PHASE III REPORT
CHRISTINA BASIN
WATER QUALITY MANAGEMENT STRATEGY

August 5, 1999

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On behalf of the Christina Basin Water Quality Management Committee

MEMORANDUM

TO: Christina Basin Water Quality Management Committee
and Friends of the Christina Basin

FROM: Gerald J. Kauffman

DATE: August 5, 1999

SUBJECT: Phase III Report

Enclosed is the Phase III report summarizing the 1998 activities of the Christina Basin Water Quality Management Strategy. For those interested in obtaining the GIS maps and data described in the report, please call or e-mail at jerryk@udel.edu. The Section 319 programs of the Delaware Department of Natural Resources and Environmental Control, the Pennsylvania Department of Environmental Protection, and the U.S. Environmental Protection Agency provided funding for this project. Thank you for your participation and interest in this clean water program in the Christina River Basin.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contributions of all the members of the Christina Basin Water Quality Management Committee. Special thanks are given to Nicole Minni and Vern Svatos from the University of Delaware for preparing the GIS maps and patiently responding to the numerous requests for data and maps from the public. Tammy Brant, Mary Jane Middelkoop, and Jennifer Egan from the University of Delaware provided valuable support in preparing creative graphics, tables, and text for this report.

FUNDING

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Introduction

This report summarizes the Phase III work of the Christina Basin Water Quality Management Committee during 1998. The Phase I and II Report published in May 1998 summarizes the work of the Christina Basin Water Quality Management Strategy during the years 1994 through 1997.

Local agencies in Delaware and Pennsylvania coordinated the activities of the overall watershed strategy on behalf of the Christina Basin Water Quality Management Committee. The Chester County Water Resources Authority and Chester County Conservation District served as local watershed coordinators for the Pennsylvania portion of the basin. The University of Delaware, Institute for Public Administration, Water Resources Agency served as local coordinator for the Delaware portion of the Basin. A cooperative mix of Federal, State, and local entities served the following roles during 1998:

Watershed Coordination:	Chester County Water Resources Authority Chester County Conservation District University of Delaware, Water Resources Agency
GIS Watershed Inventory:	University of Delaware, Water Resources Agency
Stream Monitoring:	Pennsylvania Dept. of Environmental Protection Delaware Dept. of Natural Resources and Environ. Control
Stormwater Monitoring:	U.S. Geological Survey University of Delaware, College of Agriculture
Total Maximum Daily Load (TMDL) Modeling:	Delaware River Basin Commission U.S. Environmental Protection Agency
Public Education/Outreach:	Brandywine Valley Association Red Clay Valley Association Christina Basin Task Force
BMP Implementation Projects:	Chester County Conservation District New Castle Conservation District
Integrated Watershed Programs:	Chester County Water Resources Authority (Water Resources Mgmt. Plan) Delaware DNREC (Piedmont Whole Basin Program)
Section 319 Funding:	Pennsylvania DEP, Bureau of Watershed Conservation Delaware DNREC, Div. of Soil and Water Conservation U.S. Environmental Protection Agency, Region III

The Christina Basin Water Quality Management Committee conducted the following coordination meetings during 1998 at offices in the Delaware and Pennsylvania portions of the basin:

January 15	University of Delaware, Newark, DE
March 19	Chester County GSC, West Chester, PA
May 21	University of Delaware, Newark, DE
September 24	University of Delaware, Newark, DE
December 2	Brandywine Museum, Chadds Ford, PA

Mission Statement

The mission of the Christina Basin Water Quality Management Strategy is to conduct a cooperative, interstate effort to implement programs to protect and improve the water quality of streams, waterways, and groundwater in the Brandywine, Red Clay, White Clay Creeks, and Christina River watersheds of Delaware, Maryland, and Pennsylvania.

The Watershed

The Christina River is unique because it is the only stream in Delaware that flows through three states. The Christina River Basin occupies 565 square miles - a little larger than the size of New Castle County - with the upper 2/3 in the headwaters of Pennsylvania and the lower third within Delaware and a small slice of Maryland (Figure 1-1). The watershed includes 4 major streams – the Brandywine, Red Clay, White Clay Creeks, and the Christina River – which all flow from Pennsylvania downstream through Delaware before entering the Delaware River at Wilmington. Inter-governmental coordination is a key challenge because the Christina River Basin includes 3 states; 5 counties – Chester, Lancaster, Delaware counties in Pennsylvania, New Castle County in Delaware, Cecil County in Maryland; and over 60 townships, boroughs, and cities. Like most watersheds, the Christina River Basin knows no political boundaries.

The Christina Basin is a diverse, suburbanizing watershed with waters often under conflicting uses. The streams of the watershed provide 75 % of the water supply for New Castle County and up to 40% of the water supply for Chester County. The streams provide many recreational and ecological uses such as canoeing on the Brandywine and habitat for neotropical bird species in the White Clay Creek preserve. The watershed is trivided into 3 land uses of similar, but changing proportions – urban/suburban (1/3), agriculture (1/3), and open space/forests (1/3). The watershed is well known as the site of two Revolutionary War battles, the Brandywine style of Wyeth art, the largest concentration of mushroom growers in the U.S., the corporate home of chemical and credit card companies, and some of the most abundant public gardens in the world. The Wilmington port along the tidal Christina River is ranked among the busiest nationally for tropical fruit and banana imports. Over 0.5 million people live in the watershed near the Cities of Newark and Wilmington, Delaware and Coatesville, Downingtown, Chadds Ford, and West

Chester, Pennsylvania. Due to its desirable pastoral quality and proximity to job centers, the Christina Basin has lost 15% of its open land to development since 1970. The Christina Basin is indeed a microcosm of many suburbanizing watersheds in the Delaware Valley.

Interstate Cooperation

During the early 1990's, Pennsylvania and Delaware had disagreements regarding the administration of water quality standards on both sides of the line in the Christina Basin. Perhaps conflicts in water issues are deeply rooted since the words "rival" and "river" are both derived from the Latin *rivalis* meaning "one using the same stream as another". Recognizing that interstate cooperation is crucial, the Delaware River Basin Commission (since 1961, the original watershed management agency in the Delaware Valley) and the U.S. Environmental Protection Agency played a mediating role and recommended that the two states get together to form a Christina Basin Water Resources Management Committee. Using the watershed approach, the committee now includes Federal water agencies, the Pennsylvania DEP and the Delaware DNREC, Chester County and New Castle County governments, and stakeholders such as local watershed and nonprofit environmental organizations. Local watershed coordinators are the Chester County Conservation District and the Chester County Water Resources Authority in Pennsylvania and the University of Delaware, Institute for Public Administration, Water Resources Agency. Over a few short years, the watershed strategy in the Christina Basin has evolved from an adversarial relationship to a consensus-driven effort of mutual cooperation between the two States. In Delaware, this interstate cooperation is important because most of the water supply for New Castle County originates upstream in Pennsylvania and Maryland

The Christina Basin occupies 565 square miles and includes 4 major watersheds: Brandywine Creek (325 sq. mi.), Red Clay Creek (54 sq. mi.), White Clay Creek (107 sq. mi.), and Christina River (78 sq. mi.). The Basin includes 38 subwatersheds ranging from 4 to 33 square miles.

The streams of the Christina Basin flow through 3 States – Pennsylvania (400 sq. mi./71%), Delaware (157 sq. mi./28%), and Maryland (8 sq. mi./1%) and include 5 counties:

- Chester County, PA (388 sq. mi./69%)
- Delaware County, PA (9 sq. mi./2%)
- Lancaster County, PA (3 sq. mi./1%)
- Cecil County, MD (8 sq. mi./1%)
- New Castle County, DE (156 sq. mi./28%)

Within the 5 counties, the Christina Basin includes 57 local municipal governments and large towns such as:

- Wilmington, DE
- Newark, DE
- Avondale, PA
- West Grove, PA
- Kennett Square, PA
- Downingtown, PA
- Coatesville, PA
- West Chester, PA

Existing Uses

The waters of the Christina Basin provide 75% of the public water supply for residents and businesses of New Castle County, Delaware, and 40% of the water supply for Chester County, Pennsylvania. The streams and wells provide 100 million gallons per day to over 0.5 million people in the 3 states. Public water suppliers in the Basin include:

- Artesian Water Company
- City of Newark
- United Water Delaware
- City of Wilmington
- West Grove Borough
- Avondale Borough
- Kennett Square Borough
- Downingtown Municipal Utilities Authority
- City of Coatesville Authority
- Philadelphia Suburban Water Company

In addition to water supply, the streams of the Christina Basin provide many ecological and recreational uses including:

- Over 2,700 trout stamps are sold to Delaware fisherman annually.
- In Delaware, 30,000 trout are stocked annually.
- Many canoeists and kayakers ply their craft between landings along the Brandywine Creek.
- Thousands of people visit the Marsh Creek State Park, Brandywine Creek State Park, and the White Creek Bi-State Preserve for recreational pursuits.
- Delaware mariners residing in the Basin own 8,400 registered boats.

According to State surface water quality standards, the streams in the Christina Basin provide the following designated uses:

Delaware

- Public, agricultural, and industrial water supply
- Primary and secondary contact recreation
- Fish, aquatic life, and wildlife
- Cold Water Fish (Put and Take Trout)
- Water of exceptional recreational and ecological significance

Pennsylvania

- Potable, industrial, and livestock water supply
- Irrigation
- Water contact sports and aesthetics
- Boating and Fishing
- Wildlife Water Supply
- Trout Stocking and Migratory Fishes

- Cold Water and Migratory Fishes
- High quality or exceptional value waters

Potential Pollutant Sources

Based on the Phase I and II May 1998 watershed inventory conducted for the Christina Basin Water Quality Management Strategy, the potential sources of pollutant loads in the watershed include (in alphabetical order):

Delaware

• Combined Sewer Overflows	39 CSO's
• NPDES Wastewater Discharges	10 Outfalls
• Roadways	2 % of watershed in DE
• Solid Waste/Hazardous Waste/Superfund Sites	135 Sites identified
• Underground Storage Tanks	95 sites identified
• Urban/Suburban Runoff	53% of watershed in DE

Pennsylvania

• Agriculture	40% of watershed in PA
• NPDES Wastewater Discharges	82 Outfalls
• Roadways	2 % of watershed in PA
• Urban/Suburban Runoff	27 % of watershed in PA

Water Quality Problems

According to the May 1998 water quality assessment prepared for the Christina Basin Water Quality Management Strategy, the streams of the watershed in Delaware suffer from impaired water quality due to the following problems:

1. Nutrients – 160 stream miles are impaired due to higher than desired nitrogen and phosphorus loads, which deplete dissolved oxygen levels.
2. Toxics (metals) – 100 stream miles are impaired due to elevated zinc levels.
3. Bacteria (pathogens) – Concentrations along 395 miles of streams frequently exceed the primary recreation standards for swimming of 100 colonies per 100 milliliters.
4. Fish Consumption Advisories – Health warnings advising against the consumption of fish have been posted along 82 stream miles due to PCB contaminated sediment and high PCB levels in fish tissue.
5. Sediment –The streams are degraded by high sediment loads which range between 300 to 1000 pounds per acre annually depending on the subwatershed.
6. Stream Habitat – While biological diversity of the streams has been improving, the DNREC indicates that 39% of the nontidal streams in the Piedmont have poor habitat due the increased frequency and rate of runoff from urban/suburban development and rural activities.

Implementation

The Christina Basin Water Quality Management Committee is currently crafting a Watershed Restoration Action Strategy (WRAS) which is designed to address water quality problems through a six-point implementation and funding plan. The WRAS will be presented for consideration by the Christina Basin Policy Committee during the Fall of 1999 and will include the following components:

1. Watershed Coordination
2. Monitoring and Modeling
3. Public Education/Outreach and Involvement
4. Urban/ Suburban BMPs
5. Rural and Agricultural BMPs
6. Conservation, Riparian and Non-Structural BMPs.

A Report Card

After several years of watershed management, a report card can be issued on the health of the Christina Basin. The results are mixed but there is positive news to report regarding watershed protection initiatives in the Christina Basin. Reports from both states indicate that the streams in the Christina Basin exhibit impaired water quality such as:

- Excessive nutrients like phosphorus that depress dissolved oxygen levels and disturb the "fishable" quality of the waters.
- Elevated toxics (zinc) levels from superfund and hazardous waste sites.
- Higher than desired bacteria levels which negatively affect the "swimmable" quality of the streams.
- High sediment loads which carry topsoil into turbid streams.
- Health warnings against the consumption of fish from the urban waterways.
- Degraded stream habitat due to upstream development in the watershed.

Figure 1-2 provides a report card listing of a series of environmental indicators that can be used to evaluate the state of the Christina Basin:

- **Wastewater Discharges** – These point sources in the Christina Basin of Delaware have declined by 70% from 34 discharges in 1977 to 10 in 1999 due to regional wastewater plans implemented by the Delaware DNREC, City of Wilmington, and New Castle County governments (U of D WRA and DNREC, 1998).

- **Bacteria** – Median levels have decreased 10-fold along the Brandywine Creek at Chadds Ford, Pennsylvania from 1000 coliforms in 1982 to 100 in 1995 due to improved wastewater treatment technology, agriculture conservation programs, and better septic systems (CCWRA and USGS, 1996).

- **Biological Diversity** – Since 1987, biological diversity indices have increased at 16 stream monitoring stations operated by the U.S. Geological Survey and the Chester County Water Resources Authority. This is a positive trend indicating that the macroinvertebrate

populations are becoming healthier in the streams probably due to new precautions on pesticide use (CCWRA and USGS, 1996).

- **Sediment** – Sediment loads have decreased slightly over the last several years, a trend that can only be improved by the Delaware Nature Society's Soil Watch Program and the Chester County Conservation District's and New Castle Conservation District's agriculture soil conservation projects (DNREC, 1996).

- **Dissolved Oxygen** – Dissolved oxygen levels have increased since 1990 along the Brandywine Creek due to more stringent wastewater treatment standards imposed by the Pennsylvania DEP (DRBC Consultant, 1999). High dissolved oxygen levels are necessary for the preservation of fauna species found in streams and rivers.

- **Fish Consumption Advisories** – Since the 1980's, 82 urban stream miles have been posted with warnings against the consumption of fish due to high levels of PCB's (PADEP and DNREC, 1998). In Delaware, the Whole Basin Program has embarked on a watershed initiative to identify and mitigate the sources of PCB's to the waterways. In Pennsylvania, the PADEP and the USEPA are developing a Total Maximum Daily Load for the Brandywine Creek where the pesticide chlordane (which has been banned) is the cause of fish consumption advisories.

- **Nutrients** – Concentrations of phosphorus have remained the same over the years but levels of nitrogen have increased in a worsening trend (DNREC 1996). Initiatives such as the Brandywine Valley Association's Basin-Scapes Homeowners Guides, the New Castle Conservation District Master Gardener program, USDA –Natural Resources Conservation Services PL83-566 Agriculture Watershed projects, and the CCWRA Watershed Stewardship Educational Brochure are designed to assist homeowners and farmers with progressive techniques to reduce the flow of fertilizers and manure into the streams. By the year 2000, a joint Total Maximum Daily Load (TMDL) strategy will be developed by the USEPA, Delaware, and Pennsylvania which will identify reductions in nutrients from point source wastewater discharges needed to meet the standards imposed by the Federal Clean Water Act.

- **Toxics** – Zinc levels remain the same, indicating conditions have not worsened. Both States administer superfund programs, which are cleaning up these toxic zinc pollutant sources along the Red Clay Creek in Kennett Square, Pennsylvania and NVF Yorklyn, Delaware and along the White Clay Creek at NVF Newark, Delaware. The Delaware DNREC is currently developing a zinc TMDL for these two creeks which is due by the year 2000.

- **Stream Habitat** – Biological habitat has worsened over the last few decades due to increased stormwater runoff and associated siltation from development in the upstream watersheds (DNREC, 1994). Best management practices such as the City of Newark's Experimental Bioengineering Stream Restoration Project and the Chester County Conservation District's Buck Run Riparian Corridor Planting are intended to restore the habitat of Christina Basin streams.

- **Impervious Cover** – Due to suburban growth, the impervious cover, the amount of buildings and pavement in the watershed, has increased from 9% in 1975 to 16% in 1995. An increase in impervious surface coverage is often correlated with an increase in population. That appears to hold true. The population in the Christina Basin has increased 21% from 412,000 in 1970 to 500,000 in 1995. Recent scientific literature indicates that important environmental parameters such as stream habitat, wetlands, water quality, and trout streams become impaired when the impervious cover in a watershed exceeds a threshold of 10 to 15%. Impervious cover controls are established in local ordinances and zoning codes such as the Water Resource Protection Area ordinance within the New Castle County Unified Development Code which limits roof and building areas to a maximum 20% in new developments within sensitive limestone aquifer, recharge, wellhead, and reservoir areas.

- **Superfund Sites** – While many of these contaminant sources have been identified since the 1970's, many have been cleaned up in recent years. The Pennsylvania DEP and USEPA are nearing closure on the Strasburg Landfill superfund site in the Brandywine watershed. The Delaware DNREC has recently announced the closure of the Diamond State Salvage and Wilmington Coal Gas superfund sites along the tidal Christina River in Wilmington and is initiating proceedings to remediate the superfund sites at NVF Newark and Newark Lumber within the White Clay Creek watershed.

- **Open Space** – Both States have acquired large amounts of public open space which provide multi-objective watershed protection benefits. The Delaware DNREC has assembled large tracts of state park land in the White Clay Creek and Brandywine Creek watersheds with the most recent acquisition being the Judge Morris Property in the Pike Creek watershed. Pennsylvania has preserved open space at State and County parks at the Marsh Creek Reservoir, Chambers Lake, and Struble Lake water supply impoundments. Non-profit watershed and environmental organizations such as the Brandywine Conservancy, Brandywine Valley Association, Red Clay Valley Association, Delaware Nature Society, White Clay Watershed Association and the Woodlawn trustees all actively manage open conservation lands in the Christina Basin. The Riverfront Development Corporation heads an urban waterfront restoration program along the tidal Brandywine and Christina River in Wilmington with the construction of the Riverfront Park, River Walk, and Riverfront Arts Center, and an urban wetland restoration project. While these riverfront projects improve the recreational and commercial appeal of the waterfront, they have also triggered superfund and combined sewer overflow abatement initiatives, which can only improve the water quality of the rivers. The Chester County Municipal Heritage Park and Open Space Grant Program and the County's Preservation Partnership Grant Program have assisted municipalities in purchasing 1,757 acres of lands for open space and parks. Of the 45 Chester County municipalities located within the Christina Basin, 29 have participated in these matching grant programs. In addition, Chester County has initiated its Countywide Open Space Plan ("Linking Landscapes") which will focus on a corridor and "connectedness" approach to open space planning that addresses numerous objectives including stream protection. Finally, the Chester County Commissioners have announced a commitment of an additional $75 million to open space and urban center preservation initiatives.

The Future

Through a cooperative, interstate watershed approach, much has been accomplished to protect and restore the health of the drinking water streams of the Christina River Basin. Hopefully, the watershed experiences outlined here can provide guidance for other watershed efforts throughout the Delaware Valley. Many of the water quality problems have accumulated over the 100 years since the Industrial Revolution; therefore, watershed restoration programs will take years, maybe decades, and a large dose of patience. The upcoming TMDL deadline will put greater emphasis on the voluntary watershed approach currently underway. While much has been done to improve the waters of the Christina Basin, much remains to be done such as:

- Planting forests and buffers to filter and cleanse stormwater.
- Acquiring and conserving open space.
- Limiting impervious cover from new development and encouraging infiltration of runoff through watershed-based local ordinances and zoning codes.
- Increasing the financial incentive for landowners to participate in existing federally funded agriculture conservation programs.
- Accelerating the superfund and hazardous waste clean-up programs.
- Minimizing wastewater and combined sewer overflow point source discharges.

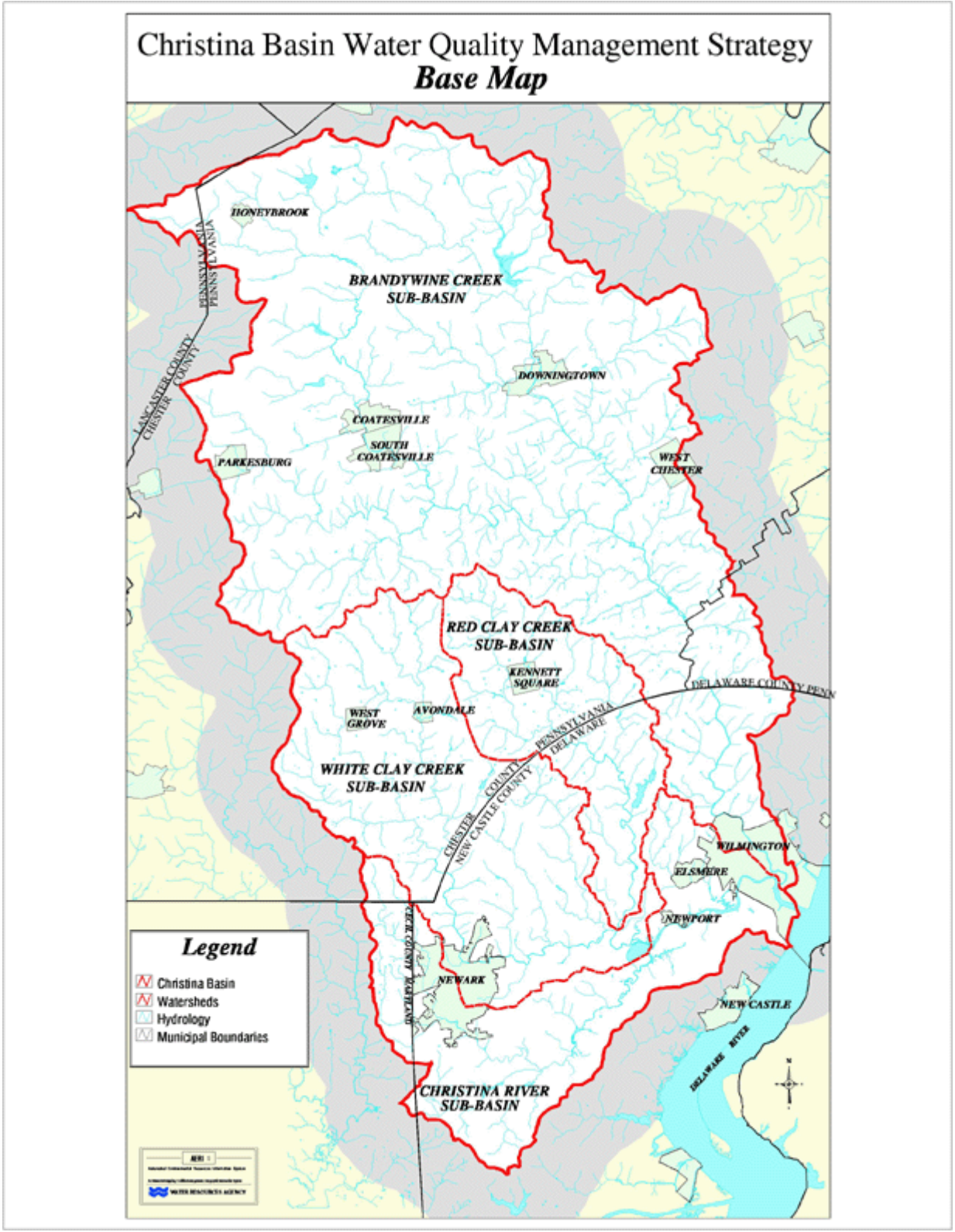

Figure 1-1. Christina Basin base map

The Christina River Basin Report Card (Since 1970)

Figure 1-2

Wastewater Discharges - These point sources in the Christina Basin of Delaware have declined by 70% from 34 discharges in 1977 to 10 in 1999 due to regional wastewater plans.

Bacteria - Levels have decreased 10-fold along the Brandywine Creek at Chadds Ford, PA from 1000 coliforms in 1982 to 100 in 1995 due to improved wastewater treatment technology, agriculture conservation programs and better septic systems.

Biological Diversity - Since 1987, biological diversity indices have increased at 16 stream monitoring stations, due to new pesticide restrictions.

Sediment - Sediment loads have decreased slightly over the last several year due to soil watch programs.

Dissolved Oxygen - Dissolved Oxygen levels have increased since 1990 due to more stringent wastewater treatment standards.

Fish Consumption Advisories - Since the 1980's, 82 urban stream miles have been posted with warnings against the consumption of fish due to high levels of PCB's. Mitigation of PCB's has become a watershed priority.

Nutrients - Concentrations of phosphorous have remained the same over years but levels of nitrogen have increased in a worsening trend. By 2000, a TMDL strategy will be developed to identify and reduce nutrient levels to comply with standards imposed by the Federal Clean Water Act.

Toxics - Zinc levels remain the same indicating conditions have not worsened. Superfund programs have been implemented to clean up toxic waste.

Stream habitat - Biological habitat has worsened over the last few decades due to increased stormwater run off from development in upstream watersheds. Best Management Practices have been implemented and are intended to restore stream habitat.

Impervious Cover - Impervious Cover has increased from 9% in 1975 to 16% in 1995. Recent scientific literature indicates that streams become impaired when impervious cover exceeds a threshold of 10 to15%. Zoning maps should focus

Superfund Sites - Identification and cleanup of sites has improved since the1970's.

Open Space -Both PA and DE have acquired large amounts of open space which provides multiple watershed protection benefits.

Watershed Indicator	Worse	Same	Improved
DE Wastewater Discharges			☺
Bacteria			☺
Biological Diversity			☺
Sediment Loads			☺
Dissolved Oxygen			
-Pennsylvania			☺
-Delaware	☹		
Fish Consumption Advisories	☹		
Phosphorous		😐	
Nitrogen	☹		
Zinc		😐	
Stream Habitat	☹		
Impervious Cover	☹		
Superfund Sites			☺
Public Open Space			☺

Figure 1-2. The Christina Basin report card

Chapter 2 – GIS Watershed Inventory

During 1998, the University of Delaware, Institute for Public Administration, Water Resources Agency updated the GIS watershed inventory for the Christina Basin in an ARCINFO format. The WRA compiled the following map layers for the project:

- Population Density
- NPDES Discharges and Monitoring Stations
- Stream Designated Uses
- Dissolved Oxygen Criteria
- Water Quality Impaired Segments

Population Density

Figure 2-1 shows the population density map for the Christina Basin. Population density (persons per square mile) can be correlated with impervious cover which in turn is an indicator of stream health. Generally, watersheds with a high population density have more impervious surface coverage, which causes more stormwater pollutant loads that in turn results in poor stream water quality. Figure 2-2 provides a correlation between impervious cover and population density for the 38 subwatersheds in the Christina Basin.

Table 2-1 summarizes the population density of watersheds in the Christina Basin which range from 10 p./sq. mi. in the rural headwaters of the Brandywine watershed to 5,700 p./sq. mile in the urban Brandywine Creek subwatershed at Wilmington. The average population density of the Christina Basin is 886 p./sq. mile. The most populous watershed is the Christina River at 1993 p./sq. mile and the least populous watershed is the Brandywine Creek at 608 p./sq. mile. The population density map confirms the development patterns that extend along the I-95 urban corridor between Newark and Wilmington. The urban/suburban corridor extends along Route 202 into Pennsylvania through West Chester and then extends east - along Route 30 between Downingtown and Coatesville.

The UDWRA compiled the population density map utilizing census data from 1995. The Chester County Planning Commission provided population data for the Townships and municipalities in the Pennsylvania portion of the Christina Basin. The UDWRA obtained census block data in a GIS format for the New Castle County portion of the basin from the New Castle County Department of Planning (now Land Use). Using the GIS, the UDWRA merged the population data from both states to estimate the population for each of the subwatersheds. The population density in persons per square mile was estimated by taking the population and dividing by the land area of each subwatershed.

NPDES Discharges

Figure 2-3 summarizes the NPDES wastewater discharges and stream monitoring stations in the Christina River Basin. Appendix A provides tables that summarize the data for the discharges and the monitoring stations. UDWRA compiled this map at the request of the Delaware River Basin Commission to support the TMDL point source, low flow modeling effort now underway

by a USEPA study contractor. The map shows the 94 NPDES discharges and 39 CSOs in the Basin. The USGS operates 23 stream flow gages in the Christina Basin. The PADEP monitors 13 stream water quality monitoring stations and the Delaware DNREC monitors 31 stations.

Stream Designated Uses

To support the TMDL modeling work, the UDWRA compiled a GIS map (Figure 2-4) identifying the designated uses of stream segments in the Christina Basin. The stream designated uses were obtained from "Tentative Determination for State of Delaware 1998 Clean Water Act Section 303(d) List of Waters Needing TMDL's" and "Rules and Regulations, Title 25 - Environmental Protection, Pennsylvania Bulletin, Volume 28, No. 36, September 5, 1998".

Dissolved Oxygen Criteria

Figure 2-5 is a map that portrays the following dissolved oxygen criteria for each stream segment in the Christina Basin based on the designated use. Table 2-2 summarizes the dissolved oxygen criteria for the streams of the Christina Basin.

Table 2-1. Population density

		Area		Pop. Density
Brandywine Creek Watershed		**(sq. mi.)**	**Population**	**(p./sq. mi.)**
B1. Upper West Branch at Honneybrook		18.49	5,069	274
B2. Upper West Branch at Hibernia		26.04	10,656	409
B3. Lower West Branch at Coatesville		17.64	18,045	1,023
B4. Lower West Branch at Embreeville		17.09	4,302	252
B5. Buck Run		27.53	8,667	315
B6. Doe Run		22.57	1,848	82
B7. Broad Creek		6.44	3,561	553
B8. Upper East Branch at Struble Lake		33.04	318	10
B9. Upper East Branch at Shamona Creek		10.00	11,473	1,147
B10. Lower East Branch		20.93	27,149	1,297
B11. Marsh Creek		19.98	4,584	229
B12. Beaver Creek		18.09	16,164	894
B13. Valley Creek		20.65	18,513	897
B14. Main Stem above Chadds Ford		24.56	13,024	530
B15. Pocopson Creek		9.14	3,053	334
B16. Main Stem below Chadds Ford		26.46	16,232	613
B17. Main Stem through Wilmington		6.06	34,802	5,743
	Subtotal	**324.71**	**197,460**	608
Red Clay Creek Watershed				
R1. West Branch		17.47	7,772	445
R2. East Branch		9.96	5,358	538
R3. Burris Run		7.11	2,280	321
R4. Main Stem above Wooddale		12.45	6,884	553
R5. Main Stem below Wooddale		7.11	17,252	2,426
	Subtotal	**54.10**	**39,546**	731
White Clay Creek Watershed				
W1. West Branch		10.18	2,305	226
W2. Middle Branch		15.87	4,455	281
W3. East Branch above Avondale		18.74	5,464	292
W4. East Branch below Avondale		14.33	5,014	350
W5. Mill Creek		12.92	24,715	1,913
W6. Pike Creek		6.64	13,788	2,077
W7. Middle Run		3.89	5,645	1,451
W8. Main Stem above Newark		10.12	9,588	947
W9. Main Stem above Delaware Park		9.05	27,289	3,015
W10. Main Stem at Churchmans Marsh		5.51	9,058	1,644
	Subtotal	**107.25**	**107,321**	1,001
Christina River Watershed				
C1. East / West Branch above Coochs Bridge		21.06	24,198	1,149
C2. Muddy Run		8.66	9,919	1,145
C3. Belltown Run		6.43	5,706	887
C4. Little Mill Creek		9.23	33,182	3,595
C5. Main Stem above Smalley's Pond		10.67	28,919	2,710
C6. Main Stem Lower Tidal		21.95	53,500	2,437
	Subtotal	**78.00**	**155,424**	1,993
Total Christina River Basin	**Total**	**564.06**	**499,751**	886

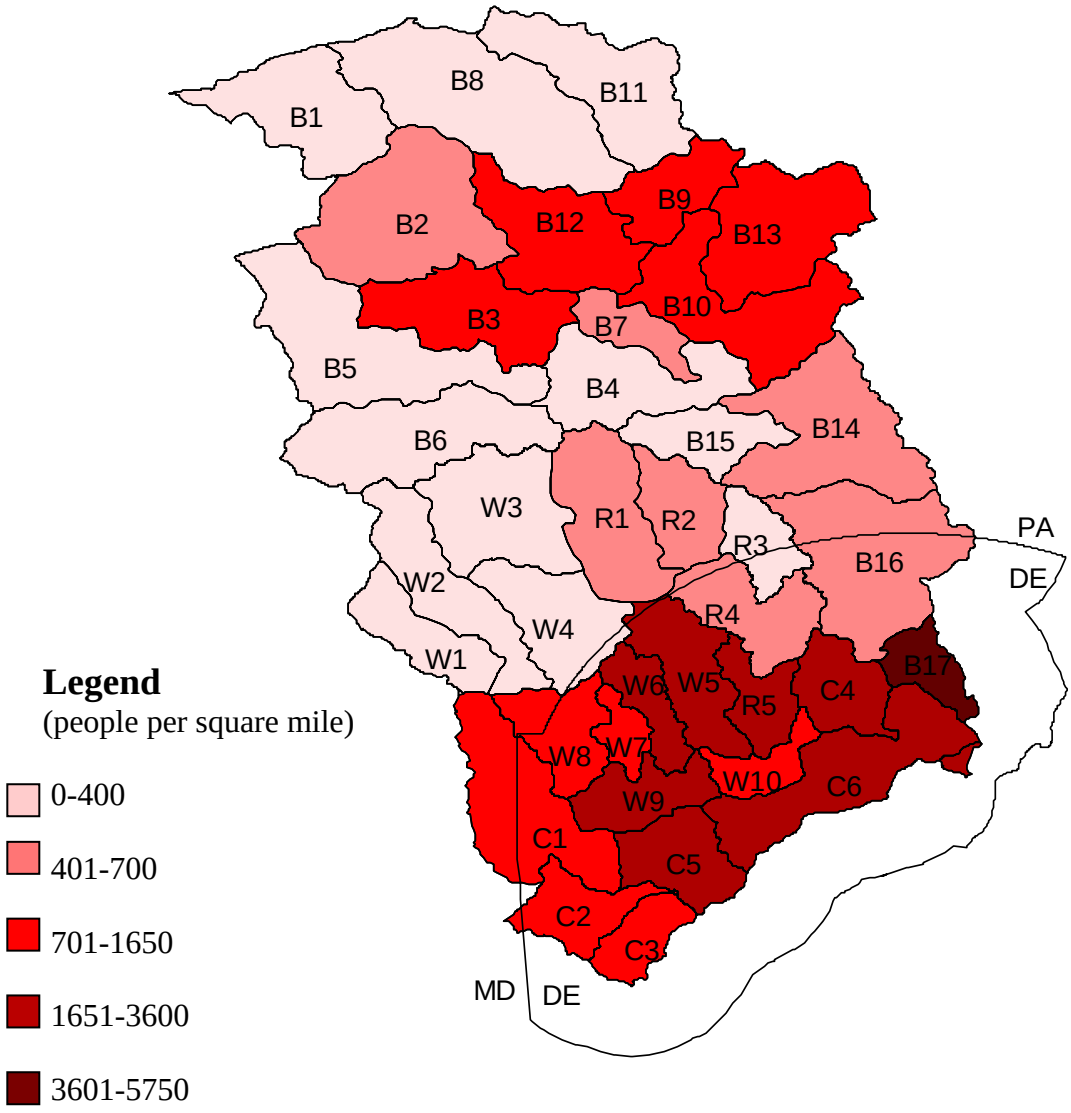

Figure 2-1. Christina Basin population density map

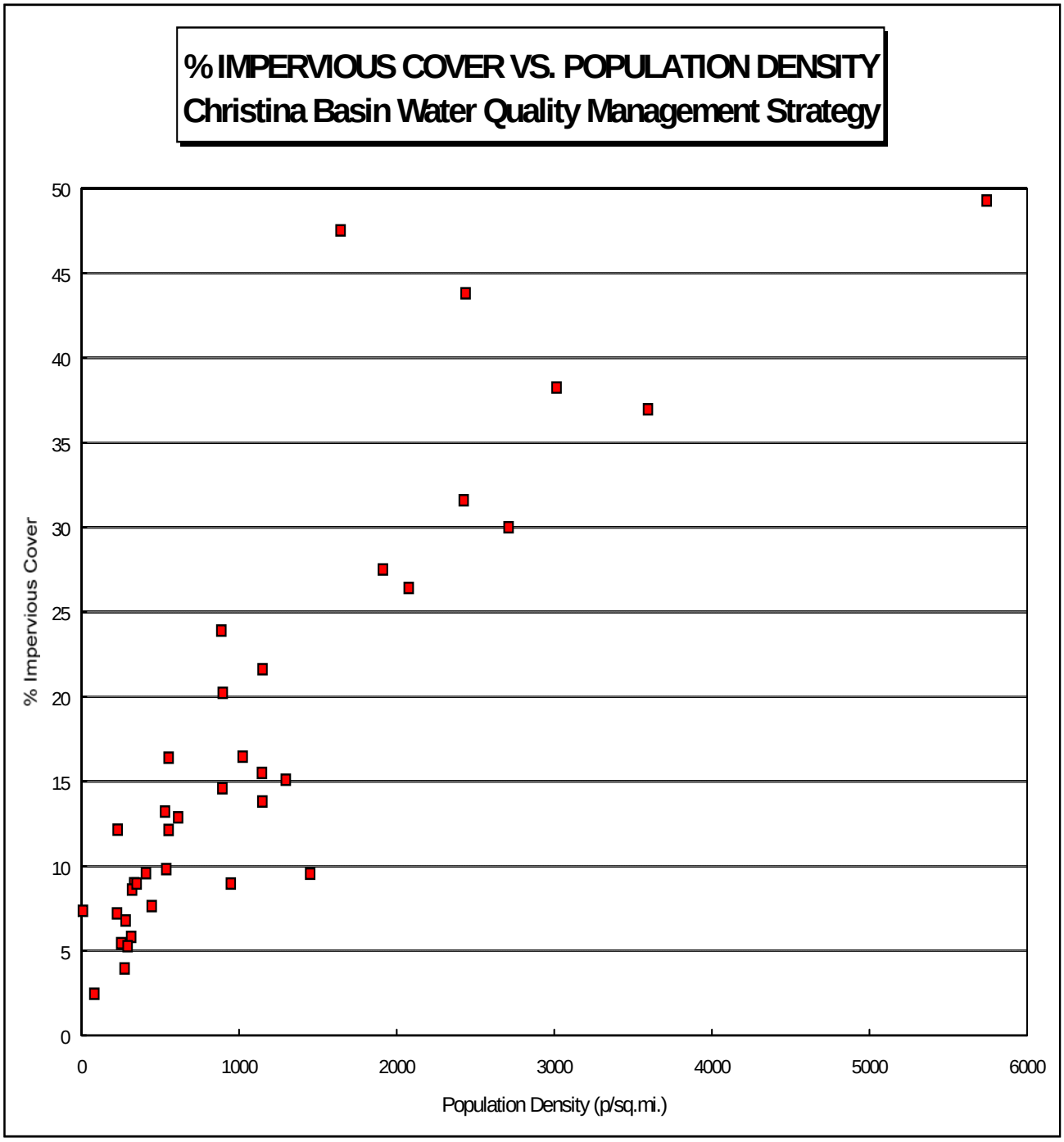

Figure 2-2. Christina Basin impervious cover vs. population density

Table 2-2. Christina Basin dissolved oxygen criteria

Designated Use	**Dissolved Oxygen Criteria (mg/l)**	
	Average D.O	**Minimum D.O**
Pennsylvania		
Cold Water Fishery	6.0	5.0
Exceptional Value	-	-
High Quality/Cold Water Fishery	-	7.0
High Quality/Trout Stocking Fishery	6.0	5.0
Trout Stocking Fishery	6.0	5.0
Warm Water Fishery	5.0	4.0
Delaware		
Fresh Water	5.5	4.0
Cold Water Fish (Put and Take Trout)	6.5	5.5
Exceptional Recreational or Ecological Significance, White Clay Creek	6.5	5.5
Exceptional Recreational or Ecological Significance, Brandywine Creek	5.5	4.0

Water Quality Impaired Segments

The UDWRA produced the water quality impaired segments map at the request of DRBC to assist with the TMDL modeling work. This map (Figure 8) identifies the water quality impairments of various stream segments as determined by the Section 303(d) list from the States of Delaware and Pennsyvania. The point source, low flow TMDLs will be determined for the following water quality impairments in the Christina Basin:

- Pennsylvania - Organic enrichment/Low Dissolved Oxygen, Nutrients (N and P), Bacteria
- Delaware - Low Dissolved Oxygen, Nutrients (N and P), Toxics (zinc), and Bacteria

Figure 2-3. Christina Basin NPDES discharges and monitoring stations

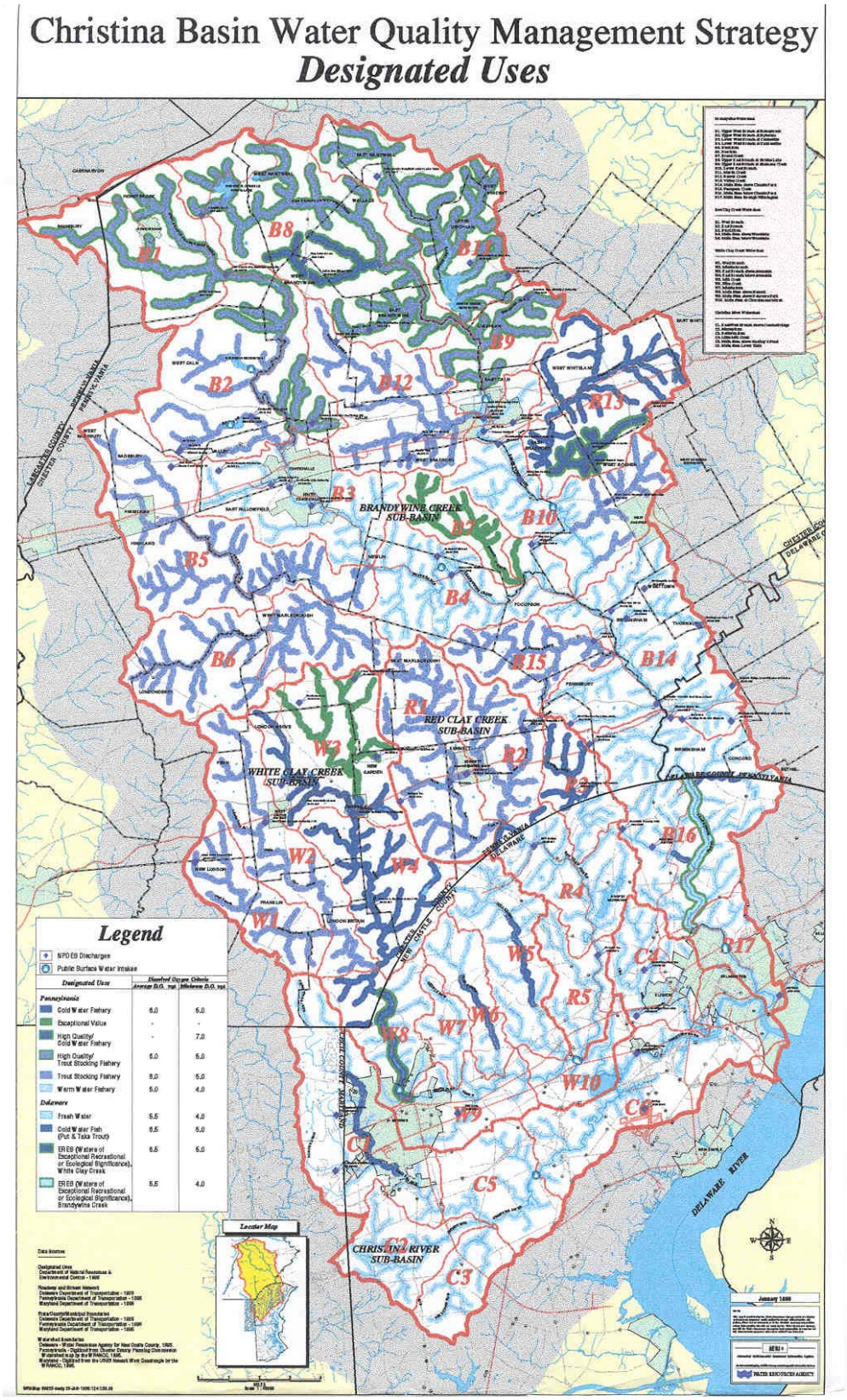

Figure 2-4. Christina Basin designated uses

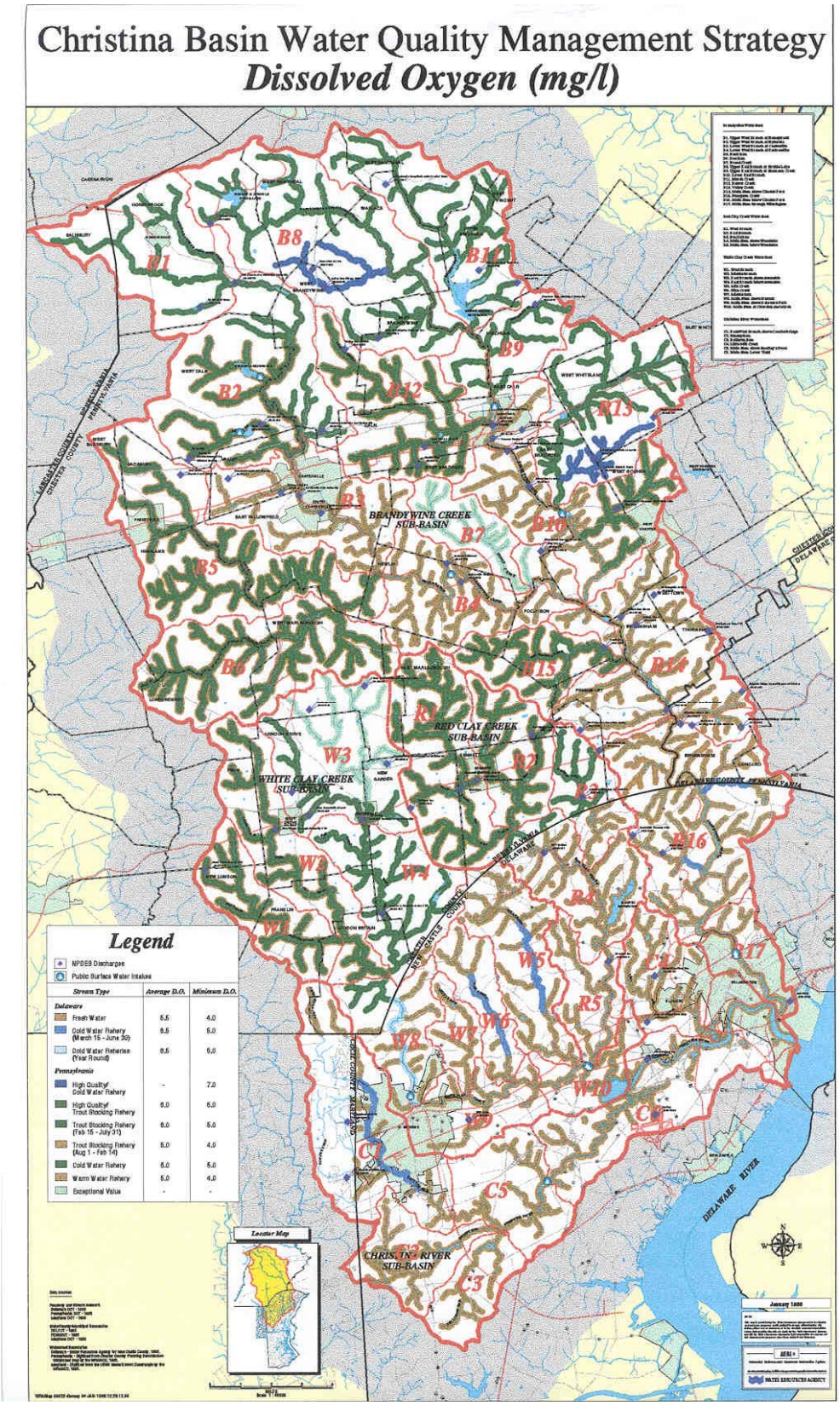

Figure 2-5. Christina Basin dissolved oxygen

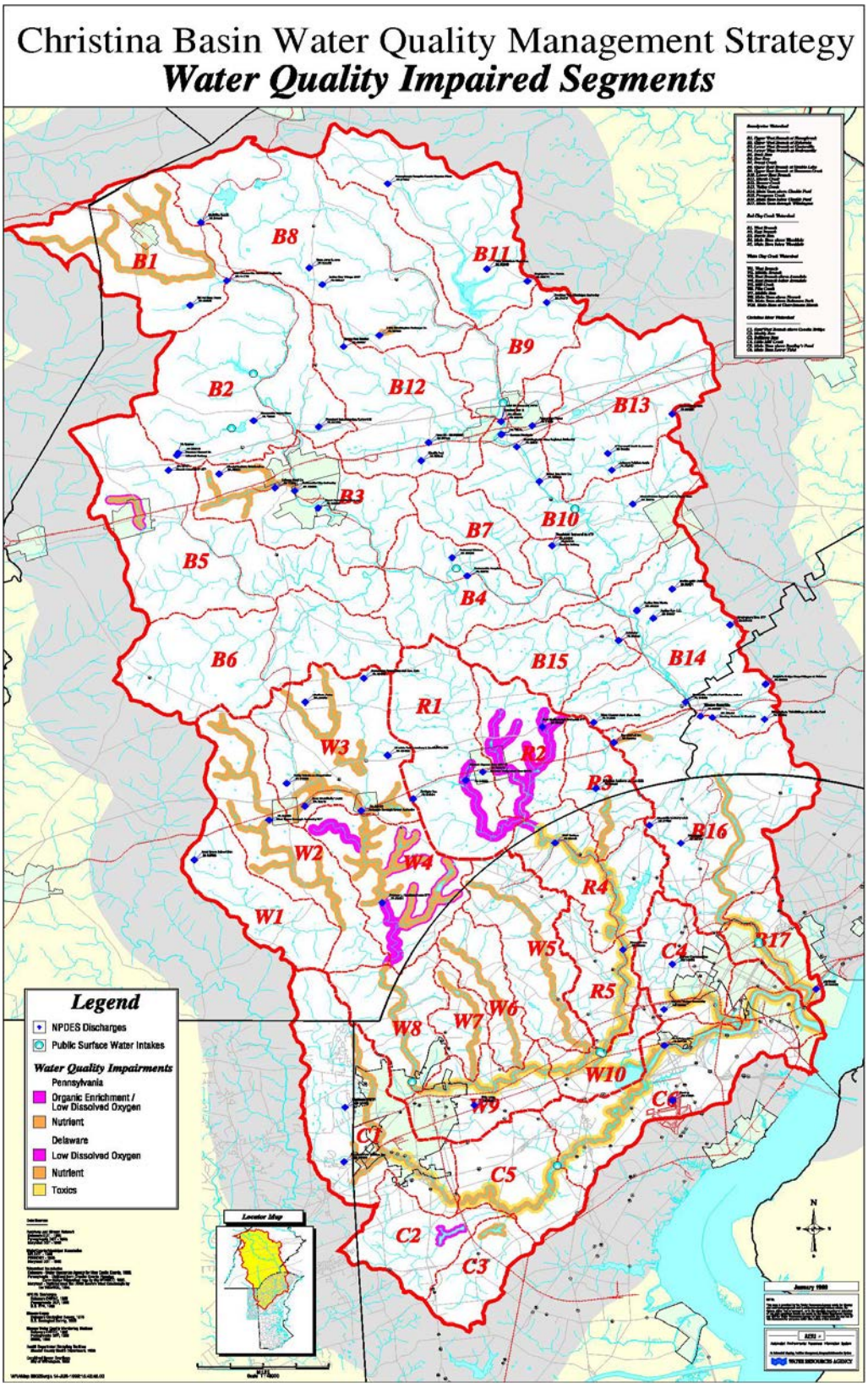

Figure 2-6. Christina Basin water quality impaired segments

Chapter 3 – Point Source Stream Monitoring

Delaware

During 1997 and 1998, Delaware DNREC continued its bi-monthly water quality monitoring in the Delaware portion of the Christina Basin. The objective of this monitoring was two-fold. First, data collected under this plan will be used to assess overall water quality condition in the Christina basin. Second, the data will be used to calibrate hydrodynamic and water quality models for the entire Christina Basin including the White Clay, Red Clay, Brandywine, and Christina. The developed models will serve as predictive tools for establishing Total Maximum Daily Loads (TMDLs) for the entire basin. The Environmental Fluid Dynamic Code (EFDC) modeling framework has been selected as the modeling platform for the receiving stream and the HSPF model has been selected as the framework for the watershed modeling.

The stream monitoring in the Delaware portion of the Christina Basin was conducted at 20 stations (Table 3-1). Monitoring consisted of grab samples and was analyzed for parameters listed in Table 3-2. In addition, instantaneous stream flow measurements were conducted at five free flowing stations identified with an asterisk (*) in Table 3-1. Monitoring at stations located in tidal portions of the Christina River (stations 4, 5, and 6) were conducted at slack tide.

In addition to water column samples, four stations was sampled and analyzed for sediment nutrient characteristics. Sampling frequency at these sites was twice per year. Table 3-3 lists the location of these sediment monitoring stations and parameters being analyzed.

In 1998, Delaware DNREC initiated monitoring at 7 new stations located on small tributaries and ponds in the basin which are on the State's 303(d) list. The objective of this element of the Christina basin monitoring activity was to collect water quality and hydrodynamic data for small tributaries and ponds that are on the State's 303(d) List, but were not included as part of the main stem monitoring. Table 3-4 lists the stations that are monitored for this purpose and Table 3-5 lists water quality parameters for these stations.

In addition to the above water quality monitoring efforts, Delaware DNREC has continued funding for the operation of two tide gages in the tidal portion of the Christina River. These tide gages are located in the Port of Wilmington and in Newport. Tidal elevations at these sites are recorded every fifteen minutes. The tidal elevation data collected at these two sites will be used to calibrate the hydrodynamic model of the Christina River. Water quality data for the Delaware portion of the Christina Basin is presented in Table 3-6.

Pennsylvania

Pennsylvania DEP completed stream water quality monitoring at 13 stations in the Christina Basin. Of the total, 7 station sites were located in the Brandywine Creek watershed, 4 in Red Clay Creek and 2 in White Clay Creek watersheds. Laboratory analyses included temperature, dissolved oxygen, pH, specific conductance, oxygen demand parameters, phosphorus, nitrogen, a number of total and dissolved metals, enterococcus bacteria and others.

Six (6) of the Brandywine stations (3 on the East Branch, 3 on the West Branch) were sampled monthly from July 1995 to December 1996 and every two months from September 1997 to September 1998. The seventh site, near the USGS gage on the main stem at Chadds Ford, is a water quality network station (WQN 105) in Pennsylvania. All WQN stations are sampled monthly. East and West Branch stations were located upstream and downstream of Downingtown and Coatesville respectively at USGS gages, and each branch was sampled near Wawaset before the confluence with the main stem of the Brandywine.

Red Clay station WQN 150 is located just downstream of the confluence of the East and West Branches. Two of the other sites were located on tributaries of the West Branch, west of Kennett Square (NVF tributary and Toughkennamon tributary), and the one East Branch site was at the Route 82 crossing south of Kennett Square. These stations were sampled monthly from July 1995 to September 1996 and every two months from November 1996 to November 1997. Two White Clay stations are WQN 179 on the East Branch and WQN 149 on the main stem.

Table 3-1. Station locations for Christina Basin survey

Location	**Storet No.**
Brandywine Creek	
1. Smith Bridge	104051
2. Rd. 279 Bridge (USGS gage 01481500)	104021
3. Foot Bridge	104011
Christina River	
1. Rt. 273, Above Newark *	106191
2. Old Baltimore Pike, Below Newark (USGS gage 01478000)	106141
3. Smalley's Dam Spillway	106031
4. Rt. 141, Newport (USGS tide gage 01480065)	106021
5. Rt. 13/Rt. 9 Bridge	106011
6. Conrail Br. (USGS tide gage 01481602)	106291
7. Little Mill Creek, Atlantic Avenue (USGS Gage 01480095)	106281
Red Clay Creek	
1. Ashland, Rd. 258a	103041
2. Wooddale, Rt. 8 (USGS gage 01480000)	103031
3. Stanton, Rt. 4 (USGS gage 01480015)	103011
4. Burrough's Run Confluence *	103061
White Clay Creek	
1. Chambers Rock Rd.	105031
2. DE Park Race Track (USGS gage 01479000)	105151
3. Stanton, Old Rt. 7 Bridge	105011
4. Mill Creek Confluence above Rt. 4 at Delaware Park *	105071
5. Pike Creek Confluence, Upper Pike Creek Rd. *	105101
6. Middle Run Confluence, Possum Park Rd. *	105131

* Flow measurements also to be taken at these stations.

Table 3-2. Water quality parameters for Christina Basin monitoring

Parameter	Analytical Method	Reporting Level
Water Column Nutrients		
Total Phosphorus	052	0.005 mg/l P
Soluble Ortho-phosphorus	052	0.005 mg/l P
Total Kjeldahl Nitrogen	041	0.03 mg/l N
Ammonia Nitrogen	043	0.002 mg/l N
Nitrite+Nitrate N	045	0.005 mg/l N
Carbon and Organics		
Total Organic Carbon	121	1 mg/l
Dissolved Organic Carbon	121	1 mg/l
Chlorophyll-a (Corr)	017	0.001 mg/l
Pheophytin	017	0.001 mg/l
BOD_5, N-Inhib (CBOD)	006	2.4 mg/l
BOD_{20}, N-Inhib (CBOD)	006	2.4 mg/l
General		
Dissolved oxygen	001	0.25 mg/l
Total Suspended Solids	056	1 mg/l
Alkalinity	026	1 mg/l
Chloride	034	1 mg/l
Hardness	031	5 mg/l
Field pH	Field	0.1 unit
Conductivity	Field	1 umho/cm
Salinity	Field	1 ppt
Temperature	Field	0.5 C
Secchi Depth**	Field	
Light Attenuation**	Field	
Turbidity	018	0.5 FTU
Bacteria		
Enterococcus	084	1/100 ml
Metals (dissolved and total)		
Copper	118	5.0 ug/l
Lead	118	3.0 * ug/l
Zinc	112	20 ug/l

* The current Delaware laboratory instrumentation can not reliably measure below the applicable water quality criterion for this metal.

** These parameters to be measured at Stations 4, 5, and 6 of the Christina. If secchi disc is visible on bottom, then field sheet will indicate depth and that disc is on bottom.

Table 3-3. Sediment stations and parameters for Christina Basin monitoring

Location	Storet No.	Frequency
1. Christina River at CONRAIL bridge, southwest of Wilmington	106291	2/year
2. Christina River at Rt. 141 Bridge, Newport	106021	2/year
3. Brandywine Creek, 0.6 miles us of the Christina R. confluence	104081	2/year
4. White Clay Creek, 0.8 miles us of confluence with Christina River	105161	2/year

Table 3-4. Parameters for Christina Basin monitoring

Sediments Parameter	Analytical Method	Reporting Level
Total Phosphorus	054	0.25 mg/kg
Total Carbon	121	20.0 mg/kg
Total Nitrogen	041/045	7.5 mg/kg
% Moisture	063	1%
Grain Size	Dry Sieve	

Table 3-5. Station locations for additional tributaries/ponds monitoring for Christina Basin

Location	Storet No.
Smallevs Pond	
1. Leathermans Run at Old Baltimore Pike Road Bridge * (lat: 39 39 25.10, long: 75 40 27.87)	106321
2. Christina River at Old Walter Road (Rd 346) Bridge * (lat: 39 38 15.17, long: 75 40 48.88)	106331
Becks Pond	
1. Belltown Run at Rt. 72 Bridge * (lat: 39 36 50.46, long: 75 43 02.31)	106341
2. Becks Pond outflow at Salem Church Rd Bridge * (lat: 39 37 30.87, long: 75 42 09.24)	106351
Sunset Pond	
1. Inflow to the Sunset Pond at Corporate Blvd. * (lat: 39 36 52.41, long.: 75 44 25.37)	106361
2. The middle of Foot Bridge on the Sunset Pond (lat.: 39 37 01.01, 75 44 16.41)	106371
3. Outflow of Sunset Pond at Rt. 72 Bridge * (lat.: 39 37 33.79, 75 43 25.63)	106381

* Flow measurements also to be taken at these stations.

Table 3-6. Water quality parameters for additional tributary/pond monitoring for Christina Basin

Parameter	Analytical Method	Program Reporting Level
Water Column Nutrients		
Total Phosphorus	052	0.005 mg/l P
Soluble Ortho-phosphorus	052	0.005 mg/l P
Total Kjeldahl Nitrogen	041	0.03 mg/l N
Ammonia Nitrogen	043	0.002 mg/l N
Nitrite+Nitrate N	045	0.005 mg/l N
Carbon and Organics		
Total Organic Carbon	121	1 mg/l
Dissolved Organic Carbon	121	1 mg/l
Chlorophyll-a (Corr)	017	0.001 mg/l
Pheophytin	017	0.001 mg/l
BOD_5, N-Inhib (CBOD)	006	2.4 mg/l
BOD_{20}, N-Inhib (CBOD)	006	2.4 mg/l
General		
Dissolved oxygen	001	0.25 mg/l
Total Suspended Solids	056	1 mg/l
Alkalinity	026	1 mg/l
Chloride	034	1 mg/l
Hardness	031	5 mg/l
Field pH	Field	0.1 unit
Conductivity	Field	1 umho/cm
Salinity	Field	1 ppt
Temperature	Field	0.5 C
Secchi Depth*	Field	
Light Attenuation*	Field	
Turbidity	018	0.5 FTU
Bacteria		
Enterococcus	084	1/100 ml

* These parameters to be measured only at Pond Stations listed in Table 4

Table 3-7. Water quality data summary for Delaware portion of Christina Basin

Table 3-6 Water Quality Data Summery for Delaware Portion of the Christina River Basin, 97-98

Storet Station #	Location	Assessed Parameters															
		Max. = Maximum, Min.= Minimum, Avg. = Average, G.M.= geometric mean															
		DO (mg/l) (Standard = 5.5 mg/l)			Total Nirogen (mg/l)			Total Phosphorous (mg/l)			Chrophyll a (ug/l)			Enterococcus Bacteria (#/100 ml)		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	G.M.
104051	Brandywine Creek, Smith Bridge	11.8	6.2	8.6	4.62	2.41	3.38	0.470	0.040	0.151	11	0	4	2000	3	107
104021	Brandywine Creek, Rd. 279 Bridge (USGS gage 01481500)	12.8	6.6	9.2	4.86	2.37	3.61	0.740	0.020	0.180	16	1	5	1000	8	179
104011	Foot Bridge	3.9	2.4	2.5	0.13	0.01	0.06	0.590	0.040	0.170	27	0	8	2000	9	132
106191	Rt. 273, Above Newark	14.4	8.2	11.1	3.89	2.27	3.00	0.280	0.004	0.050	13	1	4	2000	8	121
106141	Old Baltimore Pike, Below Newark (USGS Gage 01478000)	11.4	5.9	8.7	3.67	1.64	2.35	0.780	0.010	0.150	16	1	4	2000	0	242
106031	Smalley's Dam Spillway	13.0	3.9	8.2	0.22	0.02	0.08	0.220	0.018	0.080	11	1	4	2000	7	225
106021	Rt. 141, Newport (USGS Tide gage 0140065)	12.8	4.0	8.5	4.15	1.69	2.86	0.230	0.050	0.130	131	1	24	2000	3	255
106011	Rt. 13/Rt. 9 Bridge	13.1	5.4	8.3	4.51	1.44	2.79	0.230	0.080	0.120	45	1	15	46	20	179
106291	Conrail Br. (USGS Tide gage 01481602)	11.5	3.1	7.6	3.40	2.34	2.88	0.243	0.070	0.140	40	1	12	2000	0	148
106281	Little Mill Creek, Atlantic Avenue (USGS Gage 01480095)	12.8	4.8	9.0	2.30	0.08	0.73	0.270	0.010	0.060	8	1	3	2000	26	376
103041	Ashland, Rd 258a	12.3	6.8	9.0	6.16	1.93	4.36	0.940	0.103	0.390	21	1	8	1667	13	203
103031	Wooddale, Rt 8 (USGS Gage 01480000)	12.0	5.6	9.0	6.24	2.80	4.22	0.800	0.820	0.220	21	0	5	2000	5	132
103011	Stanton, Rt 4 (USGS Gage 01480015)	11.7	4.9	9.1	5.60	2.40	3.76	0.330	0.070	0.180	45	0	6	2000	4	213

Table 3-7. Water quality data summary for Delaware portion of Christina Basin

Table 3-6 Water Quality Data Summery for Delaware Portion of the Christina River Basin, 97-98

Storet Station #	Location	Assessed Parameters															
		Max. = Maximum, Min.= Minimum, Avg. = Average, G.M.= geometric mean															
		DO (mg/l) (Standard = 5.5 mg/l)			Total Nirogen (mg/l)			Total Phosphorous (mg/l)			Chrophyll a (ug/l)			Enterococcus Bacteria (#/100 ml)		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	G.M.
103061	Burrough's Run Confluence	14.2	8.1	11.0	3.91	0.89	2.36	0.270	0.012	0.042	13	1	3	2000	1	138
105031	Chambers Rock Rd.	12.0	5.9	9.2	6.48	3.04	4.71	0.590	0.020	0.141	16	0	4	2000	6	221
105151	DE Park Race Track (USGS Gage 01479000)	14.3	6.5	10.5	6.16	1.49	4.13	1.170	0.000	0.158	11	1	4	2000	13	253
105011	Stanton, Old Rt 7 Bridge	12.9	6.4	9.4	5.36	1.61	3.84	0.260	0.020	0.120	11	0	5	2000	7	244
105071	Mill Creek Confluence abv Rt 4 at Delaware Park	14.2	6.6	10.6	4.50	1.58	2.68	0.750	0.008	0.098	11	1	3	2000	24	298
105101	Pike Creek Confluence, Upper Pike Creek Rd	16.1	8.0	11.4	5.46	1.64	2.84	0.350	0.000	0.051	5	1	3	2000	4	136
105131	Middle Run Confluence, Possum Park Rd	14.5	8.1	11.0	4.63	1.46	2.65	0.190	0.010	0.050	24	1	5	2000	3	138
106321	Leatherinans Run at Old Baltimore Pike Road Bridge	9.6	1.5	5.1	1.77	0.20	0.95	0.090	0.020	0.060	21	3	10	2000	13	157
106331	Christina River at Old Walter Road (Rd 346) Bridge	9.9	5.1	7.5	2.14	0.98	1.56	0.209	0.037	0.123	5	3	4	2000	77	392
106341	Belltown Run at Rt 72 Bridge	10.0	3.9	6.5	2.20	1.22	1.77	0.660	0.060	0.250	64	2	19	2000	170	381
106351	Becks Pond outflow at Salem Church Rd Bridge	9.6	8.7	9.2	1.57	0.73	1.15	0.085	0.036	0.061	8	5	7	2000	34	261
106361	Inflow to the Sunset Pond at Corporate Blvd	10.1	3.0	5.9	2.02	1.47	1.66	0.110	0.020	0.060	11	5	7	2000	34	132
106371	The middle of Foot Bridge on the Sunset Pond	9.9	2.4	5.7	1.74	0.61	1.22	0.113	0.021	0.080	13	5	9	2000	3	71
106381	Outflow of Sunset Pond at Rt 72 Bridge	10.2	8.1	9.2	2.00	1.01	1.50	0.140	0.050	0.100	69	8	39	2000	14	167

Table 3-8. pH levels

		Sum	Min	Max	Count	Avg.
Brandywine Creek Watershed						
West Branch	Station 1	137.26	7.02	8.45	18.00	7.63
	Station 2	166.10	6.97	9.13	21.00	7.91
	Station 3	167.15	7.42	9.17	21.00	7.96
East Branch	Station 4	160.17	7.08	9.10	21.00	7.63
	Station 5	164.59	7.53	8.33	21.00	7.84
	Station 6	165.78	7.05	8.84	21.00	7.89
Main Stem	Station 7 - WQN 105	257.56	7.09	8.26	34.00	7.58
Red Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	NVF Trib.	173.67	7.55	9.06	21.00	8.27
	Toughkennamon Trib.	163.96	5.93	8.81	21.00	7.81
	Route 82	166.29	6.48	8.71	21.00	7.92
	WQN 150	280.91	7.48	9.24	35.00	8.03
White Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	WQN 149	287.72	7.18	8.96	36.00	7.99
	WQN 179	272.69	7.09	8.29	36.00	7.57

Table 3-9. NH3N levels (mg/L)

		Sum	Min	Max	Count	Avg.
Brandywine Creek Watershed						
West Branch	Station 1	0.87	0.02	0.27	15.00	0.06
	Station 2	1.18	0.02	0.22	20.00	0.06
	Station 3	0.68	0.02	0.15	14.00	0.05
East Branch	Station 4	0.99	0.02	0.11	21.00	0.05
	Station 5	0.78	0.02	0.11	18.00	0.04
	Station 6	0.85	0.02	0.12	18.00	0.05
Main Stem	Station 7 - WQN 105	1.54	0.02	0.15	29.00	0.05
Red Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	NVF Trib.	2.63	0.03	0.49	17.00	0.15
	Toughkennamon Trib.	1.76	0.02	0.42	15.00	0.12
	Route 82	0.59	0.02	0.15	11.00	0.05
	WQN 150	2.86	0.02	0.32	26.00	0.11
White Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	WQN 149	1.11	0.02	0.23	17.00	0.07
	WQN 179	0.24	0.02	0.07	7.00	0.03

Table 3-10. Dissolved oxygen (mg/L)

Brandywine Creek Watershed						
West Branch		Sum	Min	Max	Count	Avg.
	Station 1	218.10	7.60	15.10	21.00	10.39
	Station 2	274.80	9.10	15.50	24.00	11.45
	Station 3	268.80	8.50	15.50	24.00	11.20
East Branch						
	Station 4	247.00	8.10	13.40	24.00	10.29
	Station 5	265.60	8.50	15.70	24.00	11.07
	Station 6	248.70	7.90	15.20	24.00	10.36
Main Stem	Station 7 - WQN 105	367.30	6.20	15.30	35.00	10.49
Red Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	NVF Trib.	224.60	4.40	17.80	21.00	10.70
	Toughkennamon Trib.	248.20	7.10	17.00	21.00	11.82
	Route 82	244.40	8.00	16.10	21.00	11.64
	WQN 150	408.00	8.00	16.20	35.00	11.66
White Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	WQN 149	433.30	8.10	17.30	36.00	12.04
	WQN 179	399.50	8.70	14.70	36.00	11.10

Table 3-11. Total phosphorus (mg/L)

Brandywine Creek Watershed						
West Branch		Sum	Min	Max	Count	Avg.
	Station 1	1.82	0.02	0.28	25.00	0.07
	Station 2	7.25	0.04	3.40	25.00	0.29
	Station 3	2.18	0.03	0.26	25.00	0.09
East Branch						
	Station 4	0.79	0.02	0.12	21.00	0.04
	Station 5	3.48	0.04	0.31	25.00	0.14
	Station 6	3.05	0.03	0.28	25.00	0.12
Main Stem	Station 7 - WQN 105	3.38	0.03	0.31	36.00	0.09
Red Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	NVF Trib.	2.97	0.05	0.37	22.00	0.14
	Toughkennamon Trib	3.11	0.04	0.34	22.00	0.14
	Route 82	1.60	0.02	0.15	22.00	0.07
	WQN 150	8.93	0.05	0.87	37.00	0.24
White Clay Creek Watershed						
		Sum	Min	Max	Count	Avg.
	WQN 149	3.66	0.02	0.32	38.00	0.10
	WQN 179	0.97	0.02	0.06	30.00	0.03

Table 3-12. PADEP point source stream monitoring

		Total Phosphorus mg/l Range		**Diss. Oxygen** mg/l Range		**Ammonia as N** mg/l Range		**pH** Std Units Range	
		From	To	From	To	From	To	From	To
Brandywine Creek									
W. Branch	Station 1	0.02	0.28	7.60	15.10	<0.02	0.27	7.02	8.45
	Station 2	0.04	3.40	9.10	15.50	<0.02	0.22	6.97	9.13
	Station 3	0.03	0.26	8.50	15.50	<0.02	0.15	7.42	9.17
E. Branch	Station 4	<0.02	0.12	8.10	13.40	<0.02	0.11	7.08	9.10
	Station 5	0.04	0.31	8.50	15.70	<0.02	0.11	7.53	8.33
	Station 6	0.03	0.28	7.90	15.20	<0.02	0.12	7.05	8.84
MainStem	Station 7	0.03	0.31	6.20	15.30	<0.02	0.15	7.09	8.26
Red Clay Creek									
NVF Tributary		0.05	0.37	4.40	17.80	<0.02	0.49	7.55	9.06
Toughkennamon Trib.		0.04	0.34	7.10	17.00	<0.02	0.42	5.93	8.81
Route 82		0.02	0.15	8.00	16.10	<0.02	0.15	6.48	8.71
WQN 150		0.05	0.87	8.00	16.20	<0.02	0.32	7.48	9.24
White Clay Creek									
WQN 149		0.02	0.32	8.10	17.30	<0.02	0.23	7.18	8.96
WQN 179		<0.02	0.06	8.70	14.70	<0.02	0.07	7.09	8.29

Chapter 4 – Stormwater Quality Monitoring

The United States Geological Survey (USGS) completed a stormwater monitoring task for the Christina River Basin during 1998. The purpose of the monitoring plan is to characterize stormwater and nonpoint source pollutant loads from representative land uses in the Christina Basin. The sampling plan is designed to collect pollutant load data over a range of hydrologic conditions - including base flow and high flow. The pollutant data will be input to calibrate a watershed model (HSPF) which will be used to simulate nonpoint source loading for a Total Maximum Daily Load (TMDL) of the Christina Basin.

Appendix B includes the results of the stormwater monitoring task. The stormwater monitoring plan was supervised by the USGS with assistance from the University of Delaware, College of Agriculture. Stormwater sampling was conducted for 6 storms over one year beginning in the fall of 1997. Base flow sampling was conducted for 4 seasons. High flow grab sampling was conducted for 2 seasons. Sampling and laboratory analyses included nutrients, sediment, oxygen-demand constituents, metals, and others. Results of the stormwater monitoring program are included in Appendix B. The USGS installed stormwater sampling stations at the following locations in the Christina Basin:

Large basin sites

One water-quality site was established at a downstream location in each of the four major drainages to represent cumulative loads to the Christina River estuary. These sites are at the gage furthest downstream on the free-flowing or non-tidal reaches of the streams. Data collected at these sites is used to calculate both total loads and concentrations of selected constituents for the one-year study period in each of the streams.

Overall basin nonpoint source water quality sampling sites

1. White Clay Creek near Newark, DE USGS station 01479000 DA = 89.1 $mi.^2$

2. Red Clay Creek near Wooddale, DE USGS station 01480000 DA = 47.0 $mi.^2$

3. Brandywine Creek at Chadds Ford, PA USGS station 01481000 DA = 287 $mi.^2$

4. Christina River at Cooch's Bridge, DE USGS station 01478000 DA = 20.5 $mi.^2$

Subbasins sites having a single, dominant land use

One water-quality site was established for each land-use category. The four primary land-use categories are: urban, residential, agricultural, and forested. Residential and agricultural land uses are further subdivided for a total of 7 categories. Residential is subdivided into sewered and non-sewered uses. Agricultural is subdivided into row crop, livestock, and mushroom uses. Some sites are at existing USGS streamflow-measurement stations. At the other proposed sites, temporary gages were needed to measure streamflow.

Urban nonpoint source water quality sampling site

5. Little Mill Creek near Newport, DE USGS station 01480095 DA = 5.24 mi.^{2} , and use stormwater data for commercial and industrial sites from NPDES study for New Castle County, DE.

Residential, nonpoint source water quality sampling site:

6. Sewered - Unnamed tributary to Valley Creek at U. S. Rt. 30/Fairview Road near East Caln/West Whiteland township line. DA = 1.47 mi.^{2} (need to install gage) and use stormwater data from New Castle County study.

7. Non-sewered - Unnamed tributary to Broad Run north of Rt. 162 and 1.5 mile west of Marshallton. DA = 1.37 mi.^{2} (need to install gage)

Agricultural nonpoint source water quality sampling site:

8. Row crop - Doe Run at Rt. 841 near Springdell. DA = 11.7 mi.^{2} (need to install gage)

9. Livestock - West Branch Brandywine Creek near Honeybrook, PA USGS station 01480300 DA = 18.7 mi.^{2}

10. Mushroom - Trout Run at Rt. 41 at Toughkenamon. DA = 1.31mi.^{2}

Forested nonpoint source water quality sampling site:

11. Marsh Creek near Glenmoore, PA USGS station 01480675 DA = 8.57 mi.^{2}

Chapter 5 – TMDL Modeling

Section 303(d) of the Clean Water Act requires states to develop a list of waterbodies where stream segments do not achieve water quality standards and Total Daily Maximum Loads (TMDLs) are needed for pollutants of concern. The USEPA and the States of Delaware and Pennsylvania have agreed to a consent decree to develop TMDLs for the Christina River Basin according to the following schedule:

Component	Deadline	Agency	Model
Point Source, Low Flow	January 1, 2000	DRBC USEPA	EFDC
Nonpoint Source, High Flow	2004	USGS	HSPF

The TMDL for the Christina Basin will include 3 components:

TMDL = WLA + LA + MOS

Where:

TMDL = The Total Maximum Dail Load which is the maximum amount of a pollutant than can enter a water body without violating water quality standards.

WLA = The Waste Load Allocation which is from point sources such as NPDES wastewater discharges through a low flow, EFDC receiving stream model.

LA = the Load Allocation from nonpoint sources such as stormwater runoff through a high flow, HSPF hydrodynamic and water quality model.

MOS = The Margin of Safety, usually 5 or 10 percent set aside to account for uncertainty in the allocation process.

Point Source Model

The USEPA has retained a contractor, Tetra Tech, to develop the EFDC hydrodynamic and water quality model for the Christina River Basin. The contractor distributed a draft report dated March 1999 which summarizes the development of the EFDC model. This is a receiving stream TMDL model designed to include the NPDES point source discharges in the Basin. The contractor is required to calibrate and verify the model and then turn the model over to the DRBC to develop the point source TMDLs. The DRBC, as an interstate agency, was requested by the DNREC and PADEP to coordinate the development of the TMDLs for both states. The DRBC has retained a consultant from Widener University to utilize the calibrated model to develop the point source TMDLs by the January 2000 deadline. The point source TMDL will be developed for the 7Q10 low flow scenario since this is the watewater assimilation standard adopted by both States. The point source TMDL pollutants of concern in the Christina Basin are low dissolved oxygen, nutrients (nitrogen and phosphorus), bacteria, and toxics (zinc) for certain stream segments. The Water Resources Agency has delivered various GIS map coverages

including watershed boundaries and NPDES dischargers to the contractor to facilitate construction of the TMDL model. During 1999, the USEPA expects to complete the calibration of the model so the DRBC can then develop the point source TMDL loads by January 2000.

Nonpoint Source Model

The USGS is constructing the HSPF Nonpoint source, high flow model for the Christina Basin. The HSPF model will deliver stormwater pollutant loads from the 38 subwatersheds in the Christina Basin to the receiving streams via the EFDC model. The nonpoint source TMDL is due in 2004. During 1998, the USGS assembled the framework of the HSPF model. The USGS is developing the model for a pilot subwatershed B1, the Upper West Branch of the Brandywine Creek at Honeybrook. Once the B1 subwatershed pilot is complete, the USGS intends to continue downstream to develop the model for the remainder of the Christina Basin subwatersheds.

Chapter 6 – Public Education/Outreach

During 1998, the Brandywine Valley Association held four Christina Task Force meetings, one of which was a bus tour of sites in the basin where management practices had been installed or are to be installed. The Christina Basin Task Force is the public outreach arm of the watershed strategy and includes nonprofit watershed organizations, the public water suppliers and wastewater dischargers. In addition to these meetings, the public was made more aware of the Christina Management Program through a brochure that received further distribution during 1998 and a newsletter which was circulated through mailing lists provided by both local agencies and private organizations. In addition, a series of Basin Scapes were distributed widely by many organizations through their individual offices as well as at public events. By the end of the year, plans for a conference on June 17, 1999 had become more defined with the expectation that the conference would take place in the coming year (Appendix C).

This pretty much sums up the main activity. While it is not a lengthy report, word is getting out among residents in the basin and that we will continue to convey information on the project in a variety of ways in 1999.

Also during 1998, the University of Delaware, Water Resources Agency developed a web site at www.wr.udel.edu that summarizes the activities of the Christina Basin Water Quality Management Strategy. Staff at the University of Delaware spoke on the Christina Basin Strategy at conferences held by the American Water Resources Association in Matamoras, PA and the Riverfront Development Corporation in Wilmington, DE.

Chapter 7 – BMP Implementation Projects

Chester County, Pennsylvania

The Chester County Conservation District managed the following BMP implementation projects which are designed to protect the water quality of the Christina Basin:

Buck Run Creek Streambank Stabilization Demonstration

Buck Run, a tributary of the West Branch of the Brandywine Creek, flows generally from north to southeast in western Chester County. In Sadsbury Township, Buck Run has a fairly high gradient, traversing through forests with large exposed boulders. As the stream nears Rt. 340 it encounters a man-made encroachment, the raised Philadelphia-Harrisburg rail line. The stream channel makes two 90-degree turns in being directed into a tunnel under the railroad tracks. The land along this stretch of stream is a dedicated Township Park in Sadsbury Township. It is used by hundreds of fishermen during the trout season. PA Fish Commission stocks this portion of the stream so there is always good fishing. Stream front in the park is one of the only public lands where fishermen have free access. The stream banks in this area, however, have been eroding and in some cases 6 and 7-ft eroded banks are exposed. The township supervisors were interested in stabilizing the banks, to improve water quality, asthetics, and to limit liability in the park for an attractive nuisance. The Supervisors requested this project to be a Christina Water Resource Demonstration Project.

Natural Resources Conservation Service, PA DEP Southeast Regional Office, PA Fish and Boat Commission, Sadsbury Township's consulting engineer, and the Conservation District provided technical assistance in preparing the stabilization plan. The proposal called for the stabilization on the west side of the stream to consist of sloping the banks at least a 2:1 slope, removal of debris, and stabilization with grasses and native trees. Because of velocities and erosive conditions, the eastern bank where the stream is forced into a 90 degree turn could not be stabilized using only soft engineering. Concrete blocks, made with extra concrete at a local plant, were stacked four high to protect the bank during regular and high flows. The ground above the concrete blocks was reshaped to a 3:1 slope, and stabilized with seed, mulch, and Erosion Control Blankets. The Township Road Crew operated township equipment to complete a 150 lineal feet of streambank stabilization on both banks. Some tree seedlings from the PA Releaf Program were planted. The township is planning additional plantings in the future.

Buck Run Farm Protected Stream Crossing

William Elkins, owner of Buck Run Farm, has a beef cow operation on part of the original Buck and Doe Valley Farms, also known as The King Ranch. Most of this farm is under easement to the Brandywine Conservancy. Mr. Elkins has been a conservation innovator with this operation. He was an early practitioner of intensive rotational grazing. He has also experimented with warm season grass in his rotation. Mr. Elkins installed a protected agricultural crossing on Buck Run to allow his cows to cross the creek with minimal impact. The crossing consists of utilizing 3 4'X12' concrete slats filled with R-3 rock and fines for bedding. The area now protected previously was a used crossing that had deteriorated from use and erosion. Mr. Elkins previously had fenced the stream out from access by his livestock.

Henry J. Stoltzfus Demonstration Project

Mr. Stolzfus owns and operates a dairy farm in the Brandywine watershed just outside of Honey Brook in Honey Brook Township. Presently the Stolzfus farm houses roughly 55 milking cows with possibly another 10 head of young stock on the property. In the early fall of 1998, Mr. Stolzfus received a Christina Basin Demonstration Project Grant. The grant was used to improve the barnyard runoff treatment by installing a 30 foot long by 12 inch diameter pipe to direct the runoff (from the barnyard) to the pasture and control excessive erosion. Six hundred feet of field land were also stabilized using crushed asphalt. This field lane serves as an access road from the manure pit to the fields.

New Castle County, Delaware

The New Castle Conservation District and the USDA Natural Resources Conservation Service, Newark, DE field office installed the following BMP implementation projects in the New Castle County portion of the Christina Basin during 1998:

Hy-Point Dairy Waste Storage and Irrigation System

The Dairy facility is located in northern New Castle County, DE within the Brandywine watershed, east of Granogue and west of Route 202. The facility is a milk processing plant that provides milk and cream products to the local area. The wash water was handled by an on-site septic system that has been in failure, causing sporadic discharges into a small tributary of the Brandywine Creek. Technical and financial assistance was provided by both State and Federal programs to install a waste storage structure and an irrigation system for waste delivery. The plant currently has the ability to store the wash water for a 3-month period and irrigates on adjacent hay land when soil conditions and crop growth permit. The hay crop is removed which continually removes nitrogen and phosphorus from the soil complex. The biological oxygen demand from the wash water is treated by the soil microorganisms thus removing any threat to the nearby Brandywine Creek.

White Chapel Storm Water Management Basin

Improvements were made to the existing stormwater management facility located behind White Chapel Retirement Village, Marrows Road, in the City of Newark, DE. Runoff from the site drains to Cool Run, a tributary of the White Clay Creek. New construction on the site heightened concerns about runoff and additional sediment in the stream. The basin modifications will detain more runoff, allowing sediments to filter out in the pond prior to discharge into Cool Run. Planning efforts are also underway to increase the riparian buffer along the stream. Cooler water temperatures and less turbidity will enhance both aquatic habitat and the quality of the water entering the White Clay Creek.

Chapter 8 – Related Watershed Management Activities

The foundation of the Christina Basin Water Quality Management Strategy are 2 watershed management programs underway in the Pennsylvania and Delaware portions of the Basin. The challenge is to integrate and coordinate these programs on a total watershed basis between the two States and minimize the potential for duplication and redundancy in work effort.

Chester County Water Resources Management Plan

In a separate but coordinated effort, Chester County Water Resources Authority and cooperating agencies proceeded with preparation of the County-wide Water Resources Management Plan as one of 3 functional plans being prepared under the County's *Landscapes* implementation programs. This effort is developing a County-wide technical and management framework for integrated water resources management throughout all of the County's 19 watersheds.

The Plan is based on the premise of sustaining, to the degree possible, the water quality and water balances of the County's watersheds. It is designed to provide municipalities and other stakeholders with the technical information, techniques, strategies and prioritizations to support decision making in a manner that will preserve the County's water resources and balance the needs of all users while accommodating planned growth.

The Plan will integrate the goals of natural resources preservation, water utilization, and wastewater discharge planning and management. The Plan will address the preservation of the quality and quantity of ground water and surface waters as an inter-connected resource. The Plan is based on the sub-basin management principles and approach established by the Delaware River Basin Commission's regulations for the Ground-Water Protected Area of Southeast Pennsylvania, as adopted by DRBC in 1998.

In 1998, the CCWRA worked with the County's Water Resources Task Force to complete the general scope of the Plan, and based on that scoping, to solicit and select a technical consultant team. Substantial efforts were conducted to pursue supplemental grant funding for the project through various state and private sources.

As part of the public outreach efforts involved with the Plan, CCWRA conducted over 15 public presentations to provide public education on the need for integrated and comprehensive watershed management. This included a presentation to the Annual Conference of the Chester County Association of Township Officials, several individual municipalities, conservation and watershed associations, and civic groups.

In addition, under contract to CCWRA, the USGS completed a GIS sub-basin model for all the watersheds of which Chester County is a part. The geographic coverage of this GIS model extends beyond the borders of Chester County into Lancaster County (Brandywine and Octoraro Creek watersheds), Maryland (Big and Little Elk Creeks, Northeast Creek), Delaware (Brandywine, Red and White Clay Creeks), and Delaware County (Chester Ridley, Crum and Darby Creeks).

This GIS database is designed to quantify low flow statistics for each sub-basin based on the hydrogeologic characteristics of sub-basin. These statistics will be used as sub-basin management targets for maximum cumulative withdrawals. The GIS model includes delineation of the County's watersheds as sub-basins of approximately 25 sq. miles in size. It includes County-wide coverages of public water and wastewater service areas, census block data, detailed and generalized geology, hydrography, physical features and political boundaries.

The sub-basins delineated in the GIS database will also be used for the nonpoint source runoff assessments, source water evaluations, and other exercises to be conducted during development of the Plan. Appendix D contains a brochure that explains more about the CCWRA program.

The following initiatives were underway in Chester County during 1988:

- CCWRA/USGS FY99 Biological Stream Conditions Monitoring in Brandywine, Red Clay, and White Clay Creeks

- CCWRA/USGS Continued Stream Gages, Brandywine Creek

- CCWRA/USGS Groundwater Level Monitoring and Groundwater Quality Monitoring

- CCWRA/USGS FY99 Continuous Stream Water Quality Monitoring - Brandywine Creek Watershed

- CCWRA/USGS FY99 Investigation of Sources of Bacteria in Brandywine Creek Watershed and In-Stream Bacteria Monitoring

- Chester County Water Resources Management Plan
  NPS Source Loading Analysis
  Riparian Corridor Land Use/Vulnerability Analysis
  Water Balance Analysis

- Chester County Open Space Plan

- Chester County Municipal Heritage Park and Open Space Grant Program

- Chester County Preservation Partnership Grant Program

Delaware Piedmont Whole Basin Management Program

The Whole Basin Management approach, developed by the Department of Natural Resources and Environmental Control (the Department), focuses on protecting Delaware's environment by managing it in a comprehensive and coordinated fashion. Using major drainage basins as the chief management units, Whole Basin Management is bringing together the expertise of all the divisions within the Department (Air and Waste Management, Fish and Wildlife, Parks and Recreation, Soil and Water Conservation, Water Resources, and Office of the Secretary), as well as outside agencies like the University of Delaware Water Resources Agency and the New Castle

Conservation District to assess, monitor, and protect the health of Delaware's environment. Whole Basin Management is also working with neighboring states like Pennsylvania in efforts like the Christina Basin Water Quality Management Committee.

The Whole Basin Management approach aims at managing all the biological, chemical, and physical environments of geographic areas in Delaware. These geographic areas have been delineated on the basis of drainage patterns. Whole Basin Management utilizes a phased approach to effectively assess the health of a targeted basin and to develop implementation plans to address environmental problems. The paramount objectives of the process are to protect the environment, improve relations within and outside the Department, maximize wise resource use, and promote environmental education and stewardship.

In 1996, the Piedmont Basin Team, the first of four basin teams, assembled to focus on the six northernmost watersheds in Delaware (Red Clay Creek, White Clay Creek, Brandywine Creek, Shellpot Creek, Naamans Creek and the Christina River). In 1998, the Piedmont Team released the *Piedmont Preliminary Assessment Report* that represents a compilation of data and information as well as key issues of concern and related action items. Since that time, the Piedmont Basin Team has focused on implementing priority recommendations identified in the Piedmont assessment report and other recommendations of statewide significance identified by the other basin teams (i.e., Chesapeake and Inland Bays/Atlantic Ocean teams). The following list identifies Whole Basin initiatives currently underway or completed which relate to the Piedmont Basin.

PCBs in Piedmont Streams

Focused effort concentrating on the lower Christina to develop a pollution control strategy for PCBs that will lead to reduced human health and ecological risks.

- Phase I - Preliminary Assessment and Prioritization
- Phase II - Data Collection and Laboratory Analysis
- Phase III - Hydrodynamic and Water Quality Model
- Phase IV - Pollution Control Strategy

Riparian Corridor Inventory

Walking and boating along all USGS-mapped streams in the Piedmont Basin to collect environmental information and identify priority areas for protection and restoration.

- Inventory riparian areas
- Improve coordination with New Castle County on riparian protection

Upland Forest Protection

- Comparison of current aerial photography and land-use cover data with historical aerial photography to identify existing old growth forests.
- Review status of existing forests in the Piedmont and prioritize areas for protection and restoration

Conservation Management Plans

- Experienced Conservation Planner working with state and federal agencies to develop conservation management plans for agricultural lands.
- Develop conservation management plans for state and federal lands

Delaware's Watershed Education Program

-
- Development of a watershed unit specific to Delaware to be used by the Delaware Middle Schools
- Delaware's Department of Education has adopted "Understanding the Importance of Protecting Delaware's Watersheds" as part of 7th grade science curriculum

Surface Water Nutrient Loading

- Evaluation non-point source nutrients from lawn care specialists and develop management plans
- Survey of nutrient management practices by golf courses and lawn-care companies

Domestic Septic Mapping

- Identification of non-point pollutant septic sources
- Approximate locations of all domestic septic systems (first GIS coverage from 1992 aerials; second GIS coverage from 1997 aerials) - Completed

Site Index Database

- Statewide identification of known or potential contaminant sources
- Locations of known and potential contaminant sources (e.g., UST, Superfund, Animal Feeding Operations, NPDES, Large Septic, Landfills, etc.) with listing of site contaminants (e.g., nutrients, bacteria, petroleum, organics, pesticides/herbicides, PCBs, heavy metals, other organics).

Fish Contaminant Advisory Committee

- Provide data and information and assist in the advisory evaluation and determination process.

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Appendix A

NPDES DISCHARGE, STREAM GAGE, AND STREAM WATER QUALITY MONITORING STATIONS

APPENDIX A - STREAM GAGES

Christina Basin Water Quality Management Strategy

May 21, 1998

USGS Gage	Description	Watershed	Subwatershed	State	County	Latitude	Longitude	D A (sq mi)	Period of Record	Streamflow/Water Quality
1480400	Birch Run near Wagontown, PA	Brandywine Creek	Birch Run	PA	Chester	400138	755043	4.55	2/95-Present	SF
1480300	WB Brandywine Creek near Honeybrook, PA	Brandywine Creek	WB Brandywine Creek	PA	Chester	400422	755140	18.7	6/60 - Present	SF
1480685	Marsh Creek near Downingtown	Brandywine Creek	Marsh Creek	PA	Chester	400319	754300	20.3	6/73-Present	SF
1480684	Marsh Creek Reservoir near Downingtown	Brandywine Creek	Marsh Creek	PA	Chester	400324	754306	20.1	11/73 - Present	SF
1480675	Marsh Creek near Glenmoore, PA	Brandywine Creek	Marsh Creek	PA	Chester	400552	754431	8.57	7/66-Present	SF
1480700	EB Brandywine Creek near Downingtown, PA	Brandywine Creek	EB Brandywine Creek	PA	Chester	400205	754232	60.6	10/65 - Present	SF/WQ
1480500	WB Brandywine Creek at Coatesville, PA	Brandywine Creek	WB Brandywine Creek	PA	Chester	395908	754940	45.8	10/43 - 12/51, 1/70 - Present	SF/WQ
1480887	Valley Creek at Ravine Rd near Downingtown, PA	Brandywine Creek	Valley Creek	PA	Chester	395955	753952	14.5	10/89 - Present	SF
1480617	WB Brandywine Creek at Modena, PA	Brandywine Creek	WB Brandywine Creek	PA	Chester	395742	754806	55	1/70 - Present	SF/WQ
1480870	EB Brandywine Creek below Downingtown, PA	Brandywine Creek	EB Brandywine Creek	PA	Chester	395807	754025	89.9	2/72 - Present	SF/WQ
1481000	Brandywine Creek at Chadds Ford, PA	Brandywine Creek	MS Brandywine Creek	PA	Delaware	395211	753537	287	8/11 - 9/53, 10/62 - Present	SF/WQ
1479820	Red Clay Creek near Kennett Square, PA	Red Clay Creek	MS Red Clay Creek	PA	Chester	394900	754131	28.3	1/88 - Present	SF
1478245	White Clay Creek near Strickesville, PA	White Clay Creek	MS White Clay Creek	PA	Chester	394452	754614	50	7/96 - Present	SF
1479197	Mill Creek at Mill Creek Road at Hockessin, DE	White Clay Creek	Mill Creek	DE	New Castle	394648	754149	3.66	10/89 - 1/95	SF
1480000	Red Clay Creek at Wooddale, DE	Red Clay Creek	MS Red Clay Creek	DE	New Castle	394552	753808	47	4/43 - Present	SF
1481500	Brandywine Creek at Wilmington, DE	Brandywine Creek	MS Brandywine Creek	DE	New Castle	394609	753425	314	10/46 - Present	SF
1480095	Little Mill Creek near Newport, DE	Christina River	Little Mill Creek	DE	New Castle	394354	753614	5.24	10/90 - 9/95; 8/97 - Present	SF
1480015	Red Clay Creek near Stanton, DE	Red Clay Creek	MS Red Clay Creek	DE	New Casle	394255	753828	52.4	10/88 - Present	SF
1478650	White Clay Creek at Newark, DE	White Clay Creek	MS White Clay Creek	DE	New Castle	394120	754458	69	3/94 - Present	SF
1479000	White Clay Creek near Newark, DE	White Clay Creek	MS White Clay Creek	DE	New Castle	394147	754031	89.1	/31-9/36, 6/43-9/57, 10/59-Presen	SF
1478000	Christina River at Cooches Bridge, DE	Christina River	Christina River above Smalley's Pond	DE	New Castle	391814	754342	20.5	4/43 - Present	SF
1481602	elaware River below Christina River at Wilmington, DE	Christina River	Tidal Christina River	DE	New Castle	394300	753103	565	1983 - 1991, 1995 - 1996	SF
1480065	Christina River at Newport, DE	Christina River	Tidal Christina River	DE	New Castle	394238	753633	234	1995 - Present	SF

Appendix A - STREAM WATER QUALITY MONITORING STATIONS
Christina Basin Water Quality Management Strategy
May 21, 1998

Map Ref No	STORET No	Watershed	Subwatershed	Location	State	County	Latitude	Longitude
B1		Brandywine Creek	EB Brandywine Creek	Route 30 Bridge above Downingtown	PA	Chester	400205	754231
B2		Brandywine Creek	EB Brandywine Creek	Route 322 Bridge below Downingtown	PA	Chester	395807	754025
B3		Brandywine Creek	EB Brandywine Creek	Route 842 Bridge at Mouth of East Branch	PA	Chester	395530	753847
B4		Brandywine Creek	WB Brandywine Creek	Route 30 Bridge above Coatesville	PA	Chester	395910	754940
B5		Brandywine Creek	WB Brandywine Creek	Strasbrug Road Bridge below Coatesville	PA	Chester	395741	754808
B6		Brandywine Creek	WB Brandywine Creek	Route 842 Bridge at Mouth of West Branch	PA	Chester	395534	753949
B7		Brandywine Creek	MS Brandywine Creek	Chadds Ford Stream Gage WQ105	PA	Chester	395211	753536
B8	104051	Brandywine Creek	MS Brandywine Creek	Smith Bridge	DE	New Castle		
B9	104021	Brandywine Creek	MS Brandywine Creek	t 279 Bridge DuPont Exper. Station (USGS Gage 01481500	DE	New Castle		
B10	104011	Brandywine Creek	MS Brandywine Creek	Foot Bridge Brandywine Park	DE	New Castle		
C1	106191	Christina River	EB Christina River	DE Route 273 above Newark	DE	New Castle		
C1.1	106181	Christina River	EB Christina River	DE Route 2 at Elkton Road	DE	New Castle		
C1.2	106171	Christina River	Persimmon Run	Sandy Brae Road	DE	New Castle		
C1.3	106161	Christina River	WB Christina River	DE Route 2	DE	New Castle		
C2	106141	Christina River	MS Christina River	Old Baltimore Pike below Newark (USGS Gage 0147800)	DE	New Castle		
C2.1	106131	Christina River	Muddy Run	Sunset Lake Road	DE	New Castle		
C2.2	106121	Christina River	Belltown Run	Becks Pond Salem Church Road	DE	New Castle		
C2.3	106111	Christina River	MS Christina River	Road 346	DE	New Castle		
C3	106031	Christina River	MS Christina River	Smalley's Dam Spillway	DE	New Castle		
C4	106021	Christina River	Tidal Christina River	Rt 141 Drawbridge Newport (USGS Tide Gage 01480065)	DE	New Castle		
C5	106011	Christina River	Tidal Christina River	US Route 13 at 3rd Street Bridge	DE	New Castle		
C6	091011	Christina River	Tidal Christina River	Port of Wilmington Cherry Island Flats	DE	New Castle		
C7	106281	Christina River	Little Mill Creek	Atlantic Avenue (USGS Gage 01480095)	DE	New Castle		
C7.1	106291	Christina River	Tidal Christina River	Conrail Bridge (USGS Tide Gage 10141602)	DE	New Castle		
R1		Red Clay Creek	EB Red Clay Creek	Old Kennett Road	PA	Chester	394936	754131
R2		Red Clay Creek	WB Red Clay Creek	Hillendale Road	PA	Chester	395131	754357
R3		Red Clay Creek	MS Red Clay Creek	Marshall Bridge Road (WQN 150)	PA	Chester	394900	754131
R3.1	103051	Red Clay Creek	MS Red Clay Creek	Road 252 in Yorklyn	DE	New Castle		
R4	103041	Red Clay Creek	MS Red Clay Creek	Road 258A in Ashland	DE	New Castle		
R5	103031	Red Clay Creek	MS Red Clay Creek	DE Route 48 Wooddale (USGS Gage 01480000)	DE	New Castle		
R5.1	103021	Red Clay Creek	MS Red Clay Creek	Road 332 in Marshallton	DE	New Castle		
R6	103011	Red Clay Creek	MS Red Clay Creek	DE Route 4 at Stanton Bridge (USGS Gage 01480015)	DE	New Castle		
R7	103061	Red Clay Creek	Burroughs Run	Confluence with Red Clay Creek - Road 241 Bridge	DE	New Castle		
W1		White Clay Creek	EB White Clay Creek	London Tract Road Bridge	PA	Chester		
W2		White Clay Creek	WB White Clay Creek	London Tract Road (WQN 179)	PA	Chester	395130	754701
W3		White Clay Creek	MS White Clay Creek	Creek Road (WQN 149)	PA	Chester	394459	754612
W4	105031	White Clay Creek	MS White Clay Creek	Chambers Rock Road	DE	New Castle		
R4.1	105041	White Clay Creek	MS White Clay Creek	DE Route 72 Bridge	DE	New Castle		
R4.2	105021	White Clay Creek	MS White Clay Creek	DE Route 2 Bridge near Newark	DE	New Castle		
W5	105151	White Clay Creek	MS White Clay Creek	DE Park Race Track (USGS Gage 01479000)	DE	New Castle		
W6	105011	White Clay Creek	MS White Clay Creek	Stanton, Old Route 7 Bridge	DE	New Castle		
W7	105071	White Clay Creek	MS White Clay Creek	Above Mill Creek Confluence below Route 4	DE	New Castle		
W8	105101	White Clay Creek	Pike Creek	Upper Pike Creek Road	DE	New Castle		
W9	105131	White Clay Creek	MS White Clay Creek	Middle Run Confluence - Possum Park Road	DE	New Castle		

APPENDIX A - NPDES DISCHARGES
Christina Basin Water Quality Management Strategy
May 21, 1998

Permit No	Owner	Watershed	Stream	State	County	Latitude	Longitude	Reissue Date	Ind/Com/Mun	Flow Limit (mgd)	Description
DE 50962	AMTRAK	Brandywine Creek	TB-Brandywine Creek	DE	New Castle	394416	753125	1997	Industrial		Stormwater
DE 51004	Boeing	Christina River	Nonesuch Creek	DE	New Castle	394105	753621	2001	Industrial		Stormwater
DE 00400	Ciba-Geigy Corp.	Christina River	Christina River	DE	New Castle	394238	753638	2001	Industrial		Cooling Water
DE 00566	DuPont Chestnut Run	Christina River	Little Mill Creek	DE	New Castle	394458	753622	1997	Industrial		Stormwater/Cooling Water
DE 00191	FMC Corp.	White Clay Creek	Cool Run	DE	New Castle	394056	754310	1997	Industrial	0.0300	Stormwater/Cooling Water
DE 00523	General Motors Assembly	Christina River	Little Mill Creek	DE	New Castle	394341	753639	1997	Industrial	2.8000	Stormwater
DE 21709	Greenville Country Club	Red Clay Creek	TB-Red Clay Creek	DE	New Castle	394854	753710	2001	Municipal	0.0150	Small STP
DE 00230	Hercules, Inc.	Red Clay Creek	Red Clay Creek	DE	New Castle	394522	753804	2001	Industrial	0.3500	Cooling Water
DE 00451	NVF, Yorklyn	Red Clay Creek	Red Clay Creek	DE	New Castle	394824	754025	1997	Industrial	2.1700	Stormwater/Cooling Water
DE 21768	Winterthur	Brandywine Creek	Clenney Run	DE	New Castle	394824	753605	1997	Municipal	0.0250	Small STP
PA 53783	Avon Grove School Dist	White Clay Creek	TB-WB White Clay Creek	PA	Chester	394753	755251	2000	Commercial	0.0200	Small STP
PA 52019	Avon GroveTrailer Court	White Clay Creek	EB White Clay Creek	PA	Chester	394925	754903	2001	Municipal	0.0075	Small STP
PA 25488	Avondale Borough Sewer Authority	White Clay Creek	Indian Run	PA	Chester	394918	754706		Municipal	0.3000	Large STP
PA 43982	Broad Run Sew Co.	Brandywine Creek	EB Brandywine Creek	PA	Chester	395840	754100		Municipal	0.4000	Large STP
PA 29343	Chatham Acres	White Clay Creek	TB-EB White Clay Creek	PA	Chester	395222	754903		Municipal	0.0270	Small STP
PA 53821	Chester County Aviation Inc.	Brandywine Creek	Sucker Run	PA	Chester	395851	755204		Commercial		Stormwater
PA 26859	Coatesville City Authority	Brandywine Creek	WB Brandywine Creek	PA	Chester	395823	754927		Municipal	3.8500	Large STP
PA 31097	Radley Run C.C.	Brandywine Creek	Radley Run	PA	Chester	395448	753703		Municipal	0.0170	Small STP
PA 55425	D'Ambro Anthony, Jr. - Lot #22	Red Clay Creek	TB-EB Red Clay Creek	PA	Chester	394957	753901		Municipal	0.0005	Single Residence STP
PA 26531	Downingtown Area Regional Authority	Brandywine Creek	EB Brandywine Creek	PA	Chester	395403	754641	2001	Municipal	7.0000	Large STP
PA 36374	Eaglepoint Dev. Assoc.	Brandywine Creek	TB Marsh Creek	PA	Chester	400421	754126	2001	Municipal	0.0150	Small STP
PA 53554	Earthgro, Inc.	Red Clay Creek	WB Red Clay Creek	PA	Chester	394938	754519		Industrial		Stormwater
PA 55107	East Marlborough Township STP	Red Clay Creek	TB-EB Red Clay Creek	PA	Chester	395141	754052	1998	Municipal	0.1500	Large STP
PA 29912	Embreeville Hospital	Brandywine Creek	WB Brandywine Creek	PA	Chester	395559	754329		Municipal	0.2000	Large STP
PA 54356	Getty Petroleum Corporation	White Clay Creek	TB-EB White Clay Creek	PA	Chester	395004	754941		Industrial	no discharge since 1992	Small STP
PA 53228	Gramm, Jeffery	Brandywine Creek	WB Brandywine Creek	PA	Chester	395651	754033		Municipal	0.0005	Single Residence STP
PA 50458	Little Washington Drainage Co.	Brandywine Creek	Culbertson Run	PA	Chester	400248	754633	2002	Municipal	0.0531	Small STP
PA 57126	Hess Oil - SS #38291	Brandywine Creek	Valley Run	PA	Chester	395946	754450		Commercial		DP
PA 44776	NW Chester Co. Municipal Authority	Brandywine Creek	WB Brandywine Creek	PA	Chester	400420	755150	2002	Municipal	0.6000	Large STP
PA 50547	Indian Run Village MHP	Brandywine Creek	Indian Run	PA	Chester	400414	754832	1998	Municipal	0.0375	Small STP
PA 51365	West Chester Area Municipal Authority	Brandywine Creek	EB Brandywine Creek	PA	Chester	395149	753906	2001	Municipal	0.3690	Ingram's Mill - Filter Backwash
PA 53937	Johnson, Ralph & Gayla	Brandywine Creek	Broad Creek	PA	Chester	395900	753830		Municipal	0.0005	Single Residence STP
PA 24058	Kennett Square Boro. WWTP	Red Clay Creek	WB Red Clay Creek	PA	Chester	395010	754330		Municipal	1.1000	Large STP
PA 55531	Khalife, Paul	Brandywine Creek	TB Valley Run	PA	Chester	395915	754505		Commercial	0.0007	Small STP
PA 53678	Lambert, Earl R.	Brandywine Creek	EB Brandywine Creek	PA	Chester	400022	754220		Industrial		DP
PA 36161	Lincoln Crest MHP STP	Brandywine Creek	Buck Run	PA	Chester	395857	755349	1999	Municipal	0.0360	Small STP
PA 53660	Mobil Oil Company #016	Brandywine Creek	EB Brandywine Creek	PA	Chester	400022	754220		Commercial		Air stripper at Service Station
PA 11568	Lukens Steel Co.	Brandywine Creek	Sucker Run	PA	Chester	395828	755008		Industrial	0.5000	Large STP
PA 56324	Mobil SS#16-GPB	Brandywine Creek	TB-WB Valley Run	PA	Chester	400036	753625	2000	Commercial	0.0440	DP
PA 50679	National Vulcanized Fiber (NVF)	Red Clay Creek	TB-WB Red Clay Creek	PA	Chester	395024	754255	2001	Industrial	0.2500	Cooling Water
PA 56618	O'Cornwell, David & Jeanette	Brandywine Creek	Broad Run	PA	Chester	395928?	753838?		Municipal	0.0005	Single Residence STP
PA 52949	Phila. Suburban Water Co.	Brandywine Creek	Marsh Creek	PA	Chester	400442	754250		Industrial		Uwchlan DP
PA40436	Chadds Ford Investment Co./Red Fox GC	White Clay Creek	TB-EB White Clay Creek	PA	Chester	395052	754612		Municipal	0.0090	Small STP
PA 27987	Pennsylvania Turnpike/Caruiel Service Plaza	Brandywine Creek	Marsh Creek	PA	Chester	400706	754617	1997	Commercial	0.0500	Small STP
PA 55697	Spring Run Estates	Brandywine Creek	WB Brandywine Creek	PA	Chester	400229	754747		Commercial	0.0490	Small STP
PA 40665	Stone Barn Restuarant and Apt. Cplx	White Clay Creek	EB White Clay Creek	PA	Chester	395304	754702		Commercial	0.0100	Small STP
PA 54691	Stoltzfus, Ben Z.	Brandywine Creek	TB Brandywine Creek	PA	Chester	400559	755245		Municipal	0.0005	Single Residence STP
PA 53996	Redmond, Michael	Brandywine Creek	TB-WB Brandywine Creek	PA	Chester	395630	754400		Municipal	0.0005	Single Residence STP
PA 36897	South Coatesville Borough	Brandywine Creek	WB Brandywine Creek	PA	Chester	395819	754831	1999	Municipal	0.3900	Large STP
PA 12815	Sunoco Products	Brandywine Creek	EB Brandywine Creek	PA	Chester	400000	754219	2001	Industrial	3.0000	Paper Company - Mill Raceway
PA 54917	Uwchlan Twp. Municipal Authority	Brandywine Creek	Shamona Creek	PA	Chester	400345	754046	2001	Municipal	0.0030	Eagleview CC STP
PA 56073	Vreeland, Russell Dr.	Brandywine Creek	TB Rock Run	PA	Chester	395926	755329		Municipal	0.0005	Single Residence STP
PA 26018	West Chester Borough MUA/Taylor Run	Brandywine Creek	Taylor Run	PA	Chester	395802	753746	2000	Municipal	1.8000	Large STP
PA 34612	Tel Hai Rest Home	Brandywine Creek	Two Log Run	PA	Chester	400338	755306		Commercial	0.0550	Small STP
PA 55492	Topp, John & Jane	White Clay Creek	Indian Run	PA	Chester	400443	754859		Municipal	0.0005	Single Residence STP
PA 52728	Farmland Industries, Inc./Turkey Hill	Brandywine Creek	WB Brandywine Creek	PA	Chester	400012	754838		Industrial		Small STP
PA 30848	Unionville - Chadds Ford Elem. School	Brandywine Creek	Ring Run	PA	Chester	395224	753556		Municipal	0.0063	Small STP
PA 53236	Woodward, Raymond Sr. STP	Brandywine Creek	WB Brandywine Creek	PA	Chester	395651	754033		Municipal	0.0005	Single Residence STP
PA 24066	West Grove Borough Authority STP	White Clay Creek	MB White Clay Creek	PA	Chester	394901	755017	1999	Municipal	0.2500	Large STP
PA 55484	Keating, Herbert & Elizabeth	Brandywine Creek	TB Brandywine Creek	PA	Chester	395158	753500		Municipal	0.0005	Single Residence STP
PA 55476	Birmingham TSA/Ridings at Chadds Ford	Brandywine Creek	TB Harvey Creek	PA	Chester	395155	753312	2001	Municipal	0.0231	Small STP
PA 52663	Knight's Bridge Corp./Villages at Painters	Brandywine Creek	Harvey Run	PA	Chester	395256	753310		Commercial	0.0450	Small STP
PA 55085	Winslow, Nancy Ms.	Brandywine Creek	TB Brandywine Creek	PA	Chester	395200	753525		Municipal	0.0005	Single Residence STP
PA 36200	Radley Run Mews	Brandywine Creek	Plum Run	PA	Chester	395501	753737		Municipal	0.0320	Small STP

PA 50229	Perry Salisbury	Brandywine Creek	Indian Run Creek	PA	Chester				Municipal	0.0005	Single Residence STP
PA 12416	Coatesville Water Plant	Brandywine Creek	Rock Run	PA	Chester	400022	755053		Industrial	0.0750	ater Filtration Plant (Filter Backwash)
PA 53449	Birmingham Twp. STP	Brandywine Creek	Radley Run	PA	Chester	395437	753424	2001	Municipal	0.0230	Small STP
PA 56171	McGlaughlin, Jeffrey	Brandywine Creek	Plum Run	PA	Chester	395538	753624		Municipal	0.0005	Single Residence STP
PA 53082	Mendenhall Inn	Brandywine Creek	TB Brandywine Creek	PA	Chester	395115	753824		Commercial	0.0220	Small STP
PA 52990	Mitchell, Rodney	Brandywine Creek	Rock Run	PA	Chester	395922	755332		Municipal	0.0005	Single Residence STP
PA 52451	Frances L. Hamilton Oates STP	White Clay Creek	EB White Clay Creek	PA	Chester	394641	754622		Municipal	0.0012	Small STP
PA 51918	Pepperidge Farms	Brandywine Creek	Parke Run Creek	PA	Chester	400015	754115		Industrial	0.1440	Cooling Water
PA 56120	Schindler	Brandywine Creek	Pocopson Creek	PA	Chester	395410	753815		Municipal	0.0005	Single Residence STP
PA 47252	Pantos Corp/Painters Crossing	Brandywine Creek	Harvey Run	PA	Chester	395234	753335		STP Non Mun	0.0700	Small STP
PA 30228	Downingtown Ind. And Agricult. School	Brandywine Creek	Beaver Creek	PA	Chester	400523	753928		STP Non Mun	0.0225	Small STP
PA 51497	Lenape Forge Inc.	Brandywine Creek		PA	Chester	395453	753755		No Treatment	0.0300	Cooling Water
PA 53561	Johnson Matthey/Precious Metals	Brandywine Creek		PA	Chester	400145	753459		GWCU	0.0360	
PA 54305	Sun Company, Inc (R&M)/Exton Terminal	Brandywine Creek	Valley Creek	PA	Chester	400145	753645		PMT		
PA 54747	Trans-Materials Inc./West Chester	Brandywine Creek		PA	Chester	395835	753542		SWRO		
PA 56561	Richard M. Armstrong Co.	Brandywine Creek	Broad Run	PA	Chester	395711	754408		SWRO		
PA 57011	Thornbury Twp./Bridlewood Farms	Brandywine Creek	Radley Run	PA	Chester	395454	753608		Municipal	0.0773	Small STP
PA 57045	Shryock Bothers Inc./Dorlans Paper Mill	Brandywine Creek	EB Brandywine Creek	PA	Chester	400253	754259		SWRO		
PA 57231	Shearer Archie and Gloria	Brandywine Creek		PA	Chester	395950	755557		Municipal	0.0005	Single Residence STP
PA 57274	Hughes Michael and Antianette	Brandywine Creek	Marsh Creek	PA	Chester	400352	754139		Municipal	0.0005	Single Residence STP
PA 57282	Pope Jonathon and Susan	Brandywine Creek	Taylor Run	PA	Chester	395740	753800		Municipal	0.0005	Single Residence STP
PA 57339	Davidson, Brian and Cheryl	Brandywine Creek	WB Brandywine	PA	Chester	400626	755504		Municipal	0.0005	Single Residence STP
PA 56171	McGlaughlin Mr. And Mrs Jeffry	Brandywine Creek	Plum Run	PA	Chester	395538	753624		Municipal	0.0005	Single Residence STP
PA 50005	Sun Company, Inc / SS#15-20352	Brandywine Creek	Plum Run	PA	Chester	395612	753527		Municipal	0.1400	GWCU
PA 54755	Trans-Materials Inc./Kennett Square	Red Clay Creek		PA	Chester	395045	754206		SWRP		
PA 56898	TO-JO Mushrooms	White Clay Creek	Trout Run	PA	Chester	394933	754616		Process Water	0.0650	
PA 56952	Sun Company/SS# 0363-1496	White Clay Creek	EB White Clay Creek	PA	Chester	394928	754701			0.0029	
PA 57029	Hewlett Packard/Avondale Facil.	White Clay Creek	Egypt Run	PA	Chester	394802	754450		GWCU	0.1440	GWCU
MD 65145	Highlands WWTP	Christina River	WB Christina River	MD	Cecil				Municipal	0.0500	Small STP
MD 00000	Meadowview Utilities, Inc.	Christina River	WB Christina River	MD	Cecil				Municipal	0.4500	Small STP

Appendix B

STORMWATER MONITORING DATA FROM THE USGS

Nonpoint-Source Water-Quality Monitoring in the Christina River Basin, Pennsylvania and Delaware

The nonpoint-source water-quality sampling plan was executed in 1997-98. The principal objective of the nonpoint-source water-quality sampling plan was to provide streamflow, nutrient, and suspended solids data that can be used to: (1) estimate total loads to the Christina River Basin from point and nonpoint sources for selected constituents -- nitrate, phosphorous, and suspended sediment; (2) estimate concentrations and loads of the selected constituents from various land uses; and (3) calibrate a watershed model of the basin for these selected constituents. The watershed model, Hydrologic Simulation Program--Fortran (HSPF), will be used to simulate the delivery of nonpoint-source contaminants to main-stem streams including the hydrodynamics, chemical reactions, and physical transport in sub-basin streams. This model also can be used to evaluate options for managing contaminants from both nonpoint and point sources and provide a more comprehensive method of calculating nonpoint-source loads to meet total maximum daily load requirements. Data required for this watershed model include concentrations of contaminants of interest over a range of hydrologic conditions, including stormflow and baseflow, in land-use areas that are expected to differ in contribution of nonpoint-source contaminants and hydrologic response.

The nonpoint-source water-quality monitoring plan was designed to provide data on the concentrations and loads of nutrients and suspended solids seasonally during high flow associated with storms and base flow for the whole basin and for selected small areas predominantly covered by one land use. Four downstream sites on the main stems of the Christina River and Brandywine, White Clay, and Red Clay Creeks and seven small basins for land-use characterization (fig. 1; table 1) were monitored. Sites were located at new or existing U.S. Geological Survey (USGS) streamflow-measurement stations (gages).Four new streamflow-measurement stations were constructed and one old streamflow-measurement station was restarted for the study in small sub-basins (table 1). All eleven stations were equipped with automatic samplers for the study.

Data collected include continuous streamflow, water temperature, and water chemistry consisting primarily of dissolved and total nitrogen and phosphorus species and suspended solids concentrations (table 2). Other constituents, such as dissolved organic carbon (DOC) and chlorophyll a, and properties, such as chemical oxygen demand (COD) and biological oxygen demand (BOD), were analyzed to better understand and simulate the chemical processes involving the fate and transport of nutrients. Chloride was measured to provide data on the concentrations of a conservative solute.

Water samples for chemical and suspended solids analysis were collected during six seasonally selected stormflow events and four times during seasonally selected base flow from January to October1998. Storm samples were collected by USGS and the University of Delaware. Baseflow samples were collected by Pennsylvania Department of Environmental Protection and by Delaware Department of Natural Resources and Environment Control (DNREC). DNREC's laboratory in Dover, Del. performed all laboratory chemical analyses. Selected results of analyses are presented in this report.

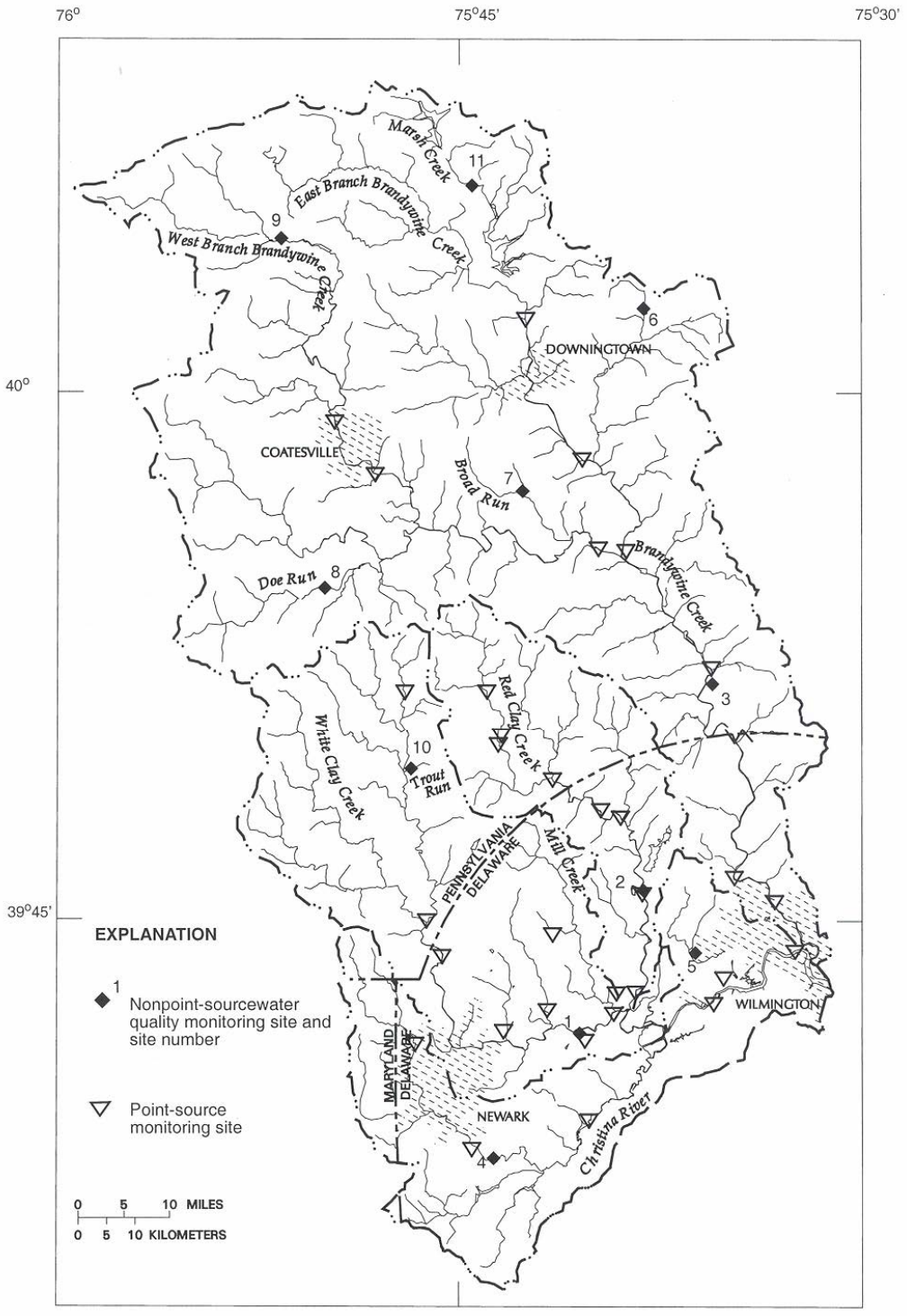


Figure 1.-- Location of nonpoint-source and point-source water-quality monitoring sites in the Christina River Basin, Pennsylvania and Delaware

Table 1. Nonpoint-source water-quality monitoring sites, Christina River Basin, Pennsylvania and Delaware (See figure 1 for location of sites).

Type of nonpoint-source water-quality sampling site	Site code on map	Location	USGS Streamflow-measurement station number	Drainage Area (square miles)
Overall basin mainstem site				
White Clay Creek	1	White Clay Creek near Newark, Del.	01479000	89.1
Red Clay Creek	2	Red Clay Creek near Woodale, Del.	01480000	47.0
Brandywine Creek	3	Brandywine Creek at Chadds Ford, Pa.	01481000	287
Christina River	4	Christina River at Cooch's Bridge, Del.	01478000	20.5
Single land-use basins				
Urban	5	Little Mill Creek near Newport, Del.	01480095[1]	5.24
Residential - sewered	6	Uwclan Run at Exton, Pa.	01480878[2]	1.47
Residential - unsewered (on septic systems)	7	Little Broad Run near Marshallton, Pa.	01480637[2]	1.37
Agricultural - row crop	8	Doe Run above tributary at Springdell, Pa.	014806318[2]	11.7
Agricultural - livestock	9	West Branch Brandywine Creek near Honeybrook, Pa.	01480300	18.7
Agricultural - mushroom	10	Trout Run at Rt. 41 at Toughkenamon, Pa.	01478137[2]	1.31
Forested	11	Marsh Creek near Glenmoore, Pa.	01480675	8.57

[1] Streamflow-measurement station restarted for study

[2] New streamflow-measurement station constructed for study

The stormflow and base-flow events were selected to be representative of seasonal variation due to climate and land use. Timing for the six stormflow events was as follows: two storms in mid to late winter (February and March 1998), one storm in early spring after pre-planting tillage (May 1998), one storm in late spring/early summer after planting of crops (June 1998), one storm in midsummer (July 1998), and one in fall after harvest (October 1998). Sampling was delayed because of dry conditions in the fall of 1997. No samples were collected from frozen-ground runoff and snow-melt events because of the mild winter of 1998. Sampled storms resulted from precipitation events that ranged from about 0.4 to 3.3 inches (in.). For Brandywine Creek at Chadds Ford, Pa. these precipitation events resulted in peak flows with a one-year or less recurrence interval. Base flow was sampled in January, April, July, and September 1998.

Two types of samples, composite and discrete, were collected during storm events. Composite samples were collected by a compositing series of flow-weighted aliquots sampled during most of the high-flow period. Discrete samples were collected at fixed time intervals during the storm event. the discrete samples represent instantaneous concentrations. Concentrations in discrete samples can be much greater than concentrations in composite samples. Figure 2 shows suspended solids concentrations for the composite and discrete samples collected during a storm in June, 1998 at Brandywine Creek at Chadds Ford, Pa.

Table 2. --Constituents in nonpoint-source monitoring samples to be determined by laboratory chemical analysis[1], Christina River Basin, Pennsylvania and Delaware

[mg/L, milligrams per liter; mL, milliliters. Sample preservation - C, chill to 4°C; F, filter; A, acidify to pH <2 with 2 mL concentrated sulfuric acid per liter; An, acidify to pH < 2 with 2 mL concentrated 1:1 nitric acid]

Constituent	STORET code	Method	Reporting limit (mg/L)	Holding time	Sample volume (mL)	Sample preserv-ation
Required constituents or properties for all samples -						
Ammonia nitrogen, dissolved Ammonia nitrogen, total	00608 00610	EPA 350.1	0.002	28 days	5 5	C,F,A C,A
Kjehldahl nitrogen, dissolved Kjehldahl nitrogen, total	00623 00625	EPA 351.2	.05	28 days	40 40	C,F,A C,A
Nitrite plus nitrate nitrogen, dissolved	00631	EPA 353.2	.05	28 days	5	C,F,A
Orthophosphorus, dissolved	00671	EPA 365.1	.005	28 days	5	C,F
Phosphorus, dissolved Phosphorous, total	00666 00665	EPA 365.1	.005	28 days	40 40	C.F.A C,A
Chloride	00940	EPA 325.2	1	28 days	5	none
Specific conductance	90095	EPA 120.1	1 µS/cm	none	10	none
Total suspended sediment - concentration	80154	EPA 160.2	1	7 days	125	C
Total suspended sediment - particle sizes						
Biological oxygen demand (BOD_{20})	00308	EPA 405.1	2.4	48 hours	600	C
Dissolved organic carbon	00681	EPA 415.1	1	28 days	25	C,F,A
Chlorophyll-a[2] Pheophytin	70953	92 STDMTD 10200H	.001	48 hours	100	C,F
Additional metals - 5 sites in Delaware						
Copper, dissolved Copper, total	01040 01042	EPA 220.2	.005	6 months	100	C,F,An C,An
Lead, dissolved Lead, total	01049 01052	EPA 239.2	.003	6 months	100	C,F,An C,An
Zinc, dissolved Zinc, total	01090 01092	EPA 200.7	.010	6 months	200	C,F,An C,An
Additional constituents - 4 downstream-most sites						
Chemical oxygen demand	00340	EPA 410.1, 410.2, 410.3	5.0	28 days	50	C,A
Total organic carbon	00680	EPA 415.1	1	28 days	25	C.A

[1] Specifications for analytical method, reporting limit, holding time, sample volume and preservation provided by the DNREC laboratory.
[2] First storm sampling event, all grab sampling events

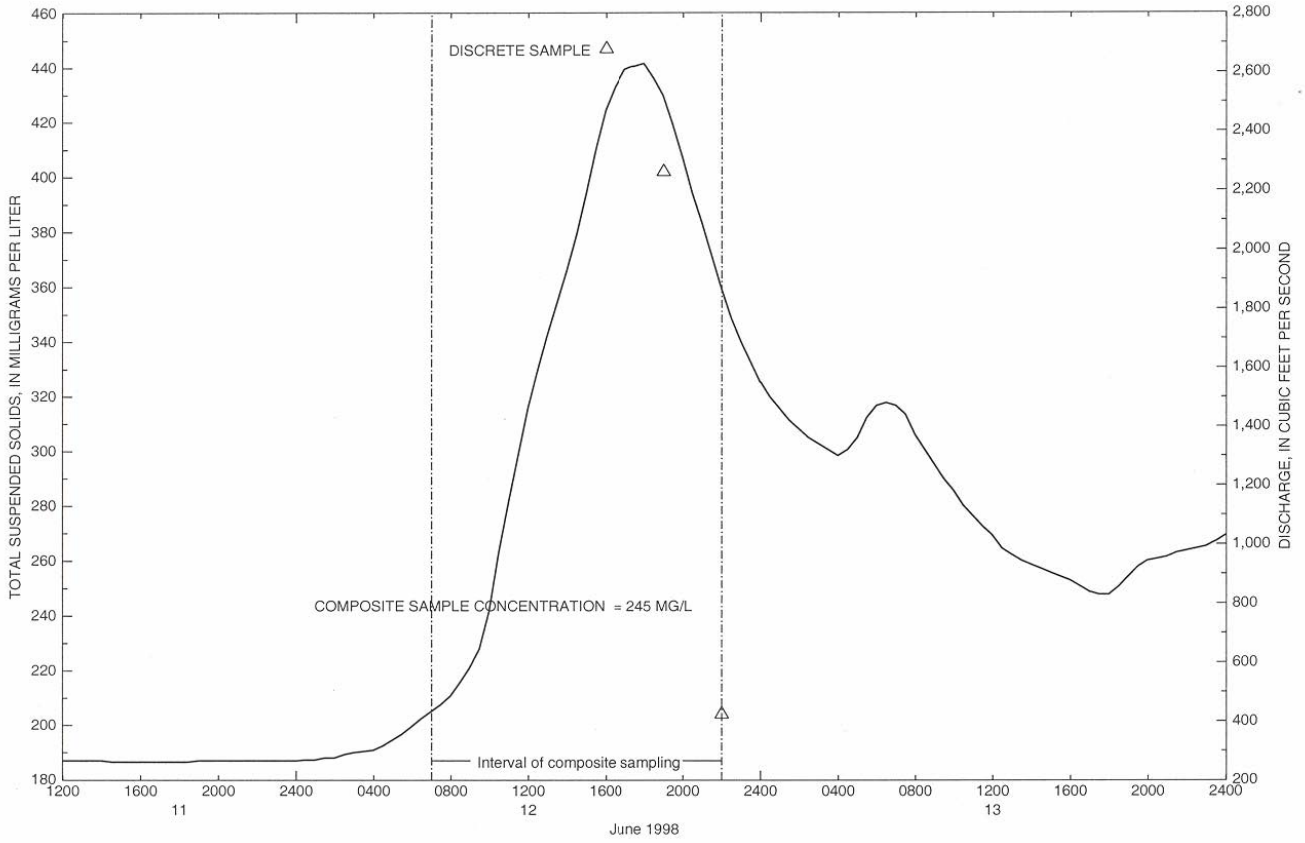


Figure 2.--Concentration of suspended solids in storm samples and stream discharge for Brandywine Creek at Chadds Ford, Pennsylvania, June 12, 1998

Composite samples can be used to estimate loads for a storm event. Boxplots showing the distribution of concentrations of nitrate, phosphorous, and suspended solids are shown in figures 3-5. The distribution and median concentrations of these constituents differ between sampling locations. For example the concentrations of the nitrate, orthophosphate, and suspended solids are less in composite samples from the stream site for the predominantly forested basin (site 11) than from stream sites for agricultural basins (sites 8, 9, and 10) (figs. 3-5).

Differences in baseflow water-quality also were apparent between monitoring sites. Concentrations of nitrate, ammonia, dissolved organic carbon, and orthophosphate for baseflow samples collected on January 12 and April 27,1998 are shown in figure 6. Nitrate concentrations in baseflow were higher in samples from agricultural basins than in samples from most other sites. Concentrations of these constituents appear to differ slightly to moderately between January and April samples.

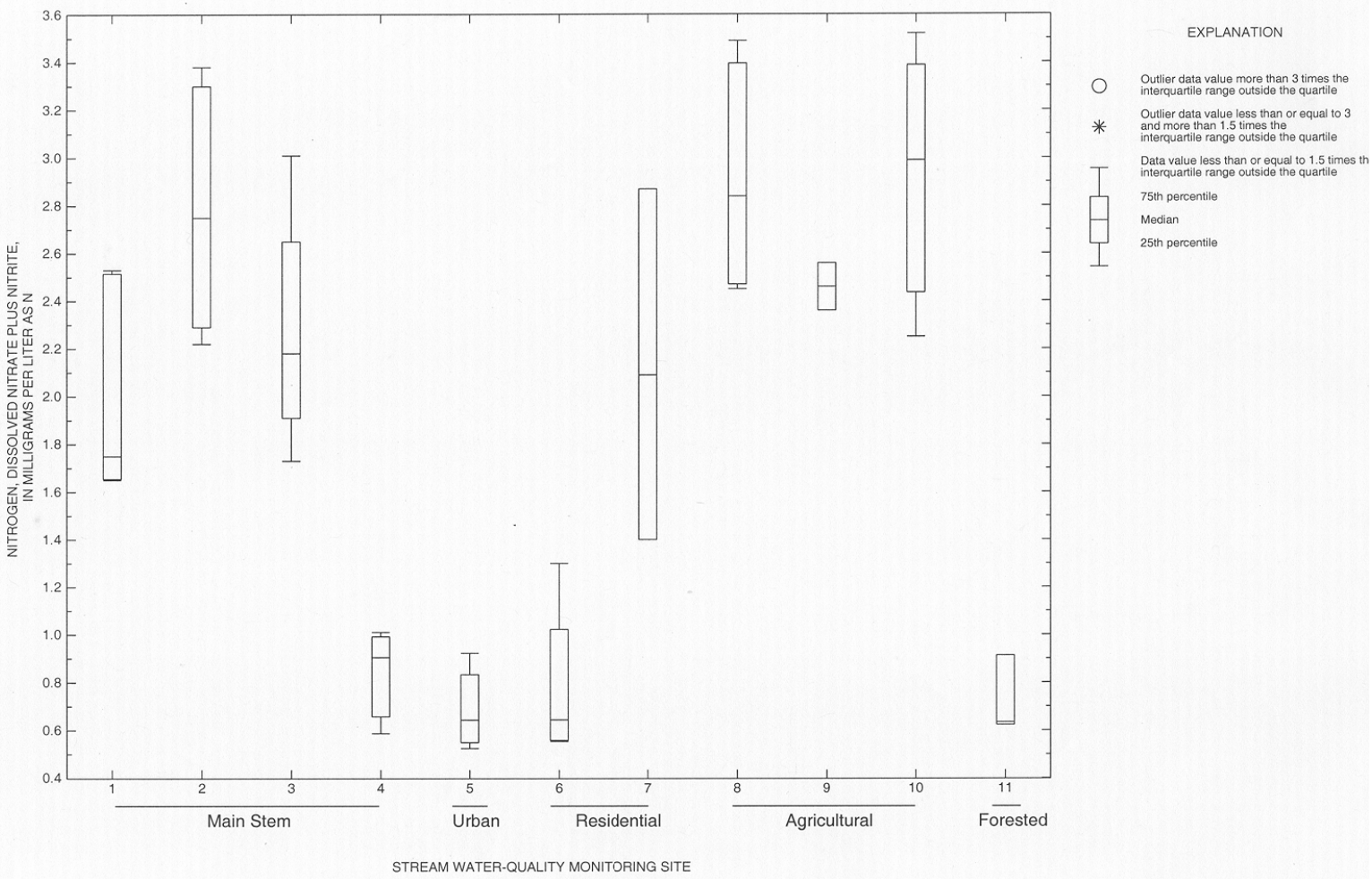


Figure 3.--Concentration of nitrate in composite samples for six storms, Christina River Basin, Pennsylvania and Delaware, 1998. See figure 1 for location of sites.

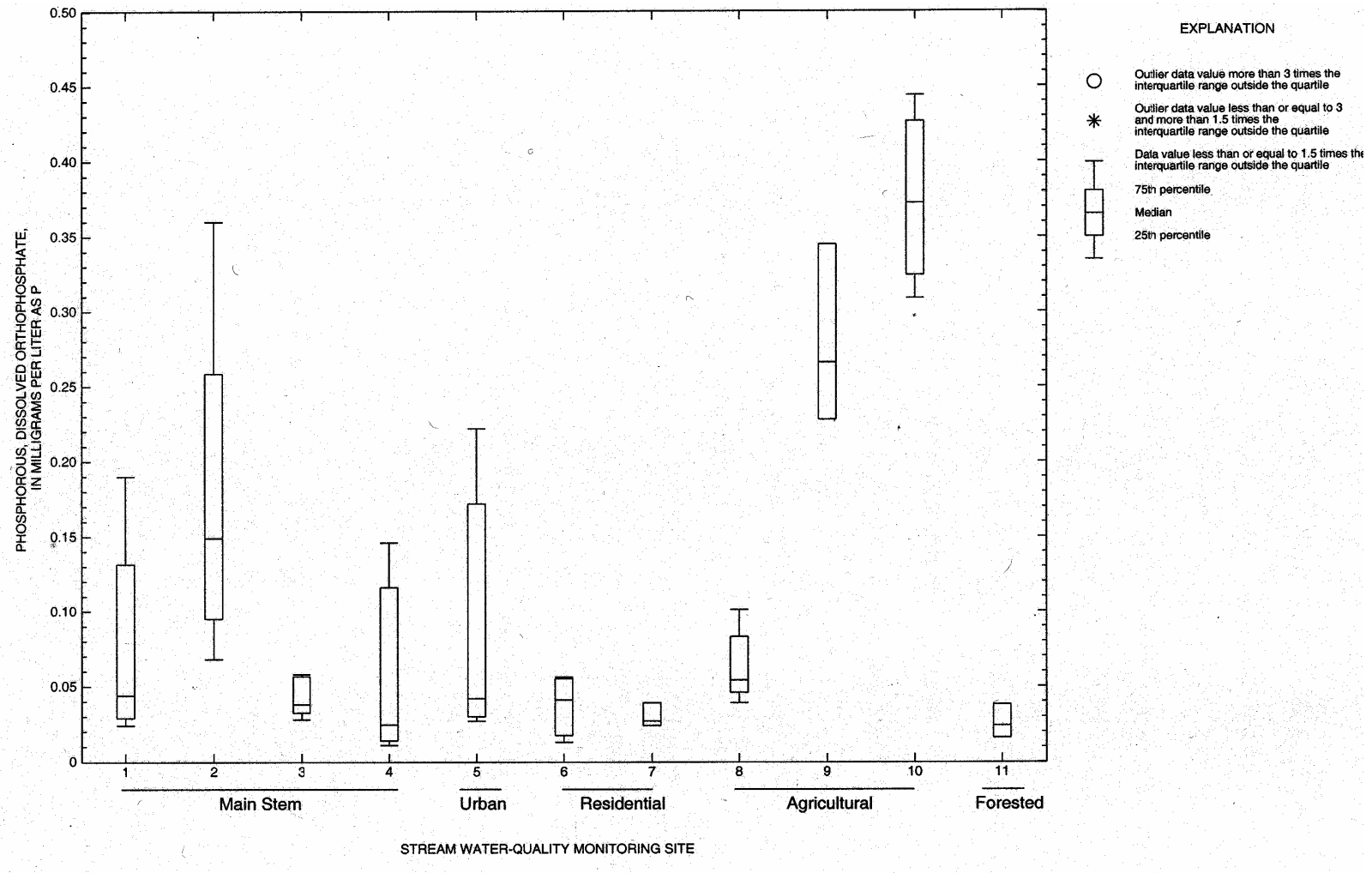


Figure 4.--Concentration of ortho-phosphate in composite samples from six storms, Christina River Basin, Pennsylvania and Delaware, 1998. See figure 1 for location of sites.

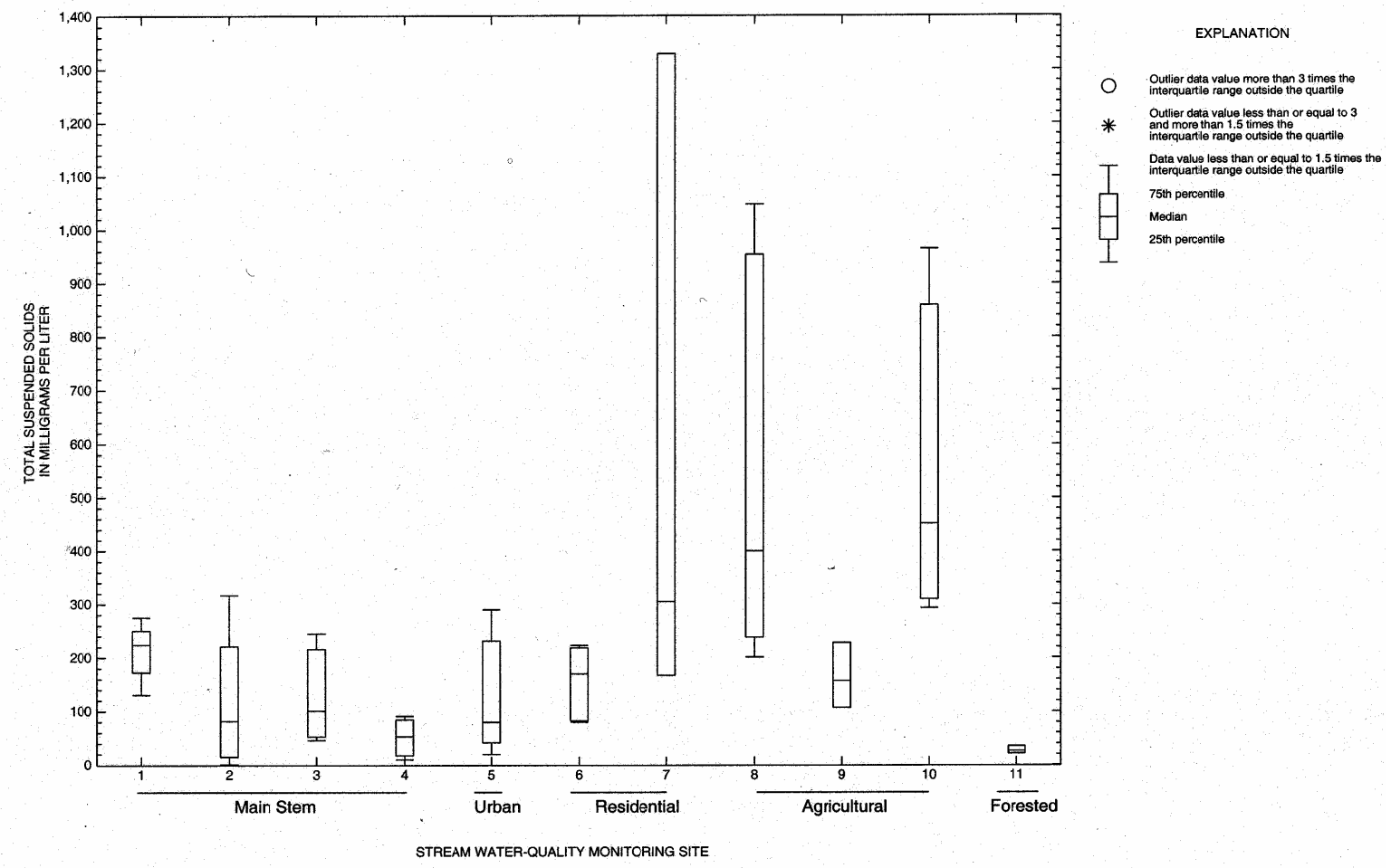
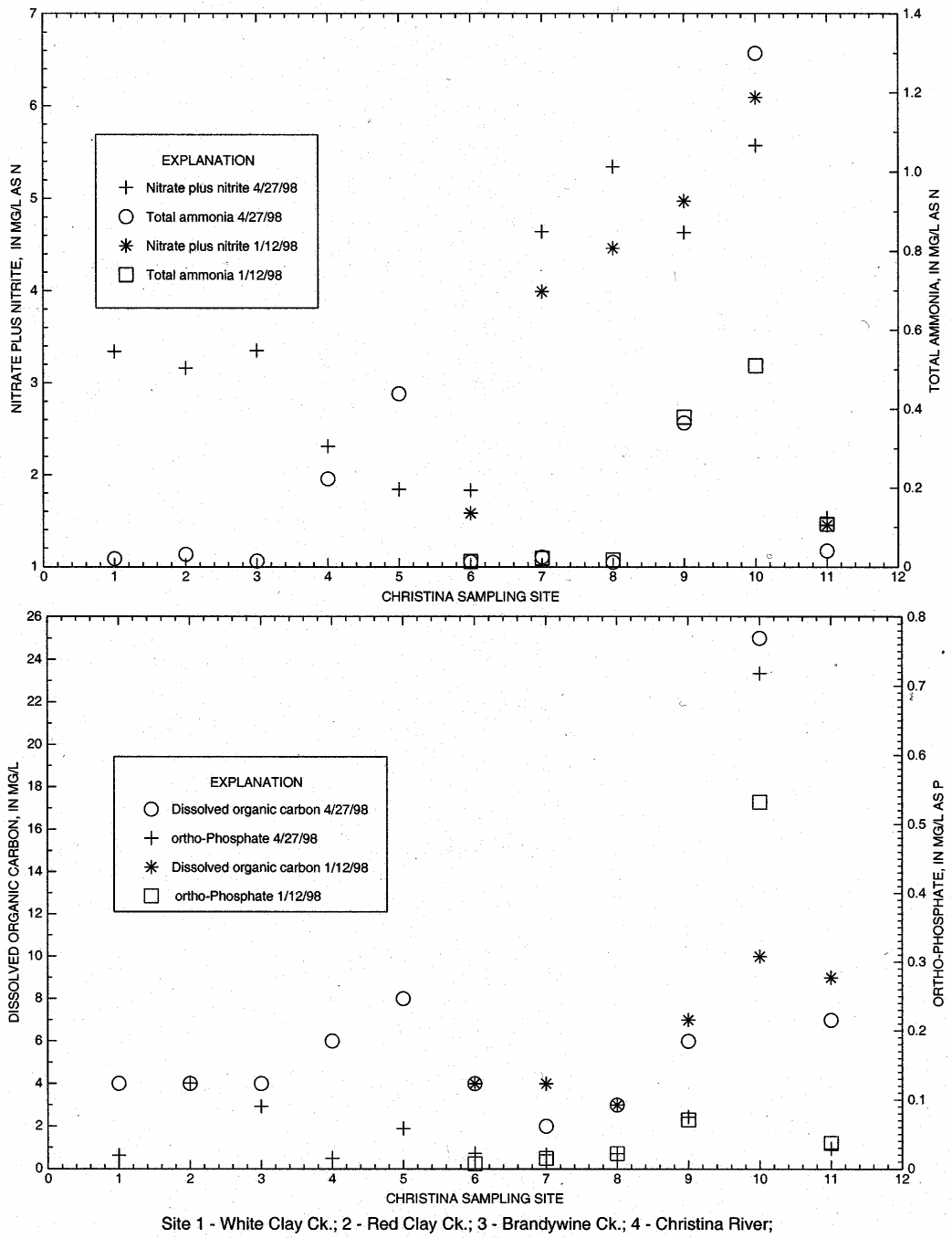


Figure 5.--Concentration of total suspended solids in composite samples from six storms, Christina River Basin, Pennsylvania and Delaware, 1998. See figure 1 for location of sites.

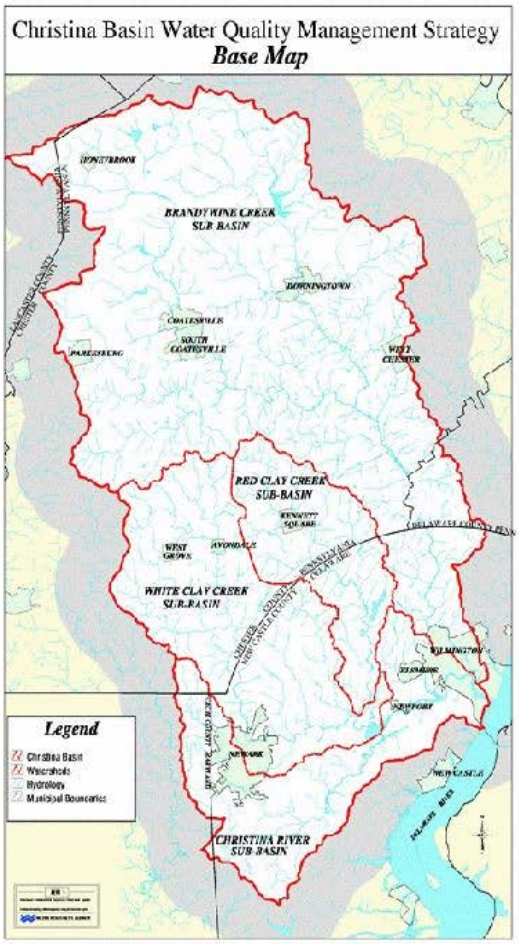


Site 1 - White Clay Ck.; 2 - Red Clay Ck.; 3 - Brandywine Ck.; 4 - Christina River;
5 - Little Mill Ck; 6 - Uwchlan Run; 7 - Broad Run; 8 - Doe Run; 9 - W. Br. Brandywine Ck.;
10 - Trout Run; 11 - Marsh Ck.

Figure 6.--Concentrations of nitrate, ammonia, dissolved organic carbon, and ortho-phosphate in baseflow samples. Christina River Basin, Pennsylvania and Delaware, January 12, 1998 and April 27, 1998. See figure 1 for location of sites.

Appendix C

SELECTED PUBLIC EDUCATION AND OUTREACH MATERIALS



The Christina Clean Water Strategy

THE MISSION:

The mission of the Christina Basin Water Quality Management Strategy is to conduct a cooperative, interstate effort to protect and improve the water quality of streams, waterways, and groundwater in the Brandywine, Red Clay, White Clay Creeks, and Christina River watersheds of Delaware, Maryland, and Pennsylvania.

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West Chester, PA 19382
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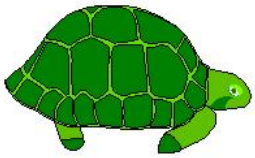
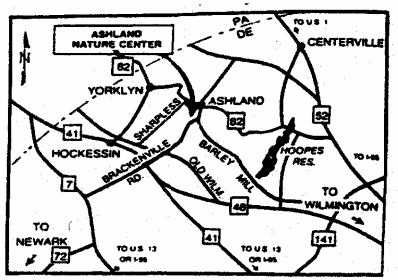
TOP 10 FACTS
DID YOU KNOW THAT THE CHRISTINA RIVER BASIN:

1. Provides 75% of the drinking water supply for New Castle County, DE and 40 % of the water supply for Chester County, PA.
2. Is a source of water supply for the following water purveyors:
   - Artesian Water Co.
   - Wilmington
   - Newark
   - United Water DE
   - Coatesville
   - Downingtown
   - Philadelphia Suburban
   - Kennett Square
   - Avondale/West Grove
3. Occupies 565 square miles and includes 4 major watersheds:
   - Brandywine Creek
   - White Clay Creek
   - Red Clay Creek
   - Christina River
4. Flows through 3 States (DE, MD, and PA) and 5 Counties: Chester Co., PA; Lancaster Co., PA; New Castle Co., DE; and Cecil Co., MD.
5. Is the home for over 0.5 million people in 57 municipalities.
6. Is a watershed where 1/3 of the land is urban/suburban development, 1/3 is agricultural, and 1/3 is open space and forested.
7. Is the home for 2 Revolutionary War battles and the inspiration for numerous Wyeth paintings.
8. Is the home of the largest concentration of mushroom growers in the U.S. and has the port with the largest volume of Chilean banana imports nationally.
9. Is the home of major chemical and credit card industries and contains some of the most productive public gardens in the world.
10. Provides some of the best trout fishing in the Delaware Valley.



Three ways you can help:

1. Cut back on water use, water lawns less frequently, take shorter showers.
2. Plant trees and native shrubs, reduce lawn fertilizer use.
3. Recycle waste oil and chemicals, try not to pour them down storm drains.



The Delaware Nature Society, a nonprofit membership organization, fosters understanding, appreciation, and enjoyment of the natural world through education, preserves ecologically significant areas; and advocates stewardship of natural resources. Visit our webpage **www.dca.net/naturesociety**

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REGISTRATION

The Conference is **FREE,** but **registration is required. Please return this form by June 7, 1999.** If you have any questions, call (302) 239-2334, ext. 32.
Mail to: Eileen Butler, Delaware Nature Society, P.O. Box 700, Hockessin, DE 19707.

Name: _____

Address: _____

_____

Organization: _____

Phone: _____

PURPOSE

This conference is designed to inform local officials, landowners, and other stakeholders about the impending Total Maximum Daily Load (TMDL) process and how it will impact point source dischargers (wastewater dischargers, industry) as well as non-point sources (industry, developers/home builders, agriculture, residents, local government). A TMDL is the maximum amount of a pollutant that can be put into a body of water without violating water quality standards. The TMDL process for point source dischargers is due to be completed by the year 2000; following that, the process for non-point sources will be completed.

DELAWARE NATURE SOCIETY
P.O. Box 700 • Hockessin, DE 19707

Non-Profit Organization
U.S. Postage
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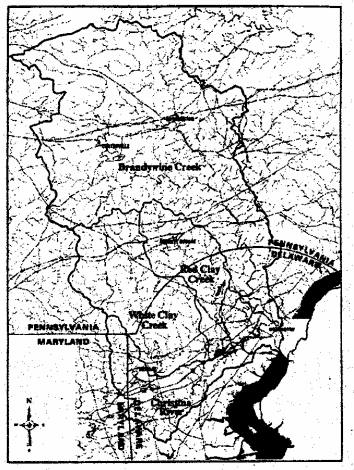
Hockessin, Delaware

Interstate Initiatives for Clean Water in the Christina Basin



Delaware Nature Society
Ashland Nature Center
June 17, 1999

AGENDA

8:00 a.m. **Registration**

8:45 a.m. **Welcome**
Linda Stapleford, Associate Director for Natural Resources Conservation, Delaware Nature Society
Robert Struble, Executive Director, Brandywine Valley/Red Clay Valley Associations

9:00 a.m. **Interstate Watershed Partnership**
David Pollison, Planning and Implementation Branch Head, Delaware River Basin Commission, gives background information and early history of interstate water quality problems and issues in the Christina basin.

9:15 a.m. **The Christina Clean Water Strategy Progress Report**
Gerard Kauffman, Water Resources Engineer, University of Delaware Water Resources Agency, and *Janet Bowers*, Executive Director, Chester County Water Resources Authority, present an overview of recent progress and recommendations for a Watershed Restoration Action Strategy.

9:45 a.m. **Break** (refreshments)

10:00 a.m. **TMDL Point Source Overview**
John Davis, Consultant, Widener University, explains what a TMDL is and the model used for crafting a TMDL for point sources in the basin.

10:20 a.m. **Zinc TMDL**
Richard Greene, Environmental Engineer, Water Assessment Section, DE Dept. of Natural Resources and Environmental Control, discusses the TMDL established for zinc in the Red Clay Creek.

10:45 a.m. **Response From Discharger Stakeholders**
Bart Ruiter, Engineer, DuPont Company, *Jeffrey Holmes*, General Motors Corporation, *Herbert Mays*, Executive Director, Downingtown Area Regional Authority, and *James Jordan*, EnvironmentalManager, NVF Company, offer their responses as representatives of point source dischargers in the basin.

11:15 a.m. **TMDL Non-Point Source Overview**
Kent Crawford, Water Quality Specialist, United States Geological Survey, presents the model which will be used to calculate the non-point source component of the TMDL.

11:30 a.m. **Lessons Learned From The Inland Bays Experience**
John Schneider, Manager, Watershed Assessment Section, DE Dept. of Natural Resources and Environmental Control, shares his experiences of the TMDL process for the Inland Bays.

11:45 a.m. **Response From Non-Point Source Stakeholder**
Saurabh Srivastava, Environmental Coordinator, New Castle County Dept. of Special Services, *James McCulley*, Consultant, Home Builders Association of Delaware, Inc., and *Jack Arrell*, Donald B. Needham Co. and President, Chester County Assoc. of Twp. Officials, share their impressions of the impending TMDL process for non-point source dischargers in the basin.

12:15 p.m. **Lunch** (video available to view)

1:00 p.m. **Implementing The Overall Strategy**
Learn about a variety of watershed restoration programs in which the public can participate to help achieve water quality standards.

Robert Struble, Executive Director, Brandywine Valley/Red Clay Valley Associations, discusses **Public Education and Outreach**.

Daniel Greig, Manager, Chester County Conservation District, explains the **Stormdrain Stenciling Program**.

David Warner, Volunteer, University of Delaware, Cooperative Extension, presents the **Master Gardener Program**.

Eileen Butler, Soil Watch Coordinator, Delaware Nature Society, gives an overview of the **Soil Watch Program**.

2:00 p.m. **Break** (refreshments)

2:15 p.m. **BMP Implementation Projects**
Learn about projects that implement Best Management Practices in the basin.

Daniel Greig, Manager, Chester County Conservation District, explains the benefits of **Pennsylvania BMP Projects**.

Jack Lakatosh, District Conservationist, New Castle Conservation District, presents the **Independence School Wetlands and Cool Run Wetlands Projects**.

Richard LaPointe, Director, Public Works, City of Newark, shares experiences from the **Newark Bioengineering Project**.

The audience is invited to share information they may have on **Other Watershed Projects** underway in the basin.

3:15 p.m. **Ongoing Local/State Watershed Programs**
Janet Bowers, Executive Director, Chester County Water Resources Authority, discusses groundwater and watershed restoration activities occurring at the County level in Pennsylvania through the **Chester County Water Resources Management Plan**.

Stephen Williams, Whole Basin Coordinator, DE Dept. of Natural Resources and Environmental Control, discusses activities happening in Delaware at the State level through the **Whole Basin Program**.

4:00 p.m. **Next Steps**
David Pollison, Planning and Implementation Branch Head, Delaware River Basin Commission, describes future activities involved in the Watershed Restoration Action Strategy for the Christina basin.

4:15 p.m. **Adjourn**

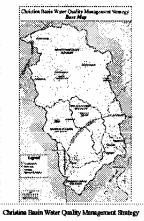
SPONSORS

- *Brandywine Valley/Red Clay Valley Associations*
- *Chester County Conservation District*
- *Chester County Water Resources Authority*
- *Delaware Department of Natural Resources and Environmental Control*
- *Delaware Nature Society*
- *Delaware River Basin Commission*
- *Environmental Protection Agency Reg. III*
- *New Castle Conservation District*
- *Pennsylvania Department of Environmental Protection*
- *United States Geological Survey*
- *University of Delaware Water Resources Agency*

Additional funding provided by Pennsylvania and Delaware Non-Point Source Section 319 programs.

The mission of the Christina Basin Water Quality Management Plan is to identify pollutants, develop a plan to reduce these pollutants and achieve and maintain water quality standards

An Interstate Approach to Protect and Restore Watersheds in the Christina River Basin of Delaware, Maryland, and Pennsylvania



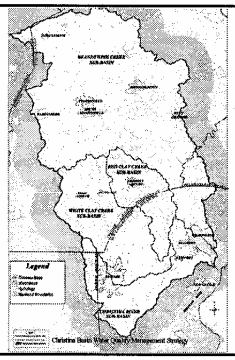
Christina Basin Water Quality Management Strategy

Christina Basin Water Quality Management Strategy

Presidents Clean Water Action Plan

- 40% of waters do not meet water quality goals
- Half of 2000 watersheds have moderate to serious water quality problems
- Recommends the WATERSHED APPROACH

Christina Basin Water Quality Management Strategy



Base Map

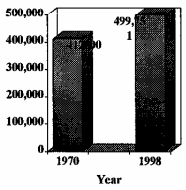
Christina Basin Water Quality Management Strategy

Christina Basin Watersheds (565 sq.mi.)

- By State:
  - DE 157 sq.mi. (28%)
  - PA 400 sq.mi. (71%)
  - MD 8 sq.mi. (1%)
- By watershed:
  - Brandywine Creek (325 sq.mi)
  - Red Clay Creek (55 sq. mi.)
  - White Clay Creek (107 sq. mi.)
  - Christina River (78 sq. mi.)

Christina Basin Water Quality Management Strategy

Christina Basin Population



The population of the Christina River Basin in DE, MD and PA has increased by 21% since 1970.

Christina Basin Water Quality Management Strategy

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Christina Basin

Water Quality Management Strategy

Mission Statement:

The mission of the Christina Basin Water Quality Management Strategy is to conduct a cooperative, interstate effort to implement programs to protect and improve the water quality of streams, waterways, and groundwater in the Brandywine, Red Clay, White Clay Creeks, and Christina watersheds of Delaware, Maryland, and Pennsylvania.

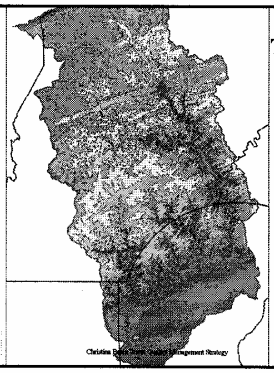
Uses of the Christina Basin :

- **Provides Water Supply for:**
  - **75% of New Castle County, DE**
  - **40% of Chester County, PA**
  - **Up to 100 mgd**
  - **0.5 Million People**
- **Recreational:**
  - **30,000 trout stocked in DE**
  - **2,700 trout stamps issued**
  - **8,400 registered boats**

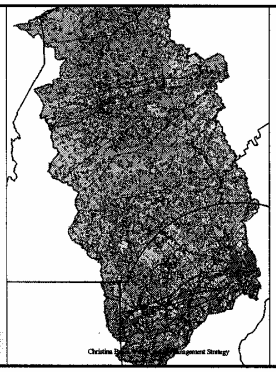
Water quality issues

- **Nutrients (nitrogen and phosphorus)**
- **Toxics (Zinc)**
- **Bacteria**
- **Fish Consumption Advisories (PCBs and Chlordane)**
- **Sediment**
- **Stream Habitat**

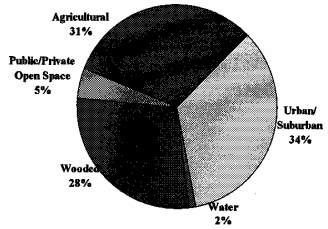
Topography Map



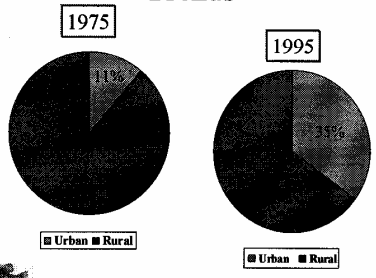
Land Use Map



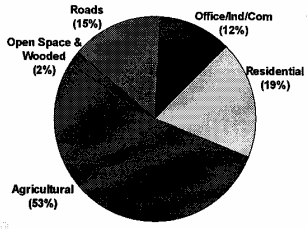
Christina Basin Land Use



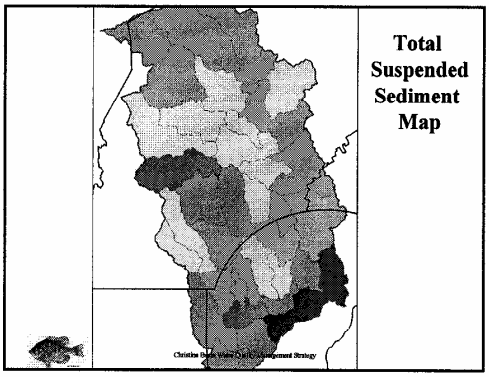
Christina Basin Land Use Trends



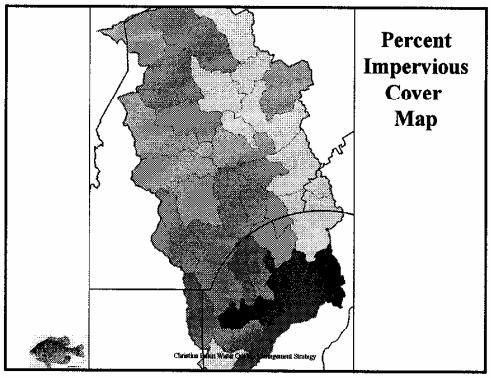
Annual Total Suspended Sediment Loads (lbs.)



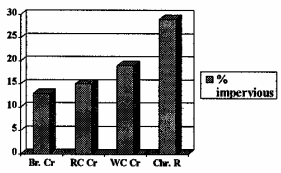
Total Suspended Sediment Map



Percent Impervious Cover Map

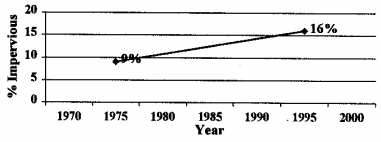


Christina Basin % Impervious

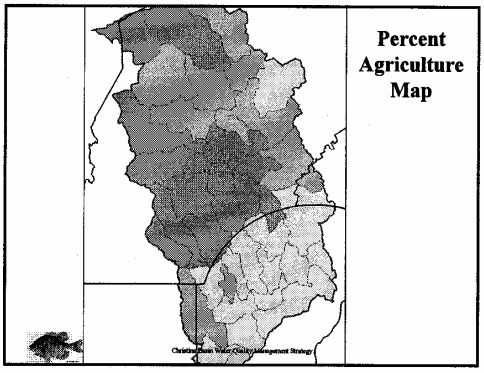


- % Impervious Cover is a key indicator of Watershed Health and Stream Water Quality

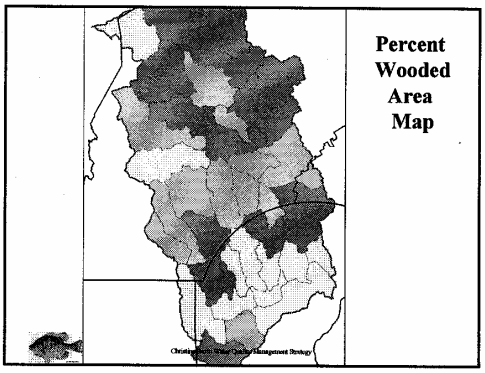
Christina Basin % Impervious Cover Trend



The percent impervious cover in the Christina River Basin has increased from 9% in 1975 to 16% in 1995.

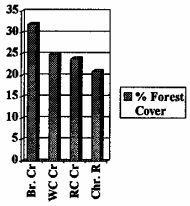


Percent Agriculture Map



Percent Wooded Area Map

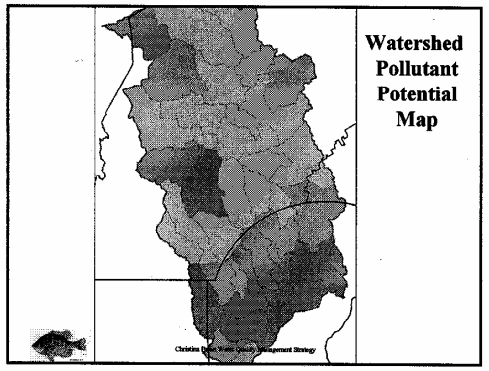
Christina Basin % Forested Area



- Large Amounts of Forested Land in a Watershed provide Significant Water Quality and Quantity Benefits

Priority Watershed Criteria:

- Using GIS mapping, the 38 watersheds are prioritized based on the following criteria:
  - Total Suspended Sediment
  - % Impervious Cover
  - % Agriculture
  - % Wooded Area
  - Stream Water Quality
  - Fish Consumption Advisories



Watershed Pollutant Potential Map

Watershed Health Ratings

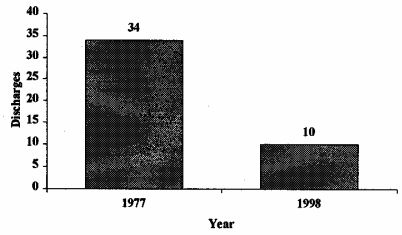
- Based on the six environmental indices, the health of the subwatersheds are broken into three categories: poor, fair, and good
  - Poor health watersheds are prioritized to improve riparian habitat using retrofitting, restoration, and reforestation BMPs (3 "R's")
  - Good health watersheds have emphasis on preservation, prevention, and protection BMPs, which include open space acquisition and conservation easements (3 "P's")

The Christina River Basin Report Card (Since 1970)

Watershed Indicator	Worse	Same	Improved
DE Wastewater Discharges			☺
Bacteria			☺
Biological Diversity			☺
Sediment Loads			☺
Dissolved Oxygen			
-Pennsylvania			☺
-Delaware	☹		
Fish Consumption Advisories	☹		
Phosphorous		😐	
Nitrogen	☹		
Zinc		😐	
Stream Habitat	☹		
Impervious Cover	☹		
Superfund Sites			☺
Public Open Space			☺

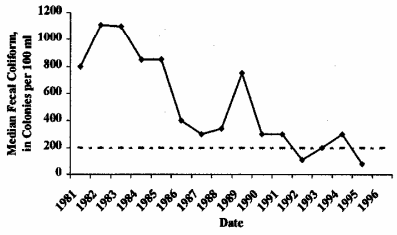
Christina Basin Water Quality Management Strategy

NPDES Wastewater Discharges Christina Basin, DE



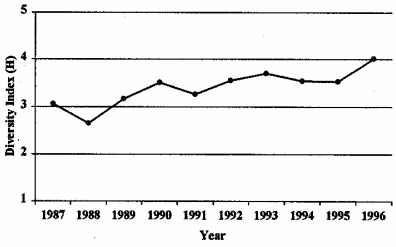
Christina Basin Water Quality Management Strategy

Fecal Coliform Bacteria Brandywine Creek at Chadds Ford, PA



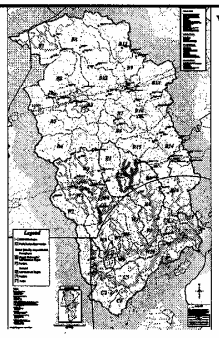
Christina Basin Water Quality Management Strategy

Biological Diversity Indicies EB Brandywine Creek near Downingtown, PA



Christina Basin Water Quality Management Strategy

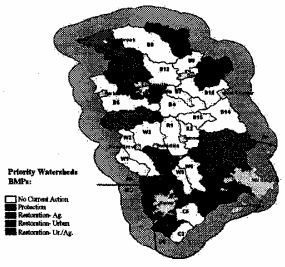
Water Quality Impaired Segments



Christina Basin Water Quality Management Strategy

Christina Basin Water Quality Management Strategy

Watershed Restoration Action Strategy (WRAS) (Draft)



Christina Basin Water Quality Management Strategy

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RECOMMENDATIONS
Next Steps

- Continue Public Outreach Program
- Develop and Implement TMDLs
- Prepare and Implement Comprehensive Watershed Restoration Action Strategy
- Implement BMPs for Rural and Urban Lands
- Conduct Water Balance Analysis

Christina Basin Water Quality Management Strategy

Continue Public Outreach

- Brochures
- Basin Scapes
- Public Outreach Meetings
- Internet Web Page
- Annual Conference
- News Letters
- Press Releases
- Storm Drain Stenciling
- Water Bill Stuffers

Christina Basin Water Quality Management Strategy

Coordinate with Watershed Organizations:

- White Clay Watershed Association
- Stroud Water Research Laboratory
- Brandywine Valley Association
- Red Clay Valley Association
- Christina Conservancy
- Brandywine Conservancy
- Delaware Nature Society

Christina Basin Water Quality Management Strategy

Integrate Existing Essential Watershed Programs:

- DNREC Whole Basin
- Chester County Water Restoration Management Plan
- CCWRA/USGS Cooperative Monitoring
- White Clay Wild and Scenic Study
- NPDES Part II Stormwater Permit
- Riverfront Development Corp

Christina Basin Water Quality Management Strategy

Install Agricultural BMP Implementation Projects:

- PL 83-566 Projects in the Red Clay and White Clay Watersheds
- Federal CRP, WHIP, WRP, and EQUIP Agriculture Conservation Programs

Christina Basin Water Quality Management Strategy
Christina Basin Water Quality Management Strategy

Urban/ Suburban BMPs

- Minimize NPDES Stormwater Loads
- Abate the Combined Sewer Overflows
- Construct Septic System Relief Projects
- Remediate Superfund and Hazardous Waste Sites
- Retrofit Ineffective Systems

Christina Basin Water Quality Management Strategy

6

In Summary, the Christina Basin Water Quality Management Strategy is Designed to:

- Utilize the Watershed Approach
- Coordinate with Interstate, Inter-agency, and Watershed Organization Initiatives
- Improve the Health of the Watersheds and Riparian Areas for Drinking Water, Recreation, and Ecological Purposes

Christina Basin Water Quality Management Strategy

7

Appendix D

CHESTER COUNTY WATER RESOURCES AUTHORITY BROCHURE

Chester County, PA

Water Resources Management Plan

MISSION STATEMENT

"The mission of the Chester County Water Resources Management Plan is to protect, sustain, and enhance the quality and quantity of all water resources to insure the health, safety, and welfare of the citizens, and preserve the diverse natural resources and aesthetic and recreational assets of Chester County."

LANDSCAPES WATER RESOURCES POLICIES

- Protect a safe, long-term supply of water which is adequate for all uses.
- Support water conservation and encourage measures to reduce water supply demands.
- Preserve and enhance the existing network of stream valleys and their aquatic habitats.
- Prevent development in floodplains to protect public safety and water quality, and reduce public costs from flood damage.
- Preserve wetlands for their ecological and hydrological functions.
- Preserve and enhance buffer areas around water bodies to mitigate environmental and visual impacts from adjacent uses and activities.
- Protect and enhance the quality and quantity of ground water.
- Support upgrades of stream quality designations by the Pennsylvania Department of Environmental Protection.
- Encourage a sustainable water cycle balance within watersheds as development occurs.

PLANNING TEAM PARTICIPANTS

- Chester County Board of Commissioners
- Chester County Water Resources Authority
- Chester County Water Resources Task Force
- Chester County Planning Commission
- Chester County Health Department
- Chester County Conservation District
- Chester County Department of Parks and Recreation
- U. S. Geological Survey
- Pennsylvania Department of Conservation and Natural Resources
- Camp Dresser and McKee, Inc.
- Gaadt Perspectives, LLC

FUNDING

- Chester County Board of Commissioners
- PA Department of Conservation and Natural Resources, Keystone Rivers Conservation Grant

TIME FRAME

- Draft Plan to be completed by Fall 2000.

Chester County Water Resources Authority

Chester County, PA
Water Resources Management Plan

THE STUDY AREA

- All watersheds and sub-watersheds of which Chester County is a part
- Includes over 1,200 stream miles in 15 major watersheds covering over 1,000 sq. miles of land area
- These watersheds cover all of Chester County and extend into Lancaster County, Delaware County, and Berks County (PA), Cecil County (MD), and New Castle County (DE).

ANALYSES TO BE PERFORMED IN DEVELOPING THE PLAN

- Develop GIS coverages of all watersheds, sub-watersheds, and sub-basins in the study area
- For Each Sub-Basin –
  - Quantify natural volume of water available for withdrawals, based on geology
  - Calculate water balance based on permitted withdrawals and discharges, and estimates of self-supplied water/septic use
  - Calculate stormwater runoff estimates
  - Calculate potential stormwater nonpoint source pollutant loads 10 parameters
  - Conduct riparian corridor needs assessment by GIS analysis of riparian land uses
  - Inventory problems based on assessment of collected data and information
  - Estimate nutrient loadings from septic systems
- For Water Supply Systems –
  - Determine growth areas/corridors, growth patterns and growth rates
  - Estimate current water demand
  - Estimate future water demand 1)based on projected growth, 2) based on *Landscapes*
  - Evaluate current sources of water
  - Evaluate future water demand versus water available in sub-basins
  - Assess need for future sources and prioritize sources for development
  - Delineate desired water supply service areas based on municipal inputs
- For Wastewater Needs –
  - Evaluate current and future wastewater discharge needs
  - Develop guidance for locating future discharges to maintain sub-basin water balances
- Prioritize Problems and Solutions (by Watershed)
- Technical guidance for municipalities for protection of ground-water and watershed resources
- Develop prioritized implementation plan for each watershed
- Develop prioritized implementation plan for Chester County overall

THE FINAL PLAN PRODUCTS

- Understandable Implementation Plan for Chester County
- Keystone Rivers Conservation Plans – Brandywine, Red Clay and Valley Creeks
- Watershed Restoration and Protection Strategies (for each watershed)
- Detailed Technical Volume
  - Ground-Water Resources Assessment and Management Strategy
  - Surface Water Resources Assessment and Management Strategy
  - Watershed Resources Assessment and Management Strategy
  - Water Supply / Wastewater Discharge Assessment and Strategy
- GIS ArcView Coverages Covering All Watersheds in Study Area

FOR FURTHER INFORMATION, CONTACT

- Chester County Water Resources Authority
  Phone: (610) 344-5400
  Website: www.chesco.org/water.html

Chester County Water Resources Authority

Appendix E

CHRISTINA BASIN FINANCIAL DATA

	Source	Funding	Description	Match Source	Match Funding	Amount Spent	Total
CCCD	NPS 319	17,575.00	BMP Demo	Other District Cost	4,200.00	17,575.00	21,775.00
NCCWRA	NPS 319	53,000.00	Phase 1 Report-GIS	DNREC Salaries	71,612.00	53,000.00	124,612.00
DRBC/USGS	NPS 319	32,000.00	Modeling/ Monitoring QAQC			32,000.00	32,000.00
PAWRA	NPS 319	8,701.00	Admin			8,701.00	8,701.00
City of Newark	NPS 319	12,000.00	BMP IMP	City of Newark	14,000.00	12,000.00	26,000.00
NCCD	NPS 319	1,268.00	BMP IMP			1,268.00	1,268.00
Sub Total		124,544.00			89,812.00	124,544.00	214,356.00

	Source	Funding	Description	Match Source	Match Funding	Amount Spent	Total
DRBC/USGS	NPS 319	56,730.00	Stream Gauges I,O,M.			56,730.00	56,730.00
DNREC	NPS 319	22,469.00	Isco Samplers	DNREC Salaries	52,826.00	22,469.00	75,295.00
Sub Total		79,199.00			52,826.00	79,199.00	132,025.00

	Source	Funding	Description	Match Source	Match Funding	Amount Spent	Total
DRBC/USGS	104(b)(3)	44,200.00	Modeling/ Monitoring				
Sub Total		44,200.00					

	Source	Funding	Description	Match Source	Match Funding	Amount Spent	Total
DRBC/USGS	NPS 319	44,373.00	Modeling			44,373.00	44,373.00
University of De	NPS 319	19,787.00	Stormwater Monitoring			19,787.00	19,787.00
DNREC	NPS 319	55,840.00	Lab-Analysis	DNREC Salaries	80,040.00		
Sub Total		120,000.00			80,040.00	64,160.00	64,160.00

	Source	Funding	Description	Match Source	Match Funding	Amount Spent	Total
CCCD	NPS 319	37,000.00	BMP Demo	PA Conservation District Fund Allocation Program	54,694.00		
NCCWRA	NPS 319	45,000.00	Administration				
DRBC/ USGS	104(b)(3)	92,410.00	Monitoring/Modeling				
Sub Total		174,410.00			54,694.00		

Note: 34,000.00 from De NPS 319
48,000.00 from PA NPS 319

	Source	Funding	Description	Match Source	Match Funding	Amount Spent	Total
CCCD	NPS 319	15,000.00	BMP Demo/ Education	PA Conservation District Fund Allocation Program	10,000.00		
WRANCC	NPS 319	35,000.00	Administration	PA Conservation District Fund Allocation Program	23,345.00		
DRBC/USGS	NPS 319	60,000.00	Monitoring	PA Conservation District Fund Allocation Program	40,020.00		
DNREC/USGS	104(b)(3)	60,000.00	Modeling				
DRBC/USGS	State Clean Water Fund	5,000.00	Low Flow TMDL Model				
Sub Total		175,000.00			73,365.00		

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
DNREC	FY99 General Funds	07/01/98 To 06/30/99	Ambient Water Quality Monitoring			63,700.00	63,700.00
DNREC	FY98 General Funds	07/01/97 To 06/30/98	Ambient Water Quality Monitoring			90,829.00	90,829.00
DNREC	FY97 General Funds	07/01/96 to06/30/97	Ambient Water Quality Monitoring			83,316.00	83,316.00
DNREC	FY96 General Funds	07/01/95 To 06/30/96	Ambient Water Quality Monitoring			229,872.00	229,872.00
DNREC	FY95 General Funds	07/01/94 To 06/30/95	Ambient Water Quality Monitoring			229,872.00	229,872.00
DNREC	FY94 General Funds	07/01/93 To 06/30/94	Ambient Water Quality Monitoring			229,872.00	229,872.00
Sub Total						927,461.00	927,461.00

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
PA DEP	FY92 & FY93 General Funds	01/01/93 To 06/30/93	Ambient Water Quality Monitoring			25,200.00	25,200.00
PA DEP	FY93 & FY94 General Funds	07/01/93 To 06/30/94	Ambient Water Quality Monitoring Invertebrate Sampling			39,150.00	39,150.00
PA DEP	FY94 & FY95 General Funds	07/01/94 To 06/30/95	Ambient Water Quality Monitoring Invertebrate Sampling			51,750.00	51,750.00
PA DEP	FY95 & FY96 General Funds	07/01/95 To 06/30/96	Ambient Water Quality Monitoring Invertebrate Sampling			102,150.00	102,150.00
PA DEP	FY96 & FY97 General Funds	07/01/96 To 06/30/97	Ambient Water Quality Monitoring Invertebrate Sampling			55,350.00	55,350.00
PA DEP	FY97 & FY98 General Funds	07/01/97 To 06/30/98	Ambient Water Quality Monitoring Invertebrate Sampling			60,750.00	60,750.00
PA DEP	FY98 & FY99 General Funds	07/01/98 To 06/30/99	Ambient Water Quality Monitoring			18,000.00	18,000.00
Sub Total						352,350.00	352,350.00

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
DNREC	General Funds	FY99	Stream Gauges			2,675.00	2,675.00
DNREC	General Funds	FY99	Stream Gauges			2,575.00	2,575.00
DNREC	General Funds	FY99	Stream Gauges			4,950.00	4,950.00
DNREC	General Funds	FY99	Stream Gauges			4,720.00	4,720.00
DNREC	General Funds	FY95	Stream Gauges			4,500.00	4,500.00
DNREC	General Funds	FY94	Stream Gauges			14,400.00	14,400.00
Sub Total						33,820.00	33,820.00

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
Chester County	Chester County General Funds	FY95	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
USGS	USGS Coop Program	FY95	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
Chester County	Chester County General Funds	FY96	Christina/PA Stream/Precip Gages			33,135.00	33,135.00
USGS	USGS Coop Program	FY96	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
Chester County	Chester County General Funds	FY97	Christina/PA Stream/Precip Gages			35,135.00	35,135.00
USGS	USGS Coop Program	FY97	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
Chester County	Chester County General Funds	FY98	Christina/PA Stream/Precip Gages			36,040.00	36,040.00
USGS	USGS Coop Program	FY98	Christina/PA Stream/Precip Gages			22,505.00	22,505.00
Chester County	Chester County General Funds	FY99	Christina/PA Stream/Precip Gages		35,730.00		35,730.00
USGS	USGS Coop Program	FY99	Christina/PA Stream/Precip Gages		22,245.00		22,245.00
Sub Total					57,975.00	218,195.00	276,170.00

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
Chester County	Chester County General Funds	FY95	Brandywine Creek Ambient Water Quality Monitoring			35,705.00	35,705.00
USGS	USGS Coop Funds	FY95	Brandywine Creek Ambient Water Quality Monitoring			30,945.00	30,945.00
Chester County	Chester County General Funds	FY96	Brandywine Creek Ambient Water Quality Monitoring			35,705.00	35,705.00
USGS	USGS Coop Funds	FY96	Brandywine Creek Ambient Water Quality Monitoring			30,945.00	30,945.00
Chester County	Chester County General Funds	FY97	Brandywine Creek Ambient Water Quality Monitoring			35,705.00	35,705.00
USGS	USGS Coop Funds	FY97	Brandywine Creek Ambient Water Quality Monitoring			30,945.00	30,945.00
Chester County	Chester County General Funds	FY98	Brandywine Creek Ambient Water Quality Monitoring			32,685.00	32,685.00
USGS	USGS Coop Funds	FY98	Brandywine Creek Ambient Water Quality Monitoring			32,685.00	32,685.00
Chester County	Chester County General Funds	FY99	Brandywine Creek Ambient Water Quality Monitoring		31,060.00		31,060.00
USGS	USGS Coop Funds	FY99	Brandywine Creek Ambient Water Quality Monitoring		31,060.00		31,060.00
Sub Total					62,120.00	265,320.00	327,440.00

	Source		Description	Match Source	Match Funding	Amount Spent	Total
Chester County	Chester County General Funds		Christina/PA Biological/ Stream Conditions Monitoring			11,400.00	11,400.00
USGS	USGS Coop Program		Christina/PA Biological/ Stream Conditions Monitoring			11,400.00	11,400.00
Chester County	Chester County General Funds		Christina/PA Biological/ Stream Conditions Monitoring			11,400.00	11,400.00
USGS	USGS Coop Program		Christina/PA Biological/ Stream Conditions Monitoring			11,400.00	11,400.00
Chester County	Chester County General Funds		Christina/PA Biological/ Stream Conditions Monitoring			11,400.00	11,400.00
USGS	USGS Coop Program		Christina/PA Biological/ Stream Conditions Monitoring			11,400.00	11,400.00
Chester County	Chester County General Funds		Christina/PA Biological/ Stream Conditions Monitoring			14,535.00	14,535.00
USGS	USGS Coop Program		Christina/PA Biological/ Stream Conditions Monitoring			14,535.00	14,535.00
Chester County	Chester County General Funds		Christina/PA Biological/ Stream Conditions Monitoring		17,850.00		17,850.00
USGS	USGS Coop Program		Christina/PA Biological/ Stream Conditions Monitoring		17,850.00		17,850.00
Sub Total					35,700.00	97,470.00	133,170.00

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
Chester County	Chester County General Funds	FY95	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
USGS	USGS Coop Program	FY95	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
Chester County	Chester County General Funds	FY96	Christina/PA Stream/Precip Gages			33,135.00	33,135.00
USGS	USGS Coop Program	FY96	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
Chester County	Chester County General Funds	FY97	Christina/PA Stream/Precip Gages			35,135.00	35,135.00
USGS	USGS Coop Program	FY97	Christina/PA Stream/Precip Gages			22,345.00	22,345.00
Chester County	Chester County General Funds	FY98	Christina/PA Stream/Precip Gages			36,040.00	36,040.00
USGS	USGS Coop Program	FY98	Christina/PA Stream/Precip Gages			22,505.00	22,505.00
Chester County	Chester County General Funds	FY99	Christina/PA Stream/Precip Gages		35,730.00		35,730.00
USGS	USGS Coop Program	FY99	Christina/PA Stream/Precip Gages		22,245.00		22,245.00
Sub Total					57,975.00	218,195.00	276,170.00

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
Chester County	Chester County General Funds	FY95	Christina/PA Ground-Water Levels & Quality Monitoring			14,750.00	14,750.00
USGS	USGS Coop Program	FY95	Christina/PA Ground-Water Levels & Quality Monitoring			14,750.00	14,750.00
Chester County	Chester County General Funds	FY96	Christina/PA Ground-Water Levels & Quality Monitoring			14,750.00	14,750.00
USGS	USGS Coop Program	FY96	Christina/PA Ground-Water Levels & Quality Monitoring			14,750.00	14,750.00
Chester County	Chester County General Funds	FY97	Christina/PA Ground-Water Levels & Quality Monitoring			14,750.00	14,750.00
USGS	USGS Coop Program	FY97	Christina/PA Ground-Water Levels & Quality Monitoring			14,750.00	14,750.00
Chester County	Chester County General Funds	FY98	Christina/PA Ground-Water Levels & Quality Monitoring			15,040.00	15,040.00
USGS	USGS Coop Program	FY98	Christina/PA Ground-Water Levels & Quality Monitoring			15,040.00	15,040.00
Chester County	Chester County General Funds	FY99	Christina/PA Ground-Water Levels & Quality Monitoring		15,220.00		15,220.00
USGS	USGS Coop Program	FY99	Christina/PA Ground-Water Levels & Quality Monitoring		15,220.00		15,220.00
Sub Total					30,440.00	118,580.00	149,020.00

	Source	Period	Description	Match Source	Match Funding	Amount Spent	Total
PA DEP	104(b)(3)	FY98 & FY99	Stream Gauge			14,482.00	14,482.00
PA DEP	104(b)(3)	FY97 & FY98	Stream Gauge			14,482.00	14,482.00
PA DEP	104(b)(3)	FY96 & FY97	Stream Gauge			14,482.00	14,482.00
PA DEP	104(b)(3)	FY95 & FY96	Stream Gauge			30,000.00	30,000.00
PA DEP	General Fund	FY97 & FY98	Photosynthesis Survey			35,000.00	35,000.00
USGS	USGS Coop Funds	FY97	Stream Gauge I,O,M		49,235.00		49,235.00
USGS	USGS Coop Funds	FY98	Modeling		88,745.00		88,745.00
USGS	USGS Coop Funds	FY98	Monitoring		15,727.00		15,727.00
Sub Total					153,707.00	108,446.00	262,153.00