
Camden - Philadelphia	P	P & N	P & N	
Philadelphia to Trenton	P	P & N	P & N	
Trenton to Easton	P	P	P & N	
Easton to Port Jervis	P	P	P & N	
Port Jervis to Headwaters				N & P

N – Non-point source runoff, P- Point sources

Table 2.2.8-3 Summary of Protection Priority Ranking of Various Tributaries for Point and Non-point Sources in Pennsylvania and New Jersey Streams

	Protection Priority			
Tributary / Watershed	**A High**	**B Moderately High**	**C Moderate**	**D-F Low**
Poquessing, Pennypack Creeks	P	N		
Tacony-Frankford Creek				N & P
Neshaminy Creek	P	N		
Tohickon Creek				N & P
Lehigh River			N & P	
Broadhead Creek				N & P
Bushkill Creek				N & P

New Jersey Streams

	Protection Priority			
Tributary / Watershed	**A High**	**B Moderately High**	**C Moderate**	**D-F Low**
Big Timber Creek	P	P	P	N
Cooper River	P	P	P	N
Rancocas Creek	P	P & N	P & N	
Assiscunk Creek			P	N
Crosswicks Creek		P		N
Musconetcong River		N	N	P
Pohatcong River			N & P	

2.2.8.1 General Recommendations

Based on the results of the susceptibility analysis, water quality data, and stream impairments, it is clear that the potential impacts from point source discharges need to be addressed from the discharges along the main stem of the Delaware River from Camden to Trenton. Efforts to reduce these impacts require:

- Enforcement of compliance requirements for industries and municipalities discharging wastewater into the protection priority corridor between Camden and Trenton;

- Development and support of watershed or local community/environmental organizations to restore and protect various segments of the protection priority corridor between Camden and Trenton and ;

- Ensure that TMDL process and requirements along the Delaware River include components to address drinking water impacts;

- Development of special state or federal legislation that provides funding and authority for water supply protection efforts in the protection priority corridor between Camden and Trenton .

- Include *Cryptosporidium* impacts in the permitting process for wastewater dischargers upstream of drinking water intakes.

In priority stormwater runoff areas such as the Pennypack Creek, Poquessing Byberry Creek, Rancocas Creek, Neshaminy Creek, and Lehigh River as well as streams near the PWD Baxter Intake the following activities are recommended for protection against non-point source runoff.

- Development of incentives for upstream communities to mitigate stormwater runoff;

- Education of township officials along the protection priority corridor about stormwater impacts;

- Preservation of existing greenspace along the Delaware River in the protection area;

- Acquisition of conservation easements or adjustment of zoning areas or local ordinances to reduce stormwater impacts from future development in priority runoff areas;

- Enforcement of the Phase II stormwater regulations for townships in priority runoff areas;

- Development of conservation easements, riparian buffers, and streambank fencing to mitigate impacts from agricultural activities.

Though the Poquessing and Pennypack Creeks were not determined to have the most potentially significant overall loadings or impacts on the PWD Baxter Intake compared to other watershed wide sources, water quality and stream impairment data suggest that it would be preduct to restore and protect the water quality in these areas.   Therefore, the following actions are recommended for continued protection efforts in the Pennypack and Poquessing Creek Watersheds:

- Assessment, prioritization and mitigation of raw sewage discharges by defective laterals from stormwater collection systems from all townships, boroughs, and cities into these watersheds.

- Development of regulatory and financial incentives for enhanced wastewater discharge for pathogen removal and inactivation to address *Cryptosporidium* impacts;

- Development of incentives and controls for mitigation of stormwater runoff impacts. This includes requiring that current TMDL efforts in the watershed include specific components to address drinking water issues and concerns. This will provide an example of how the Safe Drinking Water Act and Clean Water Act should be integrated.

- Conduct an examination of current zonings and ordinances with the Bucks and Montgomery County Planning Commissions, Bucks and Montgomery County Conservation Districts, and local townships to determine ways they can be enhanced to address current and future stormwater impacts. Identify areas where innovative techniques and incentives can be used to mitigate stormwater impacts and assist in the development and implementation of these efforts.

- Support of existing greenways, riparian corridor areas, and future riparian corridor easement and acquisition being conducted by the various townships and Bucks and Montgomery County;

- Encourage and support the development of an Act 167 Stormwater Management Plan for the Pennypack and Poquessing/Byberry Creeks.

- Establish riparian buffers and streambank fencing in all agricultural areas of the Pennypack, Poquessing/Byberry, and Neshaminy Creek Watersheds.

The Philadelphia Suburban Water Company already works with numerous stakeholders to protect its water supply in the Neshaminy Creek. The Horsham Water Authority is also involved in source water protection initiatives to protect wellhead areas in the Pennypack Creek. Therefore, it is recommended that any protection efforts be coordinated with the Philadelphia Suburban Water Company and Horhsam Water Authority in the Pennypack and Neshaminy Creeks.

In addition to the previous specific geographic recommendations, the following general efforts are recommended:

- Emergency Response Planning activities should be focused on priority AST, TRI, and RCRA facilities since they have been shown to have the greatest relative impact on water quality. Efforts should also be initiated to collect more detailed data on these sites for reprioritization. Also, state authorities should be encouraged to implement a 2-hour notice requirement for downstream users from spills instead of allowing 24- hour requirement since most spills can make it to a number of intakes in less than a day under various conditions.

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

- Long-term protection efforts by PWD should be focused on enhancing wastewater discharges and mitigating stormwater runoff. These will have the greatest overall impacts on improving source water quality.

- Sources of pathogens appear to be the sources of greatest priority to PWD when examined in the overall rankings. Therefore, these sources should be addressed accordingly.

- Given the significant amount of activity in the watershed by various organizations, protection efforts should be coordinated in such a way as to support and enhance existing efforts in the watershed.

- A corporate environmental stewardship program should be developed to educate, provide incentives, and engage businesses in water supply protection and stormwater mitigation.

- A workshop should be sponsored by PADEP to educate golf courses about the benefits of joining the environmental certification program by the Audobon Society.

- Special mechanisms and funding should be developed to allow the distribution of monies to support or initiate specific initiatives outside the City of Philadelphia that will protect or restore the water supply. This may involve development of a quasi-governmental or non-profit organization that can raise funds and distribute them to various organizations conducting protection activities beneficial to PWD. This organization may also need the ability acquire conservation easements or land in sensitive areas to maintain protected areas.

- Efforts should be made to encourage PADEP and DRBC to address and prioritize the impacts of CSOs and untreated discharges of raw sewage upstream of drinking water intakes.

2.2.8.2 Regional Recommendations:

There are several regional recommendations based on the results of the study and stakeholder input. These include the following:

- Development of a mechanism or framework to address source water protection and non point source issues in the Lower Delaware River Basin area. The DRBC has a number of water resource and watershed/TMDL related committees, but they are not focused on source water protection concerns. Finding a way to include the priority areas and issues identified in the SWAPs into the existing DRBC framework for implementation and mitigation is critical.

- Adoption of model ordinances and zoning practices to reduce stormwater runoff impacts from residential and urban areas

- Aggressive acquisition of conservation easements for riparian buffer development and streambank fencing to mitigate the impacts of agricultural activities in sensitive areas of the watershed.

- Development of a coordinated regional protection plan that will be 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 Camden and Trenton.

- Enforcement of rigorous and regular revision and implementation of ACT 537 Sewage Facilities Management Plans in Montgomery and Bucks 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.

2.2.8.3 Intake Specific Recommendations: Example Project List and Best Management Practices

There a numerous specific projects that can be implemented throughout the watershed to protect and improve water supplies. The following list of projects provides a project title and location, potential project partners, and a general description of the components that could be incorporated into the protection project.

It may not be possible to implement all of the projects listed due to numerous unforeseen and unknown issues. Therefore, this list should be used as a resource to brainstorm and provide techniques for other projects that may be just as effective and valuable for source water protection. Specific descriptions and pictures of technologies and techniques that have been used locally or nationally to address a specific issue are provided in section 2.2.8.4 so that the reader can envision the mentioned technologies.

Some specific projects or initiatives include:

1. Continued runoff control projects at the Fox Chase Farms.

2. Identification of conditions and sources of algal growth responsible for taste and odor issues.

3. Implementation of stormwater runoff controls in areas of the Pennypack Creek and Poquessing/Byberry Creek through ACT 167 Planning and obtain participation from the U.S. Army Corps of Engineers for a reconnaissance study of the watershed to address hydraulic and hydrodynamic factors influencing water quality.

4. Conduct reviews of compliance and permit information for high priority point-source discharges between Camden and Trenton. Field visits and dialogues with these sites should be developed.

5. Conduct reviews of compliance and permit information for high priority storage tanks between Camden and Trenton. Field visits and dialogues with these sites should be developed.

6. Implementation of runoff controls at horse riding stables in the Poquessing/Byberry Creek and Pennypack Creek Watershed

7. Explore alternative road salt technology initiatives in priority runoff areas near the PWD Baxter Intake.

8. Coordinated runoff protection projects with other water suppliers in the Pennypack and Neshaminy Creeks.

9. Application of innovative stormwater controls for redevelopment of waterfront properties in Philadelphia business & industrial parks

10. Implement best management practices at city and suburban golf courses.

11. Establish or encourage enrollment by priority point sources in a corporate environmental stewardship program

2.2.8.4 Data Needs

Based on the various analyses that were conducted to identify specific sources of contamination, their location, and other characteristics, the following data gaps and information needs were identified.

Study To Identify Causes, Conditions, And Sources Of Algae That Cause Taste And Odor Problems For Prediction And Mitigation Strategies

Several months a year water suppliers are impacted by nuisance algae that release chemical compounds that make the water taste and smell unpleasant to customers. This not only impacts water treatment costs, but can stigmatize a community and have economical impacts on businesses that rely on the water such as tourism and food and beverage manufacturing. Identification of the causes and sources of these taste and odor causing events and identification of the sources, their locations, and catalyzing conditions will allow for prediction of events for proper treatment as well as identify preventative measures to prevent conditions from occurring.

Study of Cryptosporidium Presence in Wastewater Effluents

The national guidance documents for the SWAPs and DEP's own SWAP process has very specific interests in identifying and ranking sources of *Cryptosporidium*. However, the information, data, and tools were not available at the local level for an accurate analysis of this information. Preliminary studies by the Philadelphia Water Department, Philadelphia Suburban Water Company, and the PADEP have detected *Cryptosporidium* frequently at elevated levels in raw and treated sewage. The potential contribution of the pathogen *Cryptosporidium* from wastewater discharges, unsewered communities, and illicit discharges upstream of drinking water supplies is necessary to understand the daily impacts they have on pathogen challenges to the water treatment plants downstream. This could lead to strategies to reduce routine levels or viability of *Cryptosporidium* from discharges and better protect water supplies. Over the past three years, the Water Environment Research Federation has been conducting a research method to accurately detect and quantify levels of *Cryptosporidium* in wastewater. This study is almost complete and it is recommended that local studies that are conducted use this new method.

Shared GIS Information

Compilation and housing of up-to-date GIS information for upstream municipalities including sewer and stormsewer infrastructure characteristics (sewersheds, outfalls), zoning areas, ACT 167 information, preserved or potentially preserved agricultural land, county and township park lands, lands with conservation easements. Better information on abandoned or historical industrial sites and brownfields is also needed. Suggested partners interested in housing this information include the Delaware River Basin Commission.

In addition, the development of watershed wide coverages of point sources and landuse for the Delaware River Basin would provide great strides in emergency planning and source water protection information. Currently each state maintains this information which limits its comparibility, detail, and usefulness and prevents any ability for a combined examination of information.

Selection Of Testing And Data Protocols For Accurate Comparison Of Stream Impairments Between States In The Delaware River Basin

Currently comparison of stream impairment data from one state to another in the basin is impossible. Different analytical protocols for data collection and systems for reporting prevent any discernable comparisons of causes and sources of impairment on a watershed wide or regional basis. Efforts should be made to develop at least some regional understanding of impairments on a standard basis.

Characterization Study Of Townships And Boroughs With Model Ordinances and BMP Implementation For Stormwater Runoff

An accurate characterization of the townships and boroughs in the watershed should be conducted to determine if municipalities have implemented ordinances, zoning, or various BMPs to control stormwater runoff. Given the upcoming Phase II stormwater permit process, this information should be tracked to determine how many, what kind, and to what extent municipalities are going to in order to control stormwater runoff. This can be compared against water quality changes over time.

2.2.8.5 Selection of Best Management Practices in Proposed Protection Projects

Selection of best management practices (BMPs) requires the careful weighting of various factors including capital and operational costs, land consumption, and effectiveness. This section describes the various costs and choices when selecting any BMPs.

There are two types of BMPs that can be employed to address stormwater runoff, structural and non-structural. Structural practices usually involve the construction of some control structure or device. Non-structural practices usually involve activities that include changing public behavior and land use practices through education, training, and legal requirements. A comprehensive list of these practices is provided below in Tables 2.2.8-4 and 2.2.8-5.

Table 2.2.8-4 Structural BMPs for Stormwater Control

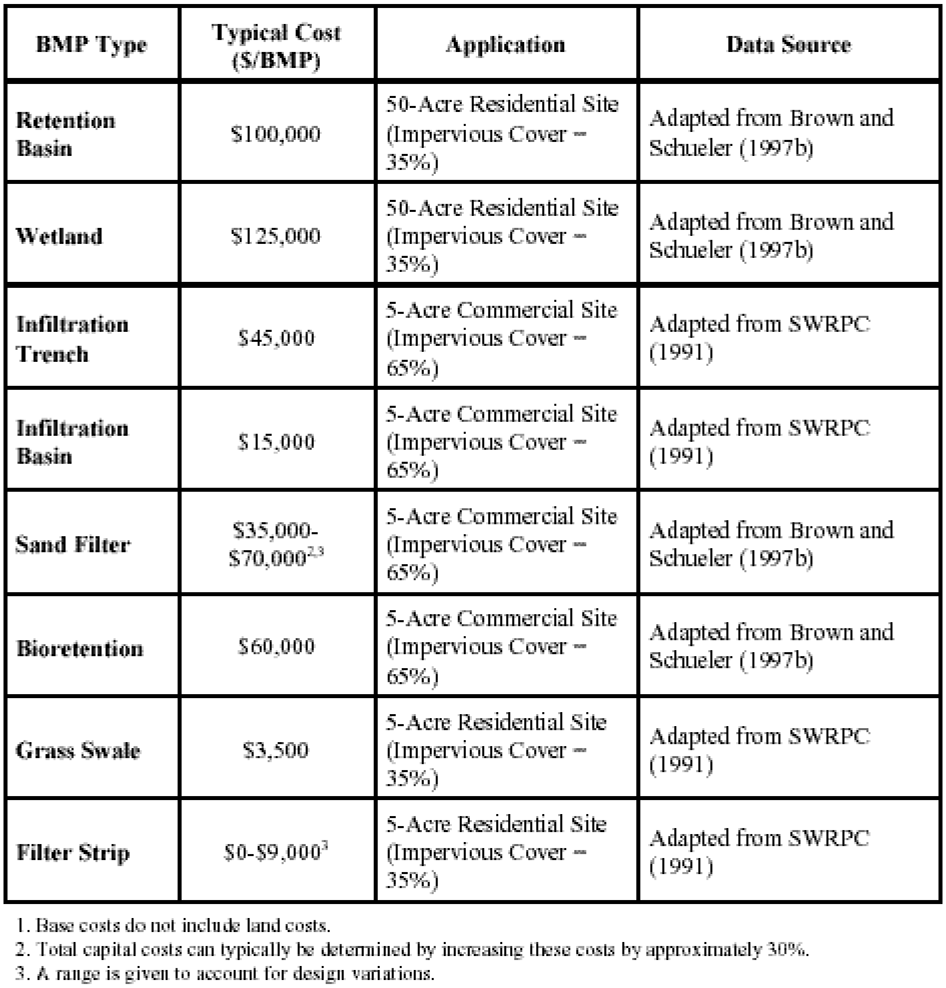
Ponds
Dry extended detention ponds
Wet ponds
Infiltration practices
Infiltration basin
Infiltration trench
Porous pavement
Filtration practices
Bio-retention
Sand and organic filters
Vegetative practices
Stormwater wetland
Grassed swales
Grassed filter strip
Runoff pretreatment practices
Catch basins/Catch basin insert
In-line storage
Manufactured products for stormwater inlets

Table 2.2.8-5 Nonstructural BMPs for Stormwater Control

Experimental practices
Alum injection
On-lot Treatment
On-Lot treatment
Better site design
Buffer zones
Open space design
Urban forestry
Conservation easements
Infrastructure planning
Narrower residential streets
Eliminating curbs and gutters
Green parking
Alternative turnarounds
Alternative pavers
BMP inspection and maintenance
Ordinances for post-construction runoff
Zoning

Employment and selection of the various structural BMP techniques and technologies requires additional familiarity with the pros and cons of the technologies, site selection and design issues, operation and maintenance and costs. Tables 2.2.8-6 and 2.2.8-7 provide examples of estimates of capital and maintenance costs of various structural BMPs. Table 2.2.8-8 provides estimated land consumption for various structural BMPs. Table 2.2.8-9 provides a description of the various contaminants non-structural BMPs can address. Table 2.2.8-10 through 14 provide data on the effectiveness of pollutant removal by various BMPs. These tables are taken directly from EPA's website at **URL:** http://www.epa.gov/ost/stormwater/usw_d.pdf .

Table 2.2.8-6 Base Costs of Typical Applications of Stormwater BMPs



BMP Type	Typical Cost ($/BMP)	Application	Data Source
Retention Basin	$100,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Wetland	$125,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Infiltration Trench	$45,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)
Infiltration Basin	$15,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)
Sand Filter	$35,000-$70,000[2,3]	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Bioretention	$60,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Grass Swale	$3,500	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)
Filter Strip	$0-$9,000[3]	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)

1. Base costs do not include land costs.
2. Total capital costs can typically be determined by increasing these costs by approximately 30%.
3. A range is given to account for design variations.

Source: *http://www.epa.gov/ost/stormwater/usw_d.pdf*

Table 2.2.8-7 Operation and Maintenance Cost Estimates

BMP	Annual Maintenance Cost (% of Construction Cost)	Source(s)
Retention Basins and Constructed Wetlands	3%-6%	Wiegand et al, 1986 Schueler, 1987 SWRPC, 1991
Detention Basins[1]	<1%	Livingston et al, 1997; Brown and Schueler, 1997b
Constructed Wetlands[1]	2%	Livingston et al, 1997; Brown and Schueler, 1997b
Infiltration Trench	5%-20%	Schueler, 1987 SWRPC, 1991
Infiltration Basin[1]	1%-3%	Livingston et al, 1997; SWRPC, 1991
	5%-10%	Wiegand et al, 1986; Schueler, 1987; SWRPC, 1991
Sand Filters[1]	11%-13%	Livingston et al, 1997; Brown and Schueler, 1997b
Swales	5%-7%	SWRPC, 1991
Bioretention	5%-7%	(Assumes the same as swales)
Filter strips	$320/acre (maintained)	SWRPC, 1991

1. Livingston et al (1997) reported maintenance costs from the maintenance budgets of several cities, and percentages were derived from costs in other studies

Table 2.2.8-8 Land Consumption of Various BMPs

BMP Type	Land consumption (% of Impervious Area)
Retention Basin	2-3%
Constructed Wetland	3-5%
Infiltration Trench	2-3%
Infiltration Basin	2-3%
Porous Pavement	0%
Sand Filters	0%-3%
Bioretention	5%
Swales	10%-20%
Filter Strips	100%

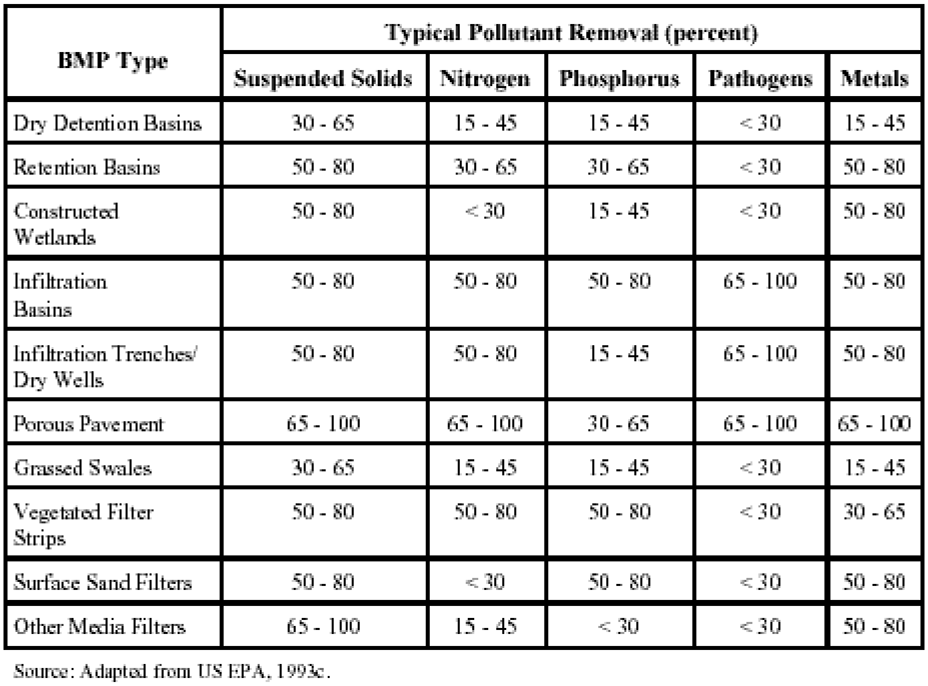
Note: Represents the amount of land needed as a percent of the impervious area that drains to the practice to achieve effective treatment.
Source: Claytor and Schueler, 1996

Table 2.2.8-9 Non-Structural BMPs Suited to Controlling Various Pollutants: Pollutant Appropriate BMPs

	BMPS
Solids	Street Sweeping Land Use Modifications
Oxygen-Demanding Substances	Street Sweeping Education: Storm Drain Stenciling Land Use Modifications Education: Pet Scoop Ordinance Illicit Connections Eliminated
Nitrogen and Phosphorus	Street Sweeping Education: Pet Scoop Ordinance Land Use Modifications Proper Materials Handling Illicit Connections Eliminated Education: Lawn Care Materials Storage and Recycling
Pathogens	Illicit Connections Eliminated Land Use Modifications Education: Pet Scoop Ordinance
Petroleum Hydrocarbons	Street Sweeping Education: Storm Drain Stenciling Proper Materials Handling Illicit Connections Eliminated Materials Storage and Recycling Land Use Modifications
Metals	Street Sweeping Education: Storm Drain Stenciling Proper Materials Handling Illicit Connections Eliminated Materials Storage and Recycling Land Use Modifications
Synthetic Organics	Illicit Connections Eliminated Education: Storm Drain Stenciling Proper Materials Handling Education: Lawn Care Materials Storage and Recycling Land Use Modifications
Temperature	Land Use Modifications
pH	Illicit Connections Eliminated Proper Materials Handling Materials Storage and Recycling Land Use Modifications

Source: http://www.epa.gov/ost/stormwater/usw_d.pdf

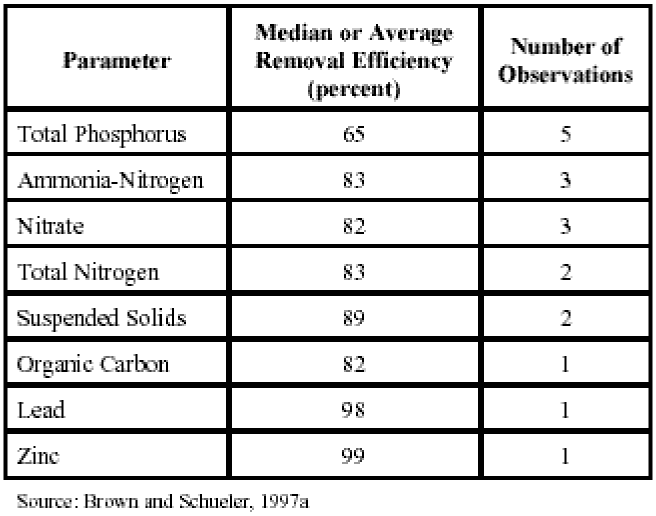
Table 2.2.8-10 Structural BMP Expected Pollutant Removal Efficiency



BMP Type	Typical Pollutant Removal (percent)				
	Suspended Solids	Nitrogen	Phosphorus	Pathogens	Metals
Dry Detention Basins	30 - 65	15 - 45	15 - 45	< 30	15 - 45
Retention Basins	50 - 80	30 - 65	30 - 65	< 30	50 - 80
Constructed Wetlands	50 - 80	< 30	15 - 45	< 30	50 - 80
Infiltration Basins	50 - 80	50 - 80	50 - 80	65 - 100	50 - 80
Infiltration Trenches/ Dry Wells	50 - 80	50 - 80	15 - 45	65 - 100	50 - 80
Porous Pavement	65 - 100	65 - 100	30 - 65	65 - 100	65 - 100
Grassed Swales	30 - 65	15 - 45	15 - 45	< 30	15 - 45
Vegetated Filter Strips	50 - 80	50 - 80	50 - 80	< 30	30 - 65
Surface Sand Filters	50 - 80	< 30	50 - 80	< 30	50 - 80
Other Media Filters	65 - 100	15 - 45	< 30	< 30	50 - 80

Source: Adapted from US EPA, 1993c.

Table 2.2.8-11 Pollutant Removal by Infiltration Practices



Parameter	Median or Average Removal Efficiency (percent)	Number of Observations
Total Phosphorus	65	5
Ammonia-Nitrogen	83	3
Nitrate	82	3
Total Nitrogen	83	2
Suspended Solids	89	2
Organic Carbon	82	1
Lead	98	1
Zinc	99	1

Source: Brown and Schueler, 1997a

Table 2.2.8-12 Pollutant Removal by Retention Basins

Parameter	Median or Average Removal Efficiency (percent)	Range of Removals (percent)		Number of Observations
		Low	High	
Soluble Phosphorus	34	-12	90	20
Total Phosphorus	46	0	91	44
Ammonia-Nitrogen	23	-107	83	14
Nitrate	23	-85	97	27
Organic Nitrogen	23	2	34	6
Total Nitrogen	30	-12	85	24
Suspended Solids	70	-33	99	43
Bacteria	74	-6	99	10
Organic Carbon	35	-30	90	29
Cadmium	47	-25	54	5
Chromium	49	25	62	5
Copper	55	10	90	18
Lead	67	-97	95	34
Zinc	51	-38	96	32

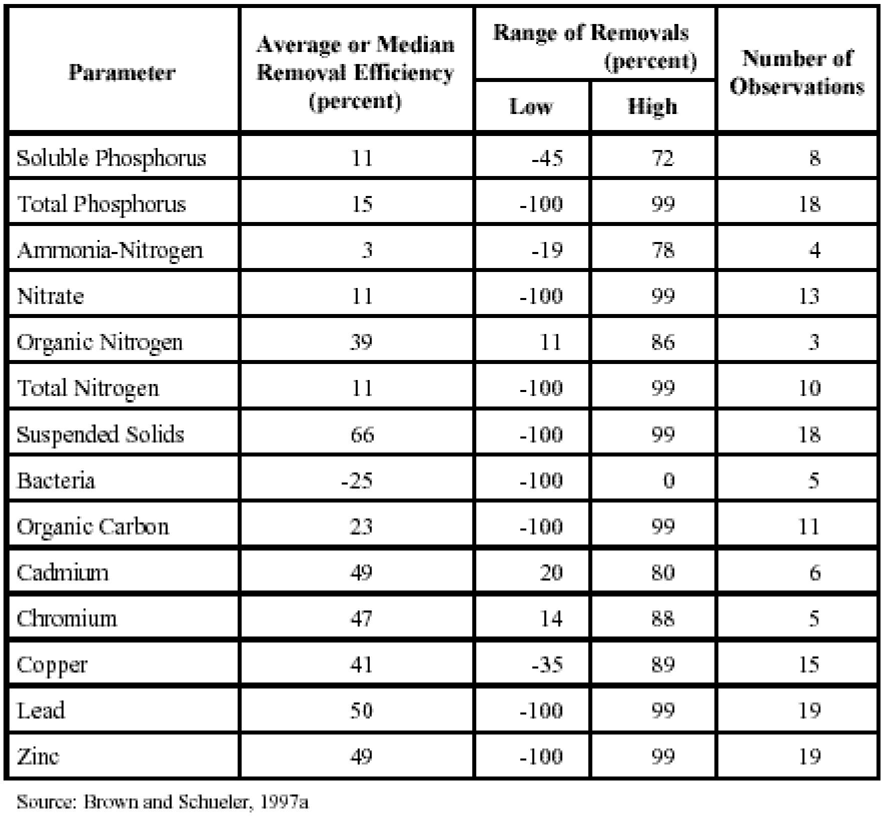
Source: Brown and Schueler, 1997a

Table 2.2.8-13 Pollutant Removal Efficiency of Constructed Wetland Systems

Parameter	Median Removal Efficiency (percent)	Range of Removals (percent)		Number of Observations
		Low	High	
Soluble Phosphorus	23	-30	78	12
Ortho-Phosphate	28	-109	93	7
Total Phosphorus	46	-120	97	37
Ammonia-Nitrogen	33	-86	62	15
Nitrate	46	4	95	18
Organic Nitrogen	7	-36	39	7
Total Nitrogen	24	-20	83	11
Suspended Solids	76	-300	98	26
Bacteria	78	55	97	3
Organic Carbon	28	-31	93	15
Cadmium	69	-80	80	6
Chromium	73	38	98	3
Copper	39	2	84	10
Lead	63	23	94	17
Zinc	54	-74	90	16

Sources: Strecker at al (1992); Organic Carbon, Bacteria and Metals from Brown and Schueler, 1997a

Table 2.2.8-14 Pollutant Removal Efficiency of Open Channel Vegetated Systems



Parameter	Average or Median Removal Efficiency (percent)	Range of Removals (percent)		Number of Observations
		Low	High	
Soluble Phosphorus	11	-45	72	8
Total Phosphorus	15	-100	99	18
Ammonia-Nitrogen	3	-19	78	4
Nitrate	11	-100	99	13
Organic Nitrogen	39	11	86	3
Total Nitrogen	11	-100	99	10
Suspended Solids	66	-100	99	18
Bacteria	-25	-100	0	5
Organic Carbon	23	-100	99	11
Cadmium	49	20	80	6
Chromium	47	14	88	5
Copper	41	-35	89	15
Lead	50	-100	99	19
Zinc	49	-100	99	19

Source: Brown and Schueler, 1997a

Source: http://www.epa.gov/ost/stormwater/usw_d.pdf

2.2.8.6 Descriptions and Pictures of Technologies for Stormwater Control

Though many technologies are recommended for use of best management practices, not everyone can envision how they would look and operate. The following section provides descriptions and pictures of these technologies. More detailed information such as design criteria, pros and cons to construction and operation, technical fact sheets, effectiveness, and various diagrams are also provided on EPA's websites at the following URLs.

http://www.epa.gov/npdes/menuofbmps/post.htm

http://www.epa.gov/ost/stormwater/usw_c.pdf

The following descriptions have been taken from these websites to provide the reader with descriptions of the following BMP technologies and techniques:

- Infiltration trenches
- Bio-retention areas

- Stormwater wetlands
- Infiltration basins
- Wet ponds
- Dry extended detention ponds
- Grass filter strips
- Grass swales
- Green parking
- Porous pavement
- Sand and organic filters
- Catch basins and inserts
- Stormwater inlet products
- Log veins and coir fabric for streambank restoration

Bioretention Areas
Post-construction Stormwater Management in New Development and Redevelopment

Bioretention areas can be used in parking areas to collect and treat storm water (Source: University of Maryland, 2000)

Description

Bioretention areas are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff forms ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system.

Infiltration Basin
Post-construction Stormwater Management in New Development and Redevelopment

Infiltration basins are designed to collect storm water from impervious areas and provide pollutant removal benefits through detention and filtration

Description

An infiltration basin is a shallow impoundment which is designed to infiltrate stormwater into the ground water. This practice is believed to have a high pollutant removal efficiency and can also help recharge the ground water, thus restoring low flows to stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

Stormwater Wetland Post-construction Stormwater Management in New Development and Redevelopment

A storm water wetland detains storm water, removes pollutants, and provides habitat and aesthetic benefits (Source: The Bioengineering Group, Inc., no date)

Description

Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds (see Wet Pond fact sheet) that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic value. Although natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

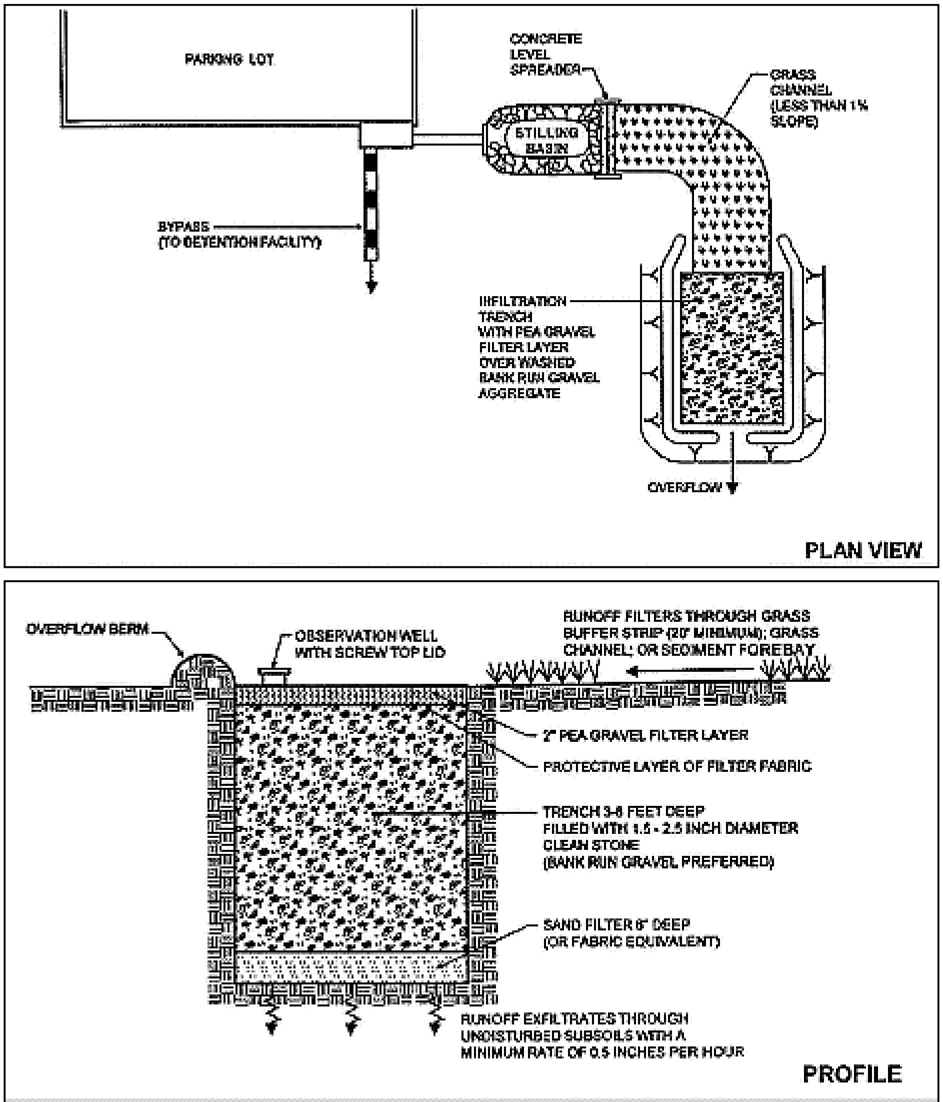
A distinction should be made between using a constructed wetland for stormwater management and diverting stormwater into a natural wetland. The latter practice is not recommended because altering the hydrology of the existing wetland with additional stormwater can degrade the resource and result in plant die-off and the destruction of wildlife habitat. In all circumstances, natural wetlands should be protected from the adverse effects of development, including impacts from increased stormwater runoff. This is especially important because natural wetlands provide stormwater and flood control benefits on a regional scale.

Infiltration Trench

Post-construction Stormwater Management in New Development and Redevelopment

Description

An infiltration trench (a.k.a. infiltration galley) is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil.



A schematic of an infiltration trench (Source: MDE, 2000)

Grassed Filter Strip
Post-construction Stormwater Management in New Development and Redevelopment

Grassed filter strips protect water quality by filtering pollutants before they reach the water (Source: USDA, 1997)

Description

Grassed filter strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment.

Grassed Swales
Post-construction Stormwater Management in New Development and Redevelopment

Grassed swales can be used along roadsides and parking lots to collect and treat storm water runoff

Description

The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter) refers to a series of vegetated, open channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows through these channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Wet Ponds
Post-construction Stormwater Management in New Development and Redevelopment

The primary functions of a wet pond are to detain storm water and facilitate pollutant removal through settling and biological uptake

Description

Wet ponds (a.k.a. stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming stormwater runoff by settling and algal uptake. The primary removal mechanism is settling as stormwater runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used stormwater practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff in order to provide settling.

Dry Extended Detention Pond
Post-construction Stormwater Management in New Development and Redevelopment

A dry extended detention pond is designed to temporarily detain runoff during storm events

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Porous Pavement
Post-construction Stormwater Management in New Development and Redevelopment

A porous pavement parking lot (Source: Invisible Structures, no date)

Description

Porous pavement is a permeable pavement surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This porous surface replaces traditional pavement, allowing parking lot stormwater to infiltrate directly and receive water quality treatment. There are a few porous pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous gridded systems with open areas designed to allow grass to grow within the void areas. Other alternative paving surfaces can help reduce the runoff from paved areas but do not incorporate the stone trench for temporary storage below the pavement (see Green Parking fact sheet). While porous pavement has the potential to be a highly effective treatment practice, maintenance has been a concern in past applications of the practice.

Green Parking
Post-construction Stormwater Management in New Development and Redevelopment

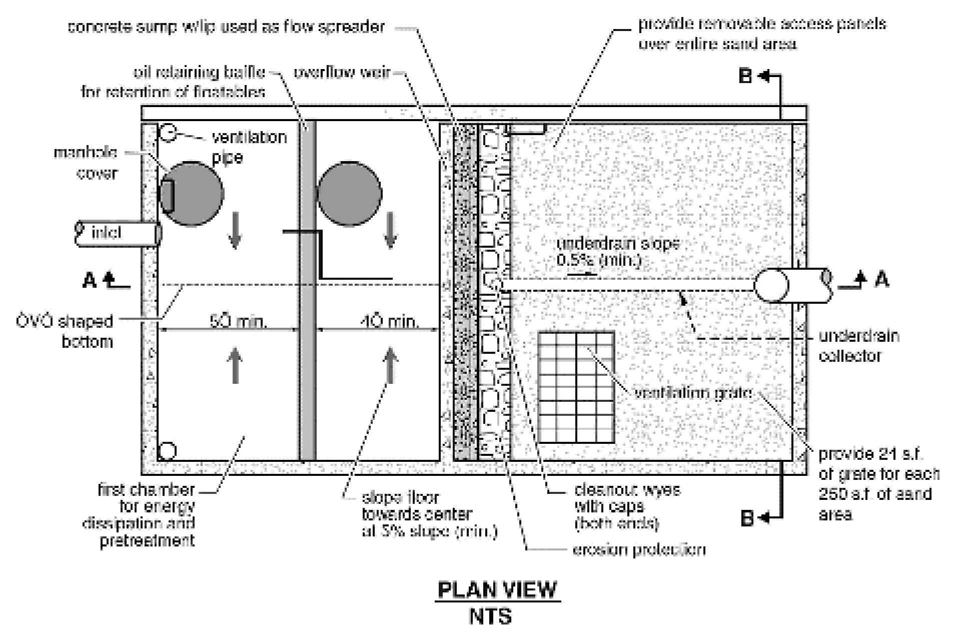
A green parking lot at the Orange Bowl in Miami, Florida (Source: Invisible Structures, no date)

Description

Green parking refers to several techniques applied together to reduce the contribution of parking lots to the total impervious cover in a lot. From a stormwater perspective, application of green parking techniques in the right combination can dramatically reduce impervious cover and, consequently, the amount of stormwater runoff. Green parking lot techniques include setting maximums for the number of parking lots created, minimizing the dimensions of parking lot spaces, utilizing alternative pavers in overflow parking areas, using bioretention areas to treat stormwater, encouraging shared parking, and providing economic incentives for structured parking.

Sand and Organic Filters
Post-construction Stormwater Management in New Development and Redevelopment
Description

Sand filters are usually two-chambered stormwater practices; the first is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle. Modifications to the traditional surface sand filter were made primarily to fit sand filters into more challenging design sites (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).



Schematic of a sand filter (Source: King County, Washington, 2000)

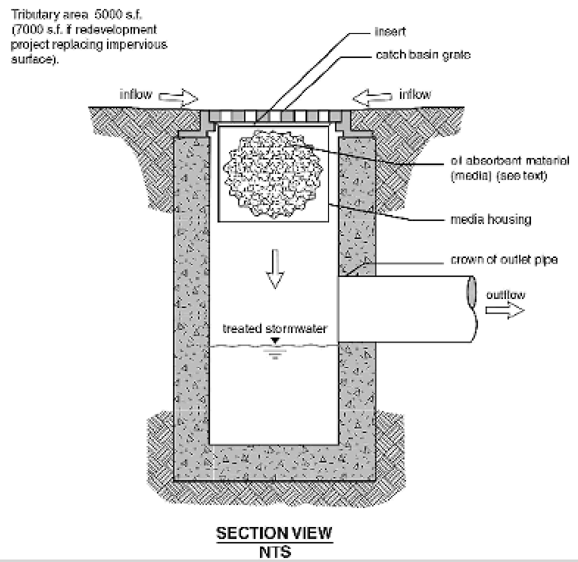
Catch Basins/Catch Basin Inserts Post-construction Stormwater Management in New Development and Redevelopment

A worker inserts a catch basin insert for oil and grease, trash, debris, and sediment removal from storm water as it enters the storm drainage system (Source: AbTech Industries, 2001)

Description

A catch basin (a.k.a. storm drain inlet, curb inlet) is an inlet to the storm drain system that typically includes a grate or curb inlet and a sump to capture sediment, debris, and associated pollutants. They are also used in combined sewer overflow (CSO) watersheds to capture floatables and settle some solids. Catch basins act as pretreatment for other treatment practices by capturing large sediments. The performance of catch basins at removing sediment and other pollutants depends on the design of the catch basin (e.g., the size of the sump) and maintenance procedures to retain the storage available in the sump to capture sediment. Catch basin efficiency can be improved using inserts, which can be designed to remove oil and grease, trash, debris, and sediment. Some inserts are designed to drop directly into existing catch basins, while others may require extensive retrofit construction.

Manufactured Products for Stormwater Inlets Post-construction Stormwater Management in New Development and Redevelopment



The typical design of a catch basin insert is a set of filters that are specifically chosen to address the pollutants expected at that site (Source: King County, Washington, 2000)

Description

A variety of products for stormwater inlets known as swirl separators, or hydrodynamic structures, have been widely applied in recent years. Swirl separators are modifications of the traditional oil-grit separator and include an internal component that creates a swirling motion as stormwater flows through a cylindrical chamber. The concept behind these designs is that sediments settle out as water moves in this swirling path. Additional compartments or chambers are sometimes present to trap oil and other floatables. There are several different types of proprietary separators, each of which incorporates slightly different design variations, such as off-line application. Another common manufactured product is the catch basin insert. These products are discussed briefly in the Catch Basin fact sheet.

Examples of Materials Used in a Streambank Restoration and Protection: Log veins redirect streamflow back to the center channel or slow side stream velocities protecting the streambank. The coir fabric stabilizes the streambank and allows new plantings such as tall warm seasoned grasses time to grow. Over time the coir fabric biodegrades back into the soil.

Conversion of Detention Ponds and Construction of Treatment Wetlands: A typical detention pond that is mowed has little water quality benefit and can be converted into something more beneficial. Treatment wetlands can be aesthetically pleasing and ecologically diverse. Both of the areas shown above are located in the Philadelphia Region.

2.2.9 PWD-Baxter Intake Public Summary

Introduction

As part of the requirements of the 1996 Safe Drinking Water Act Reauthorization, the Pennsylvania Department of Environmental Protection (PADEP) has been conducting assessments of all potentially significant sources of contamination to all public drinking water sources. The Philadelphia Water Department has prepared this Source Water Assessment Public Summary to provide information to support local and state efforts to protect the quality of the City of Philadelphia's drinking water sources. The information in this summary pertains to the water supply area for the Philadelphia Water Department's Baxter Water Treatment Plant. The water withdrawn for the Baxter Water Treatment Plant is treated and meets all state and federal regulations for safety and quality before being distributed to Northeast Philadelphia and Lower Bucks County. The assessment conducted for the Baxter Water Treatment Plant is of the "source" (river water) rather than "tap" (drinking) water. Information on "tap" (drinking) water quality is available from the Philadelphia Water Department's Annual Consumer Confidence Report that can be obtained by calling 215-685-6300 or visiting the website at www.phila.gov.

What is the Source of Your Drinking Water?

The source of water for the Philadelphia Water Department – Baxter Water Treatment Plant is surface water from the Delaware River. An average of 190 million gallons is withdrawn from the river per day. The water system serves approximately 750,000 customers in Northeast Philadelphia and Lower Bucks County. The water supply intake is located in Torresdale section of Philadelphia. Approximately 8,106 square miles of land covering portions of 3 states, 30 counties including large sections of Montgomery, and Lehigh, Bucks, and Mercer counties that drain into the river upstream from the intake. The land upstream of the intake is 70% forested/greenspace, 17% agricultural, and 10% developed. Approximately 4 million people live in the Delaware River Watershed.

Water Quality and Treatment Information

Water withdrawn from the Delaware River is coagulated, settled, filtered, and disinfected with chlorine prior to distribution to customers. Drinking water quality meets or exceeds all state or federal requirements. In addition, the Baxter Water Treatment Plant participates in the Partnership for Safe Water program. This program is an intensive voluntary program nationwide by water suppliers that strives for optimized water quality well beyond that required by state and federal agencies.

Evaluation of Significant Sources of Contamination

This assessment identifies and evaluates the possibility for contaminants to potentially enter the Schuylkill River upstream from the water intake prior to treatment. The contaminants addressed in this assessment include those regulated under the federal Safe Drinking Water Act as well as those PADEP has determined may present a concern to human health. These sources are then ranked to determine their protection priority to the water supplier. The protection priority is the level of importance and potential contamination a particular source represents for the water supply. A description of the protection priority assigned to various types of sources upstream from the Baxter Intake is provided in Table 2.2.9-1. Each type of source has a qualitative protection priority rating ranging from A to F. The "A" rating is considered a source of highest protection priority, while "F" is considered lowest protection priority. Sources with ratings between "A" and "C" are considered potentially significant sources for protection consideration. Sources with rating between "D" and "F" are considered to have less significance.

As indicated in Table 2.2.9-1, discharges of treated and untreated sewage upstream of the water intake were given the highest protection priority due to their potential to release pathogens and nutrients into the water supply. Polluted runoff from stormwater was also given a high protection priority due to the potential impacts of runoff from urban areas and agricultural lands that introduce pathogens, nutrients, and sediment into the water supply.

Ongoing Source Water Protection Activities

The Philadelphia Water Department (PWD) has an active source water protection program that works closely with state, federal, and local officials to address water quality issues. PWD also participates in various activities with upstream dischargers, businesses, communities, water suppliers, and watershed organizations that encourage communication, cooperation, education, protection, and restoration of the Schuylkill River and its tributaries.

Source Water Protection Needs

Overall, the primary focus of PWD's protection efforts to protect and improve their water supply should include continued support of efforts for the ongoing improvements of the industrial and municipal discharges the tidal areas of the Delaware River between Trenton and Philadelphia/Camden. Non-point source protection should be focused in the Pennypack, Poquessing/Byberry Creek, Rancocas Creek, and Neshaminy Creek area as well as portions of the Muscentong, Pohatcong, and Lehigh Rivers. However other parts of the watershed such as the Pennypack and Poquessing Creeks may need special attention for contaminant specific issues that do not match with the general overall priority areas or sources.

Long-term protection efforts should be focused on enhancing wastewater discharges and mitigating stormwater runoff from urban and residential areas. These will have the greatest overall impacts on improving source water quality and the Delaware River.

How to Obtain More Information

This Source Water Assessment Public Summary was completed in June 2002. Individuals interested in learning more about this water system and watershed can contact the Philadelphia Water Department at 215-685-6300 or access information from the internet at www.phila.gov/departments/water or www.phillywater/Delaware.org.

Table 2.2.9-1 Summary of Protection Priorities for Various Upstream Sources

Source	Protection Priority	Description	Priority Area(s)	Contaminants
Treated Sewage	A – C (Moderate – High)	Wastewater discharges from wastewater treatment plants	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment, organic chemicals
Untreated Sewage	A (High)	Combined and sanitary sewer overflows/discharges	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients
Urban/Residential Runoff	A – C (Moderate – High)	Stormwater runoff from roads, parking lots, roofs	Pennypack Creek Poquessing Creek Byberry Creek Neshaminy Creek	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, metals, sediment
Agricultural Runoff	A – C (Moderate – High)	Stormwater runoff from croplands, pastures, livestock	Neshaminy Creek Pohatpocong River Musconetcong River Lehigh RIver	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment
Acid Mine Drainage	C (Moderate)	Discharge from abandoned coal mining areas	Lehigh River	Metals
Industrial Facilities	C (Moderate)	Facilities that store or use hazardous chemicals	Camden to Trenton	Metals, nutrients, organic chemicals
Above Ground Storage Tanks	C (Moderate)	If storage tank spilled into river	Camden to Trenton	Petroleum hydrocarbons, metals, phosphorus
Landfills	C (Moderate)	Leaching of contaminants into streams	Camden to Trenton	Petroleum hydrocarbons, metals
Spills and Accidents	A – C (Moderate – High)	Car, truck, train, or pipeline accident spilling benzene	Watershed wide	Petroleum hydrocarbons, organic chemicals

Note: *Petroleum hydrocarbons include chemicals found in oils and greases. Organic chemicals include chemicals found in solvents, degreasers, varnishes, paints, gasoline, plastics, insect and weed killers.*

How Do I Get Involved in Protecting the River and My Water Supply?

There are many ways you can help protect the river and your water supply. You can join a local watershed organization, join a citizens advisory committee, or write your state and local representatives or congressmen about your views and opinions on issues. Instead of joining organizations, you can also lend a hand when these various organizations conduct trash cleanup, stream restoration, tree planting activities, stenciling storm drains, or conducting stream monitoring. Even the smallest of things can help protect your stream, river, or water supply. Just simply calling the proper authorities when you see illegal dumping, dead fish, or other polluting activities can make a big difference (see Table 2.2.9-2). Below are a list of numbers to call for various situations and a list of websites to find more information about local watershed and environmental organizations in the area (see Table 2.2.9-3).

Table 2.2.9-2 Who to Call to Report Various Situations

Situation	Who To Call	Phone
Dead Fish	Fish & Boat Commission PADEP	717-626-0228 800-541-2050
Illegal Dumping & Related Pollution Activities	PADEP Environmental Police Unit	800-541-2050 215-685-6300
Sewage Spills	PADEP PWD	800-541-2050 215-685-6300
Oil & Gas Spills / Accidents	PADEP PWD	800-541-2050 215-685-6300
Soil Erosion and Runoff from Construction or Farming	PADEP Bucks Co. Conservation District	610-832-6131 215-345-7577

Table 2.2.9-3 Getting Involved: Places to go for More Information About Local Organizations

Information About	*Phone Number*	Website Address
Philadelphia Area Watershed Organizations	215-685-6300	www.phillywater.org/delaware
Friends of Pennypack Park	(215) 934-7275	jryanpark9@aol.com
Fairmount Park Friends Groups		
Delaware Riverkeeper	(215) 369-1188	www.delawareriverkeeper.org
Neshaminy Creek Watershed	(215) 598-7791	myersrich@juno.com
Friends of Tacony Creek Park	215-745-8903	
Poquessing Creek	(215)-972-6275	friendsofpoquessing.org/
Cobbs Creek Environmental Education Center	(215) 471-2223	www.cobbscreek.org
Darby Creek Watershed Association	(610) 789-1814	
Pennypack Ecological Restoration Trust	(215) 657-0930	www.libertynet.org/pert
Chester Ridley Crum Watershed Organization		www.ctic.purdue.edu/crcwa/home.html
Trout Unlimited – Bucks Co.	(215) 453-7689	http://members.aol.com/troutubuck