PHASE I FINAL REPORT

Cooks Run Watershed Assessment

CZM PROJECT NUMBER: 2002-PD.14

March 31, 2004

Prepared for:

PA Dept. of Environmental Protection
Bureau of Watershed Conservation
P.O. Box 8555
Harrisburg, PA 17105-8555

Bucks Co. Conservation District
924 Town Center
New Britain, PA 18901

Prepared by:

Aqua-Link, Inc.
P.O. Box 605
Doylestown, PA 18901

Ph: 215.230.9325
www.aqualinkinc.com

Pennsylvania Coastal Zone Management Program

Cooks Run Watershed Assessment

CZM PROJECT NUMBER: 2002-PD.14

This project was financed, in part, through a Federal Coastal Zone Management Grant, administered by the Pennsylvania Department of Environmental Protection (DEP).

Funding provided by the National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce under Award Number: **NA17OZ2349**

TABLE OF CONTENTS

Section No. **Page**

Appendices

Cover Page

Cooks Run in late October 2003. Photograph taken by Edward W. Molesky of Aqua-Link, Inc.

Cooks_final.ph1_rpt.doc

List of Tables

Table No. **Page**

List of Figures

Figure No. **Page**

Acknowledgements

The first phase of the Cooks Run Watershed Assessment would not be possible without the financial support of the Pennsylvania Department of Environmental Protection and the National Oceanic and Atmospheric Administration (NOAA) through its Coastal Zone Management Program. The Coastal Zone Management Program (CZMP) is authorized by the Coastal Zone Management Act of 1972 and administered at the federal level by the Coastal Programs Division (CPD) within the National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management (OCRM).

Aqua-Link, Inc. and the District would like to thank the County Commissioners and the District Board of Directors for their support of the Cooks Run Watershed Assessment Project, thereby allowing the District to serve as the Project Sponsor. Aqua-Link commends their strong commitment for protecting and restoring the water resources of Bucks County. Special thanks are extended to the Borough of Doylestown, Doylestown Township, the Borough of New Britain, the Bucks County Water and Sewer Authority and Granor Price Homes for their commitment and additional financial support of this project.

Aqua-Link would also like to thank Gilmore and Associates, Inc. for their assistance in assessing major stormwater management facilities and evaluating municipal ordinances. We would also like to thank the Heritage Conservancy for their assistance in watershed mapping.

Lastly, Aqua-Link would like to thank Mr. Frederick Groshens, District Manager, and Ms. Gretchen Schatschneider, Watershed Specialist, of the Bucks County Conservation District for all their hard work and assistance through the entire duration of this project.

Edward W. Molesky, CLM
President
Aqua-Link, Inc.

Executive Summary

The Cooks Run watershed, which is approximately 3.3 square miles in size, is located in central Bucks County. Cooks Run flows in a southwesterly direction and discharges into the Neshaminy Creek, which in turn flows into the Delaware River. Currently, Cooks Run is classified as Warmwater Fishery (WWF), MF (Migratory Fishery) under PA DEP's Chapter 93 Water Quality Standards. Both the Neshaminy Creek and Cooks Run are listed on the State's 303(d) List of Impaired Waters.

This report describes the findings of the first phase, Phase I, of the Cooks Run watershed assessment. This report was prepared by Aqua-Link for the Bucks County Conservation District. The District served as the project sponsor for this assessment and the Pennsylvania Department of Environmental Protection (PA DEP) and the National Oceanic and Atmospheric Administration (NOAA) provided funding through the Coastal Zone Management Program. The Borough of Doylestown, Doylestown Township, the Borough of New Britain, the Bucks County Water and Sewer Authority and Graynor Price also provided additional financial support for the project. As part of this assessment, a comprehensive watershed management plan was developed to improve and further protect the water quality and aquatic habitats of Cooks Run.

The comprehensive watershed management plan, which primarily focuses on the upper subwatershed, was developed using watershed-specific data and information. Watershed data and information were compiled, analyzed and mapped using GIS (Geographical Information System) software. Stream data including macroinvertebrates (aquatic organisms) were collected and analyzed and municipal ordinances were evaluated for their overall effectiveness in protecting stream water quality and aquatic habitats. In addition, a stream and riparian visual assessment, a nonpoint source pollution assessment and stormwater management assessment were performed for the upper subwatershed.

By way of this assessment, Cooks Run is considered enriched with nutrients (phosphorus and nitrogen) during both baseflow (normal flow) and stormflow (high flow) conditions. Higher phosphorus and suspend solids (sediment) concentrations during storm events may be attributed to increased rates of streambank erosion and additional inputs from stormwater runoff. During baseflow conditions, elevated nutrient concentrations downstream of Limekiln Road are largely due to the discharge of treated effluent from the Harvey Avenue wastewater treatment plant (WWTP).

The dissolved oxygen concentrations in the stream were generally considered good and the pH values were near neutral during baseflow and stormflow conditions. Fecal coliform bacteria concentrations during baseflow and stormflow conditions were considered high and very high, respectively. The dramatic concentration increases during storms is likely due to the transportation of animal feces to the stream via stormwater runoff. Sources of animal feces within the watershed

are pets and wildlife. Overall, the high bacteria concentrations make the stream unsuitable for primary contact recreation such as swimming.

The most prevalent heavy metals in Cooks Run during the study period were chromium, copper, lead and zinc. These metals are often associated with streams in urbanized watersheds. Overall, metal concentrations increased during stormflow conditions and these concentrations were the highest in the lower section of the watershed (lower subwatershed). The upper and lower subwatersheds are defined as those portions of the Cooks Run watershed above and below the Route 611 Bypass, respectively.

Macroinvertebrate (aquatic organism) data for Cooks Run reflects impairment from organic pollution and/or habitat degradation. Overall, these data indicate that the highest levels of impairment occur in the upper portion of the watershed (above the Route 611 Bypass). Somewhat lower levels of impairment were observed in the lower portion of the watershed (below the Route 611 Bypass). Based upon field observations and water quality data, higher levels of impairment in the upper subwatershed are apparently due to loss of aquatic habitats, especially as a result of stream channel modifications and excessive sedimentation.

Overall, the primary goal of the Cooks Run watershed assessment was to develop a comprehensive management plan in order to reduce nonpoint source pollutants to Cooks Run. Key recommendations of this plan are to restore forested riparian buffers along streams, repair major nonpoint source (NPS) problem areas and retrofit major stormwater management facilities in the upper Cooks Run subwatershed. All of the identified nonpoint source problems are associated with streambank erosion. The management plan offers additional recommendations for revising municipal ordinances and continuing to monitor the water quality of Cooks Run.

1. Introduction

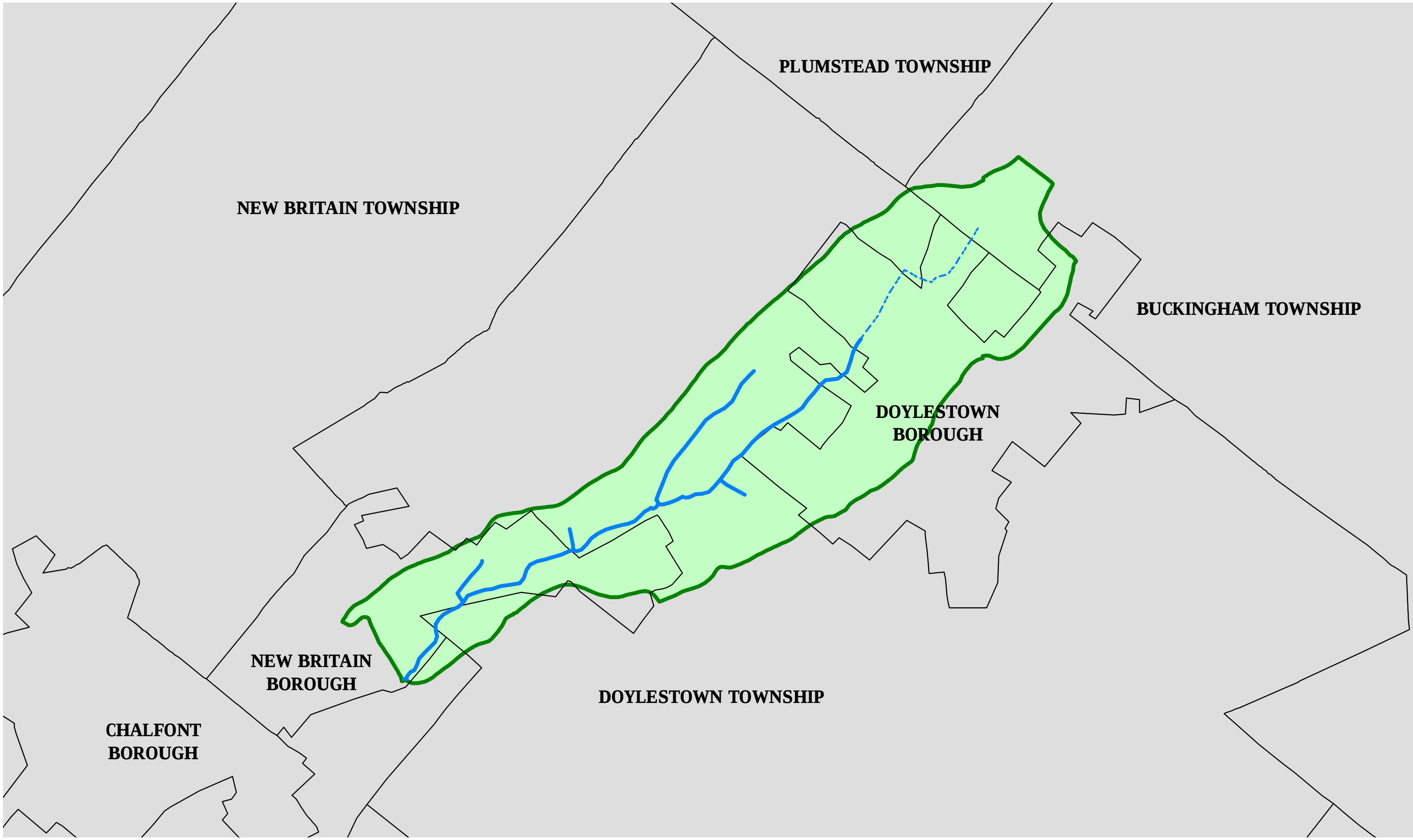
The Cooks Run watershed, which is approximately 3.3 square miles in size, is located in central Bucks County as shown in Figure 1.1. Cooks Run flows in a southwesterly direction and eventually discharges into the Neshaminy Creek. The Neshaminy Creek is a tributary to the Delaware River. Currently, Cooks Run is classified as Warmwater Fishery (WWF), MF (Migratory Fishery) under PA DEP's Chapter 93 Water Quality Standards. The headwaters of Cooks Run are located within Buckingham Township and the Borough of Doylestown. The stream then flows through Doylestown Township and the Borough of New Britain. Both the Neshaminy Creek and its tributary, Cooks Run, are listed on the State's 303(d) List of Impaired Waters.

Based upon these recent water quality concerns, the Bucks County Conservation District applied for state and/or federal funding to perform Phase I of the Cooks Run Watershed Assessment. The Phase I assessment was fully supported by the Borough of Doylestown, Doylestown Township, the Borough of New Britain and the Bucks County Water and Sewer Authority. The Pennsylvania Department of Environmental Protection (PA DEP) approved funding for the project through the federal Coastal Zone Management Program (CZMP) on December 13, 2002. In turn, the District retained Aqua-Link, Inc. of Doylestown, Pennsylvania to perform the first phase of the assessment on January 8, 2003.

Aqua-Link and its subcontractors, Gilmore and Associates and the Heritage Conservancy, performed Phase I of the Cooks Run Watershed Assessment from February 2003 through March 2004. The major tasks of the Phase I assessment are listed below:

- To develop GIS (Geographical Information System) maps for the entire watershed.
- To monitor the water quality of Cooks Run at four different stations throughout the watershed during both baseflow (normal flow) and stormflow (high flow) conditions.
- To perform a macroinvertebrate (aquatic insect) survey at four different stations throughout the watershed.

Cooks Run Watershed Assessment



Map Prepared by:
Heritage Conservancy
85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

HERITAGE CONSERVANCY

4000 0 4000 Feet

Data Source:
PA Dep, USGS

Figure 1.1 Political Boundary Map

- Cooks Run Watershed
- Municipal Boundary
- Cooks Run (USGS)
- Cooks Run (Determined by Aqua-Link, Inc. 2004)

- To identify and evaluate significant stormwater management (SWM) facilities within the upper section of the watershed. The upper section is defined as that portion of the watershed upstream (north) of Route 611 Bypass (refer to Section 2).

- To perform a stream and riparian corridor assessment of the upper section of the watershed.

- To evaluate municipal ordinances and their language to protect stream water quality and aquatic habitats throughout the watershed.

- To develop a comprehensive, watershed management plan for the upper section of the Cooks Run watershed. The primary goal of this plan is to improve and further protect stream water quality and aquatic habitats of Cooks Run and its unnamed tributaries.

In addition, the Bucks County Conservation District applied for more funding to perform the second phase, Phase II, of the Cooks Run Watershed Assessment Project. The District with the assistance of Aqua-Link prepared and submitted the Phase II grant application to PA DEP on March 4, 2004. The Phase II project targets the lower section of the watershed, which is designated as downstream (south) of Route 611 Bypass to the confluence of the Neshaminy Creek. The lower section of the watershed primarily lies within Doylestown Township and New Britain Borough. If funded, the following tasks of the Phase II project will be performed:

- To evaluate major stormwater management (SW) facilities within the lower section of the watershed.

- To perform a stream and riparian corridor assessment of the lower section of the watershed.

- To develop a comprehensive, watershed management plan to improve and further protect surface water quality in the lower section of the Cooks Run watershed.

- To provide additional GIS mapping in order to support the above Phase II tasks.

Based upon this report, the District and its watershed partners intend to apply for additional funds to begin implementing the Phase I watershed management plan. If funded, it is anticipated that Phase II of the Cooks Run Watershed Assessment will be completed by December 2005. Thereafter, the District and its partners will once again reapply for more funding to implement both phases of the watershed management plan.

1.1. Project Funding and Administration

The Pennsylvania Department of Environmental Protection (PA DEP) and the National Oceanic and Atmospheric Administration (NOAA) funded this project through the Coastal Zone Management Program. The Coastal Zone Management Program (CZMP) is authorized by the Coastal Zone Management Act of 1972 and administered at the federal level by the Coastal Programs Division (CPD) within the National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management (OCRM).

1.2. Additional Background Information

This section provides some additional background information about Cooks Run and the Neshaminy Creek. As noted in Section 1, Cooks Run flows through the Borough of Doylestown and is a major tributary to the Neshaminy Creek.

- ***Watershed Restoration Action Strategy (WRAS) State Water Plan for the Neshaminy Creek Watershed (Subbasin 02F) in Bucks and Montgomery Counties***. The Neshaminy Creek WRAS was prepared by PA DEP in September 2003 (updated) and can be viewed at their website at www.dep.state.us.

  The WRAS provides a good overview of the Neshaminy Creek watershed with respect to its physical characteristics (geology, soils, land use, water supplies, natural resources, fisheries and stream classification). This document lists past studies and management plans that were performed or developed, respectively, for portions of the watershed or the entire watershed. In addition, the WRAS discusses both water quality impairments and sources of these impairments for the entire Neshaminy Creek watershed. The WRAS also outlines specific watershed restoration needs for the entire watershed and some of its more significant subwatersheds.

  Based upon the WRAS, the Neshaminy Creek watershed is part of HUC Area 2040201, which is a Category I, FY99/2000 Priority watershed under the Unified Watershed Assessment. The major tributaries of the Neshaminy Creek are the North Branch, West Branch and Little Neshaminy Creek.

  The WRAS states that a variety of nonpoint and point source pollution sources affect the watershed. The conversion of farmland to residential development has lead to siltation problems from land construction and impairment by stream flow variability and stormwater runoff. Construction activities associated with rapid urbanization are major sources of high sediment loads. Soils are highly erodible, and disturbed areas contribute high sediment loads during storm events. In some cases, however, conversion from agriculture to suburban land use will likely reduce the siltation rates once construction is completed because raw soil is no longer exposed through regular plowing and planting. Erosion and stormwater runoff continue to carry sediments and nutrients to streams and lakes.

As noted in the WRAS, the watershed has a number of point source discharges, including 15 municipal sewage facilities that discharge into the main stem Neshaminy Creek, Little Neshaminy Creek and its unnamed tributaries and Lahaska Creek. During low summer flow periods, these discharges may comprise the majority of flow to the receiving stream. Stream degradation associated with excess nutrients, phosphates, nitrates, sludge, fecal coliform bacteria, copper, chlorine and bacteria from sewage treatment plants have been reported in the Neshaminy Creek, Little Neshaminy Creek, West and North Branches of the Neshaminy Creeks and Cooks Run.

Municipal wastewater treatment plants serving concentrated population centers within the watershed discharge treated effluent containing significant amounts of nutrients. Little Neshaminy Creek, Park Creek and Cooks Run are on the 303(d) list for nutrient enrichment from municipal point source discharges, such as sewage treatment plants. While municipal point sources are regulated under the state administered federal NPDES program, large treatment facilities on small watersheds overwhelm the streams capacity to assimilate treated effluent. Wastewater treatment facilities in the Neshaminy Creek watershed have discharge limits for phosphorous; however, instream phosphorous concentrations are well above expected ambient concentrations.

The WRAS states that the Neshaminy Creek watershed has experienced large increases in population growth since 1945. Residential, commercial and industrial land development has resulted in increased levels of imperviousness due to numerous roads, parking lots, buildings and driveways. Stormwater associated with land development impacts both the quantity and quality of water entering streams.

Many developed areas have impervious surfaces directly linked to streams through piping without stormwater controls. Other developed areas have stormwater controls that were created to attenuate peak discharges to predevelopment levels. These controls may help limit downstream flooding, but do little to protect aquatic life and habitat. Little Neshaminy Creek and Neshaminy Creek have approved Act 167 Stormwater Management Plans; however, these plans have provided little benefit for aquatic life. The plans do not require stormwater management for areas that were previously developed and do not protect channels from smaller bank-full storm events that shape aquatic habitat.

Many pollutants are deposited or placed on impervious areas and urban/suburban landscapes (lawns, golf courses, athletic fields). These pollutants include animal feces, oil, fertilizers, pesticides, anti-freeze solution and solids. These pollutants discharge directly to the stream in developed areas that lack stormwater pollution controls. Little Neshaminy Creek and Neshaminy Creek's Stormwater Management Plan have water quality objectives for new development. Some municipalities will fall under the federal stormwater regulations (Phase II). Stormwater management practices such as infiltration areas, vegetated detention basins, and retention ponds.

According to the WRAS, the highest restoration needs in the watershed are the restoration of riparian buffers, streambank stabilization, and stormwater runoff controls. Restoration efforts should be directed towards these impaired stream and lake areas:

1. Neshaminy Creek: 4.51 miles of lower main stem and 52.23 miles of unnamed tributaries: stormwater and agricultural best management practices (BMPs).

2. West Branch Neshaminy Creek: 7.77 miles of main stem and 24.03 miles of unnamed tributaries: agricultural BMPs and better controls on land development.

3. North Branch Neshaminy Creek: 3.32 miles main stem and Pine Run at Chalfont, including Lake Galena: agricultural BMPs, repair of leaky septic systems, Canada goose controls, better controls on stream flow variability and stormwater runoff, riparian restoration and stabilization.

4. Cooks Run (entire basin): stormwater management BMPs.

5. Mill Creek at Tradesville (entire basin): better controls on residential development and surface mining.

6. Little Neshaminy Creek and its tributary Park Creek (entire basin): stormwater management.

7. Core Creek: entire basin including Lake Luxembourg, agricultural BMPs and better controls on stream flow variability.

- ***Total Maximum Daily Load (TMDL) Assessment for the Neshaminy Creek Watrershed in Southeast Pennsylvania***. The Pennsylvania Department of Environmental Protection prepared this TMDL report in December 2003. For more information, the TMDL report for the Neshaminy Creek is available at PA DEP's website at www.dep.state.pa.us.

  The TMDL report states that the Neshaminy Creek is impaired due to high concentrations of phosphorus and silt covering the creek beds. The TMDL includes a plan for decreasing the instream phosphorus concentrations and for reducing the sediment loads delivered to the streams in order to meet Pennsylvania water quality standards.

  In 1996, PA DEP included Neshaminy Creek, two unnamed tributaries to Neshaminy Creek, Little Neshaminy Creek, Park Creek, Cooks Run, West Branch Neshaminy Creek and an unnamed tributary to West Branch Neshaminy Creek on the federal Clean Water Act, Section 303(d) List of Impaired Waters for aquatic life impairments due to nutrients, suspended solids and siltation.

  At extreme low flows, the streamflow in Neshaminy Creek and its tributaries is predominantly made up of discharge effluents. Therefore, the phosphorus pollution at the critical low flow period in the Neshaminy Creek watershed comes from the point source dischargers. Sediments carried to the stream in overland flow in wet weather periods are, in part, are responsible for the siltation impairment in these water bodies. Streambank erosion caused primarily by increased flow volume and altered timing is also a major contributor of sediment to these streams.

  More specifically, the TMDL report states that several stream segments in the Cooks Run watershed (Stream Segment ID# s 482 and 482A) were listed as being impaired by "nutrients" and "cause unknown" from urban runoff/storm sewers and a municipal point source. An analysis of the loads from this particular watershed reveal that the watershed is essentially a point source-dominated watershed and nutrients from all other sources are quite insignificant. On an annual basis, report states that the sole municipal point source in the watershed (PA0021172) contributes 77 percent of the total phosphorus load. During low-flow conditions, this percentage is even higher. During such conditions, the only other loads essentially are those contributed by groundwater (i.e., baseflow) and septic systems. When these are considered, the point source contribution during low-flow conditions is approximately 92 percent of the total.

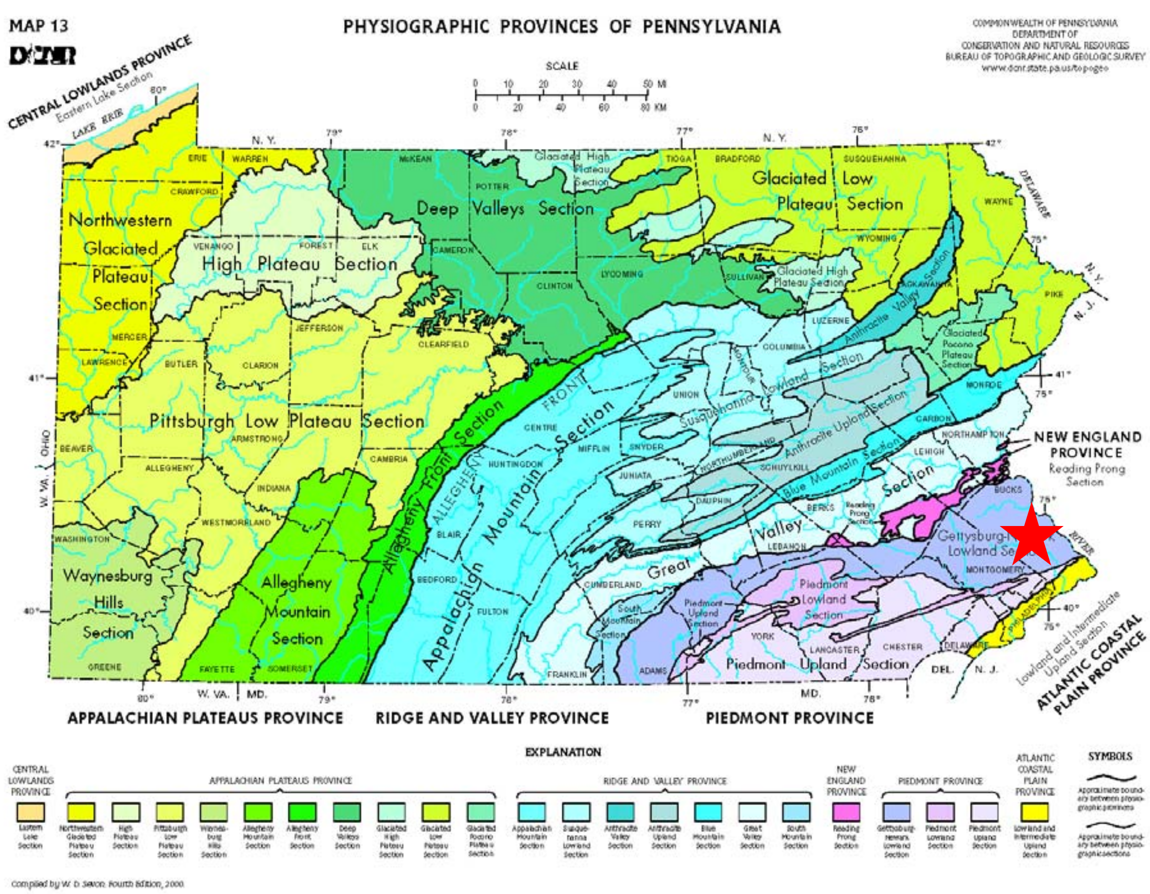
2. Watershed Characteristics

This section primarily discusses the physical characteristics of the Cooks Run watershed. The information provided below is frequently cited throughout the remainder of this report.

Specific data (hydrology, topography, roadways, soils and land use) for the Cooks Run watershed were obtained from a variety of sources. These data were then analyzed using ArcView GIS (geographical information system) Version 3.2a software with the Spatial Analyst module. Refer to
Appendix A for more information about the GIS data layers used for this project.

2.1. Physiography and Topography

The Cooks Run watershed lies within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Providence as shown below. The dominant topographic form of this section is rolling lowlands, shallow valleys and isolated hills.



In addition, the Cooks Run watershed lies within the Northern Piedmont ecoregion (Ecoregion No. 64). The Northern Piedmont is a transitional region of low rounded hills, irregular plains and open valleys in contrast to the low mountains of the Blue Ridge and Valley and Northeastern Highland ecoregions to the north and west; and, the flatter coastal plains of the Mid-Atlantic Coastal Plain and Southeastern Plain ecoregions to the east.

Overall, the Cooks Run watershed is best described as an elongated, narrow basin that is oriented along a southwest - northeast axis (Figures 2.1 and 2.2). The lowest elevation in the watershed, which is 234 feet above mean sea level (MSL), is at the confluence of Cooks Run and the Neshaminy Creek. The highest elevation of 460^{+} feet above MSL is located along the eastern watershed divide near the intersection of Court and Spruce Streets.

2.2. Hydrology

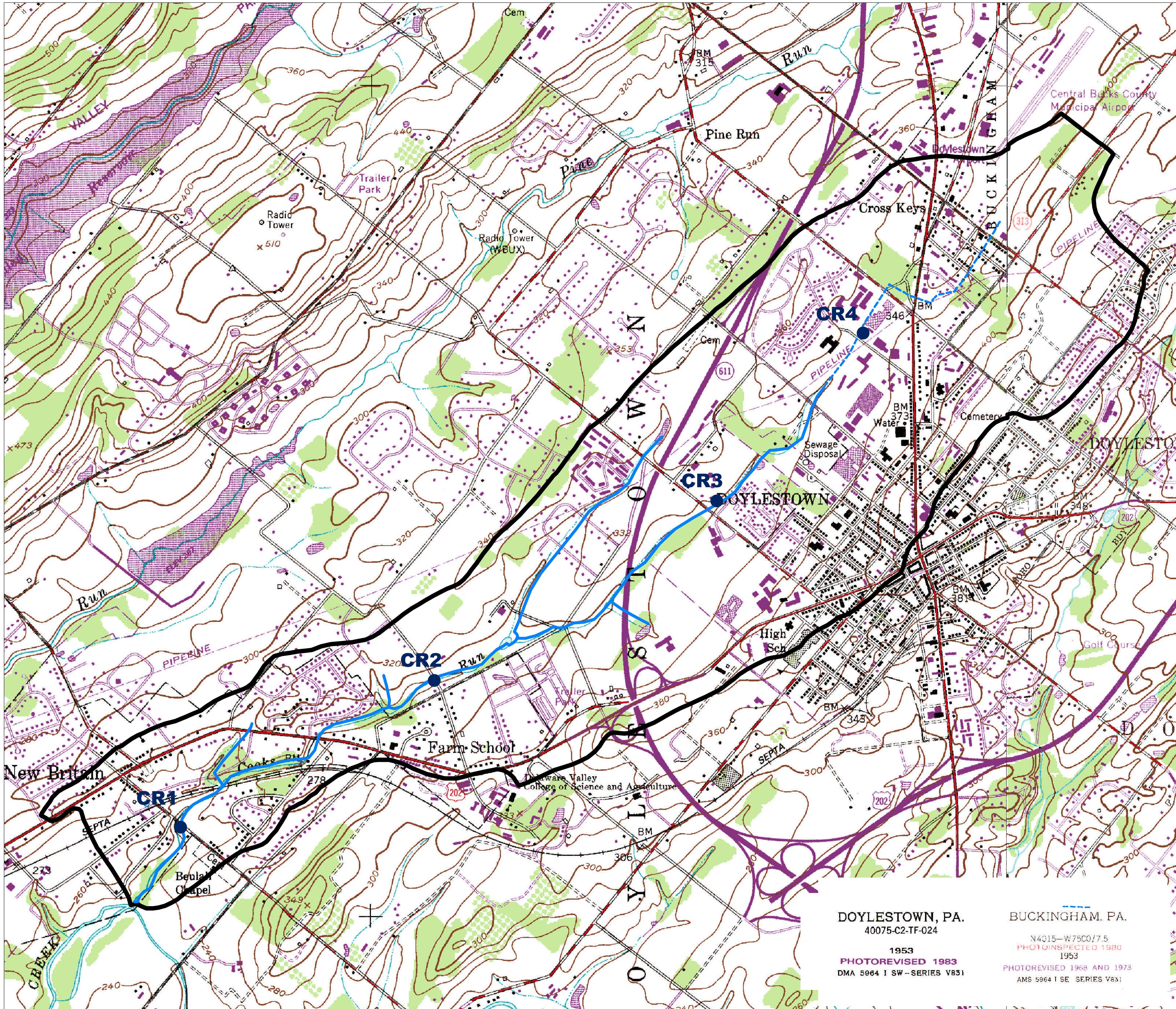
The headwaters of Cooks Run begin in the northern portion of the watershed just north of Route 313 in Buckingham Township at the Bucks County Municipal Airport (Figure 1.1 and 2.1). The stream flows in a southwesterly direction through a residential area located just southeast of Cross Keys (Figure 2.1) and next to the Font Hill County Park. Several stream segments through this residential area have either been channelized or piped underground. Next, Cooks Run flows behind the Kidd Glove Car Wash and McDonald's restaurant, which are located in the Borough of Doylestown along Main Street (Route 611). The stream travels under Main Street and flows along Old Dublin Pike within the Mercer Square Shopping Center. From Mercer Square, the stream flows beneath Old Dublin Pike and behind the Doylestown Shopping Center. From this shopping center, Cooks Run flows along Veteran's Lane to Broad Street.

Cooks Run flows beneath Broad Street and then past the Harvey Avenue wastewater treatment plant. This wastewater facility is owned and operated by the Bucks County Water and Sewer Authority. The stream continues to flow in a southwesterly direction and beneath the Route 611 Bypass. The upper section of the watershed (upper subwatershed) is defined as that portion of the watershed north of the Route 611 Bypass. Conversely, the lower section of the watershed (lower subwatershed) is defined as that portion of the watershed south of the Route 611 Bypass down to the confluence of Cooks Run and the Neshaminy Creek.

Cooks Run primarily flows through Doylestown Township and New Britain Borough in the lower watershed (Figures 1.1 and 2.1). In the lower watershed, the stream receives additional streamflow via four unnamed tributaries. The first tributary actually drains a stormwater retention pond located at the Doylestown Hospital. Thereafter, Cooks Run eventually discharges into the Neshaminy Creek approximately 1.2 miles northeast of Chalfont.

Cooks Run
Watershed Assessment

Figure 2.1
Topographic Base Map



Cooks Run Watershed

Cooks Run **(USGS)**

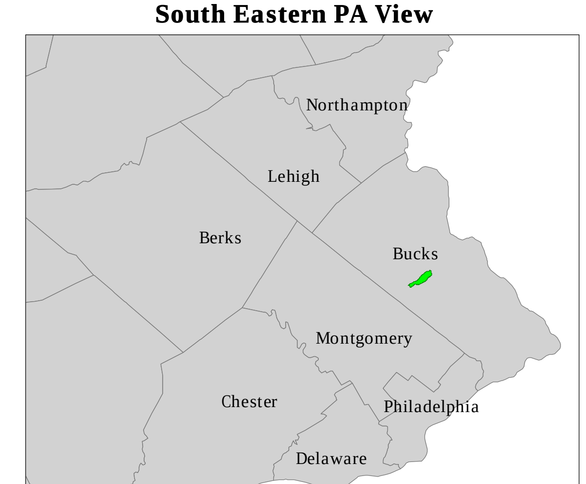
Cooks Run **(Determined by Aqua-Link, Inc. 2004)**

Stream Monitoring Stations

2000 0 2000 Feet

Data Source:
United States Geologic Survey

South Eastern PA View

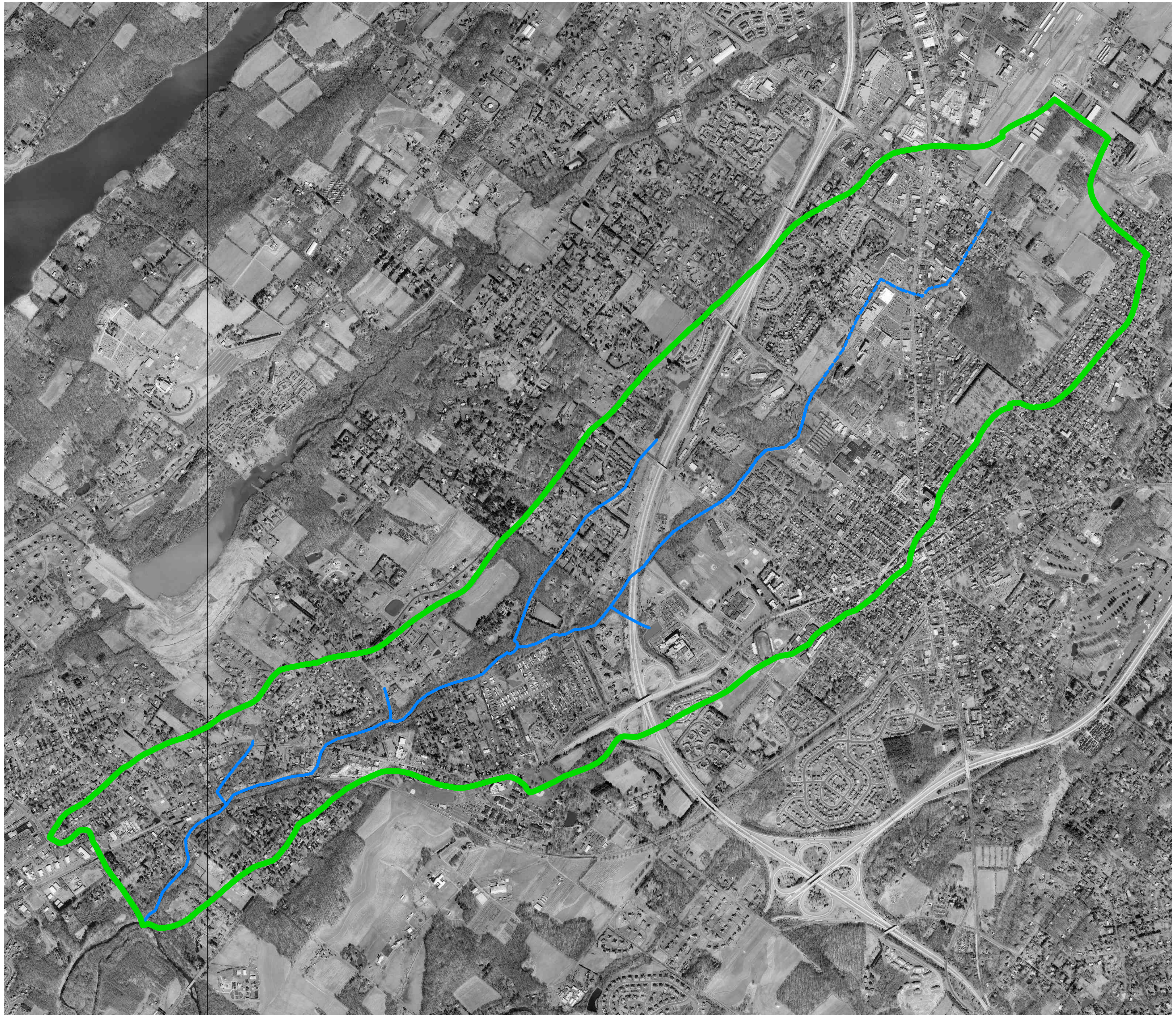


Map prepared by:

HERITAGE CONSERVANCY

85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

March 2004



Cooks Run
Watershed Assessment

Figure 2.2
Orthophoto Map

Cooks Run **(USGS)**

Cooks Run **(Determined by Aqua-Link, Inc. 2004)**

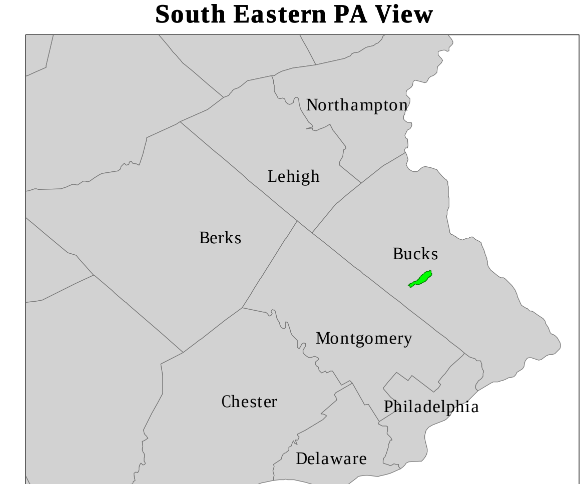
Cooks Run Watershed

DVRPC 2000 Orthophotos:
X 30 - 32 ,Y 100 - 104

2000 0 2000 Feet

Data Source:
DVRPC 2000 Orthophotos
United States Geologic Survey

South Eastern PA View



Map prepared by:

HERITAGE CONSERVANCY

85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

March 2004

2.3. Geology and Soils

As noted in Section 2.1, the Cooks Run Watershed lies within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Providence. The underlying rock type of the Gettysburg-Newark Section is mainly red shale, siltstone and sandstone with some conglomerate and diabase. Most of the soils in this section were formed via fluvial erosion of rocks of variable resistance.

Twenty-one different soil types are located within the Cooks Run watershed as shown in Figure 2.3. Of this total, the top ten soils represent over 94 percent of all soils within the watershed. The top ten frequently occurring soils in the Cooks Run watershed along with their corresponding percentages are listed in Table 2.2 and Appendix B.

The Cooks Run watershed is highly urbanized and therefore it is not surprising that five of the top ten soils in the watershed are classified as either urban land or urban land soil complexes as listed in Table 2.2 and shown in Figure 2.3.

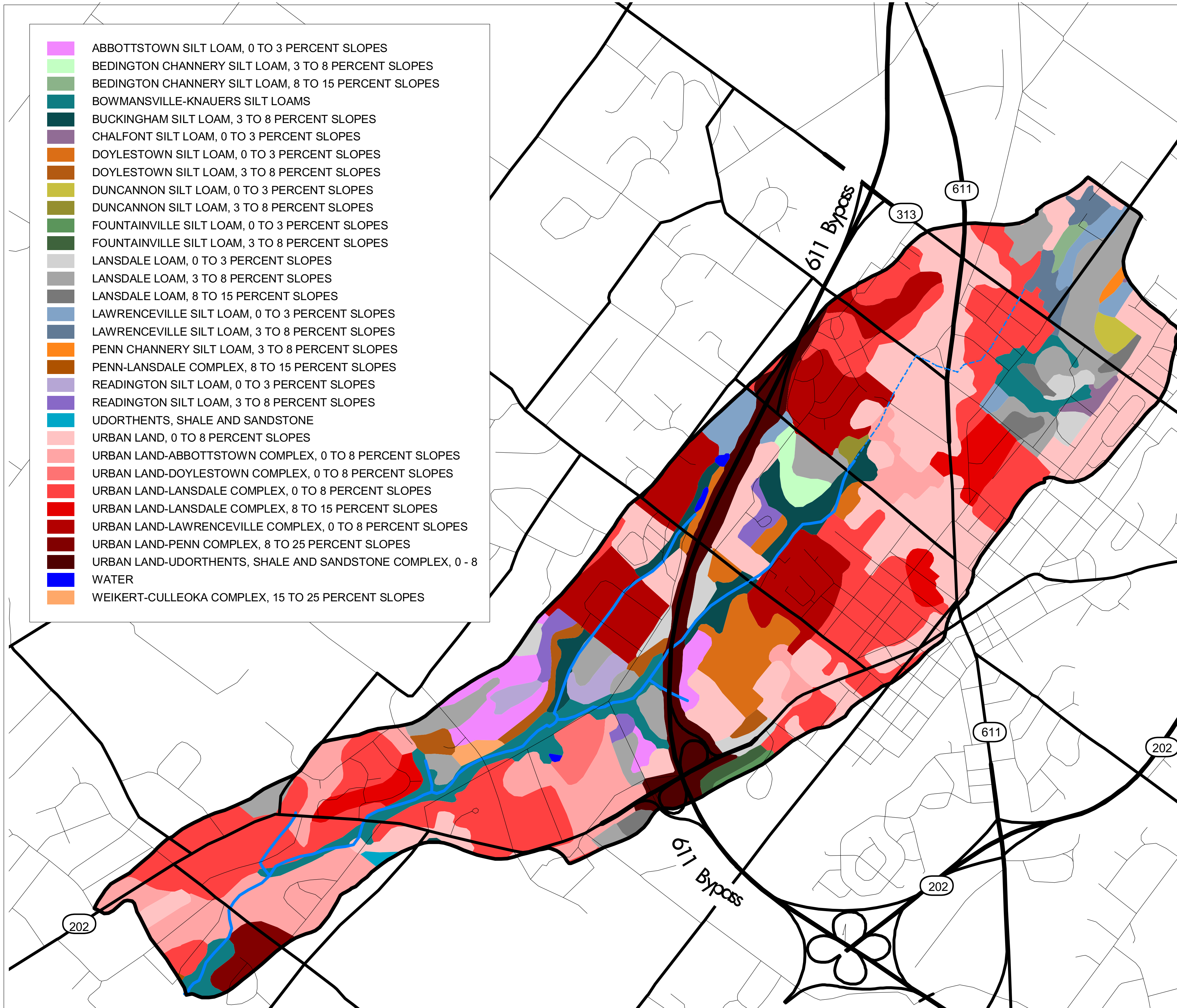
Information about the ten most abundant soils in the Cooks Run watershed are presented below. First urban land and urban land soil complexes are discussed in alphabetical order. Thereafter, soil descriptions of the major soil series in Table 2.2 are discussed alphabetically. All soil information and descriptions were obtained at the USDA NRCS National Soil Survey Center website (http://ortho.ftw.nrcs.usda.gov/osd) and the *Soil Survey of Bucks County, Pennsylvania* posted at the Bucks County Conservation District website (www.bucksconservation.org).

Table 2.1 Soils in the Cooks Run Watershed

Major Soils Types	Percent
Urban Land-Lansdale Complex	23.1
Urban Land	20.6
Urban Land-Lawrenceville Complex	9.7
Urban Land-Abbottstown Complex	9.5
Lansdale	9.4
Urban Land-Udorthents, Shale & Sandstone Complex	4.7
Knauers	4.5
Doylestown	4.2
Buckingham	2.9
Lawrenceville	2.7
Total	**94.1**

Cooks Run
Watershed Assessment

Figure 2.3
Soils Map



Cooks Run Watershed

Cooks Run (USGS)

Cooks Run (Determined by Aqua-Link, Inc. 2004)

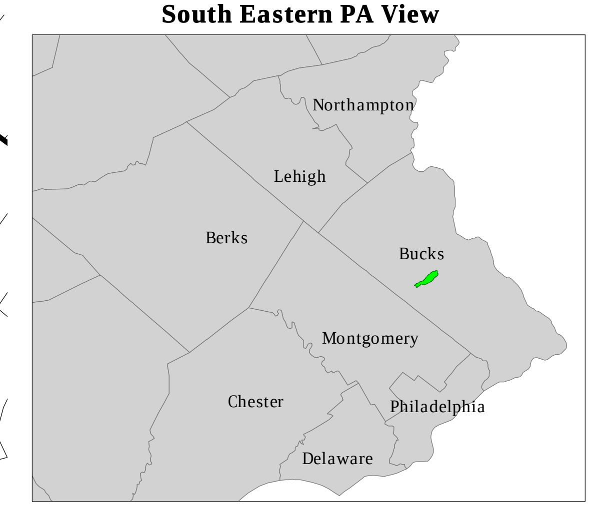
Major Road

Minor Road

2000 0 2000 Feet

Data Source:
USDA - NRCS, Penn State University

South Eastern PA View



Map prepared by:

HERITAGE CONSERVANCY

85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

March 2004

Urban Land & Urban Land Soil Complexes

Urban land consists of roads, railroads, parking lots, buildings and other structures covering over 85 percent of the surface area. On site investigation are needed to determine the suitability and limitations of these soils for most of their uses. Conversely, urban land soil complexes consist of urban lands intricately combined with one or more different soil series.

In addition, the following urban land soil complexes occur within the Cooks Run watershed: the Urban Land-Abbottstown Complex; the Urban Land-Lansdale Complex; the Urban Land-Lawrenceville Complex; and the Urban Land-Udorthents, Shale & Sandstone Complex. The Urban Land-Abbottstown Complex is 65 percent urban lands and similar components and 25 percent Abbottstown series soils. The Urban Land-Lansdale Complex is 65 percent urban lands and similar components and 25 percent Lansdale series soils. The Urban Land-Lawrenceville Complex is 65 percent urban lands and similar components and 25 percent Lawrenceville series soils. Lastly, the Urban Land-Udorthents, Shale & Sandstone Complex is 80 percent urban lands and similar components and 15 percent Udorthents, shale and sandstone and similar components.

Buckingham Series

Soils are classified as moderately deep to fragipan to very deep and somewhat poorly drained. The permeability of these soils is moderate above the fragipan and slow to moderately slow in the fragipan. Soils are found on the head slopes, in drainageways and in U-shaped valleys. The parent materials of these soils are colluvium and alluvium derived from gray and red shale, siltstone, and sandstone material eroded from adjacent uplands. Slopes range from 0 to 8 percent and associated soils with this series are Lawrenceville, Reaville, Rowland, Readington, Croton and Abbottstown.

Doylestown Series

Soils are classified as deep and poorly drained. The permeability of these soils is moderate in the upper part of the solum and slow to moderately slow in the lower part. These soils are located along foot slopes and toe slopes of nearly level to gently undulating drainageways and broad basins. The parent materials of these soils are silty materials, presumably loess, over soil materials weathered from a variety of parent materials, but principally red shale. Slopes range from 0 to 8 percent and these soils are often associated with Chalfont, Lawrenceville, Bowmansville, and Buckingham, Fountainville, Duncannon, Nockamixon and Amwell soils.

Knauers Series

Soils are classified as very deep and poorly drained. The permeability of these soils is moderate in the surface, moderately slow to moderately rapid in the subsoil and moderately rapid in the substratum. The soils are often located in river valleys in floodplains along perennial streams. The parent materials are derived from alluvium, mostly from residuum from shale, sandstone and siltstone. The slopes range from 0 to 3 percent and these soils are commonly associated with soils of the Bowmansville, Rowland and Barbour series.

Lansdale Series

Soils are classified as deep and well drained. The permeability of these soils is moderately slow to moderate in the A horizon, moderately slow to moderately rapid in the B horizon, moderately rapid in the substratum and moderately slow in the bedrock. The soils are located on the side slopes and ridges of nearly level to steep uplands in the piedmont. The parent materials of these soils are residuum mostly from sandstone and conglomerate. The slopes range from 0 to 50 percent and these soils are commonly associated with soils of the Edgemont, Steinsburg, Readington, Abbottstown, Croton, Fountainville, Brecknock and Brownsburg series.

Lawrenceville Series

Soils are classified as moderately deep to fragipan to very deep and moderately well drained. The permeability of the soils is considered moderate. These soils are located on the side slopes of upland areas. The parent material of the soils is loess from shale-siltstone material over residuum from shale siltstone material. The slopes range from 0 to 15 percent and these soils are often associated with soils of the Duncannon, Chalfont, Readington, Fountainville, Brownsburg, Buckingham and Doylestown series.

2.4. Land Use

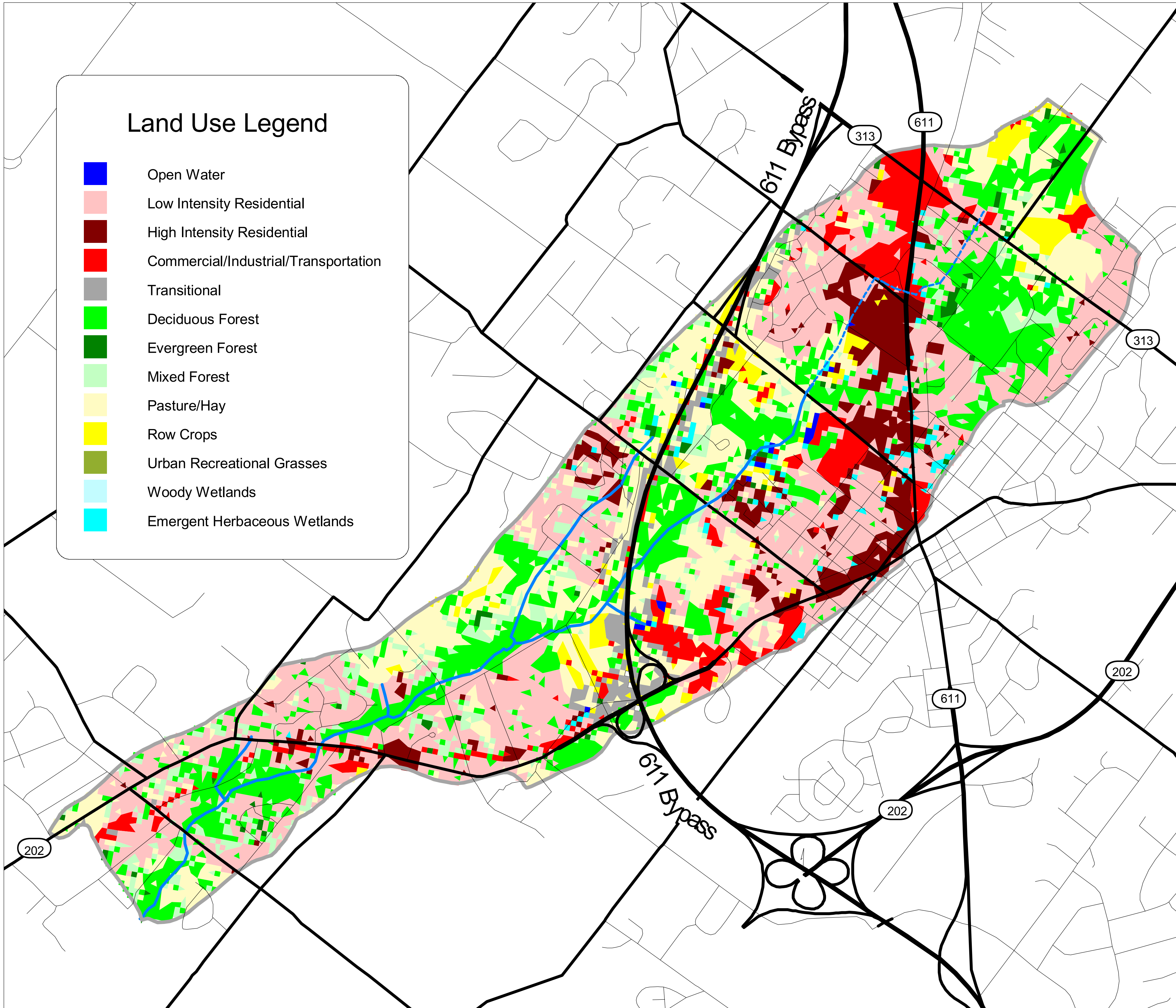
The Cooks Run watershed is best classified as a highly urbanized watershed as shown in Table 2.2 and Figure 2.4. Both low and high-density residential land uses plus commercial/industrial/transportation land uses account for 47.3 percent of all watershed land uses. Most of the high density residential and commercial/industrial/transportation land uses occur within the upper Cooks Run subwatershed along the Main Street (Route 611 Business) and Swamp Road (Route 313) corridors. The intersection of Routes 611 and 313 is locally referred to as the “Cross Keys”.

As described previously in Section 2.2, the upper section of the watershed (upper subwatershed) is defined as that portion of the watershed north of the Route 611 Bypass. Conversely, the lower section of the watershed (lower subwatershed) is defined as that portion of the watershed south of the Route 611 Bypass down to the confluence of Cooks Run and the Neshaminy Creek (Figure 2.4).

The Cross Keys area contains gas stations, fast food restaurants, automobile dealerships and other stores. Two large shopping centers, Mercer Square and Doylestown Shopping Centers, are located just south of Cross Keys. The Bucks County Court House and many specialty and novelty shops and restaurants are located in the vicinity of Court and Main Streets.

Cooks Run
Watershed Assessment

Figure 2.4
Land Use Map

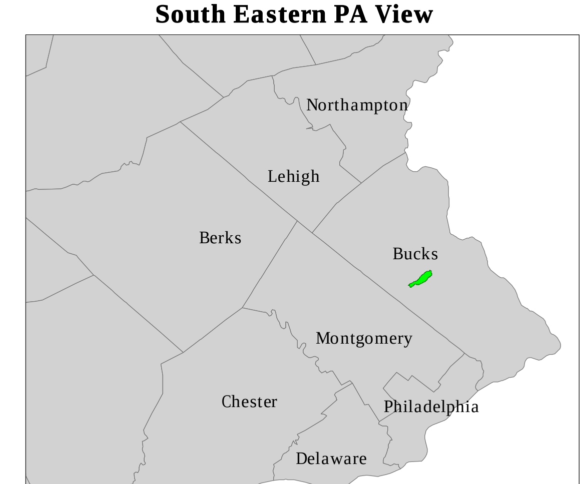


Cooks Run Watershed
Cooks Run **(USGS)**
Cooks Run **(Determined by Aqua-Link, Inc. 2004)**
Major Road
Minor Road

2000 0 2000 Feet

Data Source:
United States Geologic Survey

South Eastern PA View



Map prepared by:

HERITAGE CONSERVANCY

85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

March 2004

Table 2.2 Land Uses in the Cooks Run Watershed

Land Use	Area (acres)	Percent
Low Intensity Residential	692.5	32.7
High Intensity Residential	157.8	7.5
Commercial/Industrial/Transportation	150.6	7.1
Quarries/Strip Mines/Gravel Pits	1.6	0.1
Transitional	60.6	2.9
Deciduous Forest	421.6	19.9
Evergreen Forest	22.3	1.1
Mixed Forest	129.7	6.1
Pasture/Hay	383.9	18.1
Row Crops	70.9	3.3
Emergent Herbaceous Wetlands	21.1	1.0
Open Water	5.0	0.2
Total	**2,117.7**	**100.0**

Many sections of Cooks Run the upper subwatershed lack good, forested riparian buffers. Unfortunately, most of the forested lands in the upper subwatershed are concentrated in several tracts of land just north of Route 313 and within parkland at the Font Hill Museum. The Font Hill Museum is owned and maintained by the Bucks County Historical Society. For more information about the Font Hill Museum, visit the Bucks County Historical Society's website. Their website is http://www.buckscountyhistorical.org/fonthill.

Most of the high residential and commercial/industrial/transportation land uses in the Lower Cooks Run subwatershed occur within along the Route 202 corridor as shown in Figure 2.4. The largest tracts of forested lands within this portion of the watershed occur along Cooks Run and its unnamed tributaries (Figure 2.4). These forested tracts of land, forested riparian buffers, are easily viewed in Figure 2.2.

3. Overview of the Watershed Assessment

3.1. Primer on Stream and Watershed Dynamics

This section is intended to serve as a primer on stream and watershed dynamics as it pertains to the urbanization process. Much of the information below was obtained directly from the document entitled *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs* (Schueler 1987). First, an overview of the impacts that urbanization has on streams and other receiving waters is discussed. Next, the specific impacts of various pollutants contained in urban runoff are presented.

<u>Changes in Watershed Hydrology</u>

Urbanization has a profound influence on stream quality. These are readily seen when a stream in an older urban area is compared to in a more natural setting. The following narrative describes the changes associated with the development of hypothetical small watershed.

The hydrology of a stream changes in response to initial site clearing and grading. Trees that had intercepted rainfall are felled (Figure 3.1a). Natural depressions, which temporarily ponded water, are graded to a uniform slope. The thick humus layer of the forest floor that had absorbed rainfall is scraped off or erodes away. Having lost much of its natural storage capacity, the cleared and graded site can no longer prevent rainfall from being rapidly converted to runoff.

The situation worsens after construction is completed (Figure 3.l a). Rooftops, roads, parking lots, sidewalks and driveways make much of the site impervious to rainfall. Unable to percolate into the soil, rainfall is almost completely converted into runoff. The excess runoff becomes too great for the existing drainage system to handle. As a result, the drainage network must be "improved" to direct and convey the runoff away from the site (i.e., by installing culverts, curbs, gutters, storm sewers, or lined channels).

In a typical, moderately developed watershed, the net effect of development is a series of changes to stream hydrology (Figure 3.l b) including:

- Increased peak discharges about two to five times higher than pre-development levels.

- Increased volume of storm runoff produced by each storm, in comparison to pre-development conditions. A moderately developed watershed may produce 50% more runoff volume than a forested watershed during the same storm.

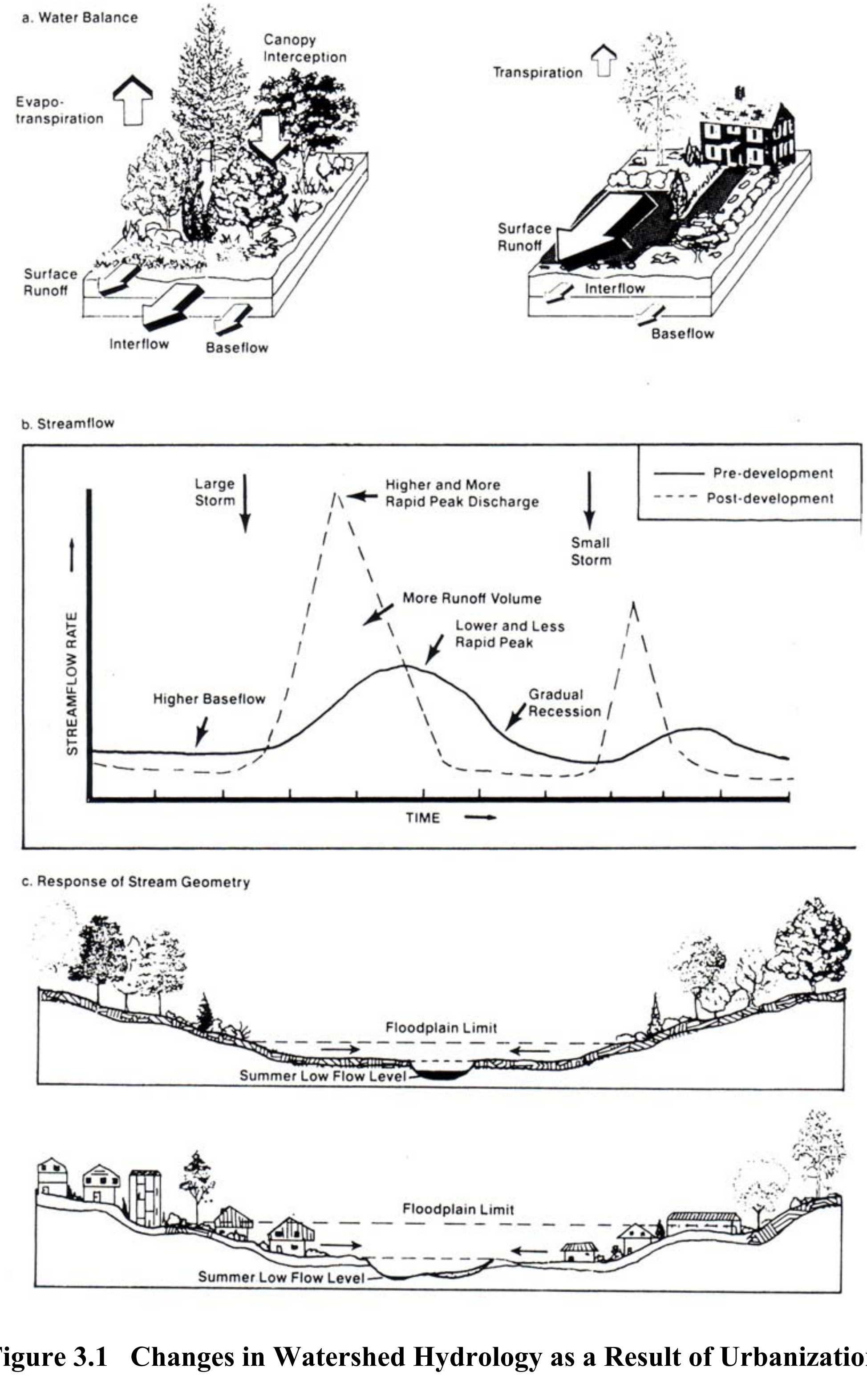


Figure 3.1 Changes in Watershed Hydrology as a Result of Urbanization

- Decreased time needed for runoff to reach the stream (termed the time concentration) by as much as 50%, particularly if extensive drainage improvements are made.

- Increased frequency and severity of flooding. A short, intense summer thunderstorm that had only slightly raised water levels in the past now turns the stream into a torrent. In a natural state, a stream experiences bankfull discharges (i.e., runoff entirely fills the stream channel) only about once every two years. In moderately developed watersheds, bankfull discharges may occur as often as three or four times a year.

- Reduced streamflow during prolonged periods of dry weather due to the reduced level of infiltration in the watershed. In smaller, headwater streams, the reduction may be enough to cause a perennial stream to become seasonally dry.

- Greater runoff velocity during storms that is due to the combined effect of higher peak discharges, rapid time of concentration, and smoother hydraulic surfaces that resulted from development.

Changes in Stream Geometry

The channel of an urbanizing stream must adjust to the new hydrological conditions, and this results in the following responses:

- The primary adjustment to the increased storm flows is through channel widening (Figure 3.l c). Numerous surveys have shown that most streams widen two to four times their original size if post-development runoff is not effectively controlled. The resulting streambank erosion is severe because most floodplain soils are unconsolidated and highly erodible.

- The elevation of the stream's floodplain must increase to accommodate the higher post-development peak discharge rate (Figure 3.l c). Property and structures, which had not previously been subject to flooding, are now may be at risk.

- Streambanks are gradually undercut and slump into the channel. Trees that had protected the banks are exposed at the roots, and are more likely to be windthrown, triggering a second phase of bank erosion.

- The unusually high quantities of the sediment eroded from streambanks and upland areas are seldom completely exported from the watershed. Much of it remains as temporary channel storage in the form of sandbars and other sediment deposits. Gradually, the extra sediment moves through the stream network as bedload. However, for many years, the channel substrate is covered by shifting deposits of mud and coarse sand.

Degradation of Aquatic Ecosystems

The aquatic ecosystems in urban headwater streams are particularly susceptible to the impacts of urbanization. The massive shift from the natural flow and channel conditions reduce the habitat value of the stream. Studies have shown that fish communities become less diverse and are composed of more tolerant species after the surrounding watershed is developed. Sensitive fish species either disappear or occur very rarely. In most cases, the total number of fish in urbanizing streams may also decline.

Similar trends have been noted among aquatic insects, which are the major food resource for fish. These species cling to rocks and rely on the passing flow of leaf litter and organic matter for sustenance. Higher post-development sediment and trace metals can interfere in their efforts to gather food. Changes in water temperature, oxygen levels, and substrate composition can further reduce the species diversity and abundance of the aquatic insect community. No single factor is responsible for the progressive degradation of urban stream ecosystems. Rather, it is probably the cumulative impacts of many individual factors such as sedimentation, scouring, increased flooding, lower summer flows, higher water temperatures, and pollution.

Pollutant Export During the Construction Phase

Pollutant export increases dramatically both during and after development. Initial clearing and grading operations during construction expose much of the surface soils. Unless adequate erosion controls are installed and maintained at the site, enormous quantities of sediment are delivered to the stream channel along with attached soil nutrients and organic matter.

Pollutant Export After Site Stabilization

Once the site is stabilized, pollutants accumulate rapidly on impervious surfaces and are easily washed off. The primary source of most pollutants is from the atmosphere in the form of wetfall and dryfall. Once deposited, up to 90% of the atmospheric pollutants deposited on impervious surfaces are delivered to receiving waters.

The various surfaces of the urban landscape are also an important source of many pollutants. Trace metals, for example, are a common component of many urban surfaces, such as flashing and other roofing materials, downspouts, galvanized pipes, metal plating, paints, wood preservatives, catalytic converters, brake linings and tires. Over time, these surfaces corrode, flake, decay, dissolve or leach out, thereby enabling these metals to wash away in urban runoff. This process is often exacerbated by the acidity of the rainfall.

Other sources of pollutants that accumulate and subsequently wash off impervious surfaces include pet droppings, vegetative matter, litter and debris. Several studies suggest that as neighborhoods become mature, some of these sources can become very important. Litter generation and pet dropping rates increase and the general level of "urban housekeeping" often declines, as neighborhoods grow older. Poor housekeeping is easier to define than to control. For example, heavy use areas often result in bare spots that erode, dumpsters are overloaded, out of sight alleyways and service areas are not kept up, used motor oil is dumped into storm sewers and homeowners fertilizers apply excessive quantities of fertilizers and pesticides, and so on.

Impacts of Urban Pollutants on Receiving Waters

The net effect of urbanization is to increase pollutant export by at least an order of magnitude over pre-development levels. The impact of the higher export is felt not only on adjacent streams, but also on downstream receiving waters such as lakes, rivers and estuaries. The nature of the impacts associated with specific urban pollutants is reviewed below..

Sediment

High concentrations of suspended sediment in streams cause many adverse consequences including increased turbidity, reduced light penetration, reduced prey capture for sight feeding predators, clogging of gills/filters of fish and aquatic invertebrates, reduced spawning and juvenile fish survival, and reduced angling success. Additional impacts result after sediment is deposited in slower moving receiving waters, such as smothering of the benthic community, changes in the composition of the bottom substrate, more rapid filling of small impoundments which create the need for costly dredging, and reduction in aesthetic values. Sediment is also an efficient carrier of toxicants and trace metals. Once deposited, pollutants in these enriched sediments can be remobilized under suitable environmental conditions posing a risk to benthic life.

The greatest sediment loads are exported during the construction phase of any development site. On stabilized development sites, the greatest sediment loads are exported from larger, intensively developed watersheds that are not served by BMPs that effectively control streambank erosion.

Nutrients

Excess levels of phosphorus and nitrogen in urban runoff can lead to undesirable algal blooms in downstream receiving waters (also known as eutrophication). Generally, phosphorus is the controlling nutrient in freshwater systems. The greatest risk of eutrophication is in urban lakes and impoundments that have long retention times (2 weeks or greater). Under optimal environmental growing conditions, these lake systems can experience chronic and severe eutrophic symptoms such as surface algal scums, water discoloration, strong odors, depressed oxygen levels (as the bloom decomposes), release of toxins and reduced palatability to aquatic consumers. High nutrient levels also promote the growth of dense mats of green algae that attach to rocks and cobbles in shallow, unshaded headwater streams. Finally, nutrient loads from urban runoff, in combination with other sources, can contribute to eutrophication in both fresh and tidal waters. As a general rule of thumb, nutrient export is greatest from development sites with the most impervious area. Exceptions include land uses that receive unusually high fertilizer inputs, such as golf courses, cemeteries, and other intensively landscaped areas.

Bacteria

Bacterial levels in undiluted urban runoff exceed public health standards for water contact recreation. Because bacteria multiply faster during warm weather, it is not uncommon to find a twenty-fold difference in bacterial levels between summer and winter.

Although nearly every urban and suburban land use exports enough bacteria to violate health standards, older and more intensively developed urban areas produce the greatest export. The problem is especially significant in urban areas that experience combined or sanitary sewer overflows that export bacteria derived from human wastes.

Oxygen Demand

Decomposition of organic matter by microorganisms depletes dissolved oxygen (DO) levels in slower moving receiving waters such as lakes and estuaries. The degree of potential DO depletion is measured by the biochemical oxygen demand (BOD) test that expresses the amount of easily oxidized organic matter present in water. Unfortunately, the BOD test is somewhat unreliable for measuring the oxygen demand of urban runoff since trace metals may inhibit bacterial growth and thus interfere with the test. The simpler chemical oxygen demand (COD) test, which measures all the oxidizable matter present in urban runoff, is not much better, since it includes some organic matter that does not ordinarily contribute to oxygen demand, and is only weakly correlated with BOD levels.

Despite the problems in measuring oxygen demand, it is clear that urban runoff can severely depress DO levels after large storms. BOD levels can exceed 10 to 20 mg/1 during storm "pulses" which can lead to anoxic conditions (zero oxygen) in shallow, slow-moving or poorly-flushed receiving waters. The problem is particularly acute in some older urban areas, where pulses of storm runoff BOD mix with overflows from combined or sanitary sewers.

The greatest export of BOD occurs from older, highly impervious residential areas with outdated combined storm sewers and large populations of pets. In contrast, only moderate BOD export has been reported from newer, low-density suburban residential development.

Oil and Grease

Oil and grease contain a wide array of hydrocarbon compounds, some of which are known to be toxic to aquatic life at low concentrations. The major source of hydrocarbons in urban runoff is through leakage of crankcase oil and other lubricating agents from the automobile. As might be expected, hydrocarbon levels are highest in the runoff from parking lots, roads and service stations. Residential land uses generate less hydrocarbon export, although illegal disposal of waste oil into storm sewers can be a local problem.

Hydrocarbons are lighter than water and are initially found in the form of a rainbow colored film on the water's surface. However, hydrocarbons have a strong affinity for sediment, and much of the hydrocarbon load eventually adsorbs to particles and settles out. If not trapped by BMPs, hydrocarbons tend to rapidly accumulate in the bottom sediments of lakes and estuaries, where they may persist for long periods of time and exert adverse impacts on benthic organisms.

Trace Metals

Trace metals are primarily a concern because of their toxic effects on aquatic life and their potential to contaminate drinking water supplies. As noted before, most of the metals found in urban runoff are derived from "leakage" of the urban landscape. A wide variety of trace metals were found in urban runoff samples taken during the special trace metals sampling program conducted as part of the Washington, D.C. area and national Nationwide Urban Runoff Program (NURP) studies. Specifically, the following metals were measured in detectable concentrations: arsenic, beryllium, cadmium, chromium, copper, cyanide, mercury, nickel, lead, selenium, thallium and zinc.

A wide variety of trace metals were found in urban runoff samples taken during the special trace metals sampling program conducted as part of the Washington, D.C. area and national Nationwide Urban Runoff Program (NURP) studies. Specifically, the following metals were measured in detectable concentrations: arsenic, beryllium, cadmium, chromium, copper, cyanide, mercury, nickel, lead, selenium, thallium, and zinc. With the significant exceptions of lead, cadmium, copper and zinc, most of the trace metals were found in only a few samples and then only in minute amounts that were well below human health or aquatic life criteria. Lead, copper and zinc were generally found in most samples and were occasionally recorded at levels an order of magnitude higher than recommended aquatic life criteria.

Toxic Chemicals

Most urban runoff rarely contains toxic chemicals in amounts that exceeded current safety criteria. Possible sources of toxic chemicals to streams are illegal disposal of household hazardous wastes, such as waste oil, paint thinners, preservatives and pesticides. In the Washington D.C area, ten different pesticides have been detected in urban runoff, but the concentrations were near the limits of detection (less than 1 ppb).

Chlorides

Chlorides or salts are often introduced into streams after they are applied to remove ice and snow from roads, parking lots and sidewalks. Salt levels in snowmelt runoff have been reported to exceed several thousand milligrams per liter. Due to its extreme solubility, almost all the chloride applied for snow removal purposes ends up in surface or ground waters. At high levels, chlorides are toxic to many freshwater aquatic organisms since most are only adapted to withstand a relatively narrow range of salinity.

Thermal Impacts

Elevated water temperatures can have dire consequences for stream biota, which are adapted to a coldwater environment. A rise in water temperature of just a few degrees Celsius over ambient conditions can reduce sensitive stream insects and fish species, such as stoneflies and trout. In general, sustained summertime water temperatures in degrees Celsius (70 degrees Fahrenheit) are considered to be stressful, if not lethal, to many coldwater organisms.

A number of factors can increase summertime water temperatures in urban headwater streams. Of these, three factors often act synergistically to increase water temperatures. First, as the urban landscape heats up on warm summer days, it tends to impart a great deal of heat to any runoff passing over it. Second, fewer trees are present on the streambanks to shade the stream channel, adding to the warming effect. Third, runoff stored in shallow wet ponds and other impoundments is heated in between storms and then may be released in a rapid pulse during a storm event.

3.2. Study Design and Data Acquisition

The Cooks Run watershed assessment was designed as a two-phased project. This multi-phased approach for this assessment was strongly encouraged and endorsed by representatives of the Pennsylvania Department of Environmental Protection (PA DEP). This report represents the first phase (Phase I) of the Cooks Run watershed assessment. Some of the tasks such as, the stream water quality monitoring, the stream macroinvertebrate survey and the evaluation of ordinances were performed for the entire watershed.

Conversely, most of the tasks requiring intensive field reconnaissance were only performed for the upper subwatershed. Tasks performed only for the upper subwatershed were the stream and riparian visual assessment, the nonpoint source assessment and the stormwater management assessment. As noted in Section 2.2, the upper section of the watershed (upper subwatershed) is defined as that portion of the watershed north of the Route 611 Bypass. The lower section of the watershed (lower subwatershed) is defined as that portion of the watershed south of the Route 611 Bypass down to the confluence of Cooks Run and the Neshaminy Creek.

The major tasks of the first phase of the Cooks Run watershed assessment are discussed in Sections 3.2.1 through 3.2.6. Specific information about the rationale behind the study design, the protocols used to collect field samples and data, and the methods used to analyze all collected samples are also discussed below.

3.2.1. Stream Water Quality Monitoring Program

Aqua-Link established four stream stations along the main stem of Cooks Run. The locations of the stream monitoring stations were recorded using a hand held GPS (Global Positioning System) unit (Garmin GPSmap 76S) and are shown in Figure 2.1. Refer to Appendix A for the actual GPS coordinates of the stream monitoring stations.

The four stream stations were monitored twice during baseflow (low flow) conditions and twice during stormflow (high flow) conditions from June through October 2003. On each study date, in-situ water quality data (dissolved oxygen, water temperature, pH and conductivity) were collected using a YSI (Yellow Springs Instruments) 600XL Sonde interfaced to a YSI 610D data logger. Stream water samples were collected as grab samples, preserved in the field and shipped to the contract laboratory for analysis. The contract laboratory selected for this project was QC, Inc. of Southampton, Pennsylvania.

All collected stream water samples were analyzed by the contract laboratory for the following parameters: alkalinity, hardness, dissolved reactive phosphorus (orthophosphorus), total phosphorus, ammonia nitrogen, nitrate + nitrite nitrogen, total Kjeldahl nitrogen, total suspended solids, priority pollutant list (PPL) metals, oil and grease, chlorides and fecal coliform bacteria.

3.2.2. Stream Macroinvertebrate Survey

Aqua-Link and the District collected macroinvertebrate (aquatic insects and other aquatic organisms) samples at the four different stream stations (Figure 2.1). A two-man crew collected the macoinvertebrate samples using a kick net. The samples were sorted in the field and preserved accordingly. Sampling was completed when more than 100 aquatic organisms were collected at a given stations. All sorted and preserved macroinvertebrate samples were shipped to Aquatic Resource Consulting of Stroudsburg, Pennsylvania for identification and enumeration.

Macroinvertebrate organisms were identified according to Peckarsky et al, 1990 using a Bausch and Lomb 0.7x-3x stereomicroscope. They were enumerated, and assigned a pollution tolerance value if known (Environmental Analysts 1990). Taxa richness, modified EPT index, percent modified mayflies, percent dominant taxon and Hilsenhoff biotic index values were calculated for each station to apply Pennsylvania Department of Environmental Protection (PA DEP) Central Office's most recent guidance for use with special protection and antidegradation studies (PA DEP 1999). Shannon-Weiner diversity index was also calculated for all samples (Weber 1973).

3.2.3. Stream & Riparian Visual Assessment

Aqua-Link with the assistance of the District performed a comprehensive stream and riparian visual assessment for the upper subwatershed. The stream and riparian visual assessment was performed during the early Spring 2003. As part of this assessment, field staff walked the entire main stem of Cooks Run within the upper subwatershed. Similar stream and riparian segments were delineated using a hand held GPS (Global Positioning System) unit (Garmin GPSmap 76S). In addition, digital photographs of each stream segment were taken.

In the field, stream segments were thoroughly evaluated using a *modified* version of the *Riparian Assessment Form* developed by Melissa Schnier of The Pennsylvania State University. The original riparian assessment form is part of the document entitled *Riparain Assessment Guide* (Schnier 2003). Aqua-Link modified version of this form is entitled the *Stream and Riparian Visual Assessment Form*. A copy of the modified assessment form as revised by Aqua-Link is provided in Appendix E.

Using Aqua-Link's modified form, stream segments were assigned a numerical score from 1 through 10 (ranging from poor to excellent) for each of the following ten attributes: riparian buffer width, riparian vegetation type, riparian vegetation density, bank vegetation type, bank vegetation density, bank stability, channel modification, in-stream cover, embeddedness and shading (canopy cover). The individual scores of all parameters were then tallied; and, based upon the total score, a stream segment was assigned an overall rating of rating of poor, marginal, good or excellent.

During the stream and riparian assessment, Aqua-Link and the District acquired additional information about the need for riparian buffers and all pipes that directly discharge to the main stem of Cooks Run. For each segment, the amount of riparian buffers needed for each stream segment was estimated using a laser range finder. Also, all pipes that discharge directly into Cooks Run were identified. The shape and diameter of all discharge pipes recorded. The locations of all discharge pipes were determined using a GPS unit and photographed with a digital camera. Information for all of the discharge pipes is presented in Appendix A.

3.2.4. Nonpoint Source Problem Assessment

Aqua-Link identified significant nonpoint source problems while performing the stream and riparian visual assessment for Cooks Run in the upper subwatershed (refer to Section 3.2.3). In addition, Aqua-Link walked several small, unnamed tributaries to Cooks Run and toured the remaining portion of the upper subwatershed via truck in order to identify any other significant nonpoint source (NPS) problem areas. The locations of all significant NPS watershed problems were recorded using a GPS receiver. Digital photographs were taken and written descriptions of the problem areas were prepared using field survey data sheets (Appendix E).

3.2.5. Stormwater Management Assessment

Gilmore & Associates (G&A) of New Britain, Pennsylvania were subcontracted by Aqua-Link to perform the stormwater management assessment of the upper subwatershed. The purpose of this assessment was to determine if any of the facilities are good candidates for stormwater retrofitting. Initially, major stormwater management (SWM) facilities were identified using an aerial photograph of the watershed. Additional sites were identified during the inspection and assessment of previously identified facilities and through discussions with the Doylestown Borough Engineer. It should be noted that Doylestown Borough is by far the largest municipality within the upper subwatershed

(Figure 1.1).

The locations of all major SWM facilities were recorded using a GPS unit. In addition, digital photographs of facilities were taken during the on-site assessments. Lastly, G&A contacted the municipalities in order to obtain any available design information for the identified SWM facilities. G&A used this additional design information to evaluate whether the SWM facilities were constructed according to their intended design.

3.2.6. Evaluation of Ordinances

Gilmore & Associates (G&A) were subcontracted by Aqua-Link to evaluate applicable municipal ordinances that can significantly impact surface water quality. As part of this task, G&A evaluated ordinances for Doylestown Township, Doylestown Borough and New Britain Borough. Based upon their review, G&A commented on these ordinances and provided their recommendations for potential ordinances revisions.

More specifically, G&A reviewed the current Zoning and Subdivision-Land Development Ordinances for New Britain Borough, Doylestown Borough and Doylestown Township. The ordinances were examined for sections on Environmental or Natural Resource Protection and particularly for riparian and stream corridor protection. In addition to protective ordinances, the sections and/or ordinances for stormwater management were reviewed with regard to the use of best management practices since the management and treatment of stormwater runoff is integral to the health and welfare of Cooks Run and the Neshaminy Creek.

4. Stream Water Quality & Macroinvertebrate Assessments

Aqua-Link established four stream stations along the main stem of Cooks Run as noted in Section 3.2.1. The locations of the monitoring stations are shown in Figure 2.1. The four stream stations were monitored twice during baseflow (low flow) conditions and twice during stormflow (high flow) conditions during the period of June through October 2003. Baseflow monitoring occurred on July 31st and October 31st, while stormflow monitoring was performed on June 4th and October 27th.

On each study date, in-situ water quality data (dissolved oxygen, water temperature, pH and conductivity) were collected using a YSI 600XL Sonde interfaced to a YSI 610D data logger. Stream water samples were collected as grab samples, preserved in the field and shipped to the contract laboratory. All collected stream water samples were analyzed by the contract laboratory for the following parameters: alkalinity, hardness, dissolved reactive phosphorus (orthophosphorus), total phosphorus, ammonia nitrogen, nitrate + nitrite nitrogen, total Kjeldahl nitrogen, total suspended solids, priority pollutant list (PPL) metals, oil and grease, chlorides and fecal coliform bacteria.

In addition, Aqua-Link and the District collected macroinvertebrate (aquatic insects and other organisms) samples at the above four stream stations (Figure 2.1). All samples were sorted and preserved in the field and later shipped to a contracted entomologist for identification, enumeration and analysis.

Additional information about the study design and data acquisition for the stream water quality monitoring program and the macroinvertebrate survey is provided in Section 3.2.1 and 3.2.2. For a complete listing of all data acquired and analyzed in this section, refer to Appendices C and D.

4.1. Stream Water Quality Data

Information about the four stream monitoring stations is presented in Table 4.1. These four stations were used for both the stream water quality monitoring program and the macroinvertebrate survey.

Table 4.1 Descriptions of Stream Monitoring Stations

Station	Location
CR4	Cooks Run @ Veterans Lane within Lantern Hill Development
CR3	Cooks Run @ Limekiln Pike near Brinker's Fuel
CR2	Cooks Run @ Iron Hill Road
CR1	Cooks Run @ Arron Avenue

Station CR4 is the further upstream station and is located just downstream of the Doylestown Shopping Center, while CR1 is located the furthest downstream above the confluence of Cooks Run and the Neshaminy Creek. It should be noted the Harvey Avenue wastewater treatment plant (WWTP) is located in between Stations CR3 and CR4.

4.1.1. In-situ Water Quality Data

The mean in-situ water quality data during baseflow and stormflow conditions are summarized in Table 4.2. In-situ water quality data that were collected during this assessment project were water temperature, dissolved oxygen, pH and specific conductance. The data in Table 4.2 are discussed in Sections 4.1.1.1 and 4.1.1.2.

Table 4.2 Mean In-situ Water Quality Data

Station	Flow Regime	Temperature (^{o} C)	Dissolved Oxygen (mg/l)	pH (s.u.)	Specific Conductance (uS/cm)
CR4	Baseflow	14.7	6.51	6.84	493
CR3	Baseflow	16.6	8.50	7.24	629
CR2	Baseflow	16.1	9.83	7.39	568
CR1	Baseflow	16.0	9.98	7.29	537
CR4	Stormflow	14.8	10.41	7.22	91
CR3	Stormflow	14.6	10.26	7.30	138
CR2	Stormflow	14.4	10.63	7.19	155
CR1	Stormflow	14.4	10.78	7.18	157

4.1.1.1. Temperature & Dissolved Oxygen

Most aquatic organisms are poikilothermic (cold blooded) meaning that most are incapable of internally regulating their body temperatures. The water temperatures of streams and lakes greatly influence the biological activity and growth of these organisms. Overall, fish, insects, zooplankton, phytoplankton and other aquatic organisms all have preferred temperature ranges. As temperatures get too far above or below this preferred range, the number of individuals of certain species will decrease until finally there are few or none. Coldwater (salmonid) fish such as trout, blacknose dace, longnose dace and sculpins require water temperatures less than 70^o F (21.1^o C) to grow and reproduce. Coolwater fish like smallmouth bass, white sucker, common shiners and creek chubs require water temperatures between 65 and 75^o F (18.3 and 23.9^o C) to grow and reproduce. Warmwater (non-salmonid) fish such as largemouth bass, bluegills and brown bullheads and catfish require water temperatures greater than 75^o F (23.9^o C) to grow and reproduce.

Water temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperatures, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warmer waters hold less oxygen that cool water, while colder waters hold more oxygen. In addition, some compounds are also more toxic to aquatic life at higher temperatures.

Dissolved oxygen is the concentration of molecular oxygen (O_2) dissolved in water. The concentration of dissolved oxygen is usually expressed in milligrams per liter (mg/l), parts per million or percent of saturation. The dissolved oxygen concentration represents one of the most important measurements of water quality and is a critical indicator of the ability of streams or lakes to support healthy ecosystems. Optimal dissolved oxygen concentrations for coldwater (salmonid) fish are 6 milligrams per liter (mg/l) or greater. Conversely, optimal dissolved oxygen concentrations for warmwater (non-salmonid) fish are 5 mg/l or greater. In general, most fish and other aquatic organisms cannot survive when dissolved oxygen concentrations fall below 3 mg/L for prolonged periods of time.

Extremely high dissolved oxygen concentrations in excess of 125 percent saturation can be harmful to aquatic life. Fish in dissolved oxygen saturated waters may suffer from "gas bubble disease"; however, this is a very rare occurrence. The bubbles block the flow of blood through blood vessels causing death. External bubbles (emphysema) can also occur and be seen on fins, skin and other tissue. Aquatic invertebrates are also affected by gas bubble disease but at levels higher than those lethal to fish.

In addition, microbial communities in water use oxygen to breakdown organic materials such as manure, sewage and decaying algae. Low dissolved oxygen concentrations may indicate excessive loadings of organic materials to stream or lake systems.

Cooks Run

The mean water temperatures in Cooks Run significantly increased from Station CR4 to CR3 during baseflow conditions (Table 4.2). Increased water temperature is likely due to the discharge of warmer treated effluent from the Harvey Avenue WWTP. Thereafter, stream water temperatures gradually decreased from Stations CR3 to CR1. This gradually decrease in water temperature was likely due to increased levels of shading by riparian vegetation. Overall, the lower subwatershed contains more stands of forested riparian buffers than the upper subwatershed.

During stormflow (high flow) conditions, the lowest and highest mean water temperatures were reported for Stations CR1 and CR4, respectively. The highest mean water temperature at CR4 is likely due to higher amounts of stormwater runoff from highly urbanized land uses (residential and commercial lands) and stormwater ponds.

Conversely, the highest instantaneous stream water temperatures were measured on the July 3rd during baseflow conditions. On this study date, stream water temperatures were 19.0, 21.7, 21.3 and 21.4 1° C at Stations CR4, CR3, CR2 and CR1, respectively (Figure 2.1). The lowest instantaneous stream water temperatures were measured once again on baseflow conditions on October 31st. Refer to Appendix C for a listing of all stream water quality data.

The mean dissolved oxygen concentrations during baseflow and stormflow conditions are presented in Table 4.2. In general, the mean dissolved oxygen concentrations were higher and more uniform among the four different stations during stormflow conditions. Higher mean concentrations during storm events were largely due to lower water temperatures. The solubility of dissolved oxygen increases as water temperature decreases.

The lowest instantaneous dissolved oxygen concentration was measured at Station CR4 on July 3rd during baseflow conditions. This concentration was 4.62 mg/l and was the only dissolved oxygen value measured below 5 mg/l. The stream channel at and above this station has been greatly modified. Apparently, many riffles in the stream have been destroyed due to extreme channel modification, thereby dramatically reducing the transfer rate of atmospheric oxygen to water via turbulent flow.

4.1.1.2. pH & Specific Conductance

The term pH is defined as the logarithm of the reciprocal (or its negative logarithm) of the hydrogen ion concentration. Therefore, a one unit change in pH represents a ten-fold increase or decrease in the hydrogen ion concentration (as pH decreases, the hydrogen ion concentration increases). The pH scale ranges 0 to 14 standard units where a value of 7 indicates neutral conditions. Water becomes more acidic when pH values fall below 7 and more basic when pH values rise above 7. In general, most natural waters usually have a pH values between 6.5 and 8.5.

Aquatic life in lakes can be adversely impacted when pH levels drop too low in lakes and streams. When pH concentrations fall below 6.0 standard units, there is a greater risk to increase the concentration of heavy metals, in particular aluminum. High concentrations of hydrogen and aluminum ions are known to adversely affect the ion regulation of aquatic organisms, a condition referred to as "osmoregulatory failure". When osmoregulatory failure occurs, high hydrogen and aluminum concentrations induce the leaching of sodium and chloride ions from the body fluids of fish and other aquatic organisms (U.S. EPA, 1990). As summarized by J. Baker, pH values ranging from 5.5 to 6.0 standard units can result in the loss of sensitive minnows and dace, which may be important as forage fish for game fish. In addition, the pH levels below 6.0 are also known to adversely affect the reproductive success rates of game fish, such as walleye (U.S. EPA, 1990).

Conductivity is a measure of the ability of water to conduct an electric current and is dependent on the number of dissolved ions in solution. Although directly correlated to the total amount of dissolved solids, conductivity provides no indication with regards to the relative quantities of the various types of dissolved solids present. Observed conductivities in lake waters vary widely and are largely a function of the geology and the soils in the watershed. Conductivity varies significantly with temperature and to a lesser extent with the nature of the individual ions present. Because temperature has a relatively large effect on conductivity, conductivity is typically corrected to 25EC and reported as specific conductance (in micro Siemens, uS/cm @ 25EC) to allow direct comparison of values that were measured at different temperatures.

Cooks Run

The mean pH values at four monitoring stations are presented in Table 4.2. The pH values at the stations were similar during both baseflow and stormflow conditions. Overall, the pH values of Cooks Run suggest near neutral stream conditions.

The mean specific conductance values at the four monitoring stations are presented in Table 4.2. The highest specific conductance values were measured during baseflow conditions. Lower specific conductance values during storm events are likely attributed to the dilution of stream baseflow concentrations by stormwater runoff.

The lowest mean specific conductance values were measured at Station CR4 during both baseflow and stormflow conditions. Station CR4 is the furthest upstream stream station as shown in Figure 2.1. Mean values increased at Station CR3 and these increased values are likely attributed to the Harvey Avenue WWTP, which is located in between Stations CR4 and CR3. Thereafter, specific conductance values slightly decreased during baseflow conditions and slightly increased during stormflow conditions (Table 4.2). For more information, refer to Appendix C, which contains a complete listing of all stream water quality data.

4.1.2. Laboratory Water Quality Data

4.1.2.1. Alkalinity & Hardness

Alkalinity refers to the capacity of water to neutralize (or buffer against) acid inputs. Alkalinity of natural waters is due primarily to the presence of hydroxides (OH^-), bicarbonates (HCO_3^-), carbonates (CO_3^{2-}) and occasionally borates, silicates and phosphates. Therefore, the carbonate–bicarbonate equilibrium system (CO_2 - HCO_3^- - CO_3^{2-}) is the major buffering mechanism in freshwater streams and lakes (Wetzel 1983).

Alkalinity is typically expressed in units of milligrams per liter (mg/l) of $CaCO_3$ (calcium carbonate). Waters having a pH below 4.5 contain no alkalinity. Low alkalinity is the main indicator of susceptibility of aquatic organisms to acidic inputs (e.g., acid rain and acidic dry fallout). Waters with pH values ranging from 6 to 9 are largely comprised of bicarbonate (HCO_3^-). At higher pH values, carbonate ($CO_3^{=}$) plays a more important role in the buffering capacity of the water.

Watersheds that contain sedimentary carbonate rocks are high in dissolved carbonates (hard-water lakes). Conversely, lakes in granite or igneous rocks are low in dissolved carbonates (soft water lakes). In the Northeastern U.S., the alkalinity of natural surface waters typically ranges from 5 to over 200 mg/L as $CaCO_3$.

Hardness is the amount of dissolved calcium and magnesium and to a lesser extent, other divalent and trivalent metallic elements such as iron, manganese and aluminum. The term hardness was originally derived to describe waters that were hard to wash clothing, thereby referring to the soap washing properties of water. Hardness prevents soap from lathering by causing the development of an insoluble precipitates in the water. Hardness typically causes the buildup or "scaling" of precipitates in pipes and water heaters and can cause numerous problems in laundry, kitchen, and bath facilities. Overall, dissolved calcium and magnesium salts are primarily responsible for most scaling problems. Hardness is often described as soft, slightly hard, moderately hard, hard and very hard. Soft water is less than 17 mg/L as calcium carbonate ($CaCO_3$). Slightly hard water is greater than 17 to 60 mg/L as $CaCO_3$. Moderately hard water is greater than 60 to 120 mg/L as $CaCO_3$. Hard water is greater than 120 to 180 mg/L as $CaCO_3$, while very hard water is above 180 mg/L as $CaCO_3$.

Cooks Run

The mean alkalinity and hardness concentrations at four monitoring stations are presented in Table 4.3. These mean concentrations were significantly higher during baseflow conditions at all four stations. Similarly to specific conductance (Section 4.1.1.2), lower values during storm events are likely attributed to the dilution of stream baseflow concentrations by stormwater runoff.

Table 4.3 Mean Alkalinity and Hardness Concentrations

Station	Flow Regime	Alkalinity (mg/l as $CaCO_3$)	Hardness (mg/l as $CaCO_3$)
CR4	Baseflow	83.1	135.0
CR3	Baseflow	92.6	165.0
CR2	Baseflow	82.6	150.0
CR1	Baseflow	82.1	145.0
CR4	Stormflow	17.2	22.0
CR3	Stormflow	29.6	33.5
CR2	Stormflow	31.1	37.0
CR1	Stormflow	33.1	42.5

In addition, the mean alkalinity and hardness concentrations peaked at Station CR3 and then gradually decreased at Stations CR2 and CR3 during baseflow conditions (Table 4.3). Alkalinity and hardness concentrations during these flow conditions are considered moderately high and moderately hard, respectively.

During stormflow conditions, the mean alkalinity and hardness concentrations once again peaked at Station CR3 (Figure 2.1). Thereafter, alkalinity and hardness concentrations then slightly increased at Stations CR2 and CR1 as shown in Table 4.3. Alkalinity and hardness concentrations of Cooks Run during storm events are considered moderately low and slightly hard, respectively.

4.1.2.2. Total Suspended Solids

The concentration of total suspended solids in a lake is a measure of the amount of particulate matter in the water column. Suspended solids include both organic matter (e.g., leaf litter, grass clippings) and inorganic materials like soil particles.

Cooks Run

The mean total suspended solids at the four monitoring stations are presented in Table 4.4. The mean total suspended solids during baseflow conditions are considered low. The mean total suspended solids concentrations dramatically increased during storm events. The highest concentrations were recorded at Stations CR2 and CR1.

Table 4.4 Mean Suspended Solids and Nutrient Concentrations

Station	Flow Regime	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l as P)	Total Nitrogen (mg/l as N)
CR4	Baseflow	2.5	0.067	1.88
CR3	Baseflow	7.2	0.295	4.08
CR2	Baseflow	3.0	0.182	4.00
CR1	Baseflow	5.5	0.190	3.88
CR4	Stormflow	61.5	0.192	1.20
CR3	Stormflow	85.0	0.291	1.66
CR2	Stormflow	149.5	0.390	2.06
CR1	Stormflow	178.5	0.468	1.75

Potential sources of suspended solids concentrations during stormflow conditions are accumulated soil particles on impervious surfaces (e.g., roof tops, sidewalks, streets, parking lots), soil erosion occurring within the watershed and streambank erosion. The significantly higher suspended solids concentrations at Stations CR1 and CR2 may be attributed to higher levels of streambank erosion occurring in the lower subwatershed (below the Route 611 Bypass).

4.1.2.3. Nutrient Concentrations

Phosphorus and nitrogen are major nutrients required for the growth of algae (phytoplankton and filamentous) and macrophytes (aquatic vascular plants). Total phosphorus represents the sum of all forms of phosphorus. Total phosphorus includes dissolved and particulate organic phosphates (e.g., algae and other aquatic organisms), inorganic particulate phosphorus as soil particles and other solids, polyphosphates from detergents and dissolved orthophosphates. Soluble (or dissolved) orthophosphate (determined analytically as dissolved reactive phosphorus) is the phosphorus form that is most readily available for algal uptake. Soluble orthophosphate is usually reported as dissolved reactive phosphorus because laboratory analysis takes place under acid conditions and may result in the hydrolysis of some other phosphorus forms.

Nitrogen compounds are also important for the growth and reproduction of phytoplankton and aquatic macrophytes. The common inorganic forms of nitrogen in water are nitrate (NO_3^-), nitrite (NO_2^-) and ammonia (NH_3). In water, ammonia is present primarily as ammonium (NH_4^+) and undissociated ammonium hydroxide (NH_4OH). Of these two forms, undissociated ammonium hydroxide is toxic and its toxicity increases as pH and water temperature increase. Overall, the most dominant form of inorganic nitrogen present in lakes depends largely on the dissolved oxygen concentrations. Nitrate is the form usually found in surface waters, while ammonia is only stable under anaerobic (low oxygen) conditions. Nitrite is an intermediate form of nitrogen, which is generally considered unstable. Nitrate and nitrite (referred to as total oxidized nitrogen) are often analyzed together and reported as $NO_3 + NO_2$-N, although nitrite concentrations are usually insignificant as noted previously. Total Kjeldahl nitrogen (TKN) concentrations include ammonia and organic nitrogen (both soluble and particulate forms). Organic nitrogen can be easily estimated by subtracting ammonia nitrogen from total Kjeldahl nitrogen concentrations. Total nitrogen is calculated by summing the nitrate-nitrite, ammonia and organic nitrogen fractions together.

Cooks Run

The mean total phosphorus and total nitrogen concentrations at the four monitoring stations are presented in Table 4.4. All nutrient data that were collected as part of this project are listed in Appendix C.

During baseflow conditions, the mean total phosphorus concentration at Station CR3 was over four times higher than the upstream station, Station CR4. This dramatic increase in concentration is attributed to the Harvey Avenue WWTP, which is located upstream of Station CR3. Thereafter, concentrations gradually decreased at Stations CR2 and CR1 and this decrease is likely due to dilution and biological assimilation.

With the exception of Station CR3, the mean total phosphorus concentrations at Stations CR4, CR2 and CR1 (Figure 2.1) more than doubled during stormflow conditions. Increased concentrations are likely due to lawn fertilizers, soil erosion and streambank erosion. Phosphorus is commonly bound or attached to soil particles (suspended soils). This relationship between total phosphorus and total suspended solids is observed in Table 4.4 during stormflow conditions.

Similarly to phosphorus, the mean total nitrogen concentration at Station CR3 was significantly higher than the mean concentration at Station CR4 during baseflow conditions. Once again, this dramatic concentration increase is attributed to the Harvey Avenue WWTP. Thereafter, concentrations slightly decreased at Stations CR2 and CR1. Conversely, the mean total nitrogen phosphorus concentrations at all stations decreased during stormflow conditions. Decreased concentrations during storm event suggest a dilution effect by introducing stormwater runoff that contains lesser quantities of nitrogen (Table 4.4).

4.1.2.4. Oil & Grease

The term oil and grease does not refer to a specific substance, but rather group of organic substances with similar physical characteristics (APHA 1985). This group of organic substances includes hydrocarbons, fats, oils, waxes and high molecular weight fatty acids (Hammer 1986). Hydrocarbon compounds, some of which are known to be toxic to aquatic life, are often transported to streams and lakes via stormwater runoff in urban settings. The major sources of hydrocarbons in urban runoff are leakage of crankcase oil and other lubricating agents from automobiles and to some extent, the illegal disposal of waste oil into storm sewers (Schueler 1987).

Cooks Run

The mean oil and grease concentrations at the four monitoring stations are presented in Table 4.5. The mean concentrations for all stations were below the detection limit of 5 mg/l during both baseflow and stormflow conditions.

4.1.2.5. Chlorides

Chlorides are salts resulting from the combination of the gas chlorine with a metal. Some common chlorides include sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). Chlorine alone as Cl_2 is highly toxic and it is often used as a disinfectant. In combination with a metal such as sodium, it becomes essential for life because small amounts of chlorides are required for normal cell functions in plant and animal life.

As noted in Section 3.1, chlorides or salts are often introduced into streams after they are applied to remove ice and snow from roads, parking lots and sidewalks. Salt levels in snowmelt runoff have been reported to exceed several thousand milligrams per liter. Due to its extreme solubility, almost all the chloride applied for snow removal purposes ends up in surface or ground waters. Other potential sources of chlorides are rocks naturally containing chlorides, agricultural runoff;

wastewater from industries and effluent from wastewater treatment plants. At high levels, chlorides are toxic to many freshwater aquatic organisms, as they are only adapted to withstand a relatively narrow range of salinity.

Table 4.5 Mean Oil/Grease, Chlorides & Fecal Colifom Bacteria Concentrations

Station	Flow Regime	Oil and Grease (mg/l)	Chlorides (mg/l)	Fecal Colifom Bacteria (No. per 100 ml)
CR4	Baseflow	< 5	81.8	305
CR3	Baseflow	< 5	98.2	260
CR2	Baseflow	< 5	96.8	200
CR1	Baseflow	< 5	86.2	315
CR4	Stormflow	< 5	5.5	2,650
CR3	Stormflow	< 5	8.9	3,100
CR2	Stormflow	< 5	14.1	2,000
CR1	Stormflow	< 5	14.5	2,400

In general, federal water quality standards require chloride levels not to exceed 250 mg/L. the criteria for protection of aquatic life require levels of less than 600 mg/L for chronic (long-term) exposure and 1200 mg/L for short-term exposure.

Cooks Run

The mean chloride concentrations at the four monitoring stations are presented in Table 4.5. The mean concentrations during baseflow conditions were similar and are considered moderate. During storm events, the mean chloride concentrations substantially decreased at all four stations. Decreased concentrations during storm event suggest a dilution effect by introducing stormwater runoff that contains lesser quantities of chlorides to the stream. It is anticipated that chloride concentrations would substantially increase in the winter months during storm events.

4.1.2.6. Fecal Coliform Bacteria

Two bacteria groups, coliforms and fecal streptococci, are used as indicators of possible sewage contamination. These groups of bacteria are commonly found in human and animal feces. Although generally not harmful themselves, these bacteria indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead. Sources of fecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal feces and storm runoff.

Total coliforms are a group of bacteria that are widespread in nature. All members of the total coliform group can occur in human feces, but some can also be present in animal manure, soil, and submerged wood and in other places outside the human body. Fecal coliforms, a subset of total coliform bacteria, are generally more fecal-specific in origin.

Fecal streptococci generally occur in the digestive systems of humans and other warm-blooded animals. In the past, fecal streptococci were monitored together with fecal coliforms and a ratio of fecal coliforms to streptococci was calculated. This ratio was used to determine whether the contamination was of human or nonhuman origin. However, this is no longer recommended as a reliable test (U.S. EPA, Office of Water @ www.epa.gov/OWOW/monitoring/volunteer/stream).

Cooks Run

The mean fecal coliform bacteria concentrations at the four monitoring stations are presented in Table 4.5. The mean concentrations during baseflow conditions were similar and are considered high. During storm events, the mean fecal coliform bacteria concentrations increased an order of magnitude. The source of this dramatic increase is likely due to the transportation of animal feces to the stream via stormwater runoff. Sources of animal feces within the watershed include pets (e.g., dogs and cats) and wildlife including ducks and geese.

Based upon the water quality standards for Pennsylvania, surface waters are deemed unacceptable for primary contact recreation when fecal coliform concentrations exceeded 200 organisms per 100 ml. As shown in Table 4.5, the mean concentrations for all stations were equal to or greater than this limit under both baseflow and stormflow conditions.

4.1.2.7. Metals

Heavy (trace) metals are primarily a concern because of their toxic effects on aquatic life and their potential to contaminate drinking water supplies. As noted before, most of the metals found in urban runoff are derived from "leakage" of the urban landscape. A wide variety of trace metals were found in urban runoff samples taken during the special trace metals sampling program conducted as part of the Washington, D.C. area and national Nationwide Urban Runoff Program (NURP) studies. Specifically, the following metals were measured in detectable concentrations: arsenic, beryllium, cadmium, chromium, copper, cyanide, mercury, nickel, lead, selenium, thallium, and zinc (Schueler 1987).

Cooks Run

The four stream stations (Figure 2.1) were analyzed for the following priority pollutant list (PPL) metals during baseflow and stormflow conditions: silver (Ag), arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), thallium (Tl), zinc (Zn) and mercury (Hg). Of these metals, only chromium, copper, lead, selenium and zinc were detected in Cooks Run during the study period (Table 4.6). Furthermore, selenium was only detected at low levels at Stations CR1 and CR2 on October 31st during baseflow conditions. Refer to Appendix C for a complete listing of all water quality data collected and analyzed for this project.

Table 4.6 Mean Heavy Metal Concentrations

Station	Flow Regime	Cr (mg/l)	Cu (mg/l)	Pb (mg/l)	Se (mg/l)	Zn (mg/l)
CR4	Baseflow	0.0050	0.0030	0.0050	0.0050	0.0050
CR3	Baseflow	0.0055	0.0162	0.0050	0.0050	0.0211
CR2	Baseflow	0.0050	0.0080	0.0050	0.0060	0.0099
CR1	Baseflow	0.0050	0.0070	0.0050	0.0060	0.0064
CR4	Stormflow	0.0056	0.0071	0.0080	0.0050	0.0266
CR3	Stormflow	0.0066	0.0126	0.0101	0.0050	0.0354
CR2	Stormflow	0.0081	0.0147	0.0122	0.0050	0.0415
CR1	Stormflow	0.0089	0.0222	0.0144	0.0050	0.0651

Note: **Red** values denote that the mean values are equal to the detection limits reported by the contract laboratory.

The mean chromium, copper, lead and zinc concentrations increased during stormflow conditions. For these four metals, the highest and lowest mean concentrations were recorded at Station CR1 and CR4, respectively (Table 4.6 and Figure 2.1).Therefore, the mean metal concentrations during storm events increased from upstream to downstream.

Chromium is a naturally occurring metal that in drinking water forms compounds with valences of +3 and +6, with the trivalent state being the more common. Although chromium is not currently mined in the United States, wastes from old mining operations may enter surface and groundwater through runoff and leaching. Chromate wastes from plating operations may also be a source of water contamination. Fossil fuel combustion, waste incineration, cement plant emissions, chrome plating, and other metallurgical and chemical operations may result in releases of chromium to the atmosphere. Chromium III and chromium VI have greatly differing toxicity characteristics. Chromium III is a nutritionally essential element. Chromium VI is much more toxic than Chromium III (Shelton 1996).

Copper, a reddish-brown metal, is often used to plumb residential and commercial structures that are connected to water distribution systems. Copper contaminating drinking water as a corrosion by-product occurs as the result of the corrosion of copper pipes that remain in contact with water for a prolonged period (Shelton 1996). In addition, copper as copper sulfate or other copper formulations is frequently used as an algaecide for treating ponds and lakes.

Lead containing materials have frequently been used in the construction of water supply distribution systems and plumbing systems in private homes and other buildings. The most commonly found materials include service lines, pipes, brass and bronze fixtures and solders and fluxes. Lead in these materials can contaminate drinking water as a result of the corrosion that takes place when water comes into contact with those materials (Shelton 1996).

Zinc is used in the vulcanization of rubber, therefore it is generally found at higher levels near highways. It also may be present in industrial discharges. Also, it is used to galvanize steel and is found in batteries, plastics, wood preservatives antiseptics and rodent poisons (Kentucky Division of Water @ http://kywater.org/ww/ramp/rmtests.htm).

4.2. Stream Macroinvertebrate Data

Aqua-Link collected macroinvertebrate samples at the four stream monitoring stations on November 4, 2003.The locations of the stream stations are shown in Figure 2.1. All preserved samples were sent to Aquatic Resource Consulting (ARC) of Stroudsburg, Pennsylvania for macroinvertebrate identification, enumeration and data analysis. The original report as prepared by ARC is presented in its entirety in Appendix D. For more information about sample collection and laboratory methods, refer to Section 3.2.2 and Appendix D.

The macroinvertebrate data for the four stations are listed in Table 4.7. This table also provides the biotic index (pollution tolerance) values for all identified taxa. The biotic index is a set of numerical values ranging from 0 (pollution intolerant) to 10 (pollution tolerant) and indicates an organism's overall tolerance to water pollution.

ARC determined the following metrics for each of the samples collected at Stations CR1 through CR4: taxa richness, modified EPT index, percent modified mayflies, percent dominant taxon, and Hilsenhoff biotic index values were calculated for each station to apply PA Department of Environmental Protection (DEP) Central Office's most recent guidance for use with special protection and antidegradation studies (PA DEP, 1999). In addition, the Shannon-Weiner diversity was also calculated for each sample (Weber, 1973). The above metrics are briefly described below and the calculated values are presented in Table 4.8:

1. Taxa Richness - is an index of diversity. The number of taxa (kinds) of invertebrates indicates the health of the benthic community. Generally, number of species increases with increased water quality. However, variability in natural habitat (stream order and size, substrate composition, current velocity) also affects this

number.

Table 4.7 Macoinvertebrates Collected at Stream Stations

Taxa	Stations				Biotic Index Value
	CR 1	CR 2	CR 3	CR 4	
Trichoptera (caddisflies)					
Hydropsyche betteni	19	25	30	0	6
Ceratopsyche sp.	1	3	0	1	5
Cheumatopsyche sp.	10	8	56	0	6
Chimarra aterrima	76	28	10	9	4
Coleoptera (beetles)					
Psephenus sp.	13	25	0	0	4
Stenelmis sp.	4	13	5	1	5
Odonata (dragon & damselflies)					
Argia sp.	2	9	0	1	6
Calopteryx sp.	0	2	0	9	6
Aeshna sp.	0	0	0	1	5
Diptera (true flies)					
Simulium sp.	3	0	0	0	6
Tipula sp.	0	1	1	0	4
Isopoda (sowbugs)					
Caecidotea sp.	14	2	0	80	6
Amphipoda (freshwater shrimp)					
Gammarus sp.	3	0	9	0	4
Hirudinea (leeches)					
Piscicola sp.	1	0	0	0	8
Myzobdella sp.	0	0	1	3	8
Oligochaeta (aquatic earthworms)					
Lumbriculidae	0	0	0	1	10
Turbellaria					
Macrostomum sp.	0	4	9	14	8

2. Modified EPT Index - is a measure of community balance. The insect orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddis flies), collectively referred to as EPT, are generally considered pollution sensitive. Thus, the total number of taxa within the EPT insect groups, minus those considered pollution tolerant (modified EPT index) is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

3. Percent Dominant Taxon - measures evenness of community structure. It is the percent of the total abundance made up by the single most abundant taxon. Dominance of a few taxa may suggest environmental stress. However, the tolerance value of the dominant taxon must be considered.

4. Percent Modified Mayflies - is another measure of balance. Mayflies are considered one of the least tolerant orders to organic pollution and acidification. Undisturbed streams usually have an abundance of mayflies. Pennsylvania DEP uses the percent contribution of mayflies to the total number of organisms as an indication of water quality. The value is modified to exclude mayflies with a tolerance value greater than 5.

5. Modified Hilsenhoff Biotic Index - is a direct measure of pollution tolerance. Since many aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollution, a biotic index is used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in the sample. This metric has been modified to use more recent pollution tolerance values, which range from 0 to 10; the higher the value, the greater the level of pollution indicated.

Biotic Index Value	Water quality	Degree of Organic Pollution
0.00 – 3.50	Excellent	None Apparent
3.51 – 4.50	Very Good	Possible Slight
4.51 – 5.50	Good	Some
5.51 – 6.50	Fair	Fairly Significant
6.51 – 7.50	Fairly Poor	Significant
7.51 – 8.50	Poor	Very Significant
8.51 - 10.00	Very Poor	Severe

6. Shannon-Weiner diversity measures the number of taxa present and evenness of distribution of organisms among the taxa (Weber, 1973). Diversity values in unpolluted waters generally range from 3 to 4. In severely polluted waters they are often less than 1.

Based upon the data presented in Tables 4.7 and 4.8 (ARC 2003), the macroinvertebrate samples reflect impairment from organic pollution and/or habitat degradation at all four stream stations. The benthic communities can be characterized as having had only moderate numbers of taxa with a predominance of pollution tolerant forms. The sensitive orders Ephemeroptera (mayflies) and Plecoptera (stoneflies) were absent from all samples (Table 4.7) and the modified EPT index value of only 1 at each station suggests a lack of intolerant taxa (Table 4.8).

The modified Hilsenhoff biotic index values (Table 4.8) suggested "good" to "fair" water quality with degree of organic pollution rated "some" to "fairly significant". Diversity values all fell below the range of 3 to 4, therefore suggesting polluted waters (ARC 2003).

Table 4.8 Calculated Macroinvertebrate Metrics for Stream Stations

Metric	Stations			
	CR1	CR2	CR3	CR 4
Number of Organisms	146	120	121	120
Taxa Richness	11	11	8	10
Modified EPT Index	1	1	1	1
Percent Modified Mayflies	0 %	0 %	0 %	0 %
Percent Dominant Taxon	52 %	23 %	46 %	68 %
Hilsenhoff Biotic Index	4.7	5.0	5.8	5.7
Shannon-Weiner Diversity	2.3	2.9	2.2	1.7

Lastly, the differences in benthic communities between the Cooks Run stations were considered subtle. EPT index values and percent modified mayflies were the same at all stations (Table 4.8). Biotic index values were generally higher (poorer) at Stations CR3 and CR4 (upstream stations within the upper subwatershed) than at Stations CR1 and CR2 (downstream stations within the lower subwatershed). Taxa richness was poorest at Station CR3 followed by Station CR4. The percent dominant taxon was highest at Station CR4 and lowest at Station CR2. The dominant taxon at Stations CR1 and CR2 was the caddisfly *Chimarra aterrima* with a pollution tolerance value of 4. At Station CR3, *Cheumatopsyche sp.* caddisfly was predominant with a tolerance value of 5. Station CR4 contained the highest percentage and the most pollution tolerant dominant taxon, *Caecidotea sp.* crustaceans (sowbugs), with a tolerance value of 6. In addition, Station CR4 had the poorest S&W diversity value.

4.3. Summary of Stream Data

Below is a brief summary of the stream water quality and macroinvertebrate data presented in Sections 4.1 and 4.2, respectively. For a complete listing of all data, refer to Appendices C and D of this report.

The locations of the stream monitoring stations are shown in Figure 2.1. The most upstream station is Station CR4, which is located off of Veteran's Lane. Conversely, the furthest downstream station, Station CR1, is located just below Aaron's Avenue and above the confluence of Cooks Run and the Neshaminy Creek.

4.3.1. Stream Water Quality Data

Cooks Run contains high levels of nutrients (phosphorus and nitrogen) during baseflow and stormflow conditions and is therefore is considered nutrient enriched. Phosphorus and suspend solids (sediment) concentrations were generally higher during storm events may be attributed to increased rates of streambank erosion plus additional inputs from stormwater runoff. During baseflow conditions, elevated nutrient concentrations at Station CR3 were largely due to the discharge of treated effluent from the Harvey Avenue wastewater treatment plant (WWTP). The highest suspended solids concentrations were recorded at Stations CR1 and CR2, which may be attributed to higher levels of streambank erosion occurring within the lower subwatershed (below the Route 611 Bypass). Dissolved oxygen concentrations were generally considered good and pH values were near neutral during both baseflow and stormflow conditions.

Fecal coliform bacteria concentrations during baseflow and stormflow conditions were considered high and very high, respectively. The dramatic concentration increases during storms is likely due to the transportation of animal feces to the stream via stormwater runoff. Sources of animal feces within the watershed include pets (e.g., dogs and cats) and wildlife including ducks and geese. These high bacteria concentrations make the stream unsuitable for primary contact recreation such as swimming.

In addition, chromium, copper, lead, selenium and zinc were detected in Cooks Run during the study period. Selenium was only detected at low levels at Stations CR1 and CR2 on October 31st during baseflow conditions and not detected any during storm events. Conversely, chromium, copper, lead and zinc concentrations increased during stormflow conditions. For these four metals, the highest and lowest mean concentrations were recorded at Station CR1 and CR4, respectively. Therefore, the mean metal concentrations during storm events increased from upstream to downstream.

4.3.2. Stream Macroinvertebrate Data

The macroinvertebrate data for all stations reflect impairment from organic pollution and/or habitat degradation. The benthic communities can be characterized as having had only moderate numbers of taxa with a predominance of pollution tolerant forms. The sensitive orders Ephemeroptera (mayflies) and Plecoptera (stoneflies) were absent from all samples and the modified EPT index value of only 1 at each station suggests a lack of intolerant taxa.

Overall, the macroinvertebrate data indicate that the highest levels of impairment occur at Stations CR3 and CR4 (upstream stations within the upper subwatershed). Somewhat lower levels of impairment were observed at Stations CR1 and CR2 (downstream stations within the lower subwatershed).

5. Stream & Riparian Visual Assessment

5.1. Methodology

Aqua-Link with field assistance provided by the Bucks County Conservation District performed a stream and riparian visual assessment of the upper subwatershed. The stream and riparian visual assessment was performed during the early Spring 2003. The upper section of the watershed (upper subwatershed) is defined as that portion of the watershed north of the Route 611 Bypass. For more information, refer to Section 3.2.2 for a detailed summary of how the stream and riparian visual assessment was performed and data were analyzed.

In addition, all stream and riparian data along with a copy of the *Stream and Riparian Visual Assessment Form* is located in Appendix E.

5.2. Results & Discussion

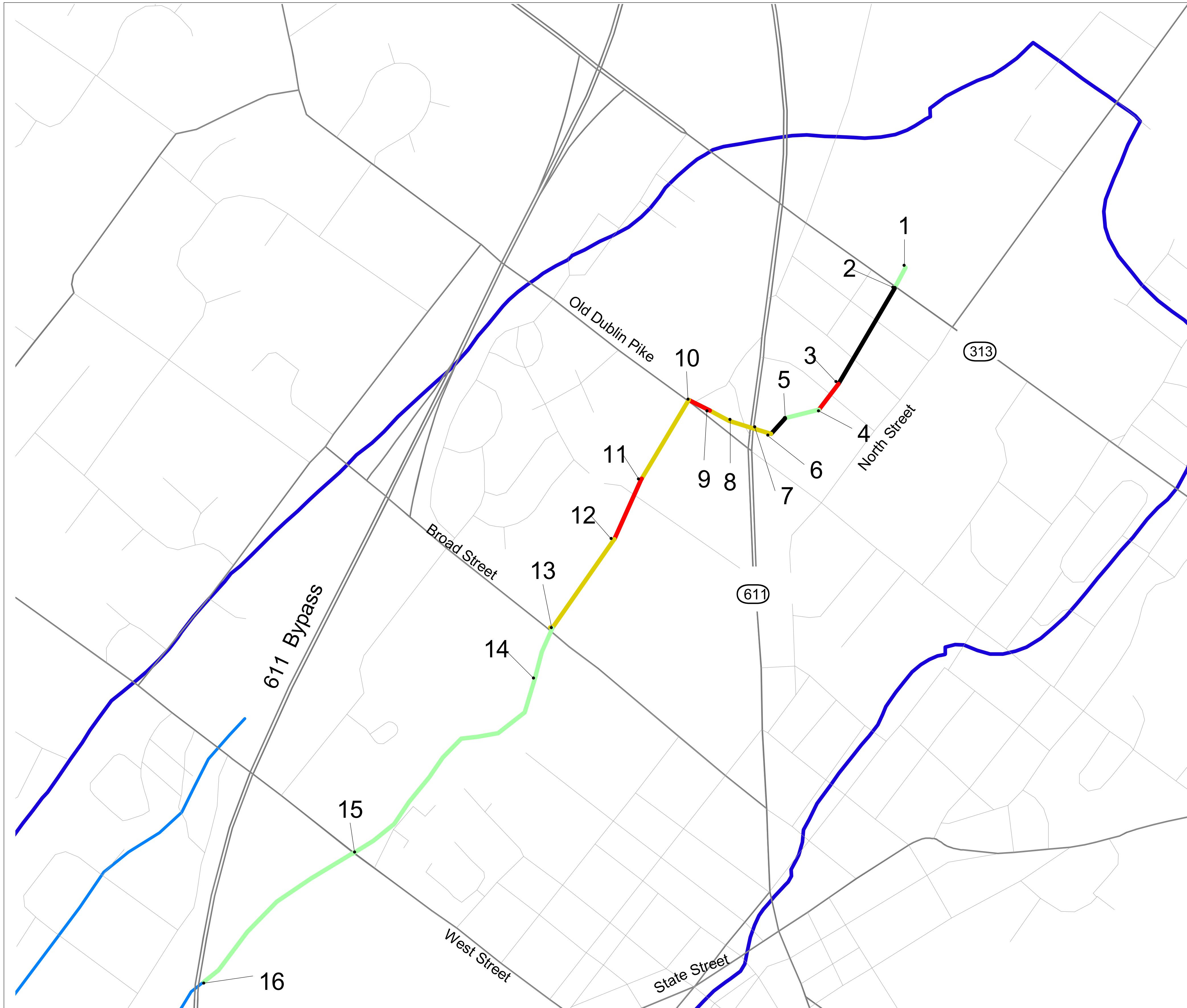
The results of the stream and riparian visual assessment are presented in Table 5.1 and graphically shown in Figures 5.1 and 5.2. Photographs of all stream segments are presented in Figure 5.3.

Table 5.1 Stream and Riparian Data for the Upper Subwatershed

Stream Segment	Stream & Riparian Score	Stream & Riparian Rating	Length of Riparian Buffer Needed	
			Left Bank (ft)	Right Bank (ft)
1-2	77%	Good	---	---
2-3	0 %	Poor	---	---
3-4	30 %	Poor	315	315
4-5	58 %	Good	---	75
5-6	0 %	Poor	---	---
6-7	44 %	Marginal	---	---
7-8	42 %	Marginal	212	212
8-9	45 %	Marginal	209	209
9-10	35 %	Poor	212	212
10-11	51 %	Marginal	645	---
11-12	34 %	Poor	600	600
12-13	46 %	Marginal	---	---
13-14	67 %	Good	---	---
14-15	77 %	Good	---	---
15-16	80 %	Good	---	---

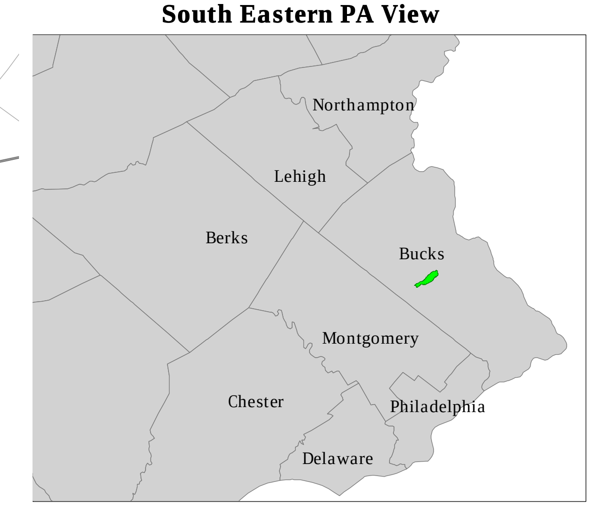
Cooks Run
Watershed Assessment

Figure 5.1
Condition of Stream Segments
Upper Subwatershed



Data Source:
USGS, Aqual-Link Inc.

South Eastern PA View



Map prepared by:

HERITAGE CONSERVANCY

85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

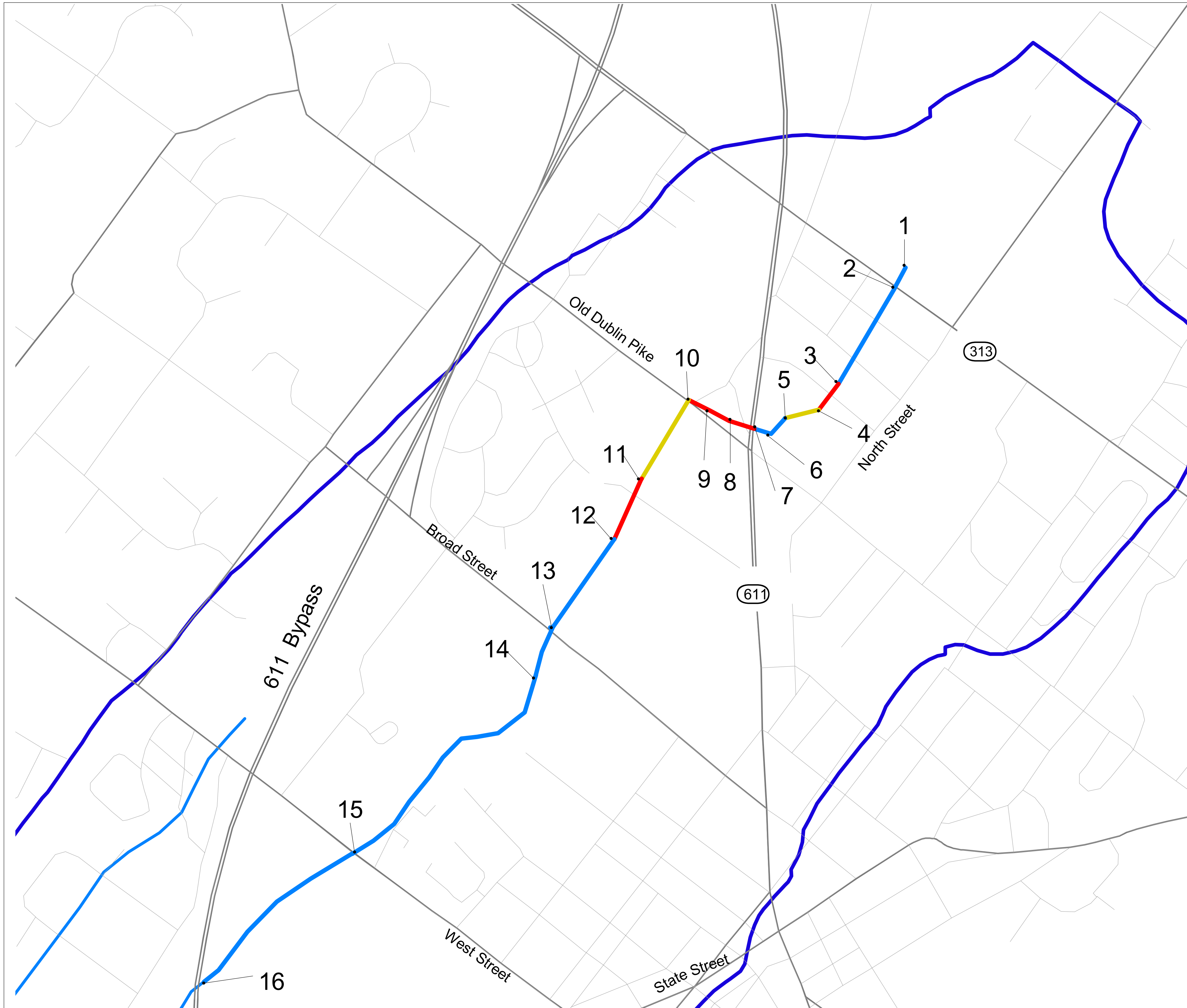
March 2004

Cooks Run
Watershed Assessment

Figure 5.2

Riparian Forested Buffers Needed

Upper Subwatershed



Cooks Run Watershed

Major Road

Minor Road

Riparian Buffer Needed

Both Banks

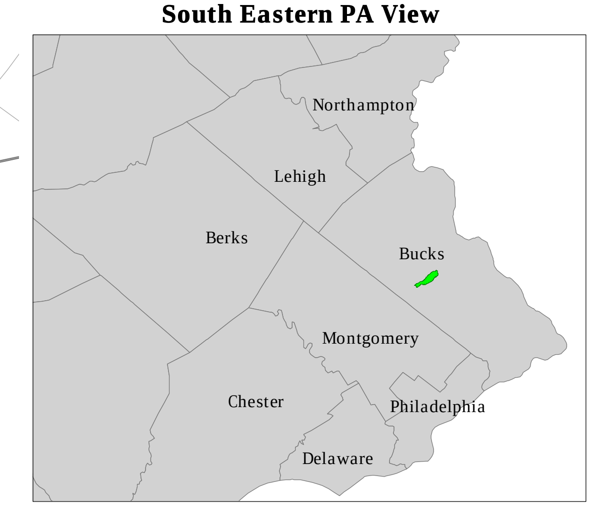
Single Bank

None

2000 0 2000 Feet

Data Source:
USGS, Aqual-Link Inc.

South Eastern PA View



Map prepared by:

HERITAGE CONSERVANCY

85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

March 2004


Segment 1-2


Segment 2-3


Segment 3-4


Segment 4-5

Figure 5.3 Photographs of Stream Segments

Segment 6-7

Segment 7-8

Segment 8-9

Segment 9-10

Figure 5.3 Photographs of Stream Segments

Segment 10-11

Segment 11-12

Segment 12-13

Segment 13-14

Figure 5.3 Photographs of Stream Segments

Segment 14-15

Segment 15-16

Figure 5.3 Photographs of Stream Segments

Stream riparian ratings in Table 5.1 were based upon the following scores: poor (0 to 35 percent), marginal (36 to 65 percent), good (66 to 85 percent) and excellent (86 to 100 percent). The length of riparian buffers needed only pertains to the to the 15 stream segments located along the main stem of Cooks Run (Table 5.1). It should be noted that all streambank designations (left or right) were recorded while facing downstream. In addition, any unnamed tributaries to Cooks Run that required riparian buffers are discussed in Section 6 as nonpoint source watershed problems.

Based upon the stream and riparian visual assessment, the scores of the fifteen stream segments ranged from 0 to 80 percent (poor to good) as shown in Table 5.1. Two segments (Segments 2-3 and 5-6) scored 0 percent because Cooks Run in these segments is completely piped underground. The highest score was for Segment 15-16 as shown in Figures 5.1 and 5.3. This segment is the furthest downstream segment within the upper subwatershed.

With the exception of Segment 4-5, the best stream segments (1-2, 13-14, 14-15 and 15-16) are located just north of Route 313 near Keenan Collision and south of Broad Street to the 611 Bypass (Figures 5.1 and 5.3). All of the poor and marginal stream segments are located south of Route 313 (Segment 2-3) downstream to Broad Street (Segment 12-13). Many of these stream segments have severely modified stream channels, degraded aquatic habitats, and poor riparian buffers.

5.3. Overview of Riparian Buffer Restoration

Riparian buffers are undisturbed vegetative strips that are adjacent to surface waters. Established vegetation along streams and lakes provide numerous benefits such as, filtering out sediments transported by surface runoff, nutrient uptake, wildlife habitat, shading and soil binding via plant roots. Grasses and herbaceous vegetation are best suited as filters, while woody vegetation (shrubs and trees) provide excellent protection against bank erosion.

Riparian buffers should consist of various layers of vegetation (grasses, herbaceous vegetation, shrubs and trees) to achieve optimal benefits. To provide an array of functions, riparian buffer are generally 35 to 100 feet in width. One approach used by the USDA Forest Service is to establish a three-zoned riparian buffer. Zone 1 is the nearest to the streambank and has a recommended fixed 15-foot width. Plants selected for this zone must exhibit excellent soil stabilizing characteristics and need to be capable of tolerating wet soil conditions and periodic flooding. Zone 2 is recommended to be at least 60-feet wide and is considered a managed forest. Within this zone, trees may be harvested to promote nutrient removal as newly planted trees take up more nitrogen. Zone 3 (if required) is recommended to be 20-feet wide and consists of dense grasses and forbs to convert concentrated water flow to uniform sheet flow (Alliance for the Chesapeake Bay 1998).

The unit cost for establishing riparian buffers is quite variable and highly depends on the type of plant materials used. The least expensive approach is to use seedlings and bare root stock, while the more expensive approach is to install plants as balled and burlapped (B&B) or large container stock. Seedlings are typically planted at 6 to 10 feet spacing or roughly 700 seedlings per acre. Bare root stock are generally planted 14 to 16 feet apart or about 200 plants per acre when the bare root plants are several feet in height and around ¾ inches in diameter. Balled and burlapped or large containerized plants are planted 16 to 18 feet apart or approximately 150 plants per acre (Alliance for the Chesapeake Bay 1998).

5.4. Recommendations

Approximately 10,350 feet (approximately 2 miles) of Cooks Run were evaluated in the upper subwatershed during the stream and riparian visual assessment. Of this total, it was estimated that approximately 720 and 1,548 feet of forested riparian buffers are needed along a single bank and both banks, respectively (Table 5.1). The stream segments requiring forested riparian buffers are listed according to priority (Figure 5.2):

- Highest Priority: Stream Segments 3-4, 9-10 and 11-12
- Medium Priority: Stream Segments 7-8, 8-9 and 10-11
- Lowest Priority: Stream Segment 4-5

Overall, as shown in Figure 5.2, most of the above stream segments are located within the Mercer Square Shopping Center, the Doylestown Shopping Center and the Lantern Hill Development along Veterans Lane.

6. Nonpoint Source Watershed Problems

6.1. Methodology

Aqua-Link identified major nonpoint source problems while performing the stream and riparian visual assessment for upper Cooks Run subwatershed (refer to Section 3.2.3). In addition, Aqua-Link walked several small, unnamed tributaries to Cooks Run and toured the remaining portion of the upper subwatershed via truck in order to identify any other significant nonpoint source (NPS) problem areas. Refer to Section 3.2.4 for more information about the methods employed to identify and gather field data about significant nonpoint source problems in the upper subwatershed.

6.2. Discussion of Major NPS Problems

The major nonpoint source (NPS) problems within the upper Cooks Run subwatershed are described below. The locations and photographs of these NPS problems are shown in Figures 6.1 and 6.2, respectively. In addition, Aqua-Link scored each of the identified problem areas with respect its overall level of impairment ranging from 1 to 5 (low to high).

NPS Problem No. 1

Problem description: stream channel widening and straightening. These stream channel and floodplain modifications were performed in the past without any attempt to maintain a natural, low flow channel. The regraded streambanks are very steep and only consist of maintained lawn. Isolated areas of streambank erosion are still occurring even though erosion control matting is still visible.

Stream Name:	Cooks Run
Stream Segment:	3-4
Level of Impairment:	4
Dimensions of NPS Problem:	315 feet occurring along both banks
Location of NPS Problem:	North of Fonthill Drive at Fonthill Apartments complex

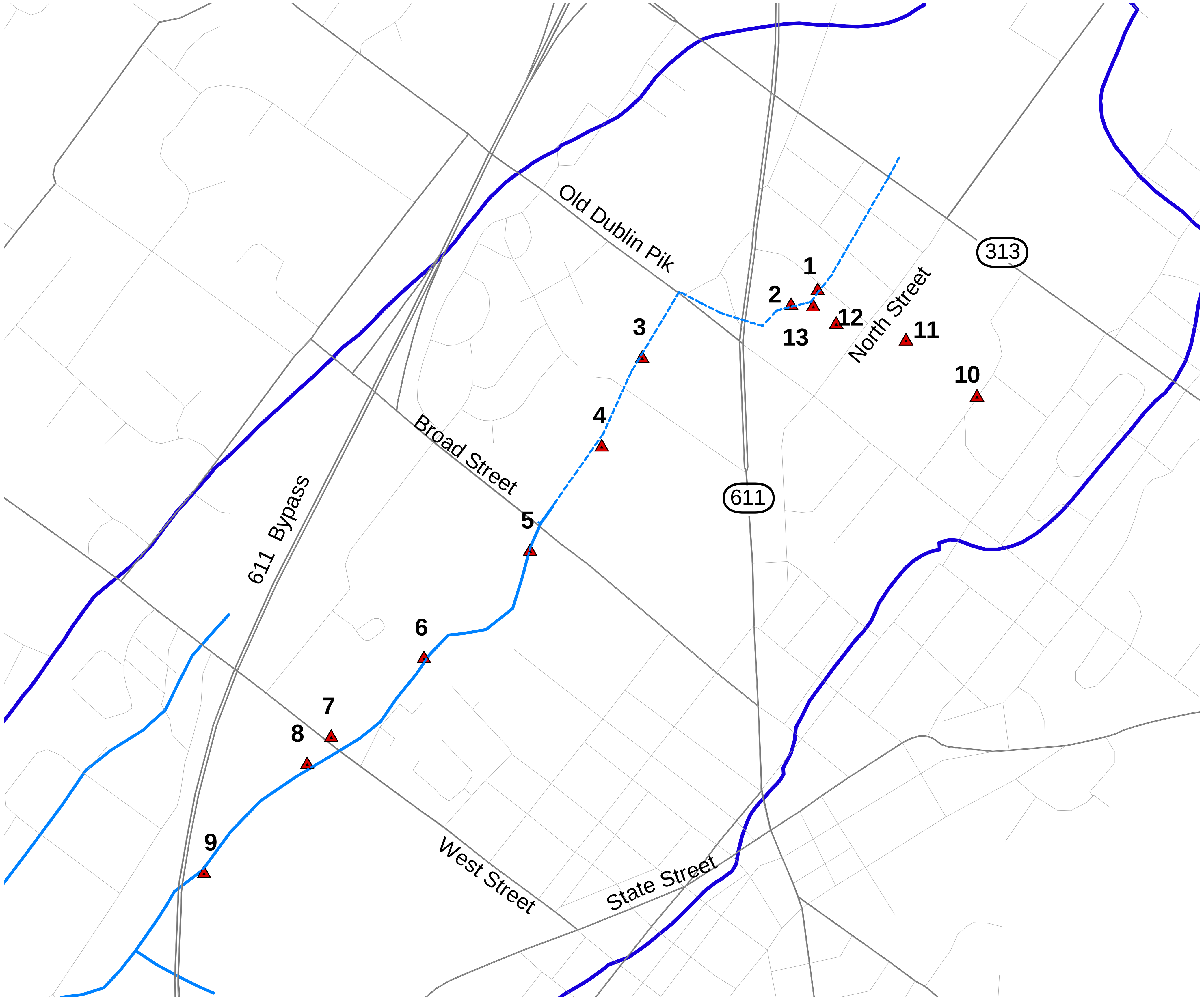
NPS Problem No. 2

Problem description: severe streambank erosion. Streambank erosion is due to lack of woody vegetation along the streambank and within the riparian zone.

Stream Name:	Cooks Run
Stream Segment:	4-5
Level of Impairment:	5
Dimensions of NPS problem:	75 feet occurring along right bank.
Location of NPS Problem:	Fonthill Apartments complex

Cooks Run
Watershed Assessment

Figure 6.1
Major NPS Problems
Upper Subwatershed

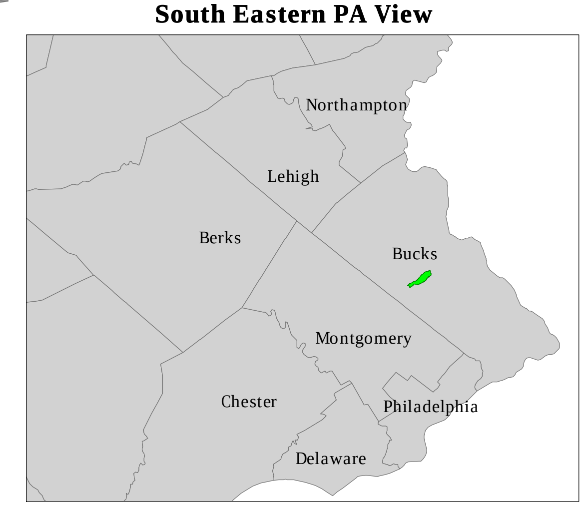


Major NPS Problems
Cooks Run (USGS)
Cooks Run (Determined by Aqua-Link, Inc. 2004)
Cooks Run Watershed
Major Road
Minor Road

1000 0 1000 Feet

Data Source:
USGS, Aqual-Link Inc.

South Eastern PA View



Map prepared by:

HERITAGE CONSERVANCY

85 Old Dublin Pike
Doylestown, PA 18901
215-345-7020
www.heritageconservancy.org

March 2004

NPS 1

NPS 2

NPS 3

NPS 4

Figure 6.2 Photographs of Major NPS Problem Areas

NPS 5 (Above Bridge)

NPS 5 (Below Bridge)

NPS 6

NPS 7

Figure 6.2 Photographs of Major NPS Problem Areas

NPS 8

NPS 9

NPS 10

NPS 11

Figure 6.2 Photographs of Major NPS Problem Areas

NPS 12

NPS 13

Figure 6.2 Photographs of Major NPS Problem Areas

NPS Problem No. 3

Problem description: moderate streambank erosion. Streambank erosion is due to lack of woody vegetation along the streambank and within the riparian zone. It should be noted that this section of stream is highly encroached by a paved road and loading dock area for the shopping center.

Stream Name:	Cooks Run
Stream Segment:	10-11
Level of Impairment:	3
Dimensions of NPS problem:	120 feet occurring along left bank.
Location of NPS Problem:	Doylestown Shopping Center

NPS Problem No. 4

Problem description: severe streambank erosion. Erosion is due to streamflow striking the bank at nearly a right angle plus the lack of woody vegetation along streambank and riparian areas.

Stream Name:	Cooks Run
Stream Segment:	12-13
Level of Impairment:	5
Dimensions of NPS problem:	30 feet occurring along left bank.
Location of NPS Problem:	Heritage Towers (downstream of Veterans Lane crossing)

NPS Problem No. 5

Problem description: moderate streambank erosion. Streambank erosion is due to insufficient quantities of woody vegetation along the streambank and within the riparian zone.

Stream Name:	Cooks Run
Stream Segment:	13-14
Level of Impairment:	3
Dimensions of NPS problem:	150 feet occurring along left bank.
Location of NPS Problem:	Private land (up and downstream of private bridge crossing)

NPS Problem No. 6

Problem description: minor streambank erosion. Streambank erosion is due to debris jam within the stream channel.

Stream Name:	Cooks Run
Stream Segment:	14-15
Level of Impairment:	2

Dimensions of NPS problem:	10 feet occurring along left bank.
Location of NPS Problem:	Upstream of Westwyck Development

NPS Problem No. 7

Problem description: moderate streambank erosion and stormwater pipe requiring repair work. Streambank erosion is due to lack of woody vegetation along the streambank and within the riparian zone. Streambank erosion has adversely affected the stability and functionality of a stormwater discharge pipe.

Stream Name:	Cooks Run
Stream Segment:	14-15
Level of Impairment:	4
Dimensions of NPS problem:	100 feet occurring along both banks Stormwater discharge pipe is located along left bank
Location of NPS Problem:	Private land (up and downstream of private bridge crossing)

NPS Problem No. 8

Problem description: minor streambank erosion. Streambank erosion is due to insufficient quantities of woody vegetation along outer bend of the stream channel and within the riparian zone. Good stream restoration demonstration project for students.

Stream Name:	Cooks Run
Stream Segment:	15-16
Level of Impairment:	1
Dimensions of NPS problem:	60 feet occurring along left bank.
Location of NPS Problem:	Near Doyle Elementary School

NPS Problem No. 9

Problem description: Potential site for moderate to severe streambank erosion. All woody vegetation along steep-sided streambanks and the riparian zone were recently removed. Apparently, this vegetation was removed to provide better visibility of a new heliport at a hospital.

Stream Name:	Cooks Run
Stream Segment:	15-16
Level of Impairment:	2
Dimensions of NPS problem:	210 feet occurring along both banks.
Location of NPS Problem:	Doylestown Hospital (up and downstream of Progress Drive)

NPS Problem No. 10

Problem description: minor streambank erosion. Streambank erosion is due to no woody vegetation along the streambanks and within the riparian zone.

Stream Name:	Unnamed tributary to Cooks Run
Stream Segment:	Not applicable
Level of Impairment:	2
Dimensions of NPS problem:	425 feet occurring along both banks.
Location of NPS Problem:	Font Hill Museum

NPS Problem No. 11

Problem description: minor streambank erosion. Streambank erosion is due to debris jam within the stream channel.

Stream Name:	Unnamed tributary to Cooks Run
Stream Segment:	Not applicable
Level of Impairment:	2
Dimensions of NPS problem:	less than 10 feet along left bank
Location of NPS Problem:	Woodlot at Font Hill Museum

NPS Problem No. 12

Problem description: moderate streambank erosion. Streambank erosion is due to insufficient quantities of woody vegetation along the streambanks and within the riparian zone. The most significant erosion is occurring immediately below installed rock-filled gabion baskets.

Stream Name:	Unnamed tributary to Cooks Run
Stream Segment:	Not applicable
Level of Impairment:	3
Dimensions of NPS problem:	80 feet along left bank
Location of NPS Problem:	Behind Fonthill Apartments complex

NPS Problem No. 13

Problem description: moderate streambank erosion. Streambank erosion is due to lack of woody vegetation along the streambanks and within the riparian zone.

Stream Name:	Unnamed tributary to Cooks Run
Stream Segment:	Not applicable
Level of Impairment:	3

Dimensions of NPS problem:	100 feet along left bank
Location of NPS Problem:	Behind Fonthill Apartments complex at confluence of the unnamed tributary and Cooks Run

6.3. Overview of Streambank Stabilization Practices

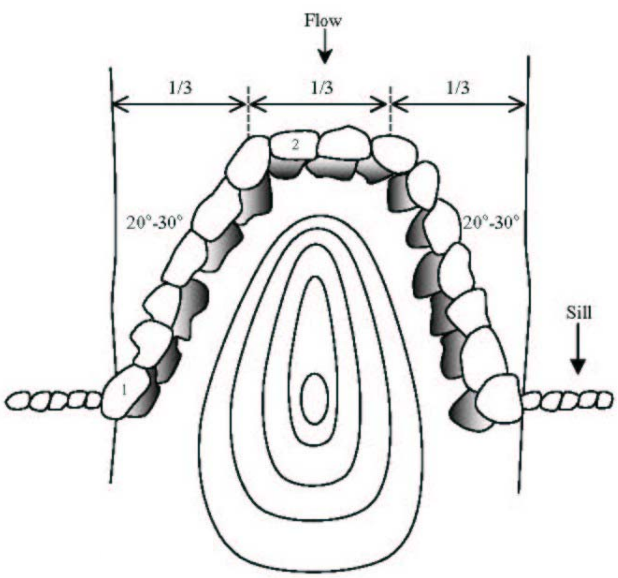
Streambank protective measures generally can be grouped into three categories: vegetative plantings, soil bioengineered practices and structural techniques. Soil bioengineering is a system of living plant materials that are used as structural components for bank stabilization. Common soil bioengineered techniques for streams are brush mattresses, live stakes, joint plantings, vegetated geo-grids, branch packing and live fascines (USDA 1996). Structural techniques include placed rock or boulders, riprap, gabions and retaining walls. In many instances, these three categories are used in combination with one another when stabilizing eroding streambanks.

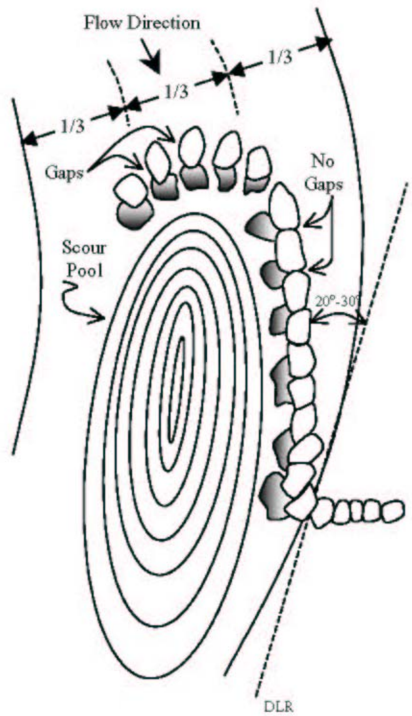
Marginal levels of streambank erosion are often stabilized using vegetative plantings such as, live stakes from willow (e.g., black willow, basket willow or purple osier willow) and dogwood trees. Live stakes should be about 24 inches long with a 3/8-inch minimum diameter at the butt end. Live stakes frequently are planted three-foot on center. Soil bioengineered techniques such as, live fascines, in conjunction with coir fiber logs and live stakes can be used to stabilize moderately eroding streambanks. Live fascines (bundles of live branch cuttings generally from willow trees) may be installed along the lower third of the bank and at mid-bank, while coir fiber logs are often installed at the toe of the bank (edge of water) for additional support and stabilization. Typical costs for purchasing and installing live stakes and live fascines are $1 and $18 per stake and linear foot, respectively (King et al 1994). Costs for purchasing and installing coir fiber logs may range from $8 to $15 per linear foot.

Severely eroding streambanks are often stabilized using a combination of vegetative plantings, soil bioengineered techniques and structural practices. First, the streambanks are typically cut back and regarded to a 2:1 to 3:1 slope if possible. Rock with a geo-textile fabric is generally placed at the toe of the bank. The re-graded bank is seeded with desirable, erosion resistant grasses. Woody plant materials (as live stakes, seedlings or containerized plants), which are approved for soil bioengineering in riparian areas, are installed adjacent to the placed rock to the top of the bank. Live stakes from willow (e.g., black willow, basket willow or purple osier willow) and dogwood trees are installed in between the placed rocks for additional stability and enhancing the overall appearance of the project site. The installation of live stakes within placed rock is commonly referred to as “joint planting”. Also depending upon the length of the slope, live fascines may be installed along the lower third of the bank and at mid-bank for additional support and stabilization. Typical costs for purchasing and installing rock with live stakes is $80 per linear foot, respectively (King et. al. 1994).

In addition, natural stream channel design (NSCD) structures can be installed along the outer bend or across stream channels. Common NSCD structures used in Pennsylvania are J hook rock vanes (J hooks), log vanes, rock vanes or rock cross vanes. These NSCD structures are commonly to deflect flow away from eroding stream banks, concentrate the flow in the center of the channel or enhance pool and riffle habitats.

Plan Views of Rock Cross Vane and J Hook Rock Vane





Prior to implementation, it will be necessary to obtain the proper permits from the Pennsylvania Department of Environmental Protection (PA DEP) for these projects. Under normal circumstances, a general permit (GP-3) is commonly issued for projects that are less than 500 linear feet and an Individual Permit for Small Projects is issued for projects greater than 500 linear feet. The proposed installation of any NSCD structures will likely require an individual permit regardless of the size of the project area.

6.4. Recommendations

As part of this assessment, Aqua-Link has provided its recommendations to stabilize those major nonpoint source (NPS) problems discussed in Section 6.2. Our recommendations are discussed below in detail. As previously stated, the locations and photographs of the NPS problems are presented in Figures 6.1 and 6.2, respectively. The NPS problems were placed in one of the following categories:

- Highest Priority

- Medium Priority
- Lowest Priority

All of the recommendations involve implementing streambank stabilization practices, riparian buffer restoration measures or a combination of both. An overview of streambank stabilization and riparian buffer restoration best management practices are discussed in Sections 5.3 and 6.3, respectively.

6.4.1. Highest Priority

NPS Problem No. 1

Solution to the Problem: The first, simpler option is to regrade the steep banks and then stabilize these banks using soil bioengineered practices. In addition, appropriate woody plant materials should be installed in order to establish a good, forested riparian buffer along the repaired streambanks.

The second, more difficult option is to completely redesign the stream channel in order to recreate a natural, low flow stream channel and floodplain complex. The new, low flow channel should be created within the existing stream channel. Several cross vane rock structures may be installed within the new stream channel to create deeper scour holes. Presently, the stream reach is very shallow and uniform as a result of past stream channel widening activities. Next, the existing steep streambanks should be cut back and regraded in order to create a new floodplain for the newly created low flow stream channel. Thereafter, appropriate woody plant materials should be installed along the reconstructed streambanks and floodplain, thereby establishing a forested riparian buffer.

Stream Name:	Cooks Run
Stream Segment:	3-4
Level of Impairment:	4
Dimensions of NPS Problem:	315 feet occurring along both banks
Location of NPS Problem:	North of Fonthill Drive at Fonthill Apartments complex

NPS Problem No. 2

Solution to the Problem: The streambank should be stabilized using soil bioengineered practices such as live stakes, live willow posts and live fascines. Steep bank should be regraded and either rock or coir fiber logs may be placed at the toe of the bank for added protection and stability. In addition, appropriate woody plant materials should be installed to establish a forested riparian buffer.

Stream Name:	Cooks Run
Stream Segment:	4-5
Level of Impairment:	5

Dimensions of NPS problem:	75 feet occurring along right bank.
Location of NPS Problem:	Fonthill Apartments complex

NPS Problem No. 4

Solution to the Problem: The streambank should be stabilized using a combination of soil bioengineered, structural and natural stream channel design (NSCD) practices. The steep should be regraded and large rocks should be place at the toe of the bank. The place rock should also extend at least half way up the bank. The placed rocks should be later planted with live willow stakes for added stability and aesthetics. Soil bioengineered practices such as, live stakes, live willow posts and live fascines should be installed above the rock and extend to the top of the bank. Appropriate woody plant materials should be installed to establish within the floodplain to create forested riparian buffer. Lastly, a natural stream channel design structure such as a J hook or rock vane may be installed to concentrate flow away form the problem area.

Stream Name:	Cooks Run
Stream Segment:	12-13
Level of Impairment:	5
Dimensions of NPS problem:	30 feet occurring along left bank.
Location of NPS Problem:	Heritage Towers (downstream of Veterans Lane crossing)

NPS Problem No. 7

Solution to the Problem: The streambanks should be stabilized using soil bioengineered practices such as live stakes and live fascines. Prior to installing any plant materials, the steep banks should be regraded and coir fiber logs should be installed at the toe of the bank for added protection. Thereafter, additional appropriate woody plant materials should be installed to establish a forested riparian buffer along both repaired streambanks. In addition, the stormwater discharge pipe along Limekiln Road should be repaired, as needed, which includes installing a rock or concrete end wall structure.

Stream Name:	Cooks Run
Stream Segment:	14-15
Level of Impairment:	4
Dimensions of NPS problem:	100 feet occurring along both banks. Stormwater discharge pipe is located along left bank
Location of NPS Problem:	Private land (up and downstream of private bridge crossing)

6.4.2. Medium Priority

NPS Problem No. 3

Solution to the Problem: The streambank should be stabilized using soil bioengineered practices such as live stakes and live fascines. Prior to installing any plant materials, a coir fiber log should be installed at the toe of the bank for added protection. Thereafter, additional appropriate woody plant materials should be installed to establish a forested riparian buffer along both repaired section of streambank. It should be noted that the width of the riparian buffer is limited by the encroachment of a paved road and loading dock area for the shopping center.

Stream Name:	Cooks Run
Stream Segment:	10-11
Level of Impairment:	3
Dimensions of NPS problem:	120 feet occurring along left bank.
Location of NPS Problem:	Doylestown Shopping Center

NPS Problem No. 5

Solution to the Problem: The streambank should be stabilized using soil bioengineered practices such as live stakes, live willow posts and live fascines. The steep bank first should be regraded and rock should be installed at the toe of the bank for added protection and stability. In addition, appropriate woody plant materials should be installed upslope of the repaired section of streambank, thereby establishing a good, forested riparian buffer.

Stream Name:	Cooks Run
Stream Segment:	13-14
Level of Impairment:	3
Dimensions of NPS problem:	150 feet occurring along left bank.
Location of NPS Problem:	Private land (up and downstream of private bridge crossing)

NPS Problem No. 12

Solution to the Problem: The streambanks should be stabilized using soil bioengineered practices such as live stakes and live fascines. Prior to installing any plant materials, the steep banks should be regraded and wither coir fiber logs or rock should be installed at the toe of the bank for added protection. Thereafter, additional appropriate woody plant materials should be installed to establish a forested riparian buffer along both repaired streambanks. In addition, large rock (boulders) should be installed immediately below the existing rock-filled gabion baskets. Large placed rocks should be joint-planted with live willow stakes for added aesthetics and protection.

Stream Name:	Unnamed tributary to Cooks Run
Stream Segment:	Not applicable
Level of Impairment:	3

Dimensions of NPS problem:	80 feet along left bank
Location of NPS Problem:	Behind Fonthill Apartments complex

NPS Problem No. 13

Solution to the Problem: The streambanks should be stabilized using soil bioengineered practices such as live stakes and live fascines. Prior to installing any plant materials, the steep banks should be regraded and coir fiber logs should be installed at the toe of the bank for added protection. Thereafter, additional appropriate woody plant materials should be installed to establish a forested riparian buffer along both repaired streambanks.

Stream Name:	Unnamed tributary to Cooks Run
Stream Segment:	Not applicable
Level of Impairment:	3
Dimensions of NPS problem:	100 feet along left bank
Location of NPS Problem:	Behind Fonthill Apartments complex at confluence of the unnamed tributary and Cooks Run

6.4.3. Lowest Priority

NPS Problem No. 6

Solution to the Problem: Remove the debris jam and allow for natural streambank healing. As opposed to natural healing, woody plant materials as live stakes, seedlings, containerized plants may be installed to repair area exhibiting minor streambank erosion. All selected plant materials should be approved for streambank and riparian soil bioengineering practices.

Stream Name:	Cooks Run
Stream Segment:	14-15
Level of Impairment:	1
Dimensions of NPS problem:	10 feet occurring along left bank.
Location of NPS Problem:	Upstream of Westwyck Development

NPS Problem No. 8

Solution to the Problem: The streambank should be stabilized using soil bioengineered practices such as live willow posts, live stakes and live fascines. Prior to installing any plant materials, the banks should be regraded and coir fiber logs should be installed at the toe of the bank for added protection. This section of stream is located near a school and therefore, may serve as an excellent demonstration project for local students.

Stream Name: Cooks Run
Stream Segment: 15-16
Level of Impairment: 2
Dimensions of NPS problem: 60 feet occurring along left bank.
Location of NPS Problem: Near Doyle Elementary School

NPS Problem No. 9

Solution to the Problem: The streambanks should be replanted with woody plant materials (live stakes, seedlings or containerized plants), which are approved for soil bioengineering in riparian areas. Replanting should occur immediately before any severe streambank erosion has had a chance to occur. Selected plant materials should only consist of low lying shrubs, thereby maintaining good visibility for the heliport at the Doylestown Hospital.

Stream Name: Cooks Run
Stream Segment: 15-16
Level of Impairment: 2
Dimensions of NPS problem: 210 feet occurring along both banks.
Location of NPS Problem: Doylestown Hospital (up and downstream of Progress Drive)

NPS Problem No. 10

Solution to the Problem: Streambanks and adjacent riparian areas should be planted with live stakes, seedlings, containerized plants or a combination of all three. All selected plant materials should be approved for streambank and riparian soil bioengineering practices. In addition, some minor, isolated areas of streambank erosion will likely require some regrading work. These eroding areas will likely benefit by installing coir fiber logs at the toe of the bank for added protection.

Stream Name: Unnamed tributary to Cooks Run
Stream Segment: Not applicable
Level of Impairment: 2
Dimensions of NPS problem: 425 feet occurring along both banks.
Location of NPS Problem: Font Hill Museum

NPS Problem No. 11

Solution to the Problem: Remove the debris jam and allow for natural streambank healing. As opposed to natural healing, woody plant materials as live stakes, seedlings, containerized plants may be installed along this area exhibiting minor streambank erosion. All selected plant materials should be approved for streambank and riparian soil bioengineering practices.

Stream Name:	Unnamed tributary to Cooks Run
Stream Segment:	Not applicable
Level of Impairment:	2
Dimensions of NPS problem:	less than 10 feet along left bank
Location of NPS Problem:	Woodlot at Font Hill Museum

7. Stormwater Management Assessment

7.1. Methodology

Gilmore & Associates (G&A) were subcontracted by Aqua-Link to perform the stormwater management assessment of the upper subwatershed. The purpose of this assessment was to determine if any of the facilities are good candidates for stormwater retrofitting. Refer to Section 3.2.5 for more information about the methods used to perform the stormwater management assessment.

7.2. Discussion of Major SWM Facilities

G&A identified a total of 17 major stormwater management (SWM) facilities in the upper subwatershed. A description of each facility is presented below. The locations and photographs of the facilities are presented in Figures 7.1 and 7.2, respectively.

SWM-1 Doylestown Hospital

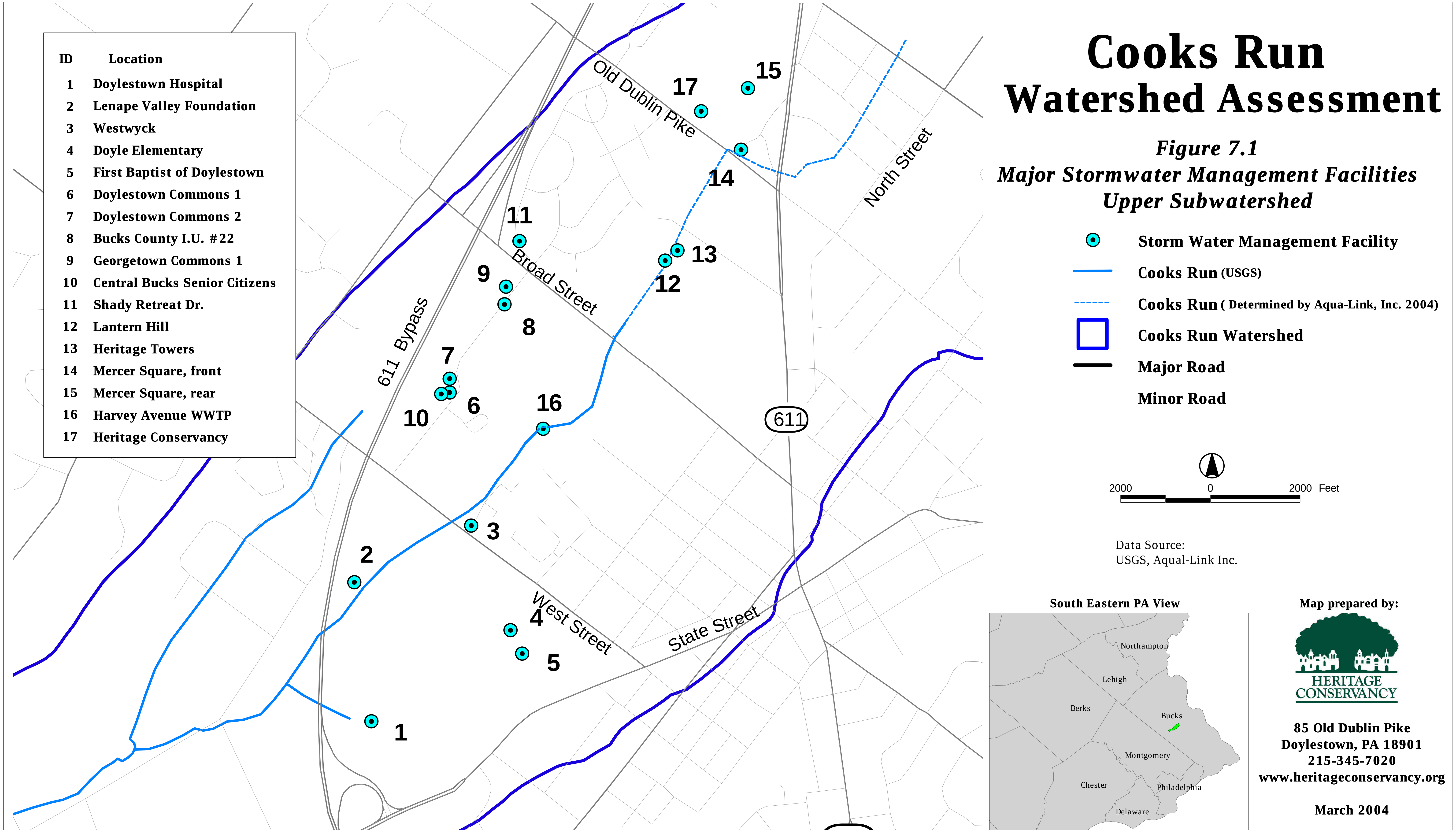
Detention basin is located at the Doylestown Hospital. The walls have been planted with herbaceous perennials. The basin is in fair condition with some minor erosion on the banks. The outlet structure is in fair condition, with some damage due to age. Water quality is fair to poor, algae blooms are present and cover approximately 50 percent of the waters surface. Most likely the water has excessive nitrogen and phosphorus concentrations due to the surrounding parking lot and hospital lawns. Various oil slicks are visible in the parking lot. These most likely are caused by nonpoint source pollution from vehicles and delivery trucks.

As the hospital has expanded over the years, the basin has been designed and redesigned to compensate for additional runoff. At this point the structure has maximized the use of the space available, therefore any recommended improvements would have to be careful not to reduce its available storage volume.

SWM-2 Lenape Valley Foundation

The Lenape Valley Foundation retention basin is a dry basin with manicured grass. The inlet and outlet structures are in good condition. There is little to no erosion evident. This basin has a spillway that overflows directly into Cooks Run.

This basin has been reexamined on several occasions as well due to expansion of the Foundation and its parking lot is still functioning well. Construction of a new addition and parking lot began in September 2003 and the extent of additional stormwater management is still unknown at this time.



Cooks Run Watershed Assessment

Figure 7.1
Major Stormwater Management Facilities
Upper Subwatershed

SWM 1

SWM 2

SWM 3

SWM 4

Figure 7.2 Photographs of Major SWM Facilities

SWM 5

SWM 6

SWM 7

SWM 8

Figure 7.2 Photographs of Major SWM Facilities

SWM 9

SWM 10

SWM 11

SWM 12 (Basin)

Figure 7.2 Photographs of Major SWM Facilities

SWM 12 (Floodway Project)

SWM 13

SWM 14

SWM 15

Figure 7.2 Photographs of Major SWM Facilities

SWM 16

SWM 17

Figure 7.2 Photographs of Major SWM Facilities

SWM-3 Westwyck Community

Westwyck is a residential community. The stormwater facility is interplanted with shrubs and herbaceous plant material. The basin is in good condition with little erosion. The outlet structure is clogged with debris and needs to be cleaned. The outfall pipe empties directly into Cooks Run.

SWM-4 Doyle Elementary School / Doyle Park

The Doyle Elementary School basin is actually a pond, which captures runoff from a nearby apartment complex. The basin is a wet basin with various herbaceous plant material planted on the banks. Water quality in this basin appears to be good. There is little to no erosion on the banks. The outlet structure is in good condition and empties into a grass swale that runs behind the elementary school.

SWM-5 First Baptist Church of Doylestown

The Church basin collects water from a building and adjacent parking lots. The structure is acting as a wet basin, and the outlet structure is an overflow swale. The water quality in this basin is fair to poor. There is evidence of heavy sedimentation collection and algae blooms. The sedimentation resulted largely from the construction of a recent addition for the church. The visible algal mats floating on the basin is most likely present due to nearby lawns and fertilization practices. The banks are planted with some herbaceous vegetation. Erosion is apparent around the banks of the structure and along the outfall channel.

SWM-6 & 7 Doylestown Commons

Doylestown Commons is a Condominium complex. There are two basins in this development. Both basins are similar grass planted swales. The two basins show signs of heavy rill erosion and sedimentation. The outlet structures are clogged with debris. The lawn is subject to fertilization, causing excessive nitrogen and phosphorous to be distributed Cooks Run. Cooks run is located within 100 yards of these basins.

SWM-8 Bucks County Intermediate Unit #22

The Bucks County Intermediate Unit's retention basin is a grass basin with some trees and shrubs. There is moderate erosion present at the inlet structure and the drainage swale that runs to the outlet structure. The basin is a fairly new basin and the inlet and outlet structures are in good condition. The basin collects water from a nearby parking lot and building and is subject to nonpoint source pollution.

SWM-9 Georgetown Commons

The Georgetown Commons detention basin is a wet pond with various wetland plantings. The pond is in very good condition with little to no erosion on the banks. Water quality is affected by lawn fertilization. The inlet and outlet structures are in good condition.

SWM-10 Central Bucks Senior Citizens

The Central Bucks Senior Citizens retention basin is in good condition. The basin collects runoff from parking lots and buildings, thereby making it vulnerable to nonpoint source pollution. The basin abuts to the parking lot. The inlet and outlet structures are in good condition. The entire basin is manicured lawn.

SWM-11 Shady Retreat Drive

The retention basin at Shady Retreat Drive collects runoff from a residential development. The basin is subject to fertilization runoff as well as nonpoint source pollutants. The basin is lined with a concrete channel, which carries water from one end to the other. The concrete channel inhibits infiltration and eliminates bioretention. The inlet and outlet structures are in fair condition.

SWM-12 Lantern Hill

The Lantern Hill detention basin is located directly adjacent from Cooks Run stream channel. There is a structural stormwater detention basin within the development. This basin is made of pre stressed concrete blocks. There is an aerating device located in the pond. The basins located on this site are brand new and all outfall and inlet structures are in good condition. The stormwater management area was designed primarily for rate control with some consideration given to aesthetics with the installed water feature. Based upon the design, the only water quality benefits provided by this facility is the permanent pool of water with the fountain aeration.

The Lantern Hill project also included work on the floodway of Cooks Run. The banks and surrounding area, including Veterans Lane (crosses the stream) were regraded to alleviate local flooding concerns. The overbank area was graded and planted with emergent vegetation as part of this project.

SWM-13 Heritage Towers

The Heritage Towers retention basin is a grass swale that discharges directly into Cooks Run. The basin is subject to nonpoint source discharges from the parking lot located to the east. The basin also receives salt spray and runoff during the winter months. The inlet and outlet structures are new and in good condition.

SWM-14 Mercer Square (Front)

The Mercer Square system is a series of detention basins with a low flow concrete channel flowing through it. The low flow channel inhibits infiltration and bioretention. The basin receives runoff from the shopping center, parking lots and roadway, thereby making it susceptible to nonpoint source pollution. The basin is planted with wetland vegetation. Presently, there is an abundance of cattails and purple loosestrife. Both of these plants are considered highly invasive plant species.

SWM-15 Mercer Square (Rear)

The second Mercer Square basin is located behind the shopping center is a grass basin with a low flow concrete channel. The basin collects runoff from nearby developments and parking lots, thereby making it susceptible to point source and non point source pollution. The low flow channel does not allow for infiltration or bioretention. The inlet and outlet structures are in good condition.

SWM-16 Harvey Avenue Wastewater Treatment Plant

This basin was installed and configured as a sediment basin, however the ‘temporary’ sediment riser was never removed. Doylestown Borough prepared plans to rehabilitate this basin into a wetland basin, however this plan was not implemented due to budgetary concerns.

SWM-17 Heritage Conservancy

This small, grassed basin was designed to utilize the space available between existing mature trees. The basin was designed in such a way that the inflow pipe is located directly opposite the outlet structure, thereby resulting in a short-circuiting effect. Also, the basin outlet is a single stage structure consisting of a simple headwall. At the time of this report, the owner of the site, the Heritage Conservancy, had recently applied for funding in order to retrofit the basin for water quality improvements.

7.3. Overview of Stormwater Retrofitting

Urbanization has a profound influence on stream and lake water quality. These impacts are more readily observed in older urban settings without any or inadequate stormwater controls as compared to newer urban areas (Schueler 1987). In general, stormwater management systems in older urban areas were designed to quickly capture surface runoff from impervious areas (roof tops, sidewalks, roadways, parking lots) and pipe it directly to receiving streams. In addition, increased imperviousness in a watershed subsequently results in less rainfall infiltration and percolation resulting in lower levels of groundwater recharge.

Urbanization allows for changes in watershed hydrology, changes in stream geometry, the degradation of aquatic ecosystems and pollutant export during construction and after site stabilization. Watershed hydrology is significantly altered after urbanization. Peak stream discharges are increased about 2 to 5 times higher than pre-development levels. The volume of stormwater runoff produced by individual storms is increased. For example, a moderately developed watershed many produce 50 percent more runoff than a forest watershed. The time required for runoff to reach a stream (time of concentration) is significantly decreased by as much as 50 percent. In addition, changes in watershed hydrology result in increased frequency and severity of flooding, reduced streamflow during prolonged periods of dry weather (due to decreased rates of soil infiltration) and greater runoff velocities during storm events (Schueler 1987).

Streams now must readjust (change in geometry) to the new hydrologic conditions in urban areas. The primary adjustment for increased stormwater volumes is channel widening. Stream channels may widen 2 to 4 times their original size if post-development runoff is not effectively controlled. The elevation of the stream's floodplain also will increase to accommodate higher post-development peak discharge rates, therefore, property and structures not previously at risk to flooding now may be at risk. Streambanks are gradually undercut and slump into the stream channel. Trees that previously protected the banks are now exposed at the roots and sometimes become windthrown, thereby triggering a second phase of bank erosion. Eroded soils from streambanks and upland areas are temporarily stored in the stream channel as sand bars and other sediment deposits. Gradually, these sediments migrate throughout the stream network as bedload, but unfortunately the stream channel will inevitably be covered by shifting deposited mud and coarse sands for many years to come (Schueler 1987).

In addition, urbanization adversely affects the overall composition of aquatic ecosystems. Increased levels of pollutants to receiving waters often result in lower levels of species diversity and the dominance of more tolerate, less desirable aquatic insects and fish. Pollutants are exported during construction and after site stabilization. There is a very high potential for large quantities of sediment with attached nutrients and organic matter to be transported to streams and lakes from active construction sites. This potential is greatly reduced when adequate erosion and sediment controls are properly installed and maintained. After construction, pollutants rapidly accumulate on impervious surface and are readily transported to receiving waters via stormwater runoff. These pollutants include sediments, nutrients, bacteria, oxygen consuming substances, oil and grease, metals, toxic chemicals and chlorides. In addition, increased temperatures of stormwater runoff (thermal pollution) will result in increased temperatures of receiving waters (Schueler 1987).

Land development (urbanization) prior to the 1970's had little to no stormwater management practices. Stormwater systems were primarily built only to transport runoff rapidly to receiving waters. In the 1970's, efforts began to address runoff induced flooding. Stormwater control structures including detention basins were generally designed to accommodate only peak rates of runoff. Therefore, these structures only held runoff for a few hours until it was deliberately discharged to receiving waters and did not address the loss of groundwater recharge, poorer runoff water quality or increased runoff volumes over pre-development conditions (Delaware Riverkeeper 2001).

The primary problem with the peak rate of runoff design for stormwater control structures (detention basins) is that receiving waters receive increased stormwater volumes for longer periods of time. Structures of this design throughout a watershed have a cumulative net effect of actually increasing the instream peak discharge rates and water volumes for extended periods. Therefore, the final result is that downstream flooding is exacerbated since flood flow is increased and extended (Delaware Riverkeeper 2001).

In addition, most detention basins are designed to control only 10 to 100-year frequency storms and fail to impact the 2 to 5-year storms. Many detention basins are designed to pass these smaller storm runoff volumes directly to streams. In general, the 2-year storm in a natural watershed produces bankfull discharge. Bankfull discharge is that amount of flow that fills the stream to the top of its banks. In urban areas, smaller, more frequent storms can result in bankfull conditions because of increased runoff volumes. Bankfull discharge is considered the effective discharge for stream channel formation (channel widening, channel downcutting and bank erosion).

Stormwater best management practices (BMP's) that are later incorporated into existing developments and urban areas is referred to as stormwater retrofitting. Retrofitting may only require minor modifications to existing control structures like detention basins or the construction of new control structures or devices. The underlying goal of retrofitting is to correct many of the problems that were described above. Below is a list of common retrofits that may be employed for existing stormwater detention basins (CH2MHill et. al. 1998):

- Modifying the outfall to create a two-stage release to better control smaller storms while not significantly compromising the major detention required for flood control
- Eliminating paved low-flow channels and replacing them with meandering vegetated swales
- Eliminating low-flow bypasses
- Incorporating low berms to lengthen the flow path and eliminate short-circuiting
- Incorporating stilling and settling basin at inlets

- Regrading the basin bottom to create a wetland area near the outlet or revegetating parts of the basin bottom with wetland vegetation to enhance pollutant removal, reduce mowing and improve aesthetics

- Creating a wetland shelf along the periphery of a wet basin to improve shoreline stabilization, enhance pollutant filtering and enhance esthetic habitat functions

7.4. Recommendations

As part of this assessment, G&A has provided its recommendations for retrofitting the stormwater management (SWM) facitilites that were discussed in Section 7.2. These recommendations are discussed below in detail. As previously noted, the locations and photographs of the facilities are presented in Figures 7.1 and 7.2, respectively. The SWM facilities were placed in one of the following categories:

- Strongly Recommended (Critical for Watershed Health)
- Recommended (Beneficial for Watershed Health)
- No Improvements Necessary

7.4.1. Strongly Recommended (Critical For Watershed Health)

SWM-1 Doylestown Hospital

There are two recommendations for this facility. The first is to install bio-filters in the parking lot inlets, which will intercept the nonpoint pollution. A device similar to "Flogard" filters (KriStar Enterprises Inc., Santa Rosa, CA), which are designed to be installed in existing inlet boxes and filter out fossil fuels as well as sediments. The second recommendation is to install some form of aeration device to prevent stagnation and reduce the frequency of algal blooms.

SWM-14 Mercer Square (Front)

The concrete channel should be removed and forebays installed at the inflow points. Pools and channels could be excavated throughout, thereby creating areas of both deep and shallow water and mounds of dry ground. Wetland plants would be used to provide filtration and water quality improvement. This basin would also benefit from the installation of bio-filters as described in SWM1.

SWM-16 Harvey Avenue Wastewater Treatment Plant

Doylestown Borough prepared plans to rehabilitate this basin into a wetland basin, however this plan was not implemented due to budgetary concerns. Based on a review of these plans, it is recommended that the existing basin be retrofitted according to the Borough's design plans.

7.4.2. Recommended (Beneficial to Watershed Health)

SWM-2 Lenape Valley Foundation

Since capacity is an issue in this basin, recommended improvements would be seeding the basin with a wet meadow mix and restrict or reduce the grass cutting. This area is not used as a lawn for any recreational purposes, therefore the additional vegetation will provide filtration, add attractive plants and create a habitat for migratory birds.

SWM-3 Westwyck Community

The basin is obviously in good condition and very little needs to be done. It is recommended that the outlet structure be cleaned of debris to insure it functions as intended.

SWM-6 Doylestown Commons

Similar to SWM-2, this structure is not used as a lawn area despite being maintained as such. The addition of the meadow seeding and reduction of grass cutting will improve both the aesthetics and the water quality of these basins. And it will reduce maintenance costs and clogging of the outlet structure with debris.

SWM-8 Bucks County Intermediate Unit #22

Similar to SWM-2, this structure is not used as a lawn area despite being maintained as such. The addition of the meadow seeding and reduction of grass cutting will improve both the aesthetics and the water quality of these basins. And it will reduce maintenance costs and clogging of the outlet structure with debris. This basin would also benefit from the installation of bio-filters as described in SWM-1.

SWM-12 Lantern Hill (Floodway)

The improvements to the floodway were beneficial to the surrounding community, however it also removed significant amounts of vegetation in the process. After construction, the site was reseeded with grass and replanted unnaturally with a few shrubs and trees. Unfortunately, the quantity of shrubs and trees planted is considered inadequate and therefore, this site requires extensive riparian restoration. This riparian restoration for this SWM facility is thoroughly discussed in Section 5 as Stream Segment 11-12.

SWM-13 Heritage Towers

Portions of this area were regraded in conjunction with the Lantern Hill Development and associated Veterans Lane Improvements (SW-12). This area is not used as a lawn area despite being maintained as such. With the adjacent parking area, this site would be ideal for installation of a bioretention facility. It would provide filtration of the runoff, attractive plant material and provide treatment for the water quality volume.

SWM-15 Mercer Square (Rear)

Given the generally low slope of this basin, it would do very well as a wetland structure. The concrete channel should be removed and a forebay installed at the inflow point(s). Pools and channels could be excavated throughout, thereby creating areas of both deep and shallow water and mounds of dry ground. Wetland plants would be used to provide filtration and water quality improvement.

7.4.3. No Improvements Necessary

SWM-4 Doyle Elementary School / Doyle Park

There are no recommended improvements for this facility. Overall, the water quality of this basin appears to be good.

SWM-5 First Baptist Church of Doylestown

This structure was originally intended to be an infiltration basin, which obviously is not working properly. There are plans currently under review to fix this situation, which include the installation of an outlet structure and a pipe tied into the storm sewer system at the adjoining Lenape Middle School. It is the intent to rehabilitate the basin floor as well and re-establish the absorptive capacity of the basin. If this is accomplished the outlet structure will be acting as a ‘release valve’ for large storm events. Since the Church is in the process of developing a solution to this problem, no further recommendations are made at this time. Once the proposed work is completed however, this site should be revisited to determine if the infiltration structure is functioning.

SWM-9 Georgetown Commons

In general this facility is well conceived and built. The perimeter plantings appear to be immature, but this is a temporary condition.

SWM-10 Central Bucks Senior Citizens

This basin was designed to be low profile so that it blends into the surrounding topography and may be used of other purposes in fair weather. Since it remains in good condition, there are no recommended improvements to the facility.

SWM-11 Shady Retreat Drive

This basin was designed to be low profile so that it blends into the surrounding topography and may be used of other purposes in fair weather. Although replacing the concrete low flow channel with a more environmentally friendly option would improve the water quality, this is a very expensive undertaking and would result in minimal benefits to the watershed. Since it remains in good condition, there are no recommended improvements to the facility.

SWM-17 Heritage Conservancy

At the time of this report, Heritage Conservancy has applied for funding to retrofit their basin to improve water quality. The proposed retrofit includes modifications to the existing outlet to provide a longer detention time. The plan also proposes to add micro-contouring and native vegetation intended to increase the flow path of the smaller storms through the basin and to provide filtration for removal of suspended solids and nutrients. In general the proposal will benefit the watershed and provide a demonstration site for rehabilitation of an urban stormwater management facility. Had this project not pursued separate funding, it would have been listed as a project beneficial to the watershed in this report.

8. Evaluation of Ordinances

8.1. Methodology

Gilmore & Associates (G&A) was subcontracted by Aqua-Link to evaluate applicable municipal ordinances that can have a significant impact on surface water quality in the Cooks Run watershed. As part of this task, G&A evaluated municipal ordinances for Doylestown Township, Doylestown Borough and New Britain Borough.

As noted in Section 3.2.6, G&A reviewed the current zoning and subdivision land development ordinances for the above three municipalities. The ordinances were examined for sections on Environmental or Natural Resource Protection and particularly for riparian and stream corridor protection. In addition to protective ordinances, the sections and/or ordinances for stormwater management were reviewed with regard to the use of best management practices since the management and treatment of stormwater runoff is integral to the health and welfare of Cooks Run and the Neshaminy Creek.

8.2. Comments & Recommendations

Based upon their evaluation, G&A has provided their comments on the current zoning and subdivision land development ordinances and other environmental protection ordinances for Doylestown Township, Doylestown Borough and New Britain Borough. Where applicable, G&A provided specific recommendations for revising these ordinances in order to better protect the water quality and aquatic habitats of Cooks Run and the Neshaminy Creek.

8.2.1. Doylestown Township

<u>Chapter 175, Section 27 "Environmental Protection Standards"</u>

Section 175-27 covers all natural resources from flood plains to steep slopes. Wetlands, waters, and floodplains are protected at 100% except where permits are obtained from the Pennsylvania Department of Environmental Protection (PA DEP). This section also refers to section 175-103.1 for protection of Riparian Corridors. There is only one recommended improvement to this ordinance and this recommendation involves the protection of 'Ponds (natural or man-made) and Pond Shorelines.' This sub-section includes retention and detention basins within the structures, which are protected at 100%. Stormwater management facilities should be exempt from this ordinance in order to allow for periodic maintenance, particularly since it would be required to obtain a Zoning Variance to perform any maintenance or basin retrofit which requires earth moving. It should be noted that these structures are exempt from PA DEP regulations, provided that their drainage area is less than 100 acres.

Chapter 175, Section 103 "Riparian Corridor Conservation District"

Of the three townships that include the Cooks Run Watershed, only Doylestown Township has a specific ordinance for the protection of the riparian corridor. The protection is set up in two zones: Zone 1 at 25 feet from the edge of the stream or waterway and Zone 2 extending for an additional 50 feet or to 100-year floodplain, whichever is greater. Permitted uses within Zone 1 are primarily passive with only reforestation and streambank stabilization being disturbances allowed by right. Stream crossings for driveways, roads or utilities are permitted as Conditional Use. Zone 2 has similar restrictions, however it does allow any existing agricultural use to continue by right. In addition to the Zone 1 uses under a conditional use approval, Zone 2 may be used for new agricultural areas, stormwater management facilities, passive recreation areas such as campgrounds or picnic areas, and active recreation such as ball fields or playgrounds.

Sub-section 175-103.5 lists very specific prohibited uses, and this area could use some modification. For one, it does not allow for the riparian corridor to be included in the minimum yard setback (paragraph B). This appears to be overly restrictive, forcing residential homes to be more than 100 feet from any stream. Provided that the house and other structures are located above the 100-year flood plain, there is no reason why Zone 2 could not include the required yard setbacks particularly since this zone allows for both passive and active recreational use. If the intent of this paragraph is to protect natural vegetation, it could be revised to allow for use as minimum yard area and shall not be disturbed for more than a certain percentage of the required width.

Chapter 153, Section 38 "Stormwater management and surface runoff control"

The stormwater management section of the Subdivision and Land Development Ordinance was revised in 2000 to include infiltration practices for groundwater discharge. It has also been noted through past experiences that the Township is willing to entertain alternative best management practices (BMPs) proposed by the design engineer of a project. There are three major points that should be re-examined within this ordinance section:

1. Although the section does reference the Pennsylvania BMP Manual with regard to the design of infiltration practices, it has several design parameters that conflict with this manual. This should be resolved.

2. The section references the Soil Survey of Bucks County, 1975 Edition, which was revised in September 2002. It should be amended to reference the current soil study.

3. Although the Township no longer allows for their use, the ordinance still references several plant species, which have proven to invasive, nuisance species. More specifically, these species are crown vetch, purple loosestrife, and cattails. Section 153-34 should be amended to remove invasive species.

8.2.2. Doylestown Borough

Environmental Protection Ordinances

The Borough does not have any natural resource protection ordinances in place. This is not unusual for an urbanized borough such as Doylestown. Since the majority of the borough has already been developed, there are few if any resource to protect. The preservation of natural watercourses is referenced in the Stormwater Management Ordinance.

Chapter 8, Part 1: "Doylestown Borough Stormwater Management Ordinance"

A stormwater management ordinance was adopted in 1994 following the general guidelines of the model ordinance published in the Neshaminy Creek Watershed Study. The ordinance details the design of stormwater management facilities including infiltration practices, wet ponds or artificial wetlands, and dual purpose detention basins which is common in most current ordinances. Most of the recommended improvements to the Ordinance listed below are relatively minor.

1) Section 110.7 indicates that dry weather flows shall be discharged to a natural watercourse or storm sewer. This type of discharge includes swimming pools, roof drains, sump pumps, etc. Caution should be taken with regard to discharging swimming pools to a natural stream as the chemicals in pool water would significantly impact the stream habitat.

2) Section 110.8.D states that 'Doylestown Borough Council may require an easement to protect an existing watercourse.' It further goes on to define the easement as having a minimum width of twenty (20) feet, but the final width to be determined by the Borough Engineer, US Army Corps of Engineers, PA DEP, or other agency having jurisdiction. This section could be more definitive. Understanding that the Borough is highly developed already, the stream corridor should be protected wherever possible with a minimum width being established from the top of bank rather than a pre-determined quantity.

3) Section 113.4.C. (4) references the Soil Survey of Bucks and Philadelphia Counties (1975 edition). This should be modified to reference the current Soil Study for September 2002.

4) Section 113.4.F. states that "Any areas designed to initially be gravel, crushed stone, porous pavement, etc, shall be assumed to be impervious of the purpose of this Part." Although this position is understandable with regard to gravel and stone areas, it might be a disincentive for the use of porous pavement. Developers may be more inclined to consider using this (more expensive) pavement option if they are allowed some relief with

regard to impervious cover, whether by a specific runoff curve number or a percent reduction.

5) Section 116.10.J. 'Slope of Basin Bottom' allows for a one (1) percent slope for channel flow, which usually means a concrete channel. Water quality and infiltration potential would be increased if the constructed of a permeable material such as rip-rap, grass pavers, cable concrete or other similar products which provide stability but allow for natural vegetation to be established. This section should be modified to require specific channel materials or a channel design, which provides additional water quality benefits.

8.2.3. New Britain Borough

Article 6, Section 608: "Environmental Protection Standards"

The Zoning Ordinance provides for 100% protection of lakes, ponds, watercourses, and wetlands except as permitted through the PA DEP and/or the US Army Corps of Engineers. It does not, however, provide any protection to riparian corridors nor does it establish any buffer zone for streams and watercourses. Similar to Doylestown Borough, these provisions are covered under the Stormwater Management Ordinance.

Chapter 8, Part 1: "Doylestown Borough Stormwater Management Ordinance"

A stormwater management ordinance was adopted in 1993 following the general guidelines of the model ordinance published in the Neshaminy Creek Watershed Study. The ordinance details the design of stormwater management facilities including infiltration practices, wet ponds or artificial wetlands, and dual purpose detention basins which is common in most current ordinances. Most of the recommended improvements to the Ordinance listed below are relatively minor.

1. Section 301.02.C. states that 'Borough Council may require a permanent easement to protect an existing watercourse.' It further goes on to define the easement as having a minimum width of fifty (50) feet, but the final width to be determined by the Borough Engineer, US Army Corps of Engineers, PA DEP, or other agency having jurisdiction. This section could be more definitive. Although the fifty-foot width provides greater protection that the twenty specified by Doylestown Borough, the stream corridor easement should be required rather than a vague possibility. Also, the stream corridor should be established using a minimum width from the top of bank rather than a pre-determined quantity. This would allow for greater protection of the corridor in wider sections of the watercourse.
2. Section 304.05.F states that "Any areas designed to initially be gravel,

crushed stone, porous pavement, etc, but intended to ultimately become impervious, shall be assumed to be impervious of the purpose of this ordinance." Although this position is understandable with regard to gravel and stone areas, it might be a disincentive for the use of porous pavement. Developers may be more inclined to consider using this (more expensive) pavement option if they are allowed some relief with regard to impervious cover, whether by a specific runoff curve number or a percent reduction.

Subdivision and Land Development Ordinance, Section 606
"Stormwater Management and Surface Runoff Control"

This section, although it references the Stormwater Management Ordinance, contains many sections, which should be included in said ordinance such as sub-section D. 'Design Criteria – Detention and Retention Basins.'

Paragraph 9 allows for a one (1) percent slope for channel flow in the bottom of basins, which usually means a concrete channel. Water quality and infiltration potential would be increased if the constructed of a permeable material such as rip-rap, grass pavers, cable concrete or other similar products which provide stability but allow for natural vegetation to be established. This section should be modified to require specific channel materials or a channel design, which provides additional water quality benefits.

9. Comprehensive Watershed Management Plan

By way of this assessment, Cooks Run is considered enriched with nutrients (phosphorus and nitrogen) during both baseflow (normal flow) and stormflow (high flow) conditions. Higher phosphorus and suspend solids (sediment) concentrations during storm events may be attributed to increased rates of streambank erosion plus additional inputs from stormwater runoff. During baseflow conditions, elevated nutrient concentrations downstream of Limekiln Road are largely due to the discharge of treated effluent from the Harvey Avenue wastewater treatment plant (WWTP).

The dissolved oxygen concentrations in the stream were generally considered good and the pH values were near neutral during baseflow and stormflow conditions. Fecal coliform bacteria concentrations during baseflow and stormflow conditions were considered high and very high, respectively. Dramatic concentration increases during storms is likely due to the transportation of animal feces to the stream via stormwater runoff. Sources of animal feces within the watershed are pets and wildlife. Overall, the high bacteria concentrations make the stream unsuitable for primary contact recreation such as swimming.

The most prevalent heavy metals in Cooks Run during the study period were chromium, copper, lead and zinc. These metals are often associated with streams in urbanized watersheds. Overall, metal concentrations increased during stormflow conditions and these concentrations were the highest in the lower section of the watershed (lower subwatershed). The upper and lower subwatersheds are defined as those portions of the Cooks Run watershed above and below the Route 611 Bypass, respectively.

The macroinvertebrate (aquatic organism) data for Cooks Run reflect impairment from organic pollution and/or habitat degradation. The benthic communities can be characterized as having had only moderate numbers of taxa with a predominance of pollution tolerant forms. The sensitive orders Ephemeroptera (mayflies) and Plecoptera (stoneflies) were absent from all samples. Overall, the macroinvertebrate data indicate that the highest levels of impairment occur in the upper portion of the watershed (above the Route 611 Bypass). Somewhat lower levels of impairment were observed in the lower portion of the watershed (below the Route 611 Bypass). Based upon field observations and water quality data, higher levels of impairment in the upper subwatershed are apparently due to loss of aquatic habitats due to stream channel modifications and excessive sedimentation.

Overall, the primary goal of the Cooks Run watershed assessment was to develop a comprehensive management plan to reduce nonpoint source pollutants to Cooks Run, which is a tributary to the Neshaminy Creek. Information and data, as presented in Sections 1 through 8, were used extensively in developing this watershed management plan. Key recommendations of this plan are to restore forested riparian buffers along streams, repair major nonpoint source (NPS) problem areas and retrofit major stormwater management facilities in the upper Cooks Run subwatershed. These key recommendations are summarized in Table 9.1 and discussed in Sections 9.1 through 9.3.

Table 9.1 Recommended Implementation Projects for the Upper Subwatershed

Category	Priority	Identification		Section
Riparian Buffer Restoration Projects	Highest	Segment No.	3-4, 9-10 & 11-12	5.4
	Medium	Segment No.	7-8, 8-9 & 10-11	5.4
	Lowest	Segment No.	4-5	5.4
Nonpoint Source Projects	Highest	NPS No.	1, 2, 4 & 7	6.4
	Medium	NPS No.	3, 5, 12, & 13	6.4
	Lowest	NPS No.	6, 8, 9, 10 & 11	6.4
Stormwater Retrofitting Projects	Strongly Recommended	SWM No.	1, 14 & 16	7.4
	Recommended	SWM No.	2, 3, 6, 6, 12, 13 & 15	7.4
	No Improvements Necessary	SWM No.	4, 5, 9, 10, 11 & 17	7.4

The Bucks County Conservation District and other watershed stakeholders including Doylestown Township, Doylestown Borough and New Britain Borough should assume the responsibility of implementing the watershed best management projects listed in Table 9.1. Many of these recommendations will require a high level of technical expertise; therefore, watershed stakeholders will likely require the professional services of a qualified environmental consultant. Some of the recommendations such as riparian buffer restoration projects should attempt to maximize the use of local volunteers.

Lastly, recommendations for revising municipal ordinances and continuing to monitor stream water quality are discussed in Sections 9.4 and 9.5, respectively. Potential funding sources for implementing all the offered recommendations in comprehensive management plan are presented in Section 9.6.

9.1. Riparian Buffer Restoration Projects

The stream and riparian assessment of the upper subwatershed revealed that all of the poor and marginal stream segments are located south of Route 313 downstream to Broad Street. This portion of the watershed is highly urbanized with residential and commercial land uses. Many of these stream segments have severely modified stream channels, degraded aquatic habitats, and poor riparian buffers. Table 9.1 provides a list of riparian restoration projects that are ranked according to priority for future implementation.

9.2. Nonpoint Source Projects

A total of thirteen major nonpoint source (NPS) watershed problems were identified in the upper subwatershed during this assessment. All of the problem areas involve some degree of streambank erosion. Field reconnaissance revealed that the primary causes of streambank erosion are inadequate forested riparian buffers and to a lesser degree, debris jams within stream channels. Table 9.1 provides a list of priority ranked nonpoint source projects for implementation.

9.3. Stormwater Retrofitting Projects

A total of seventeen major stormwater management facilities were identified in the upper subwatershed. This management plan recommends retrofitting ten of these facilities, which are considered either critical or beneficial to the overall health of the Cooks Run watershed. Table 9.1 provides a list of stormwater retrofitting projects that are ranked according to priority for future implementation.

9.4. Municipal Ordinances

As part of this assessment, current zoning and subdivision land development ordinances and other environmental protection ordinances were reviewed and evaluated for Doylestown Township, Doylestown Borough and New Britain Borough. Where applicable, specific recommendations for revising these ordinances were offered in order to better protect the water quality and aquatic habitat resources of Cooks Run. At this time, it is recommended that Doylestown Township, Doylestown Borough and New Britain Borough consider revising their ordinances based upon the recommendations offered in Section 8.

9.5. Baseline Stream Monitoring Program

Baseline water quality monitoring programs are often implemented after a comprehensive assessment has been completed. Newly acquired data are routinely entered into the existing water quality database and analyzed. The comparison of newly acquired data to past data is commonly referred to as "water quality trend analysis". Water quality trend analysis is an extremely valuable tool in assessing water quality improvements or degradation over time. Hence, water quality trend analysis provides water resource professionals and watershed stakeholders the opportunity to carefully evaluate the overall success of any implemented watershed restoration measures.

Aqua-Link strongly recommends that the water quality and macroinvertebrate monitoring be performed annually and biannually, respectively. Monitoring should be performed at the established stream stations that were used during this assessment. All stream stations should be monitored once again during both baseflow and stormflow conditions. All collected stream samples should be analyzed by a certified laboratory for the same parameters as listed in Section 3.2.1. It is highly recommended that the certified laboratory use the same analytical procedures and detection limits as cited in this report.

9.6. Phase II Watershed Assessment

As discussed in Section 1, the District with the assistance of Aqua-Link prepared the Cooks Run Phase II grant application. This grant application, which was submitted to PA DEP in March 2004, targets the lower section of the watershed. The lower section, the lower subwatershed, is designated as downstream (south) of Route 611 to the confluence of the Neshaminy Creek. The lower section of the watershed primarily lies within Doylestown Township and New Britain Borough. If funded, the Phase II assessment will evaluate major stormwater management (SW) facilities and assess stream and riparian corridors in the lower section of the watershed.

9.7. Sources of Funding

Many of the recommendations offered in the comprehensive management plan are eligible for state or federal funding. State funding may be obtained through the Pennsylvania Department of Environmental Protection's Growing Greener Grant Program.

Federal funding may be obtained through U.S. Environmental Protection Agency's Section 319 (Nonpoint Source) Program and the National Oceanic and Atmospheric Administration's (NOAA) Coastal Zone Management Program.

If funding is not available, the watershed stakeholders are strongly encouraged to implement some of the recommendations using their own financial resources. This type of commitment is viewed highly by the above agencies and can greatly improve the success of receiving state and federal funding in the future.

10. Literature Cited

Alliance for the Chesapeake Bay. 1998. Stream Releaf Forest Buffer Toolkit. Funded by U.S. EPA and PA DEP. Section 319 NPS Program.

American Public Health Association. 1985. Standard Methods for the Examination of Water and Wastewater (16th Edition). American Public Health Association. Washington, DC.

CH2MHill. 1998. Pennsylvania Handbook of Best Management Practices for Developing Areas.

Delaware Riverkeeper. 2001. Stormwater Runoff, Lost Resource or Community Assest? A Guide to Preventing, Capturing and Recovering Stormwater Runoff. Washington Crossing, PA.

Georgia Soil and Water Conservation Commission. Guidelines for Streambank Restoration. Prepared for the U.S. Environmental Protection Agency.

Hammer, M.J. 1986. Water and Wastewater Technology (2nd Edition). John Wiley & Sons, New York.

King, D.M., C.C. Bohlen and M.L. Kraus. April 1994. Stream Restoration: The Costs of Engineering and Bio-Engineered Alternatives. University of Maryland, Center for Environmental and Estuarine Studies. Chesapeake Biological Laboratory, Solomons Island, MD. EPA Agreement No. CR-818277-C1.

North Carolina University. River Course: Natural Stream Processes (Fact Sheet No. 1). North Carolina Stream Restoration Institute.

Pennsylvania Department of Environmental Protection (PA DEP). 1999. Application of the Rapid Bioassessment Protocol multimedia approach to Pennsylvania's Water Quality Network Sites (draft).

Schueler, T.R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's*. Washington Metropolitan Council of Governments. Washington, DC.

Schnier, M. 2003. Riparian Assessment Guide. The Pennsylvania State University.

Shelton, T.B. 1996. Interpreting DrinkingWater Quality Analysis: What Do the Numbers Mean? 5th Edition. Publication No. E214. Rutgers University. New Brunswick, N.J.

United States Department of Agriculture, Natural Resources and Conservation Service. 2002. Soils Survey of Bucks County, PA.

United States Department of Agriculture, Natural Resources and Conservation Service. 1996. Engineering Field Handbook – Chapter 16: Streambank and Shoreline Protection.

Weber, Cornelius I. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-600/4-73-001.

APPENDIX A

Summary of GIS & GPS Data

Cooks Run Watershed Analysis GIS Data Layers

Prepared by:

Aqua-Link, Inc. & Heritage Conservancy

---

1. Streams from ERRI, 1998
2. Municipalities from Penn DOT, 2003
3. USGS Digital Raster Graphics: Doylestown and Buckingham Quadrangles
4. Stream Monitoring Stations: Aqua-Link, Inc. 2004
5. Orthophotos From DVRPC 2000 Orthophotos: X30-32, Y100-104
6. Soil from USDA NRCS, 1996 Soil Survey of Bucks County
7. Land Cover from USGS Land Cover Data Set, 1993
8. Stream and Riparian Conditions: Aqua-Link, Inc., 2004
9. NPS Problems from Aqua-Link, Inc., 2004
10. Stormwater Management Facilities: Gilmore & Associates, Inc., 2003

Cooks Run Watershed Assessment **Prepared by Aqua-Link, Inc.**
Project 1005-05

Stream & Riparian Visual Assessment - GPS Data

Stream Node	Latitude	Longitude	Date & Time	Stream Segment	Digital Photographs Upstream	Downstream
1	40.32652413	75.12542626	4/16/2004 9:42	1-2	336	337
2	40.32601275	75.12580932	4/16/2004 10:08	2-3	339	340
3	40.32365534	75.12773699	4/16/2004 10:20	3-4	342	343
4	40.32301815	75.12841642	4/16/2004 10:36	4-5	344	346
5	40.32282813	75.12953298	4/16/2004 11:34	5-6		
6	40.32245371	75.13000018	4/16/2004 12:10	6-7		347 348
7	40.32258975	75.13053637	4/16/2004 12:26	7-8	349	
8	40.32280298	75.13133794	4/16/2004 12:40	8-9	352	
9	40.32307799	75.13198552	4/16/2004 13:15	9-10	356	
10	40.32336675	75.13266068	4/16/2004 13:37	10-11	363	364
11	40.32141586	75.13429129	4/20/2004 11:04	11-12	371	372
12	40.31991693	75.1352454	4/20/2004 11:43	12-13	380	383
13	40.31776237	75.13742897	4/20/2004 12:42	13-14	390	391
14	40.31656643	75.13812249	4/20/2004 13:53	14-15	398	392
15	40.31269365	75.14450137	4/20/2004 15:20	15-16	421	423 425
16	40.30900537	75.14914412	4/25/2004 10:56			

Cooks Run Watershed Assessment
Project 1005-05

Prepared by Aqua-Link, Inc.

Watershed Problems - GPS Data

Problem	Latitude	Longitude	Date & Time	Digital Photographs
P1	40.3233396	75.1281881	4/16/2004 11:24	342 343
P2	40.3229959	75.1290643	4/16/2004 11:28	345
P3	40.3217946	75.1339370	4/20/2004 10:49	362
P4	40.3196327	75.1353144	4/20/2004 11:54	376 377
P5	40.3170922	75.1377399	4/20/2004 13:41	388 389
P6	40.3145143	75.1412679	4/20/2004 14:36	400
P7	40.3126387	75.1443487	4/20/2004 15:15	406
P08	40.31197985	75.1451488	4/25/2004 9:39	420
P09	40.30935187	75.14858068	4/25/2004 10:30	429
P10	40.3205907	75.1231449	4/27/2004 14:38	434 435
P11	40.3220289	75.1253811	4/27/2004 14:56	439
P12	40.3224903	75.1276212	4/27/2004 15:12	442 441
P13	40.3229381	75.1283520	4/27/2004 15:07	440

1005-05 Cooks Run Watershed Assessment

Summarized by: Aqua-Link, Inc.
Data Acquired by: Gilmore & Associates, Inc.

Stormwater Management Facilities:
GPS Coordinates (State Plane Coordinates)

Code	I.D.	Basin Location	Northing	Easting
SWM	1	Doylestown Hospital	365,107.85	2,694,214.02
SWM	2	Lenape Valley Foundation	366,653.58	2,694,023.21
SWM	3	Westwyck	367,284.24	2,695,325.00
SWM	4	Doyle Elementary	366,119.83	2,695,759.92
SWM	5	Lenape Middle School	365,861.51	2,695,892.66
SWM	6	Doylestown Commons 1	368,762.92	2,695,085.76
SWM	7	Doylestown Commons 2	368,917.57	2,695,085.04
SWM	8	Bucks County I.U. #22	369,743.21	2,695,693.10
SWM	9	Georgetown Commons 1	369,941.47	2,695,710.86
SWM	10	Central Bucks Senior Citizens	368,748.52	2,694,992.78
SWM	11	Shady Retreat Dr.	370,448.36	2,695,862.46
SWM	12	Lantern Hill	370,229.32	2,697,480.66
SWM	13	Heritage Towers	370,345.16	2,697,618.59
SWM	14	Mercer Square, front	371,465.23	2,698,323.38
SWM	15	Mercer Square, rear	372,146.98	2,698,400.67
SWM	16	Harvey Avenue WWTP	368,362.01	2,696,123.84
SWM	17	Heritage Conservancy	371,891.46	2,697,880.30

Cooks Run Watershed Assessment
Project 1005-05

Prepared by Aqua-Link, Inc.

Stream Discharge Point GPS Data

Discharge	Latitude	Longitude	Date & Time	Digital Photographs
D01	40.3264847	75.1254273	4/16/2004 9:48	335
D02	40.3260560	75.1256838	4/16/2004 10:04	338
D03	40.3225755	75.13054467	4/27/2004 13:57	432
D04	40.32251473	75.13053017	4/27/2004 14:01	433
D05	40.3224862	75.1309124	4/16/2004 12:47	350
D06	40.3230500	75.1310488	4/16/2004 12:53	351
D07	40.3227507	75.1315186	4/16/2004 13:20	353
D08	40.3229710	75.1314572	4/16/2004 13:29	354
D09	40.3231617	75.1318730	4/16/2004 13:33	355
D10	40.3233546	75.1323325	4/16/2004 13:46	357
D11	40.3235453	75.1326679	4/16/2004 13:48	358
D12	40.3232539	75.1328901	4/20/2004 10:27	359
D13	40.3232062	75.1328558	4/20/2004 10:31	360
D14	40.3218454	75.1339601	4/20/2004 10:45	361
D15	40.3212241	75.1344675	4/20/2004 10:58	365
D16	40.3210313	75.1343481	4/20/2004 11:14	366
D17	40.3209797	75.1345490	4/20/2004 11:17	367
D18	40.3208257	75.1344192	4/20/2004 11:19	368
D19	40.3210575	75.1347367	4/20/2004 11:23	369
D20	40.3205070	75.1348720	4/20/2004 11:28	370
D21	40.3203970	75.1349513	4/20/2004 11:30	373
D22	40.3202567	75.1350414	4/20/2004 11:35	374
D23	40.3197594	75.1351783	4/20/2004 11:50	375
D24	40.3194765	75.1355717	4/20/2004 11:58	378
D25	40.3194045	75.1356740	4/20/2004 12:06	379
D26	40.3191703	75.1359505	4/20/2004 12:16	381
D27	40.3187296	75.1362206	4/20/2004 12:21	382
D28	40.3182378	75.1367089	4/20/2004 12:26	384
D29	40.3183022	75.1369695	4/20/2004 12:30	385
D30	40.3176438	75.1374537	4/20/2004 13:18	386
D31	40.3176131	75.1374842	4/20/2004 13:20	387
D32	40.3153991	75.1387138	4/20/2004 14:02	393
D33	40.3153244	75.1390704	4/20/2004 14:05	394
D34	40.3150475	75.1391888		395
D35	40.3150042	75.1402827	4/20/2004 14:17	397
D36	40.3145899	75.1411679	4/20/2004 14:33	399
D37	40.3132352	75.1425613	4/20/2004 14:52	401
D38	40.3127844	75.1428159	4/20/2004 14:57	402
D39	40.3126078	75.1431553	4/20/2004 15:00	403
D40	40.3124981	75.1432417	4/20/2004 15:03	404
D41	40.3125355	75.1442194	4/20/2004 15:10	405
D42	40.3127506	75.1445388	4/20/2004 15:13	407
D43	40.31027204	75.14802002	4/25/2004 10:03	426
D44	40.31020825	75.14804349	4/25/2004 10:08	427
D45	40.30950719	75.14850977	4/25/2004 10:17	428
D46	40.30918616	75.14858932	4/25/2004 10:35	430
D47	40.30913855	75.14836862	4/25/2004 10:39	431

APPENDIX B

Summary of Soils and Land Use Data

1005-05 Cooks Run Watershed Project **Prepared by Aqua-Link, Inc.**

Soils Data Summary: Reduced & Sorted

Soil Series	Hydric Group	Hydric	Acres	Percent
URBAN LAND-LANSDALE COMPLEX		N	489.6	23.1
URBAN LAND		N	434.9	20.6
URBAN LAND-LAWRENCEVILLE COMPLEX		N	205.8	9.7
URBAN LAND-ABBOTTSTOWN COMPLEX	C	N	200.7	9.5
LANSDALE	B	N	198.7	9.4
URBAN LAND-UDORTHENTS, SHALE AND SANDSTONE COMPLEX	B/D	N	99.9	4.7
KNAUERS		Y	96.0	4.5
DOYLESTOWN	D	Y	88.8	4.2
BUCKINGHAM	C	N	61.3	2.9
LAWRENCEVILLE	C	N	57.7	2.7
ABBOTTSTOWN	C	N	46.3	2.2
READINGTON	C	N	37.5	1.8
URBAN LAND-PENN COMPLEX	C	N	21.3	1.0
BEDINGTON	B	N	19.4	0.9
URBAN LAND-DOYLESTOWN COMPLEX		N	18.1	0.9
DUNCANNON	B	N	12.0	0.6
FOUNTAINVILLE	C	N	10.2	0.5
CHALFONT	C	N	6.2	0.3
WEIKERT-CULLEOKA COMPLEX	B/D	N	5.8	0.3
PENN	C	N	3.1	0.1
UDORTHENTS	B/D	N	2.6	0.1
WATER		U	2.8	2.8
	Total w/ water		**2,118.5**	
	Total w/o water		**2,115.7**	**100.0**
	Count w/o water		**21**	

Soils Data: Full Data Set

Soil I.D.	Soil Series		Hydric Group	Hydric	Acres
017AbA	ABBOTTSTOWN	ABBOTTSTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	0.72
017AbA	ABBOTTSTOWN	ABBOTTSTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	10.10
017AbA	ABBOTTSTOWN	ABBOTTSTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	31.10
017AbA	ABBOTTSTOWN	ABBOTTSTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	4.34
017BeB	BEDINGTON	BEDINGTON CHANNERY SILT LOAM, 3 TO 8 PERCENT SLOPES	B	N	14.21
017BeC	BEDINGTON	BEDINGTON CHANNERY SILT LOAM, 8 TO 15 PERCENT SLOPES	B	N	5.22
017Bo	KNAUERS	BOWMANSVILLE-KNAUERS SILT LOAMS		Y	20.55
017Bo	KNAUERS	BOWMANSVILLE-KNAUERS SILT LOAMS		Y	63.72
017Bo	KNAUERS	BOWMANSVILLE-KNAUERS SILT LOAMS		Y	11.72
017BwB	BUCKINGHAM	BUCKINGHAM SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	29.17
017BwB	BUCKINGHAM	BUCKINGHAM SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	9.56
017BwB	BUCKINGHAM	BUCKINGHAM SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	12.54
017BwB	BUCKINGHAM	BUCKINGHAM SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	9.54
017BwB	BUCKINGHAM	BUCKINGHAM SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	0.48
017CbA	CHALFONT	CHALFONT SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	0.18
017CbA	CHALFONT	CHALFONT SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	6.03
017DdA	DOYLESTOWN	DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	D	Y	4.73
017DdA	DOYLESTOWN	DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	D	Y	4.72
017DdA	DOYLESTOWN	DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	D	Y	4.28
017DdA	DOYLESTOWN	DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	D	Y	5.45
017DdA	DOYLESTOWN	DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	D	Y	45.14
017DdB	DOYLESTOWN	DOYLESTOWN SILT LOAM, 3 TO 8 PERCENT SLOPES	D	Y	10.22
017DdB	DOYLESTOWN	DOYLESTOWN SILT LOAM, 3 TO 8 PERCENT SLOPES	D	Y	4.31
017DdB	DOYLESTOWN	DOYLESTOWN SILT LOAM, 3 TO 8 PERCENT SLOPES	D	Y	3.55
017DdB	DOYLESTOWN	DOYLESTOWN SILT LOAM, 3 TO 8 PERCENT SLOPES	D	Y	6.38
017DuA	DUNCANNON	DUNCANNON SILT LOAM, 0 TO 3 PERCENT SLOPES	B	N	8.25
017DuB	DUNCANNON	DUNCANNON SILT LOAM, 3 TO 8 PERCENT SLOPES	B	N	3.74
017FoA	FOUNTAINVILLE	FOUNTAINVILLE SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	3.43
017FoB	FOUNTAINVILLE	FOUNTAINVILLE SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	6.76
017LgA	LANSDALE	LANSDALE LOAM, 0 TO 3 PERCENT SLOPES	B	N	6.63
017LgA	LANSDALE	LANSDALE LOAM, 0 TO 3 PERCENT SLOPES	B	N	6.01
017LgA	LANSDALE	LANSDALE LOAM, 0 TO 3 PERCENT SLOPES	B	N	7.73
017LgA	LANSDALE	LANSDALE LOAM, 0 TO 3 PERCENT SLOPES	B	N	4.71
017LgA	LANSDALE	LANSDALE LOAM, 0 TO 3 PERCENT SLOPES	B	N	4.34
017LgA	LANSDALE	LANSDALE LOAM, 0 TO 3 PERCENT SLOPES	B	N	7.49
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	11.88

Soils Data: Full Data Set

Soil I.D.	Soil Series		Hydric Group	Hydric	Acres
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	51.19
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	10.36
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	12.19
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	8.71
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	3.50
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	13.51
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	7.62
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	6.73
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	5.65
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	8.33
017LgB	LANSDALE	LANSDALE LOAM, 3 TO 8 PERCENT SLOPES	B	N	3.57
017LgC	LANSDALE	LANSDALE LOAM, 8 TO 15 PERCENT SLOPES	B	N	4.49
017LgC	LANSDALE	LANSDALE LOAM, 8 TO 15 PERCENT SLOPES	B	N	3.71
017LgC	LANSDALE	LANSDALE LOAM, 8 TO 15 PERCENT SLOPES	B	N	5.88
017LgC	LANSDALE	LANSDALE LOAM, 8 TO 15 PERCENT SLOPES	B	N	4.49
017LkA	LAWRENCEVILLE	LAWRENCEVILLE SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	11.90
017LkA	LAWRENCEVILLE	LAWRENCEVILLE SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	4.86
017LkA	LAWRENCEVILLE	LAWRENCEVILLE SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	3.76
017LkA	LAWRENCEVILLE	LAWRENCEVILLE SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	13.98
017LkA	LAWRENCEVILLE	LAWRENCEVILLE SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	3.23
017LkB	LAWRENCEVILLE	LAWRENCEVILLE SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	7.52
017LkB	LAWRENCEVILLE	LAWRENCEVILLE SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	12.41
017PeB	PENN	PENN CHANNERY SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	2.79
017PnC	PENN	PENN-LANSDALE COMPLEX, 8 TO 15 PERCENT SLOPES	C	N	0.34
017ReA	READINGTON	READINGTON SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	10.88
017ReA	READINGTON	READINGTON SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	0.06
017ReA	READINGTON	READINGTON SILT LOAM, 0 TO 3 PERCENT SLOPES	C	N	6.68
017ReB	READINGTON	READINGTON SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	8.13
017ReB	READINGTON	READINGTON SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	8.31
017ReB	READINGTON	READINGTON SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	3.46
017ReB	READINGTON	READINGTON SILT LOAM, 3 TO 8 PERCENT SLOPES	C	N	0.01
017UdB	UDORTHENTS	UDORTHENTS, SHALE AND SANDSTONE	B/D	N	2.56
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	122.09
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	11.95
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	157.65
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	4.99

Soils Data: Full Data Set

Soil I.D.	Soil Series		Hydric Group	Hydric	Acres
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	4.36
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	25.79
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	17.87
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	9.87
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	19.17
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	11.31
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	17.42
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	2.22
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	4.99
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	17.64
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	0.39
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	0.04
017UfuB	URBAN LAND	URBAN LAND, 0 TO 8 PERCENT SLOPES		N	7.12
017UgB	URBAN LAND	URBAN LAND-ABBOTTSTOWN COMPLEX, 0 TO 8 PERCENT SLOPES	C	N	21.30
017UgB	URBAN LAND	URBAN LAND-ABBOTTSTOWN COMPLEX, 0 TO 8 PERCENT SLOPES	C	N	8.26
017UgB	URBAN LAND	URBAN LAND-ABBOTTSTOWN COMPLEX, 0 TO 8 PERCENT SLOPES	C	N	25.65
017UgB	URBAN LAND	URBAN LAND-ABBOTTSTOWN COMPLEX, 0 TO 8 PERCENT SLOPES	C	N	54.82
017UgB	URBAN LAND	URBAN LAND-ABBOTTSTOWN COMPLEX, 0 TO 8 PERCENT SLOPES	C	N	90.70
017UmB	URBAN LAND	URBAN LAND-DOYLESTOWN COMPLEX, 0 TO 8 PERCENT SLOPES		N	18.07
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	66.58
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	15.23
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	29.79
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	1.45
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	3.51
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	25.04
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	99.35
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	21.79
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	68.09
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	92.32
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	0.69
017UrB	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 0 TO 8 PERCENT SLOPES		N	7.81
017UrC	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 8 TO 15 PERCENT SLOPES		N	27.23
017UrC	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 8 TO 15 PERCENT SLOPES		N	11.60
017UrC	URBAN LAND	URBAN LAND-LANSDALE COMPLEX, 8 TO 15 PERCENT SLOPES		N	19.08
017UsB	URBAN LAND	URBAN LAND-LAWRENCEVILLE COMPLEX, 0 TO 8 PERCENT SLOPES		N	28.28
017UsB	URBAN LAND	URBAN LAND-LAWRENCEVILLE COMPLEX, 0 TO 8 PERCENT SLOPES		N	21.94

Soils Data: Full Data Set

Soil I.D.	Soil Series		Hydric Group	Hydric	Acres
017UsB	URBAN LAND	URBAN LAND-LAWRENCEVILLE COMPLEX, 0 TO 8 PERCENT SLOPES		N	48.14
017UsB	URBAN LAND	URBAN LAND-LAWRENCEVILLE COMPLEX, 0 TO 8 PERCENT SLOPES		N	54.18
017UsB	URBAN LAND	URBAN LAND-LAWRENCEVILLE COMPLEX, 0 TO 8 PERCENT SLOPES		N	53.26
017UxD	PENN	URBAN LAND-PENN COMPLEX, 8 TO 25 PERCENT SLOPES	C	N	21.32
017UzcB	UDORTHENTS	URBAN LAND-UDORTHENTS, SHALE AND SANDSTONE COMPLEX, 0 TO 8	B/D	N	99.90
017W	WATER	WATER		U	0.05
017W	WATER	WATER		U	1.06
017W	WATER	WATER		U	1.10
017W	WATER	WATER		U	0.61
017WfD	WEIKERT	WEIKERT-CULLEOKA COMPLEX, 15 TO 25 PERCENT SLOPES	B/D	N	5.77
			Total (acres)		2,118.50

Land Use Data:

Land Use	Area (acres)	Percent (%)
Open Water	5.03	0.2
Low Intensity Residential	692.52	32.7
High Intensity Residential	157.78	7.5
Commercial/Industrial/Transportation	150.56	7.1
Quarries/Strip Mines/Gravel Pits	1.56	0.1
Transitional	60.61	2.9
Deciduous Forest	421.64	19.9
Evergreen Forest	22.33	1.1
Mixed Forest	129.73	6.1
Pasture/Hay	383.91	18.1
Row Crops	70.92	3.3
Emergent Herbaceous Wetlands	21.07	1.0
Total w/ water	**2,117.66**	**100.0**
Total w/o water	**2,112.63**	

APPENDIX C

Stream Water Quality Data

Cooks Run Watershed Assessment
ALI Project No. 1005-05

Prepared by Aqua-Link, Inc.

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime	Temp. (degrees C)	D.O. (mg/l)	pH (s.u.)	Cond. (uS/cm)	Sp. Cond. (uS/cm)	Alkalinity (mg/l)	Hardness (mg/l)	DRP (mg/l as P)	TP (mg/l as P)
CR4	7/3/2003	Baseflow	19.0	4.62	6.80	494	558	85.4	150.0	0.055	0.094
CR4	10/31/2003	Baseflow	10.4	8.40	6.88	308	427	80.8	120.0	0.025	0.040
CR3	7/3/2003	Baseflow	21.7	7.32	7.11	700	746	91.2	180.0	0.378	0.416
CR3	10/31/2003	Baseflow	11.5	9.67	7.37	380	511	93.9	150.0	0.114	0.173
CR2	7/3/2003	Baseflow	21.3	8.96	7.31	663	681	84.4	170.0	0.242	0.255
CR2	10/31/2003	Baseflow	10.8	10.69	7.47	331	454	80.8	130.0	0.102	0.108
CR1	7/3/2003	Baseflow	21.4	9.22	7.29	592	636	83.4	160.0	0.260	0.277
CR1	10/31/2003	Baseflow	10.6	10.73	7.28	317	438	80.8	130.0	0.106	0.103
CR4	6/4/2003	Stormflow	13.0	11.24	7.50	96	124	23.3	26.0	0.063	0.215
CR4	10/27/2003	Stormflow	16.5	9.57	6.93	49	58	11.1	18.0	0.059	0.168
CR3	6/4/2003	Stormflow	12.9	11.19	7.60	134	174	34.9	36.0	0.061	0.278
CR3	10/27/2003	Stormflow	16.2	9.32	6.99	84	101	24.2	31.0	0.098	0.303
CR2	6/4/2003	Stormflow	13.0	11.76	7.40	153	199	36.9	40.0	0.089	0.360
CR2	10/27/2003	Stormflow	15.8	9.50	6.98	90	110	25.2	34.0	0.140	0.420
CR1	6/4/2003	Stormflow	13.0	11.70	7.40	146	190	36.9	43.0	0.096	0.413
CR1	10/27/2003	Stormflow	15.8	9.85	6.96	102	124	29.3	42.0	0.165	0.523

Cooks Run Watershed Assessment
ALI Project No. 1005-05

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime		Ammonia (mg/l as N)	Nitrate-Nitrite (mg/l as N)	TKN (mg/l as N)	TN* (mg/l as N)	TSS (mg/l)		FC Bacteria (col./100 ml)		O&G (mg/l)		Chloride (mg/l)		Ag (mg/l)
CR4	7/3/2003	Baseflow	b	0.050	1.340	0.93	2.27	3.0		520	b	5.00		96.4	b	0.0020
CR4	10/31/2003	Baseflow		0.190	1.130	0.36	1.49	2.0		90	b	5.00		67.1	b	0.0020
CR3	7/3/2003	Baseflow	b	0.050	3.900	1.13	5.03	11.0		470	b	5.00		123.0	b	0.0020
CR3	10/31/2003	Baseflow		0.120	2.680	0.45	3.13	3.3		50	b	5.00		73.4	b	0.0020
CR2	7/3/2003	Baseflow	b	0.050	3.620	0.99	4.61	4.0		360	b	5.00		124.0	b	0.0020
CR2	10/31/2003	Baseflow	b	0.050	2.820	0.56	3.38	2.0		40	b	5.00		69.5	b	0.0020
CR1	7/3/2003	Baseflow	b	0.050	3.490	0.91	4.40	8.0		530	b	5.00		111.0	b	0.0020
CR1	10/31/2003	Baseflow		0.120	2.790	0.56	3.35	3.0		100	b	5.00		61.3	b	0.0020
CR4	6/4/2003	Stormflow		0.110	0.350	1.02	1.37	53.0	>	600	b	5.00		6.0	b	0.0020
CR4	10/27/2003	Stormflow		0.110	0.120	0.90	1.02	70.0		4700	b	5.00	b	5.0	b	0.0020
CR3	6/4/2003	Stormflow		0.130	0.650	1.16	1.81	56.0	>	600	b	5.00		10.7	b	0.0020
CR3	10/27/2003	Stormflow		0.100	0.280	1.22	1.50	114.0		5600	b	5.00		7.0	b	0.0020
CR2	6/4/2003	Stormflow		0.130	0.620	1.24	1.86	101.0	>	600	b	5.00		18.8	b	0.0020
CR2	10/27/2003	Stormflow		0.110	0.290	1.97	2.26	198.0		3400	b	5.00		9.3	b	0.0020
CR1	6/4/2003	Stormflow		0.130	0.620	1.62	2.24	125.0	>	600	b	5.00		18.0	b	0.0020
CR1	10/27/2003	Stormflow		0.100	0.360	0.89	1.25	232.0		4200	b	5.00		10.9	b	0.0020

Cooks Run Watershed Assessment
ALI Project No. 1005-05

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime		As (mg/l)		Be (mg/l)		Cd (mg/l)		Cr (mg/l)		Cu (mg/l)		Ni (mg/l)		Pb (mg/l)		Sb (mg/l)		Se (mg/l)		Tl (mg/l)
CR4	7/3/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050	b	0.0030	b	0.0100	b	0.0050	b	0.0200	b	0.0050	b	0.0100
CR4	10/31/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050	b	0.0030	b	0.0100	b	0.0050	b	0.0200	b	0.0050	b	0.0100
CR3	7/3/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050		0.0222	b	0.0100	b	0.0050	b	0.0200	b	0.0050	b	0.0100
CR3	10/31/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040		0.0059		0.0102	b	0.0100	b	0.0050	b	0.0200	b	0.0050	b	0.0100
CR2	7/3/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050		0.0102	b	0.0100	b	0.0050	b	0.0200		0.0069	b	0.0100
CR2	10/31/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050		0.0057	b	0.0100	b	0.0050	b	0.0200	b	0.0050	b	0.0100
CR1	7/3/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050		0.0084	b	0.0100	b	0.0050	b	0.0200		0.0070	b	0.0100
CR1	10/31/2003	Baseflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050		0.0055	b	0.0100	b	0.0050	b	0.0200	b	0.0050	b	0.0100
CR4	6/4/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050		0.0053	b	0.0100	b	0.0050	b	0.0200	b	0.0050	b	0.0100
CR4	10/27/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040		0.0062		0.0088	b	0.0100		0.0110	b	0.0200	b	0.0050	b	0.0100
CR3	6/4/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040	b	0.0050		0.0071	b	0.0100		0.0051	b	0.0200	b	0.0050	b	0.0100
CR3	10/27/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040		0.0082		0.0180	b	0.0100		0.0151	b	0.0200	b	0.0050	b	0.0100
CR2	6/4/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040		0.0056		0.0100	b	0.0100		0.0060	b	0.0200	b	0.0050	b	0.0100
CR2	10/27/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040		0.0105		0.0194	b	0.0100		0.0184	b	0.0200	b	0.0050	b	0.0100
CR1	6/4/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040		0.0063		0.0125	b	0.0100		0.0101	b	0.0200	b	0.0050	b	0.0100
CR1	10/27/2003	Stormflow	b	0.0080	b	0.0020	b	0.0040		0.0115		0.0318	b	0.0100		0.0186	b	0.0200	b	0.0050	b	0.0100

Cooks Run Watershed Assessment
ALI Project No. 1005-05

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime		Zn (mg/l)		Hg (mg/l)
CR4	7/3/2003	Baseflow	b	0.0050	b	0.0002
CR4	10/31/2003	Baseflow	b	0.0050	b	0.0002
CR3	7/3/2003	Baseflow		0.0258	b	0.0002
CR3	10/31/2003	Baseflow		0.0164	b	0.0002
CR2	7/3/2003	Baseflow		0.0099	b	0.0002
CR2	10/31/2003	Baseflow		0.0098	b	0.0002
CR1	7/3/2003	Baseflow		0.0061	b	0.0002
CR1	10/31/2003	Baseflow		0.0067	b	0.0002
CR4	6/4/2003	Stormflow		0.0161	b	0.0002
CR4	10/27/2003	Stormflow		0.0371	b	0.0020
CR3	6/4/2003	Stormflow		0.0237	b	0.0002
CR3	10/27/2003	Stormflow		0.0470	b	0.0020
CR2	6/4/2003	Stormflow		0.0284	b	0.0002
CR2	10/27/2003	Stormflow		0.0545	b	0.0020
CR1	6/4/2003	Stormflow		0.0377	b	0.0002
CR1	10/27/2003	Stormflow		0.0925	b	0.0020

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime	Temp. (degrees C)	D.O. (mg/l)	pH (s.u.)	Cond. (uS/cm)	Sp. Cond. (uS/cm)	Alkalinity (mg/l)	Hardness (mg/l)	DRP (mg/l as P)	TP (mg/l as P)
CR4	Baseflow	Mean	14.7	6.51	6.84	401	493	83.1	135.0	0.040	0.067
CR3	Baseflow	Mean	16.6	8.50	7.24	540	629	92.6	165.0	0.246	0.295
CR2	Baseflow	Mean	16.1	9.83	7.39	497	568	82.6	150.0	0.172	0.182
CR1	Baseflow	Mean	16.0	9.98	7.29	455	537	82.1	145.0	0.183	0.190
CR4	Stormflow	Mean	14.8	10.41	7.22	73	91	17.2	22.0	0.061	0.192
CR3	Stormflow	Mean	14.6	10.26	7.30	109	138	29.6	33.5	0.080	0.291
CR2	Stormflow	Mean	14.4	10.63	7.19	122	155	31.1	37.0	0.115	0.390
CR1	Stormflow	Mean	14.4	10.78	7.18	124	157	33.1	42.5	0.131	0.468
CR4	Baseflow	Mean	14.7	6.51	6.84	401	493	83.1	135.0	0.040	0.067
CR4	Stormflow	Mean	14.8	10.41	7.22	73	91	17.2	22.0	0.061	0.192
		Difference	0.1	3.90	0.38	-329	-402	-65.9	-113.0	0.021	0.125
CR3	Baseflow	Mean	16.6	8.50	7.24	540	629	92.6	165.0	0.246	0.295
CR3	Stormflow	Mean	14.6	10.26	7.30	109	138	29.6	33.5	0.080	0.291
		Difference	-2.1	1.76	0.05	-431	-491	-63.0	-131.5	-0.167	-0.004
CR2	Baseflow	Mean	16.1	9.83	7.39	497	568	82.6	150.0	0.172	0.182
CR2	Stormflow	Mean	14.4	10.63	7.19	122	155	31.1	37.0	0.115	0.390
		Difference	-1.7	0.81	-0.20	-376	-413	-51.6	-113.0	-0.058	0.209
CR1	Baseflow	Mean	16.0	9.98	7.29	455	537	82.1	145.0	0.183	0.190
CR1	Stormflow	Mean	14.4	10.78	7.18	124	157	33.1	42.5	0.131	0.468
		Difference	-1.6	0.80	-0.11	-331	-380	-49.0	-102.5	-0.053	0.278

Cooks Run Watershed Assessment
ALI Project No. 1005-05

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime	Ammonia (mg/l as N)	Nitrate-Nitrite (mg/l as N)	TKN (mg/l as N)	TN* (mg/l as N)		TSS (mg/l)	FC Bacteria (col./100 ml)	O&G (mg/l)	Chloride (mg/l)	Ag (mg/l)
CR4	Baseflow	Mean	0.120	1.235	0.65	1.88		2.5	305	5.00	81.8	0.0020
CR3	Baseflow	Mean	0.085	3.290	0.79	4.08		7.2	260	5.00	98.2	0.0020
CR2	Baseflow	Mean	0.050	3.220	0.78	4.00		3.0	200	5.00	96.8	0.0020
CR1	Baseflow	Mean	0.085	3.140	0.74	3.88		5.5	315	5.00	86.2	0.0020
CR4	Stormflow	Mean	0.110	0.235	0.96	1.20		61.5	2650	5.00	5.5	0.0020
CR3	Stormflow	Mean	0.115	0.465	1.19	1.66		85.0	3100	5.00	8.9	0.0020
CR2	Stormflow	Mean	0.120	0.455	1.61	2.06		149.5	2000	5.00	14.1	0.0020
CR1	Stormflow	Mean	0.115	0.490	1.26	1.75		178.5	2400	5.00	14.5	0.0020
CR4	Baseflow	Mean	0.120	1.235	0.65	1.88	#	2.5	305	5.00	81.8	0.0020
CR4	Stormflow	Mean	0.110	0.235	0.96	1.20	#	61.5	2650	5.00	5.5	0.0020
		Difference	-0.010	-1.000	0.32	-0.69	#	59.0	2345	0.00	-76.3	0.0000
CR3	Baseflow	Mean	0.085	3.290	0.79	4.08	#	7.2	260	5.00	98.2	0.0020
CR3	Stormflow	Mean	0.115	0.465	1.19	1.66	#	85.0	3100	5.00	8.9	0.0020
		Difference	0.030	-2.825	0.40	-2.43	#	77.9	2840	0.00	-89.4	0.0000
CR2	Baseflow	Mean	0.050	3.220	0.78	4.00	#	3.0	200	5.00	96.8	0.0020
CR2	Stormflow	Mean	0.120	0.455	1.61	2.06	#	149.5	2000	5.00	14.1	0.0020
		Difference	0.070	-2.765	0.83	-1.94	#	146.5	1800	0.00	-82.7	0.0000
CR1	Baseflow	Mean	0.085	3.140	0.74	3.88	#	5.5	315	5.00	86.2	0.0020
CR1	Stormflow	Mean	0.115	0.490	1.26	1.75	#	178.5	2400	5.00	14.5	0.0020
		Difference	0.030	-2.650	0.52	-2.13	#	173.0	2085	0.00	-71.7	0.0000

Cooks Run Watershed Assessment
ALI Project No. 1005-05

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime	As (mg/l)	Be (mg/l)	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Sb (mg/l)	Se (mg/l)	Tl (mg/l)
CR4	Baseflow	Mean	0.0080	0.0020	0.0040	0.0050	0.0030	0.0100	0.0050	0.0200	0.0050	0.0100
CR3	Baseflow	Mean	0.0080	0.0020	0.0040	0.0055	0.0162	0.0100	0.0050	0.0200	0.0050	0.0100
CR2	Baseflow	Mean	0.0080	0.0020	0.0040	0.0050	0.0080	0.0100	0.0050	0.0200	0.0060	0.0100
CR1	Baseflow	Mean	0.0080	0.0020	0.0040	0.0050	0.0070	0.0100	0.0050	0.0200	0.0060	0.0100
CR4	Stormflow	Mean	0.0080	0.0020	0.0040	0.0056	0.0071	0.0100	0.0080	0.0200	0.0050	0.0100
CR3	Stormflow	Mean	0.0080	0.0020	0.0040	0.0066	0.0126	0.0100	0.0101	0.0200	0.0050	0.0100
CR2	Stormflow	Mean	0.0080	0.0020	0.0040	0.0081	0.0147	0.0100	0.0122	0.0200	0.0050	0.0100
CR1	Stormflow	Mean	0.0080	0.0020	0.0040	0.0089	0.0222	0.0100	0.0144	0.0200	0.0050	0.0100
CR4	Baseflow	Mean	0.0080	0.0020	0.0040	0.0050	0.0030	0.0100	0.0050	0.0200	0.0050	0.0100
CR4	Stormflow	Mean	0.0080	0.0020	0.0040	0.0056	0.0071	0.0100	0.0080	0.0200	0.0050	0.0100
		Difference	0.0000	0.0000	0.0000	0.0006	0.0041	0.0000	0.0030	0.0000	0.0000	0.0000
CR3	Baseflow	Mean	0.0080	0.0020	0.0040	0.0055	0.0162	0.0100	0.0050	0.0200	0.0050	0.0100
CR3	Stormflow	Mean	0.0080	0.0020	0.0040	0.0066	0.0126	0.0100	0.0101	0.0200	0.0050	0.0100
		Difference	0.0000	0.0000	0.0000	0.0012	-0.0037	0.0000	0.0051	0.0000	0.0000	0.0000
CR2	Baseflow	Mean	0.0080	0.0020	0.0040	0.0050	0.0080	0.0100	0.0050	0.0200	0.0060	0.0100
CR2	Stormflow	Mean	0.0080	0.0020	0.0040	0.0081	0.0147	0.0100	0.0122	0.0200	0.0050	0.0100
		Difference	0.0000	0.0000	0.0000	0.0031	0.0068	0.0000	0.0072	0.0000	-0.0010	0.0000
CR1	Baseflow	Mean	0.0080	0.0020	0.0040	0.0050	0.0070	0.0100	0.0050	0.0200	0.0060	0.0100
CR1	Stormflow	Mean	0.0080	0.0020	0.0040	0.0089	0.0222	0.0100	0.0144	0.0200	0.0050	0.0100
		Difference	0.0000	0.0000	0.0000	0.0039	0.0152	0.0000	0.0094	0.0000	-0.0010	0.0000

Cooks Run Watershed Assessment
ALI Project No. 1005-05

Water Quality Data: Insitu & Laboratory Data

Station	Date	Flow Regime	Zn (mg/l)	Hg (mg/l)
CR4	Baseflow	Mean	0.0050	0.0002
CR3	Baseflow	Mean	0.0211	0.0002
CR2	Baseflow	Mean	0.0099	0.0002
CR1	Baseflow	Mean	0.0064	0.0002
CR4	Stormflow	Mean	0.0266	0.0011
CR3	Stormflow	Mean	0.0354	0.0011
CR2	Stormflow	Mean	0.0415	0.0011
CR1	Stormflow	Mean	0.0651	0.0011
CR4	Baseflow	Mean	0.0050	0.0002
CR4	Stormflow	Mean	0.0266	0.0011
		Difference	0.0216	0.0009
CR3	Baseflow	Mean	0.0211	0.0002
CR3	Stormflow	Mean	0.0354	0.0011
		Difference	0.0143	0.0009
CR2	Baseflow	Mean	0.0099	0.0002
CR2	Stormflow	Mean	0.0415	0.0011
		Difference	0.0316	0.0009
CR1	Baseflow	Mean	0.0064	0.0002
CR1	Stormflow	Mean	0.0651	0.0011
		Difference	0.0587	0.0009

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac 07/09/03 08:48am

Regarding:

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN — P.O. No: — Inv. No: 515811
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN — PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1040686-1	COOKS RUN 1005-05 CR4 VETERANS LANE Received Temp: 38°F Iced (Y/N): Y	06/04/03 11:15am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	06/09/03 01:42PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
CALCIUM	EPA 600 Method 200.7	7.11 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	18 mg/l	0.50 mg/l	06/09/03 01:42PM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	06/09/03 01:42PM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
COPPER	EPA 600 Method 200.7	0.00530 mg/l	0.00300 mg/l	06/09/03 01:42PM GJH
MAGNESIUM	EPA 600 Method 200.7	2.09 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	8.6 mg/l	0.50 mg/l	06/09/03 01:42PM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	06/09/03 01:42PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	26 mg/l	5.0 mg/l	06/09/03 01:42PM
ZINC	EPA 600 Method 200.7	0.0161 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	06/12/03 01:36PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	06/16/03 03:00PM JS
CHLORIDE	EPA 600 Method 300.0	6.00 mg/l	5.00 mg/l	06/05/03 01:48PM LC
ALKALINITY	SM 19th Ed. 2320B	23.3 mg/l	2.00 mg/l	06/13/03 01:00PM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	1.02 mg/l	0.300 mg/l	06/06/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3 F	0.110 mg/l	0.0500 mg/l	06/18/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0630 mg/l	0.0100 mg/l	06/05/03 08:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.215 mg/l	0.0100 mg/l	06/18/03 09:00AM TS

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 327216

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

07/09/03 08:48am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN P.O. No: Inv. No: 515811
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1040686-1	COOKS RUN 1005-05 CR4 VETERANS LANE	06/04/03 11:15am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.350 mg/l	0.100 mg/l	06/12/03 09:00AM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	53.0 mg/l	2.00 mg/l	06/05/03 09:45AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	>600 col/100ml	10 col/100ml	06/04/03 05:00PM JMM

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1040686-2	CR3 LIMEKILN PIKE Received Temp: 38°F Iced (Y/N): Y	06/04/03 11:30am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	06/09/03 01:42PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
CALCIUM	EPA 600 Method 200.7	9.61 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	24 mg/l	0.50 mg/l	06/09/03 01:42PM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	06/09/03 01:42PM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
COPPER	EPA 600 Method 200.7	0.00710 mg/l	0.00300 mg/l	06/09/03 01:42PM GJH
MAGNESIUM	EPA 600 Method 200.7	2.80 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	12 mg/l	0.50 mg/l	06/09/03 01:42PM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
LEAD	EPA 600 Method 200.7	0.00510 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	06/09/03 01:42PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	36 mg/l	5.0 mg/l	06/09/03 01:42PM
ZINC	EPA 600 Method 200.7	0.0237 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	06/12/03 01:36PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	06/16/03 03:00PM JS
CHLORIDE	EPA 600 Method 300.0	10.7 mg/l	5.00 mg/l	06/05/03 01:48PM LC
ALKALINITY	SM 19th Ed. 2320B	34.9 mg/l	2.00 mg/l	06/13/03 01:00PM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	1.16 mg/l	0.300 mg/l	06/06/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3 F	0.130 mg/l	0.0500 mg/l	06/18/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0610 mg/l	0.0100 mg/l	06/05/03 08:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.278 mg/l	0.0100 mg/l	06/18/03 09:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.650 mg/l	0.100 mg/l	06/12/03 09:00AM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	56.0 mg/l	2.00 mg/l	06/05/03 09:45AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	>600 col/100ml	10 col/100ml	06/04/03 05:00PM JMM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 327216

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
07/09/03 08:48am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN   P.O. No: Inv. No: 515811
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN   PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1040686-3	CR2 IRON HILL ROAD	06/04/03 11:45am NA°F	Customer Sampled
	Received Temp: 38°F Iced (Y/N): Y		

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	06/09/03 01:42PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
CALCIUM	EPA 600 Method 200.7	10.6 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	26 mg/l	0.50 mg/l	06/09/03 01:42PM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	06/09/03 01:42PM GJH
CHROMIUM	EPA 600 Method 200.7	0.00560 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
COPPER	EPA 600 Method 200.7	0.0100 mg/l	0.00300 mg/l	06/09/03 01:42PM GJH
MAGNESIUM	EPA 600 Method 200.7	3.35 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	14 mg/l	0.50 mg/l	06/09/03 01:42PM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
LEAD	EPA 600 Method 200.7	0.00600 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	06/09/03 01:42PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	40 mg/l	5.0 mg/l	06/09/03 01:42PM
ZINC	EPA 600 Method 200.7	0.0284 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	06/12/03 01:36PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	06/16/03 03:00PM JS
CHLORIDE	EPA 600 Method 300.0	18.8 mg/l	5.00 mg/l	06/05/03 01:48PM LC
ALKALINITY	SM 19th Ed. 2320B	36.9 mg/l	2.00 mg/l	06/13/03 01:00PM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	1.24 mg/l	0.300 mg/l	06/06/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3 F	0.130 mg/l	0.0500 mg/l	06/18/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0890 mg/l	0.0100 mg/l	06/05/03 08:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.306 mg/l	0.0100 mg/l	06/18/03 09:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.620 mg/l	0.100 mg/l	06/12/03 09:00AM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	101 mg/l	2.00 mg/l	06/05/03 09:45AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	>600 col/100ml	10 col/100ml	06/04/03 05:00PM JMM

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1040686-4	CR1 AARONS AVENUE	06/04/03 12:00pm NA°F	Customer Sampled
	Received Temp: 38°F Iced (Y/N): Y		

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	06/09/03 01:42PM GJH

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 327216

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
07/09/03 08:48am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN P.O. No: Inv. No: 515811
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1040686-4	CR1 AARONS AVENUE	06/04/03 12:00pm NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	06/09/03 01:42PM GJH
CALCIUM	EPA 600 Method 200.7	11.1 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	28 mg/l	0.50 mg/l	06/09/03 01:42PM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	06/09/03 01:42PM GJH
CHROMIUM	EPA 600 Method 200.7	0.00630 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
COPPER	EPA 600 Method 200.7	0.0125 mg/l	0.00300 mg/l	06/09/03 01:42PM GJH
MAGNESIUM	EPA 600 Method 200.7	3.73 mg/l	0.100 mg/l	06/09/03 01:42PM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	15 mg/l	0.50 mg/l	06/09/03 01:42PM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
LEAD	EPA 600 Method 200.7	0.0101 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	06/09/03 01:42PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	06/09/03 01:42PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	43 mg/l	5.0 mg/l	06/09/03 01:42PM
ZINC	EPA 600 Method 200.7	0.0377 mg/l	0.00500 mg/l	06/09/03 01:42PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	06/12/03 01:36PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	06/16/03 03:00PM JS
CHLORIDE	EPA 600 Method 300.0	18.0 mg/l	5.00 mg/l	06/05/03 01:48PM LC
ALKALINITY	SM 19th Ed. 2320B	36.9 mg/l	2.00 mg/l	06/13/03 01:00PM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	1.62 mg/l	0.300 mg/l	06/06/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3 F	0.130 mg/l	0.0500 mg/l	06/18/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0960 mg/l	0.0100 mg/l	06/05/03 08:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.413 mg/l	0.0100 mg/l	06/18/03 09:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.620 mg/l	0.100 mg/l	06/12/03 09:00AM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	125 mg/l	2.00 mg/l	06/05/03 09:45AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	>600 col/100ml	10 col/100ml	06/04/03 05:00PM JMM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

 Serial Number: 327216

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
07/26/03 11:18am

Regarding:

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN   P.O. No: Inv. No: 523983
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN   PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1059142-1	COOKS RUN 1005-05 CR4 COOKS RUN @ VETERANS LANE Received Temp: 38°F Iced (Y/N): Y	07/07/03 09:00am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	07/10/03 02:48PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
CALCIUM	EPA 600 Method 200.7	38.5 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	96 mg/l	0.50 mg/l	07/10/03 10:04AM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	07/10/03 02:48PM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
COPPER LOW LEVEL	EPA 600 Method 200.7	ND mg/l	0.00300 mg/l	07/10/03 10:04AM GJH
MAGNESIUM	EPA 600 Method 200.7	13.4 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	55 mg/l	0.50 mg/l	07/10/03 10:04AM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	07/10/03 02:48PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	150 mg/l	5.0 mg/l	07/10/03 10:04AM
ZINC	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	07/11/03 02:01PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	07/17/03 08:30AM MW
CHLORIDE	EPA 600 Method 300.0	96.4 mg/l	5.00 mg/l	07/08/03 04:50PM LC
ALKALINITY	SM 19th Ed. 2320B	85.4 mg/l	2.00 mg/l	07/14/03 05:00PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.930 mg/l	0.300 mg/l	07/11/03 10:30AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	ND mg/l	0.0500 mg/l	07/17/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0550 mg/l	0.0100 mg/l	07/09/03 06:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.0940 mg/l	0.0100 mg/l	07/10/03 05:00AM TS

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 336239

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac 07/26/03 11:18am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN   P.O. No: Inv. No: 523983
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN   PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1059142-1	COOKS RUN 1005-05 CR4 COOKS RUN @ VETERANS LANE	07/07/03 09:00am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	1.34 mg/l	0.100 mg/l	07/08/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	3.00 mg/l	2.00 mg/l	07/10/03 08:35AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	520 col/100ml	10 col/100ml	07/07/03 04:30PM JMM

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1059142-2	CR3 COOKS RUN @ LIMEKILN PIKE Received Temp: 38°F Iced (Y/N): Y	07/07/03 09:15am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	07/10/03 02:48PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
CALCIUM	EPA 600 Method 200.7	43.3 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	110 mg/l	0.50 mg/l	07/10/03 10:04AM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	07/10/03 02:48PM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
COPPER LOW LEVEL	EPA 600 Method 200.7	0.0222 mg/l	0.00300 mg/l	07/10/03 10:04AM GJH
MAGNESIUM	EPA 600 Method 200.7	16.3 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	67 mg/l	0.50 mg/l	07/10/03 10:04AM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	07/10/03 02:48PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	180 mg/l	5.0 mg/l	07/10/03 10:04AM
ZINC	EPA 600 Method 200.7	0.0258 mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	07/11/03 02:01PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	07/17/03 08:30AM MW
CHLORIDE	EPA 600 Method 300.0	123 mg/l	25.0 mg/l	07/08/03 04:50PM LC
ALKALINITY	SM 19th Ed. 2320B	91.2 mg/l	2.00 mg/l	07/14/03 05:00PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	1.13 mg/l	0.300 mg/l	07/11/03 10:30AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	ND mg/l	0.0500 mg/l	07/17/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.378 mg/l	0.0100 mg/l	07/09/03 06:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.416 mg/l	0.0100 mg/l	07/10/03 05:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	3.90 mg/l	0.500 mg/l	07/08/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	11.0 mg/l	2.00 mg/l	07/10/03 08:35AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	470 col/100ml	10 col/100ml	07/07/03 04:30PM JMM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 336239

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac

07/26/03 11:18am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN P.O. No: Inv. No: 523983
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1059142-3	CR2 COOKS RUN @ IRON HILL ROAD Received Temp: 38°F Iced (Y/N): Y	07/07/03 09:39am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	07/10/03 02:48PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
CALCIUM	EPA 600 Method 200.7	40.4 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	100 mg/l	0.50 mg/l	07/10/03 10:04AM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	07/10/03 02:48PM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
COPPER LOW LEVEL	EPA 600 Method 200.7	0.0102 mg/l	0.00300 mg/l	07/10/03 10:04AM GJH
MAGNESIUM	EPA 600 Method 200.7	16.4 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	68 mg/l	0.50 mg/l	07/10/03 10:04AM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	07/10/03 02:48PM GJH
SELENIUM	EPA 600 Method 200.7	0.00690 mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	170 mg/l	5.0 mg/l	07/10/03 10:04AM
ZINC	EPA 600 Method 200.7	0.00990 mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	07/11/03 02:01PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	07/17/03 08:30AM MW
CHLORIDE	EPA 600 Method 300.0	124 mg/l	25.0 mg/l	07/08/03 04:50PM LC
ALKALINITY	SM 19th Ed. 2320B	84.4 mg/l	2.00 mg/l	07/14/03 05:00PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.990 mg/l	0.300 mg/l	07/11/03 10:30AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	ND mg/l	0.0500 mg/l	07/17/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.242 mg/l	0.0100 mg/l	07/09/03 06:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.255 mg/l	0.0100 mg/l	07/10/03 05:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	3.62 mg/l	0.500 mg/l	07/08/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	4.00 mg/l	2.00 mg/l	07/10/03 08:35AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	360 col/100ml	10 col/100ml	07/07/03 04:30PM JMM

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1059142-4	CR1 COOKS RUN @ ARRON AVENUE Received Temp: 38°F Iced (Y/N): Y	07/07/03 09:54am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	07/10/03 02:48PM GJH

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 336239

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

07/26/03 11:18am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN P.O. No: Inv. No: 523983
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1059142-4	CR1 COOKS RUN @ ARRON AVENUE	07/07/03 09:54am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	07/10/03 02:48PM GJH
CALCIUM	EPA 600 Method 200.7	39.4 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
CALCIUM HARDNESS	Calculation Method(200.7)	98 mg/l	0.50 mg/l	07/10/03 10:04AM
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	07/10/03 02:48PM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
COPPER LOW LEVEL	EPA 600 Method 200.7	0.00840 mg/l	0.00300 mg/l	07/10/03 10:04AM GJH
MAGNESIUM	EPA 600 Method 200.7	15.3 mg/l	0.100 mg/l	07/10/03 10:04AM GJH
MAGNESIUM HARDNESS	Calculation Method(200.7)	63 mg/l	0.50 mg/l	07/10/03 10:04AM
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	07/10/03 02:48PM GJH
SELENIUM	EPA 600 Method 200.7	0.00700 mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	07/10/03 02:48PM GJH
TOTAL HARDNESS	Calculation Method(200.7)	160 mg/l	5.0 mg/l	07/10/03 10:04AM
ZINC	EPA 600 Method 200.7	0.00610 mg/l	0.00500 mg/l	07/10/03 02:48PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	07/11/03 02:01PM JAD
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	07/17/03 08:30AM MW
CHLORIDE	EPA 600 Method 300.0	111 mg/l	25.0 mg/l	07/08/03 04:50PM LC
ALKALINITY	SM 19th Ed. 2320B	83.4 mg/l	2.00 mg/l	07/14/03 05:00PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.910 mg/l	0.300 mg/l	07/11/03 10:30AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	ND mg/l	0.0500 mg/l	07/17/03 11:00AM DGP
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.260 mg/l	0.0100 mg/l	07/09/03 06:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.277 mg/l	0.0100 mg/l	07/10/03 05:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	3.49 mg/l	0.500 mg/l	07/08/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	8.00 mg/l	2.00 mg/l	07/10/03 08:35AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	530 col/100ml	10 col/100ml	07/07/03 04:30PM JMM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <30 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 336239

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
11/19/03 05:11pm

Regarding:

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN   P.O. No: Inv. No: 552165
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN   PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1110444-1	CR4 @ VETERANS LANE Received Temp: 54°F Iced (Y/N): Y	10/27/03 01:00pm NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	12 mg/l	0.50 mg/l	11/06/03 01:28PM
MAGNESIUM HARDNESS	Calculation Method(200.7)	6.1 mg/l	0.50 mg/l	11/06/03 01:28PM
TOTAL HARDNESS	Calculation Method(200.7)	18 mg/l	5.0 mg/l	11/06/03 01:28PM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:28PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/06/03 01:28PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:28PM GJH
CALCIUM	EPA 600 Method 200.7	4.62 mg/l	0.100 mg/l	11/06/03 01:28PM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/06/03 01:28PM GJH
CHROMIUM	EPA 600 Method 200.7	0.00620 mg/l	0.00500 mg/l	11/06/03 01:28PM GJH
COPPER	EPA 600 Method 200.7	0.00880 mg/l	0.00300 mg/l	11/06/03 01:28PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	10/31/03 11:36AM JAD
MAGNESIUM	EPA 600 Method 200.7	1.49 mg/l	0.100 mg/l	11/06/03 01:28PM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:28PM GJH
LEAD	EPA 600 Method 200.7	0.0111 mg/l	0.00500 mg/l	11/06/03 01:28PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/06/03 01:28PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/06/03 01:28PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:28PM GJH
ZINC	EPA 600 Method 200.7	0.0371 mg/l	0.00500 mg/l	11/06/03 01:28PM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/06/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	ND mg/l	5.00 mg/l	10/28/03 03:58PM LC
ALKALINITY	SM 19th Ed. 2320B	11.1 mg/l	2.00 mg/l	11/04/03 11:00AM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.900 mg/l	0.300 mg/l	10/31/03 09:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	0.110 mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0590 mg/l	0.0100 mg/l	10/25/03 07:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.168 mg/l	0.0100 mg/l	10/31/03 08:00AM TS

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 376416

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac

11/19/03 05:11pm

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN   P.O. No: Inv. No: 552165
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN   PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1110444-1	CR4 @ VETERANS LANE	10/27/03 01:00pm NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.120 mg/l	0.100 mg/l	10/29/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	70.0 mg/l	2.00 mg/l	10/29/03 11:38AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	4700 col/100ml	100 col/100ml	10/27/03 02:30PM JMM

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1110444-2	CR3 @ LIMEKILN PIKE Received Temp: 54°F Iced (Y/N): Y	10/27/03 01:15pm NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	19 mg/l	0.50 mg/l	11/06/03 01:32PM
MAGNESIUM HARDNESS	Calculation Method(200.7)	12 mg/l	0.50 mg/l	11/06/03 01:32PM
TOTAL HARDNESS	Calculation Method(200.7)	31 mg/l	5.0 mg/l	11/06/03 01:32PM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:32PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/06/03 01:32PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:32PM GJH
CALCIUM	EPA 600 Method 200.7	7.55 mg/l	0.100 mg/l	11/06/03 01:32PM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/06/03 01:32PM GJH
CHROMIUM	EPA 600 Method 200.7	0.00820 mg/l	0.00500 mg/l	11/06/03 01:32PM GJH
COPPER	EPA 600 Method 200.7	0.0180 mg/l	0.00300 mg/l	11/06/03 01:32PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	10/31/03 11:39AM JAD
MAGNESIUM	EPA 600 Method 200.7	2.87 mg/l	0.100 mg/l	11/06/03 01:32PM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:32PM GJH
LEAD	EPA 600 Method 200.7	0.0151 mg/l	0.00500 mg/l	11/06/03 01:32PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/06/03 01:32PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/06/03 01:32PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:32PM GJH
ZINC	EPA 600 Method 200.7	0.0470 mg/l	0.00500 mg/l	11/06/03 01:32PM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/06/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	7.00 mg/l	5.00 mg/l	10/28/03 03:58PM LC
ALKALINITY	SM 19th Ed. 2320B	24.2 mg/l	2.00 mg/l	11/04/03 11:00AM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	1.22 mg/l	0.300 mg/l	10/31/03 09:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	0.100 mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0980 mg/l	0.0100 mg/l	10/25/03 07:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.303 mg/l	0.0100 mg/l	10/31/03 08:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.280 mg/l	0.100 mg/l	10/29/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	114 mg/l	2.00 mg/l	10/29/03 11:38AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	5600 col/100ml	100 col/100ml	10/27/03 02:30PM JMM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

    Serial Number: 376416

Allen D. Schopbach, President

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
11/19/03 05:11pm

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN   P.O. No: Inv. No: 552165
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN   PWSID No:

Sample Number: L1110444-3
Sample Description: CR2 @ IRON HILL ROAD
Received Temp: 54°F   Iced (Y/N): Y
Samp. Date/Time/Temp: 10/27/03 01:30pm NA°F
Sampled by: Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	20 mg/l	0.50 mg/l	11/06/03 01:35PM
MAGNESIUM HARDNESS	Calculation Method(200.7)	13 mg/l	0.50 mg/l	11/06/03 01:35PM
TOTAL HARDNESS	Calculation Method(200.7)	34 mg/l	5.0 mg/l	11/06/03 01:35PM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:35PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/06/03 01:35PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:35PM GJH
CALCIUM	EPA 600 Method 200.7	8.12 mg/l	0.100 mg/l	11/06/03 01:35PM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/06/03 01:35PM GJH
CHROMIUM	EPA 600 Method 200.7	0.0105 mg/l	0.00500 mg/l	11/06/03 01:35PM GJH
COPPER	EPA 600 Method 200.7	0.0194 mg/l	0.00300 mg/l	11/06/03 01:35PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	10/31/03 11:41AM JAD
MAGNESIUM	EPA 600 Method 200.7	3.23 mg/l	0.100 mg/l	11/06/03 01:35PM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:35PM GJH
LEAD	EPA 600 Method 200.7	0.0184 mg/l	0.00500 mg/l	11/06/03 01:35PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/06/03 01:35PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/06/03 01:35PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:35PM GJH
ZINC	EPA 600 Method 200.7	0.0545 mg/l	0.00500 mg/l	11/06/03 01:35PM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/06/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	9.30 mg/l	5.00 mg/l	10/28/03 03:58PM LC
ALKALINITY	SM 19th Ed. 2320B	25.2 mg/l	2.00 mg/l	11/04/03 11:00AM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	1.97 mg/l	0.300 mg/l	10/31/03 09:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	0.110 mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.140 mg/l	0.0100 mg/l	10/25/03 07:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.420 mg/l	0.0100 mg/l	10/31/03 08:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.290 mg/l	0.100 mg/l	10/29/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	198 mg/l	2.00 mg/l	10/29/03 11:39AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	3400 col/100ml	100 col/100ml	10/27/03 02:30PM JMM

Sample Number: L1110444-4
Sample Description: CR1 @ ARRON AVENUE
Received Temp: 54°F   Iced (Y/N): Y
Samp. Date/Time/Temp: 10/27/03 02:00pm NA°F
Sampled by: Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	27 mg/l	0.50 mg/l	11/06/03 01:44PM
MAGNESIUM HARDNESS	Calculation Method(200.7)	15 mg/l	0.50 mg/l	11/06/03 01:44PM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

    Serial Number: 376416

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
11/19/03 05:11pm

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN P.O. No: Inv. No: 552165
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1110444-4	CR1 @ ARRON AVENUE	10/27/03 02:00pm NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
TOTAL HARDNESS	Calculation Method(200.7)	42 mg/l	5.0 mg/l	11/06/03 01:44PM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:44PM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/06/03 01:44PM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/06/03 01:44PM GJH
CALCIUM	EPA 600 Method 200.7	10.8 mg/l	0.100 mg/l	11/06/03 01:44PM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/06/03 01:44PM GJH
CHROMIUM	EPA 600 Method 200.7	0.0115 mg/l	0.00500 mg/l	11/06/03 01:44PM GJH
COPPER	EPA 600 Method 200.7	0.0318 mg/l	0.00300 mg/l	11/06/03 01:44PM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	10/31/03 11:43AM JAD
MAGNESIUM	EPA 600 Method 200.7	3.76 mg/l	0.100 mg/l	11/06/03 01:44PM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:44PM GJH
LEAD	EPA 600 Method 200.7	0.0186 mg/l	0.00500 mg/l	11/06/03 01:44PM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/06/03 01:44PM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/06/03 01:44PM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/06/03 01:44PM GJH
ZINC	EPA 600 Method 200.7	0.0925 mg/l	0.00500 mg/l	11/06/03 01:44PM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/06/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	10.9 mg/l	5.00 mg/l	10/28/03 03:58PM LC
ALKALINITY	SM 19th Ed. 2320B	29.3 mg/l	2.00 mg/l	11/04/03 11:00AM LS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.890 mg/l	0.300 mg/l	10/31/03 09:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	0.100 mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.165 mg/l	0.0100 mg/l	10/25/03 07:00AM TS
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.523 mg/l	0.0100 mg/l	10/31/03 08:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	0.360 mg/l	0.100 mg/l	10/29/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	232 mg/l	2.00 mg/l	10/29/03 11:40AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	4200 col/100ml	100 col/100ml	10/27/03 02:30PM JMM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 376416

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
12/01/03 10:56am

Regarding:

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

ED MOLESKY
AQUA-LINK, INC.
3531 WINDRIDGE DRIVE
DOYLESTOWN, PA 18901

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN — P.O. No: — Inv. No: 553487
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN — PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1111985-1	CR4 @ VETERANS LANE Received Temp: 35°F Iced (Y/N): Y	10/31/03 10:30am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	76 mg/l	0.50 mg/l	11/14/03 11:04AM
MAGNESIUM HARDNESS	Calculation Method(200.7)	43 mg/l	0.50 mg/l	11/14/03 11:04AM
TOTAL HARDNESS	Calculation Method(200.7)	120 mg/l	5.0 mg/l	11/14/03 11:04AM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:04AM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/14/03 11:04AM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:04AM GJH
CALCIUM	EPA 600 Method 200.7	30.5 mg/l	0.100 mg/l	11/14/03 11:04AM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/14/03 11:04AM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:04AM GJH
COPPER	EPA 600 Method 200.7	ND mg/l	0.00300 mg/l	11/14/03 11:04AM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	11/05/03 09:20AM JAD
MAGNESIUM	EPA 600 Method 200.7	10.4 mg/l	0.100 mg/l	11/14/03 11:04AM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:04AM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:04AM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/14/03 11:04AM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:04AM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:04AM GJH
ZINC	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:04AM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/12/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	67.1 mg/l	5.00 mg/l	11/03/03 07:53AM LC
ALKALINITY	SM 19th Ed. 2320B	80.8 mg/l	2.00 mg/l	11/09/03 01:30PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.360 mg/l	0.300 mg/l	11/05/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	0.190 mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.0250 mg/l	0.0100 mg/l	11/01/03 10:00AM DGP
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.0400 mg/l	0.0100 mg/l	11/05/03 10:00AM TS

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 379110

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

000002

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac

12/01/03 10:56am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN   P.O. No: Inv. No: 553487
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN   PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1111985-1	CR4 @ VETERANS LANE	10/31/03 10:30am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	1.13 mg/l	0.100 mg/l	11/03/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	2.00 mg/l	2.00 mg/l	11/04/03 11:51AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	90 col/100ml	10 col/100ml	10/31/03 03:50PM JMM

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1111985-2	CR3 @ LIMEKILN PIKE Received Temp: 35°F Iced (Y/N): Y	10/31/03 11:00am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	94 mg/l	0.50 mg/l	11/14/03 11:15AM
MAGNESIUM HARDNESS	Calculation Method(200.7)	53 mg/l	0.50 mg/l	11/14/03 11:15AM
TOTAL HARDNESS	Calculation Method(200.7)	150 mg/l	5.0 mg/l	11/14/03 11:15AM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:15AM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/14/03 11:15AM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:15AM GJH
CALCIUM	EPA 600 Method 200.7	37.5 mg/l	0.100 mg/l	11/14/03 11:15AM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/14/03 11:15AM GJH
CHROMIUM	EPA 600 Method 200.7	0.00590 mg/l	0.00500 mg/l	11/14/03 11:15AM GJH
COPPER	EPA 600 Method 200.7	0.0102 mg/l	0.00300 mg/l	11/14/03 11:15AM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	11/05/03 09:22AM JAD
MAGNESIUM	EPA 600 Method 200.7	12.9 mg/l	0.100 mg/l	11/14/03 11:15AM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:15AM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:15AM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/14/03 11:15AM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:15AM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:15AM GJH
ZINC	EPA 600 Method 200.7	0.0164 mg/l	0.00500 mg/l	11/14/03 11:15AM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/12/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	73.4 mg/l	5.00 mg/l	11/03/03 07:53AM LC
ALKALINITY	SM 19th Ed. 2320B	93.9 mg/l	2.00 mg/l	11/09/03 01:30PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.450 mg/l	0.300 mg/l	11/05/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	0.120 mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.114 mg/l	0.0100 mg/l	11/01/03 10:00AM DGP
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.173 mg/l	0.0100 mg/l	11/05/03 10:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	2.68 mg/l	0.200 mg/l	11/03/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	3.30 mg/l	2.00 mg/l	11/04/03 11:51AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	50 col/100ml	10 col/100ml	10/31/03 03:50PM JMM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 379110

Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
12/01/03 10:56am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN | P.O. No: | Inv. No: 553487
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN | PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1111985-3	CR2 @ IRON HILL ROAD Received Temp: 35°F Iced (Y/N): Y	10/31/03 11:15am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	79 mg/l	0.50 mg/l	11/14/03 11:24AM
MAGNESIUM HARDNESS	Calculation Method(200.7)	47 mg/l	0.50 mg/l	11/14/03 11:24AM
TOTAL HARDNESS	Calculation Method(200.7)	130 mg/l	5.0 mg/l	11/14/03 11:24AM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:24AM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/14/03 11:24AM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:24AM GJH
CALCIUM	EPA 600 Method 200.7	31.8 mg/l	0.100 mg/l	11/14/03 11:24AM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/14/03 11:24AM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:24AM GJH
COPPER	EPA 600 Method 200.7	0.00570 mg/l	0.00300 mg/l	11/14/03 11:24AM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	11/05/03 09:25AM JAD
MAGNESIUM	EPA 600 Method 200.7	11.5 mg/l	0.100 mg/l	11/14/03 11:24AM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:24AM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:24AM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/14/03 11:24AM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:24AM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:24AM GJH
ZINC	EPA 600 Method 200.7	0.00980 mg/l	0.00500 mg/l	11/14/03 11:24AM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/12/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	69.5 mg/l	5.00 mg/l	11/03/03 07:53AM LC
ALKALINITY	SM 19th Ed. 2320B	80.8 mg/l	2.00 mg/l	11/09/03 01:30PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.560 mg/l	0.300 mg/l	11/05/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	ND mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.102 mg/l	0.0100 mg/l	11/01/03 10:00AM DGP
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.108 mg/l	0.0100 mg/l	11/05/03 10:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	2.82 mg/l	0.200 mg/l	11/03/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	2.00 mg/l	2.00 mg/l	11/04/03 11:52AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	40 col/100ml	10 col/100ml	10/31/03 03:50PM JMM

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1111985-4	CR1 @ ARRONS AVENUE Received Temp: 35°F Iced (Y/N): Y	10/31/03 11:30am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
CALCIUM HARDNESS	Calculation Method(200.7)	80 mg/l	0.50 mg/l	11/14/03 11:27AM
MAGNESIUM HARDNESS	Calculation Method(200.7)	47 mg/l	0.50 mg/l	11/14/03 11:27AM

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

Serial Number: 379110

Allen D. Schopbach
Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

QC Laboratories

Analytical Results

ACCREDITED IN ACCORDANCE WITH nelac
12/01/03 10:56am

Account No: B00085, AQUA-LINK, INC. DOYLESTOWN P.O. No: Inv. No: 553487
Project No: B00085, AQUA-LINK, INC. DOYLESTOWN PWSID No:

Sample Number	Sample Description	Samp. Date/Time/Temp	Sampled by
L1111985-4	CR1 @ ARRONS AVENUE	10/31/03 11:30am NA°F	Customer Sampled

Parameter	Method	Result	RLs	Test Date, Time, Analyst
TOTAL HARDNESS	Calculation Method(200.7)	130 mg/l	5.0 mg/l	11/14/03 11:27AM
SILVER	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:27AM GJH
ARSENIC	EPA 600 Method 200.7	ND mg/l	0.00800 mg/l	11/14/03 11:27AM GJH
BERYLLIUM	EPA 600 Method 200.7	ND mg/l	0.00200 mg/l	11/14/03 11:27AM GJH
CALCIUM	EPA 600 Method 200.7	32.1 mg/l	0.100 mg/l	11/14/03 11:27AM GJH
CADMIUM	EPA 600 Method 200.7	ND mg/l	0.00400 mg/l	11/14/03 11:27AM GJH
CHROMIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:27AM GJH
COPPER	EPA 600 Method 200.7	0.00550 mg/l	0.00300 mg/l	11/14/03 11:27AM GJH
MERCURY	EPA 600 Method 245.1	ND mg/l	0.000200 mg/l	11/05/03 09:27AM JAD
MAGNESIUM	EPA 600 Method 200.7	11.4 mg/l	0.100 mg/l	11/14/03 11:27AM GJH
NICKEL	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:27AM GJH
LEAD	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:27AM GJH
ANTIMONY	EPA 600 Method 200.7	ND mg/l	0.0200 mg/l	11/14/03 11:27AM GJH
SELENIUM	EPA 600 Method 200.7	ND mg/l	0.00500 mg/l	11/14/03 11:27AM GJH
THALLIUM	EPA 600 Method 200.7	ND mg/l	0.0100 mg/l	11/14/03 11:27AM GJH
ZINC	EPA 600 Method 200.7	0.00670 mg/l	0.00500 mg/l	11/14/03 11:27AM GJH
HEXANE EXTR.-HEM (OIL+GREASE)	Method 1664A H.E.M.	ND mg/l	5.00 mg/l	11/12/03 08:30AM MP
CHLORIDE	EPA 600 Method 300.0	61.3 mg/l	5.00 mg/l	11/03/03 07:53AM LC
ALKALINITY	SM 19th Ed. 2320B	80.8 mg/l	2.00 mg/l	11/09/03 01:30PM JS
KJELDAHL NITROGEN LOW LEVEL	EPA 600 Method 351.2	0.560 mg/l	0.300 mg/l	11/05/03 10:00AM CWM
AMMONIA NITROGEN AS N LOW LEVE	SM 19th Ed. 4500-NH3-D	0.120 mg/l	0.0500 mg/l	11/05/03 02:00PM JW
ORTHO PHOSPHATE AS P LOW LEVEL	EPA 600 Method 365.2	0.106 mg/l	0.0100 mg/l	11/01/03 10:00AM DGP
PHOSPHORUS TOTAL LOW LEVEL	EPA 600 Method 365.2	0.103 mg/l	0.0100 mg/l	11/05/03 10:00AM TS
TOTAL NITRATE/NITRITE LOW	SM 19th Ed. 4500-NO3 F	2.79 mg/l	0.200 mg/l	11/03/03 02:00PM XJY
TOTAL SUSPENDED SOLIDS	SM 19th Ed. 2540D	3.00 mg/l	2.00 mg/l	11/04/03 11:52AM PBP
FECAL COLIFORM-MF	SM 19th Ed.9222D	100 col/100ml	10 col/100ml	10/31/03 03:50PM JMM

1. The sample submitted for orthophosphate was not filtered by the laboratory prior to analysis; therefore, the result reported represents total orthophosphate.

A result of "ND" indicates the concentration of the analyte tested was either not detected or below the RLs.
Definitions: ND=not detected; NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC=too numerous to count
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
All analysis, except field tests are conducted in Southampton, PA unless otherwise identified.
The test"pH lab"is analyzed upon receipt at the laboratory, the result will not be suitable for regulatory purposes.
Actual times of analysis for parameters reported <24 hrs are available upon request. All testing is completed within the required holding time unless otherwise noted..
QC Inc's laboratory certification ID's are: Southampton (NELAP) PADEP 09-131,NJDEP PA166. NON-NELAP labs: Wind Gap-NJ PA001, Alltest-NJ 02015, Vineland-NJ 06005;PA 68-580.
All samples are collected as "grab" samples unless otherwise identified.

 Serial Number: 379110

Allen D. Schopbach
Allen D. Schopbach, President

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 Phone: 215-355-3900 Fax: 215-355-7231

APPENDIX D

Macroinvertebrate Data & Report

BENTHIC MACROINVERTEBRATES OF COOKS RUN, BUCKS COUNTY, PA COLLECTED NOVEMBER 4, 2003

FOR

AQUA LINK, INC.

Submitted by

Donald L. Baylor

For

Aquatic Resource Consulting

202 Quail Ridge

Stroudsburg, PA 18360

BENTHIC MACROINVERTEBRATES OF COOKS RUN

LABORATORY METHODS

Organisms from Cooks Run were identified according to Peckarsky et al, 1990 using a Bausch and Lomb 0.7x-3x stereo microscope. They were enumerated, and assigned a pollution tolerance value if known (Environmental Analysts 1990). Taxa richness, modified EPT index, percent modified mayflies, percent dominant taxon, and Hilsenhoff biotic index values were calculated for each station to apply PA Department of Environmental Protection (DEP) Central Office's most recent guidance for use with special protection and antidegradation studies (PA DEP, 1999). Shannon-Weiner diversity was also calculated for each sample (Weber, 1973). Following are explanations of the metrics:

1. Taxa Richness - is an index of diversity. The number of taxa (kinds) of invertebrates indicates the health of the benthic community. Generally, number of species increases with increased water quality. However, variability in natural habitat (stream order and size, substrate composition, current velocity) also affects this number.

2. Modified EPT Index - is a measure of community balance. The insect orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddi flies), collectively referred to as EPT, are generally considered pollution sensitive. Thus, the total number of taxa within the EPT insect groups, minus those considered pollution tolerant (modified EPT index) is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

3. Percent Dominant Taxon - measures evenness of community structure. It is the percent of the total abundance made up by the single most abundant taxon. Dominance of a few taxa may suggest environmental stress. However, the tolerance value of the dominant taxon must be considered.

4. Percent Modified Mayflies - is another measure of balance. Mayflies are considered one of the least tolerant orders to organic pollution and acidification. Undisturbed streams usually have an abundance of mayflies. Pennsylvania DEP uses the percent contribution of mayflies to the total number of organisms as an indication of water quality. The value is modified to exclude mayflies with a tolerance value greater than 5.

5. Modified Hilsenhoff Biotic Index - is a direct measure of pollution tolerance. Since many aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollution, a biotic index is used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in the sample. This metric has been modified to use more recent pollution tolerance values, which range from 0 to 10; the higher the value, the greater the level of pollution indicated (Table 1).

Table 1. Evaluation of water quality using biotic index values (Hilsenhoff 1987)

BIOTIC INDEX	WATER QUALITY	DEGREE OF ORGANIC POLLUTION
0.00-3.50	Excellent	None Apparent
3.51-4.50	Very Good	Possible Slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly Significant
6.51-7.50	Fairly Poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.00	Very Poor	Severe

6. Shannon-Weiner diversity measures the number of taxa present and evenness of distribution of organisms among the taxa (Weber, 1973). Diversity values in unpolluted waters generally range from 3 to 4. In severely polluted waters they are often less than 1.

RESULTS AND DISCUSSION

Benthic macroinvertebrate samples from all stations on Cooks Run reflected impairment from organic pollution and/or habitat degradation. The benthic communities can be characterized as having had only moderate numbers of taxa with a predominance of pollution tolerant forms. The sensitive orders Ephemeroptera (mayflies) and Plecoptera (stoneflies) were absent from all samples (Appendix A). The modified EPT index value of only 1 at each station suggests a dearth of intolerant taxa, as well (Table 2). No organisms with a pollution tolerance value of less than 4 were collected from the four stations (Appendix A). The modified Hilsenhoff biotic index values suggested "good" to "fair" water quality with degree of organic pollution rated "some" to "fairly significant" (Tables 1 and 2). Diversity values all fell below the range expected in unpolluted waters.

Table 2. Benthic macroinvertebrate community metrics for 4 samples from Cooks Run collected on November 4, 2003.

METRIC	STATIONS			
	CR 1 AARON'S AVE	CR 2 IRON HILL RD	CR 3 LIMEKILN PK	CR 4 VETERANS LN
Number of Organisms	146	120	121	120
Taxa Richness	11	11	8	10
Modified EPT Index	1	1	1	1
Percent Modified Mayflies	0%	0%	0%	0%
Percent Dominant Taxon	52.05%	23.33%	46.28%	67.66%
Hilsenhoff Biotic Index	4.72	5.03	5.79	5.72
Shannon-Weiner Diversity	2.33	2.87	2.17	1.73

Differences in benthic communities between the Cooks Run stations were subtle. EPT index values and percent modified mayflies were the same at all stations (Table 2). Biotic index values were generally higher (poorer) at stations 3 and 4 than at stations 1 and 2. Taxa richness was poorest at Station 3, and slightly poorer at Station 4 than at stations 1 and 2. The percent dominant taxon was highest at Station 4 and lowest at Station 2. The dominant taxon at stations 1 and 2 was the caddisfly *Chimarra aterrima* with a pollution tolerance value of 4. At Station 3, *Cheumatopsyche* sp. caddis were predominant with a tolerance value of 5. Station 4 had, not only the highest percentage, but also the most tolerant dominant taxon – *Caecidotea* sp. crustaceans (sowbugs) with a tolerance value of 6. In addition, Station 4 had the poorest diversity value.

Appendix A. Taxa, numbers, and biotic index value (BI) of benthic macroinvertebrates collected from Cooks Run, November 4, 2003.

TAXA	STATIONS				BI
	CR 1 Aaron's Avenue	**CR 2 Iron Hill Rdoad**	**CR 3 Limekiln Pike**	**CR 4 Veteran's Lane**	
Trichoptera (caddisflies)					
Hydropsyche betteni	19	25	30	-	6
Ceratopsyche sp.	1	3	-	1	5
Cheumatopsyche sp.	10	8	56	-	6
Chimarra aterrima	76	28	10	9	4
Coleoptera (beetles)					
Psephenus sp.	13	25	-	-	4
Stenelmis sp.	4	13	5	1	5
Odonata (dragon & damselflies)					
Argia sp.	2	9	-	1	6
Calopteryx sp.	-	2	-	9	6
Aeshna sp.	-	-	-	1	5
Diptera (true flies)					
Simulium sp.	3	-	-	-	6
Tipula sp.	-	1	1	-	4
Isopoda (sowbugs)					
Caecidotea sp.	14	2	-	80	6
Amphipoda (freshwater shrimp)					
Gammarus sp.	3	-	9	-	4
Hirudinea (leeches)					
Piscicola sp.	1	-	-	-	8
Myzobdella sp.	-	-	1	3	8
Oligochaeta (aquatic earthworms)					
Lumbriculidae	-	-	-	1	10
Turbellaria					
Macrostomum sp.	-	4	9	14	8

REFERENCES

Environmental Analysts Mid-Atlantic Regional Operations Engineering, Science and Technology, Inc. 1990. Freshwater macroinvertebrate species list including tolerance values and functional Feeding group designations for use in rapid bioassessment protocols. U. S. Environmental Protection Agency, Washington, D.C. Report No. 11075.05

Hilsenhoff, William L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist, 20(1): 31-39.

Peckarsky, Barbara L. et al. 1990. Freshwater macroinvertebrates of northeastern North America. Cornell U. Press: New York. 442 pp.

Pennsylvania Department of Environmental Protection. 1999. Application of the Rapid Bioassessment Protocol multimedia approach to Pennsylvania's Water Quality Network Sites (draft).

Plafkin, J. L. et al. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. EPA/440/4-98/001. U. S. Environmental Protection Agency, Office of Water Quality Regulations and Standards, Washington D. C. 20460.

Weber, Cornelius I. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-600/4-73-001.

APPENDIX E

Stream and Riparian Visual Assessment Data

Cooks Run Watershed Assessment **Prepared by Aqua-Link, Inc.**
Project 1005-05

Stream & Riparian Visual Assessment - Forms

Riparian Rating:

- Piped
- Poor (0-35%)
- Marginal (36-65%)
- Good (66-85%)
- Excellent (86-100%)

Riparian Buffers Needed:

- Both Banks
- Single Bank

No.	Parameter		Points	No. of Parameters	1-2 Points	2-3 Points	3-4 Points	4-5 Points	5-6 Points
1	Riparian Buffer Width	Left	10	1	6	0	1	4	0
		Right	10	1	6	0	1	2	0
2	Riparian Vegetation Type	Left	10	1	9	0	2	9	0
		Right	10	1	9	0	2	2	0
3	Riparian Vegetation Density	Left	10	1	9	0	9	9	0
		Right	10	1	9	0	9	6	0
4	Bank Vegetation Type	Left	10	1	9	0	1	9	0
		Right	10	1	9	0	1	2	0
5	Bank Vegetation Density	Left	10	1	7	0	7	7	0
		Right	10	1	7	0	7	4	0
6	Bank Stability	Left	10	1	9	0	4	5	0
		Right	10	1	9	0	4	2	0
7	Channel Modification	Both	10	1	9	0	1	7	0
8	In-Stream Modification	Both	10	1	7	0	2	8	0
9	Embeddedness	Both	10	1	4	0	1	6	0
10	Shading (Canopy Cover)	Both	10	1	8	0	2	6	0
			100	10	77	0	30	58	0
			Riparian Rating:		77	0	30	58	0
					G		**P**	**G**	
	Personal Rating of Stream	(Poor - Marginal - Good - Excellent)			Good	Poor	Poor	Good	Poor
	No. Stormwater Discharges				2	0	0	0	0
	No. Watershed Problems				0	0	1	1	0
	Mean Stream Width (ft)				2	piped	13	6	piped
	Segment Length - Desktop	(ft using digital maps)			196	1,002	315	330	173
	Riparian Buffer Needed?	(yes or no)			no	na	yes	yes	na
	Segment Length - Field	(ft)					nd	nd	
	Left Bank?	(distance in ft)					315	0	
	Right Bank?	(distance in ft)					315	75	

Riparian Buffer Mapping:

Stream & Riparian Visual Assessment - Forms

Riparian Rating:

- Piped
- Poor (0-35%)
- Marginal (36-65%)
- Good (66-85%)
- Excellent (86-100%)

Riparian Buffers Needed:

- Both Banks
- Single Bank

No.	Parameter		Points	No. of Parameters	6-7 Points	7-8 Points	8-9 Points	9-10 Points
1	Riparian Buffer Width	Left	10	1	1	3	5	5
		Right	10	1	3	3	5	5
2	Riparian Vegetation Type	Left	10	1	6	2	4	1
		Right	10	1	6	2	4	1
3	Riparian Vegetation Density	Left	10	1	3	9	8	8
		Right	10	1	4	9	8	8
4	Bank Vegetation Type	Left	10	1	9	4	5	1
		Right	10	1	9	4	5	1
5	Bank Vegetation Density	Left	10	1	6	9	9	8
		Right	10	1	6	9	9	8
6	Bank Stability	Left	10	1	1	9	9	8
		Right	10	1	2	9	9	8
7	Channel Modification	Both	10	1	2	1	1	1
8	In-Stream Modification	Both	10	1	5	2	1	1
9	Embeddedness	Both	10	1	2	2	1	1
10	Shading (Canopy Cover)	Both	10	1	7	1	2	1
			100	10	44	42	45	35
	Riparian Rating:				44	42	45	35
					M	M	M	P

		6-7	7-8	8-9	9-10
Personal Rating of Stream	(Poor - Marginal - Good - Excellent)	Marginal	Marginal	Marginal	Poor
No. Stormwater Discharges		2	2	3	2
No. Watershed Problems		0	0	0	0
Mean Stream Width (ft)		6	braided	3	3
Segment Length - Desktop	(ft using digital maps)	165	212	209	212
Riparian Buffer Needed?	(yes or no)	yes	yes	yes	yes
Segment Length - Field	(ft)	nd	156	nd	nd
Left Bank?	(distance in ft)	restricted	212	209	212
Right Bank?	(distance in ft)	restricted	212	209	212

Riparian Buffer Mapping:

Cooks Run Watershed Assessment Prepared by Aqua-Link, Inc.
Project 1005-05

Stream & Riparian Visual Assessment - Forms

Riparian Rating:

- Piped
- Poor (0-35%)
- Marginal (36-65%)
- Good (66-85%)
- Excellent (86-100%)

Riparian Buffers Needed:

- Both Banks
- Single Bank

No.	Parameter		Points	No. of Parameters	10-11 Points	11-12 Points	12-13 Points	13-14 Points
1	Riparian Buffer Width	Left	10	1	2	3	3	8
		Right	10	1	5	5	4	7
2	Riparian Vegetation Type	Left	10	1	2	1	2	9
		Right	10	1	9	2	2	9
3	Riparian Vegetation Density	Left	10	1	4	6	5	8
		Right	10	1	7	6	5	8
4	Bank Vegetation Type	Left	10	1	2	1	9	9
		Right	10	1	8	1	9	9
5	Bank Vegetation Density	Left	10	1	4	5	7	6
		Right	10	1	7	5	7	6
6	Bank Stability	Left	10	1	4	7	3	4
		Right	10	1	7	7	3	5
7	Channel Modification	Both	10	1	5	4	3	9
8	In-Stream Modification	Both	10	1	5	2	3	5
9	Embeddedness	Both	10	1	5	2	3	3
10	Shading (Canopy Cover)	Both	10	1	5	1	7	6
			100	10	51	34	46	67
	Riparian Rating:				51	34	46	67
					M	P	M	G
	Personal Rating of Stream	(Poor - Marginal - Good - Excellent)			Marginal	Poor	Marginal	Good
	No. Stormwater Discharges				3	8	7	2
	No. Watershed Problems				1	0	1	1
	Mean Stream Width (ft)				4	3	4	7
	Segment Length - Desktop	(ft using digital maps)			825	600	995	400
	Riparian Buffer Needed?	(yes or no)			yes	yes	yes	no
	Segment Length - Field	(ft)			nd	546	nd	no
	Left Bank?	(distance in ft)			645	600	restricted	
	Right Bank?	(distance in ft)			0	600	restricted	

Riparian Buffer Mapping:

Cooks Run Watershed Assessment
Project 1005-05

Prepared by Aqua-Link, Inc.

Stream & Riparian Visual Assessment - Forms

Riparian Rating:

- Piped
- Poor (0-35%)
- Marginal (36-65%)
- Good (66-85%)
- Excellent (86-100%)

Riparian Buffers Needed:

- Both Banks
- Single Bank

No.	Parameter		Points	No. of Parameters	14-15 Points	15-16 Points	Total
1	Riparian Buffer Width	Left	10	1	6	9	
		Right	10	1	10	8	
2	Riparian Vegetation Type	Left	10	1	9	9	
		Right	10	1	9	9	
3	Riparian Vegetation Density	Left	10	1	9	9	
		Right	10	1	9	9	
4	Bank Vegetation Type	Left	10	1	9	8	
		Right	10	1	9	8	
5	Bank Vegetation Density	Left	10	1	8	8	
		Right	10	1	8	8	
6	Bank Stability	Left	10	1	8	7	
		Right	10	1	8	7	
7	Channel Modification	Both	10	1	9	9	
8	In-Stream Modification	Both	10	1	7	7	
9	Embeddedness	Both	10	1	1	6	
10	Shading (Canopy Cover)	Both	10	1	9	8	
			100	10	77	80	
			Riparian Rating:		77	80	
					G	G	
	Personal Rating of Stream	(Poor - Marginal - Good - Excellent)			Good	Good	
	No. Stormwater Discharges				11	5	**47**
	No. Watershed Problems				2	2	**9**
	Mean Stream Width (ft)				7	15	
	Segment Length - Desktop	(ft using digital maps)			2525	1925	**10,084**
	Riparian Buffer Needed?	(yes or no)			no	no	
	Segment Length - Field	(ft)			no	no	
	Left Bank?	(distance in ft)					**2,193**
	Right Bank?	(distance in ft)					**1,623**

Riparian Buffer Mapping:

Stream & Riparian Visual Assessment

Aqua-Link, Inc.

Project Name: Cooks Run
Project No. 1005-05
Initials: ______________

Stream Name: ____________________
Date: ____________________
Time: ____________________

Flow Conditions: _____ Baseflow _____ Stormflow

Location in the Watershed: _____ Headwaters _____ Middle ______ Lower

Distances Reported: _____ Measuring Tape _____ Range Finder _____ Estimated

Mean Stream Width: ______________ ft.

GPS Information for Segment (record in d.ddddd):

Upstream point of Segment: _______ Waypoint ID ___________ Lat. ___________ Long.
Downstream point of Segment: _______ Waypoint ID ___________ Lat. ___________ Long.

Photograph Information:

Upstream Photograph ID ______________ Other ______________________
Downstream Photograph ID ______________ Other ______________________

Land Uses (Estimate Percentage):

_____ Urban/Commercial _____ Residential (lawn) _____ Residential (forest)
_____ Park & Fields (lawn) _____ Ag Row Crop _____ Ag Pasture (fallow)
_____ Forest _____ Field (scrub & shrub) _____ Meadow
_____ Other (describe): ________________________________

1. Riparian Buffer Width

	Poor		*Marginal*		*Moderate*		*Good*		*Excellent*	
	0 - 9 feet 0 - 3 yards		9 - 30 feet 3 - 10 yards		30 – 75 feet 10 - 25 yards		75 - 150 feet 25 - 50 yards		150+ feet 50+ yards	
Left	1	2	3	4	5	6	7	8	9	10
Right	1	2	3	4	5	6	7	8	9	10

2. Riparian Vegetation Type

	Poor		*Marginal*			*Good*			*Excellent*	
	Grasses & herb. plants (grazed or mowed)		Grasses & herb. plants (full height)			Shrub or Shrub & grass mix			Forest or Forest mix w/ shrubs &/or grass	
Left	1	2	3	4	5	6	7	8	9	10
Right	1	2	3	4	5	6	7	8	9	10

3. Riparian Vegetation Density

	Poor		*Marginal*			*Good*			*Excellent*	
	Vegetation very sparse Covers < 25% of ground Large bare spots visible		Vegetation somewhat sparse Covers 25-50% of ground Several bare spots are visible			Vegetation fairly thick Covers 50-80% of ground Few bare spots			Vegetation thick Covers > 80% of ground No bare spots	
Left	1	2	3	4	5	6	7	8	9	10
Right	1	2	3	4	5	6	7	8	9	10

4. Bank Vegetation Type

	Poor		Marginal			Good			Excellent	
	Grasses & herb. plants (grazed or mowed)		Grasses & herb. plants (full height)			Shrub or Shrub & grass mix			Trees or trees mix w/ shrubs &/or grass	
Left	1	2	3	4	5	6	7	8	9	10
Right	1	2	3	4	5	6	7	8	9	10

5. Bank Vegetation Density

	Poor		Marginal			Good			Excellent	
	Vegetation very sparse Covers < 25% of bank Large bare spots visible		Vegetation somewhat sparse Covers 25-50% of bank Several bare spots are visible			Vegetation fairly thick Covers 50-80% of bank Few bare spots			Vegetation thick Covers > 80% of ground No bare spots	
Left	1	2	3	4	5	6	7	8	9	10
Right	1	2	3	4	5	6	7	8	9	10

6. Bank Stability

	Poor		Marginal			Good			Excellent	
	Unstable, Severe undercutting or erosion Bare roots visible Vertical slopes		Largely unstable, High level of undercutting or erosion Some bare roots visible Steep slopes			Moderately stable, Low level of undercutting or erosion Banks are healing Moderate slopes			Stable No areas of erosion No bank failure Gently sloping (low banks)	
Left	1	2	3	4	5	6	7	8	9	10
Right	1	2	3	4	5	6	7	8	9	10

7. Channel Modification

Poor		Marginal			Good			Excellent	
Channel – highly modified Concrete channel Both sides modified		Channel – slightly modified One side of channel has been rip rapped or hard stabilized			Channel – slight alterations Occasional modifications are present but overall free-flowing			Channel - not modified Stream is completely free-flowing on both sides	
1	2	3	4	5	6	7	8	9	10

8. In-Stream Cover
(undercut banks, overhanging vegetation, pools, logs & rocks)

Poor		Marginal			Good			Excellent	
Virtual no habitat		Infrequent habitats, Habitats are further than 25 yards apart			Frequent habitats, Habitats are within 10 yards of one another			Many habitats Continuous throughout stream	
1	2	3	4	5	6	7	8	9	10

9. Embeddedness

Poor		Marginal			Good			Excellent	
Rocks deeply stuck into sediments Rocks barely visible		Rocks more than ½ surrounded by sediments Rocks can not be easily flipped			Rocks partially surrounded by sediments Rocks can be easily flipped			Rocks free from sediments Little sediments along stream bottom	
1	2	3	4	5	6	7	8	9	10

10. Shading (Canopy Cover)

Poor			Good				Excellent		
Little to no canopy < 25% of stream shaded			Partial coverage of canopy 25 - 75% of stream shaded				Nearly complete canopy coverage > 75% of stream shaded		
1	2	3	4	5	6	7	8	9	10

*************************************** SCORE ***************************************	
A. Total Number of Points Scored (Add Number of Points Scored in 1 through 10*) Scores for 1-6 are determined by added individual bank scores & then dividing by 2	pts
B. Total Number of Possible Points	100 pts.
C. Score (divide A by B & multiply by 100)	%

Score	**0 - 35%**	**36 – 65%**	**66 – 85%**	**86 – 100%**
Rating	***Poor***	***Marginal***	***Good***	***Excellent***

Personal Rating of Stream Segment:

Poor Marginal Good Excellent (circle one)

Stormwater Discharge Pipes:

No. Observed: None 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 (circle one)

Livestock Access to Stream:

Yes No (circle one)

Brief Description of Stream Segment:

____

____

Suggestions for Improving the Stream Segment:

____

____

❑ Riparian Buffer (trees & shrubs): Left Bank ____________ ft / yd Left Bank ____________ ft / yd
❑ Riparian Buffer (grasses & herb.): Left Bank ____________ ft / yd Left Bank ____________ ft / yd

Distance Determined: _____ Measuring Tape _____ Range Finder _____ Estimated

Sketch of Assessed Stream Segment

Watershed Assessment: Problem Areas

Aqua-Link, Inc.

Project Name: Cooks Run
Project No. 1005-05
Initials: ______________

Stream Name: ____________________
Date: ____________________________
Time: ____________________________

Stream Segment (if applicable): ______ - ______

Flow Conditions: _____ Baseflow _____ Stormflow

Distances Reported: _____ Measuring Tape _____ Range Finder _____ Estimated

Mean Stream Width: _____________ ft.

GPS Information (record in d.ddddd):

Location of Problem Area: _______ Waypoint ID ____________ Lat. ___________ Long.

Photograph Information:

Photograph ID ________________ Description ___________________________________
Photograph ID ________________ Description ___________________________________
Photograph ID ________________ Description ___________________________________
Photograph ID ________________ Description ___________________________________
Photograph ID ________________ Description ___________________________________

Land Uses (Estimate Percentage):

_____ Urban/Commercial
_____ Park & Fields (lawn)
_____ Forest
_____ Residential (lawn)
_____ Ag Row Crop
_____ Field (scrub & shrub)
_____ Residential (forest)
_____ Ag Pasture (fallow)
_____ Meadow
_____ Other (describe): ____

Type of Problem (Circle):

SBE	Streambank erosion
LBE	Lake bank erosion
SCE	Stream channel erosion (incision)
SCW	Stream channel widening
RBN	Riparian buffer - none
RBP	Riparian buffer – poor
AGL	Agriculture – livestock
AGH	Agriculture – horses
AGP	Agriculture - pasture erosion
AGR	Agriculutre - row crops
AGM	Agriculutre – manure
BYR	Barnyard runoff
SS	Septic systems
SWR	Stormwater runoff
LOG	Logging
CON	Construction
AMD	Acid mine drainage
RDE	Roadside ditch erosion
RSE	Road surface erosion

OTH Other ____

Suggestions for Improving the Problem Area:

____

____

____

____

RBW	Riparian buffer (trees & shrubs)
RBH	Riparian buffer (grass & herb.)
BSP	Bank stabilization (plantings only)
BSB	Bank stabilization (bioengineering)
BS	Bank stabilization (gabions, rip rap)
FDS	Flow deflecting structures
FHS	Fish habitat structures
SCR	Stream Channel Restoration
EF	Exclusionary fencing
PSC	Protected stream crossing
OSWS	Off-stream water source
SOI	Stormwater outlet improvements
DGRI	Dirt & gravel road improvements
NMP	Nutrient management plans
BYI	Barnyard improvements

OTH Other ____

Sketch of Problem Area:

APPENDIX F

NPS Problems & Discharge Pipe Data

NPS Watershed Problems - Information

Site ID	Location	Stream Segment	Site Priority Ranking	Problem(s)	Banks	Distance (feet)	Corrective Measure(s)
P1	CR	3-4	4	SBE SCW RBN	both	315	BSB BSP RBW
P2	CR	4-5	5	SBE RBN	right	75	BSB RBW
P3	CR	10-11	3	SBE RBN	left	120	BSB RBW or SCR BSB RBW
P4	CR	12-13	5	SBE RBN	left	30	BS RBW + FDS
P5	CR	13-14	3	SBE RBP	left	150	BSB RBW
P6	CR	14-15	1	Debris + SBE minor	left	10	Remove debris jam
P7	CR	14-15	4	SBE RBN	both	100	BSP RBW + Fix SW Pipe
P8	CR	15-16	2	SBE	left	60	BSP
P9	CR	15-16	2	All woody vegetation removed	both	210	BSP (low shrubs - heliport)
P10	UNT		2	SBE RBN	both	425	RBW RBH
P11	UNT		2	SBE minor + Debris			BSP + remove debris jam
P12	UNT		3	SBE RBP	both	80	BSB + large rock in channel
P13	UNT		3	SBE RBN	both	100	BSB

NPS Problems

SBE	Streambank erosion
LBE	Lake bank erosion
SCE	Stream channel erosion (incision)
SCW	Stream channel widening
RBN	Riparian buffer - none
RBP	Riparian buffer - poor
AGL	Agriculture - livestock
AGH	Agriculture - horses
AGP	Agriculture - pasture erosion
AGR	Agriculutre - row crops
AGM	Agriculutre - manure
BYR	Barnyard runoff
SS	Septic systems
SWR	Stormwater runoff
LOG	Logging
AMD	Acid mine drainage
RDE	Roadside ditch erosion
RSE	Road surface erosion

Corrective Measures

RBW	Riparian buffer (trees & shrubs)
RBH	Riparian buffer (grass & herb. plantings)
BSP	Bank stabilization (plantings only)
BSB	Bank stabilization (bioengineering)
BS	Bank stabilization (gabions, rip rap)
FDS	Flow deflecting structures
FHS	Fish habitat structures
SCR	Stream Channel Restoration
EF	Exclusionary fencing
PSC	Protected stream crossing
OSWS	Off-stream water source
SOI	Stormwater outlet improvements
DGRI	Dirt & gravel road improvements
NMP	Nutrient management plans
BYI	Barnyard improvements

Stream Discharge Point Information

Discharge	Type	Stream Segment	Shape	Diameter (inches)	Drainage	Problem	Severity
D01	SW	1-2	round	12	Keenan Collision	PFS (50%)	1
D02	SW	1-2	round	24	Route 313		
D03	SW	6-7	round	12	Main St.	SCS	2
D04	SW	6-7	round	24	Main St.	SCS	2
D05	SW	7-8	round	18	Main St.		
D06	SW	7-8	round	18	Mercer Sq. Shop Center		
D07	SW	8-9	round	12	Old Dublin Pike		
D08	SW	8-9	round	18	Mercer Sq. Shop Center		
D09	SW	8-9	round	18	Mercer Sq. Shop Center		
D10	SW	9-10	round	36	Mercer Sq. Shop Center		
D11	SW	9-10	round	18	Mercer Sq. Shop Center		
D12	SW	10-11	round	36	Old Dublin Pike		
D13	SW	10-11	round	18	Old Dublin Pike		
D14	SW	10-11	round	18	Doylestown Shop Center		
D15	SW	11-12	round	18	Lantern Hill Develop.		
D16	SW	11-12	square	36 x 60	Doylestown Shop Center		
D17	SW	11-12	round	12	Veteran's Lane		
D18	SW	11-12	round	24	Lantern Hill Develop.		
D19	SW	11-12	round	36	Lantern Hill Develop.		
D20	SW	11-12	round	20	Veteran's Lane		
D21	SW	11-12	round	4 pipes @ 24	Detention Basin @ Heritage Towers		
D22	SW	11-12	round	15	Veteran's Lane		
D23	SW	12-13	round	30	Basin @ Heritage Commons		
D24	SW	12-13	round	10	Heritage Commons		
D25	SW	12-13	round	12	Heritage Commons		
D26	SW	12-13	round	12	Veteran's Lane		
D27	SW	12-13	round	24	Basin @ Heritage Commons		
D28	SW	12-13	round	16	Veteran's Lane		
D29	SW	12-13	round	12	Veteran's Lane		
D30	SW	13-14	round	30	Broad Street		
D31	SW	13-14	round	15	Broad Street	SBE-1	3
D32	SW	14-15	round	18	Behind WWTP		
D33	SW	14-15	round	15	Behind WWTP		

Stream Discharge Point Information

Discharge	Type	Stream Segment	Shape	Diameter (inches)	Drainage	Problem	Severity
D34	WWTP	14-15	round	30	WWTP Point Source		
D35	SW	14-15	round	30	Retention Basin @ WWTP		
D36	SW	14-15	round	34	Hampton Court		
D37	SW	14-15	round	12	Hampton Court (Westwyck Develop.)		
D38	SW	14-15	round	12	Hampton Court (Westwyck Develop.)	Other - clogged with debris	2
D39	SW	14-15	round	12	Hampton Court (Westwyck Develop.)		
D40	SW	14-15	round	24	Hampton Court & Limekiln Pike (Westwyck Develop.)		
D41	SW	14-15	round	24	Limekiln Pike	SBE-1	5
D42	SW	14-15	round	15	Limekiln Pike		
D43	SW	15-16	round	12	Progress Drive (20 yds away from bank)		
D44	SW	15-16	round	12	Progress Drive (20 yds away from bank)		
D45	SW	15-16	round	16	Progress Drive @ stream crossing		
D46	SW	15-16	round	24	Drainage at hospital near heliport		
D47	SW	15-16	elliptical	14 X 23	Drainage at hospital near heliport		

Notes:

PFS	Partially filled with sediment
SCS	Stream channel scour
SBE-1	Stream bank erosion around pipe
SBE-2	Streambank erosion - opposite bank
Other	