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We would also like to thank all of the municipalities in the watershed including the city of Allentown, East Penn Township, Heidelberg Township, Lowhill Township, Lynn Township, Upper Macungie Township, Washington Township, Weisenberg Township, Whitehall Township, North Whitehall Township and South Whitehall Township. We thank you for all of your cooperation and assistance in meeting with Conservancy staff to identify valuable resources as well as potential problems within the watershed, discussing management options and for providing recommendations to be included in the management plan.

Jordan Creek Watershed Conservation Management Plan

2000

Wildlands Conservancy

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INTRODUCTION

Vildlands Conservancy has selected the Jordan Creek for this project because recent threats om non-point source pollution have resulted in the creek's listing as a high-priority water body n the Degraded Watershed List for Pennsylvania. In addition, the Jordan Creek has been owngraded from the high quality status it held until 1987.

Vildlands Conservancy has received a Pennsylvania Rivers Conservation Program Planning Grant for the Jordan Creek. A study of the Jordan Creek and the preparation and publication of a comprehensive Jordan Creek Watershed Management Plan were the intended outcomes of the grant. The Pennsylvania Rivers Conservation Program was created by the Pennsylvania Department of Conservation and Natural Resources (Pa. DCNR). The objective of the program is to conserve, restore and enhance Pennsylvania's rivers through partnership, education, awareness and stewardship.

The primary goals of the Jordan Creek Project are to restore the physical and biological health of the stream; establish management practices to prevent additional degradation of the stream; preserve critical cultural and natural resource areas within the watershed; and ultimately have the Jordan Creek listed on the Pennsylvania Rivers Registry. Inclusion on the Registry will qualify the Jordan Creek watershed for technical and financial assistance from the state for restoration and improvement projects.

In order for the Jordan Creek to be included on the Registry, Wildlands Conservancy has created this conservation management plan, which identifies the historical, cultural, natural and physical resources along the creek. The plan also characterizes the water quality and aquatic life of the stream, as well as identifies any problem areas in the watershed. In addition, the plan contains recommendations for conservation and preservation of the Jordan Creek based on information collected as part of this project and on input from public hearings and informational meetings with municipalities.

1.0 PHYSICAL RESOURCES

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1.1 Size and Location

The entire 82.3 square mile Jordan Creek watershed (Figure 1), which is located within nine townships and the city of Allentown in Lehigh County, Pa., was evaluated comprehensively as part of this Rivers Conservation planning project. The headwaters of Jordan Creek are located in Heidelberg Township at the base of Blue Mountain, just north of Jordan Valley and Germans Corners. The main stem of the Jordan Creek winds its way 31.3 miles southeast through Lowhill, North Whitehall, South Whitehall, and Whitehall Townships, and lastly through the city of Allentown to its confluence with the Little Lehigh Creek (Figure 2).

The Jordan Creek has four main tributaries (Figure 3 and Table 1). Switzer Creek, which is the first to enter the main stem, originates in Lynn Township and flows northeast to the confluence in Lowhill Township. The second major tributary to enter the Jordan is Lyon Creek. It forms just south of Hynemansville in Weisenberg Township proceeding north to its confluence with the Jordan in Lowhill Township, slightly west of Weidasville and south of State Game Lands No. 205. The headwaters of Mill Creek are located in Washington and Heidelberg Townships. They combine in the southeast corner of Heidelberg and continue flowing south through the State Game Lands No. 205 to the confluence with Jordan Creek in Lowhill Township. The source of Haasen Creek is also located in Weisenberg Township; however, it first flows east to Upper Macungie Township and then northeast past Fogelsville Pond to the confluence with Jordan Creek in the west end of South Whitehall Township.

Table 1. Jordan Creek Tributaries and Drainage Areas

Tributary	Length (mi)	Drainage Area (mi^2)
Switzer Creek	6.25	8.38
Lyon Creek	5.10	12.60
Mill Creek	4.75	9.60
Haasen Creek	3.11	7.74
Jordan Creek (main stem)	31.3 0	43.98
Watershed Total		82.30

1.2 Physiography and Topography

The Jordan Creek watershed is located within the Great Valley Section of the Valley and Ridge Physiographic Province of Pennsylvania. The elevation of the headwaters is at 1530 feet in Heidelberg Township. The creek winds its way toward Allentown with an average slope of 13.8 feet per mile. The mouth of the creek where it flows into the Little Lehigh Creek is at an elevation of 268 feet. Typical of most streams in this region of Pennsylvania, the drainage of the watershed forms a dendritic (branching) pattern. The main drainage channel of Jordan

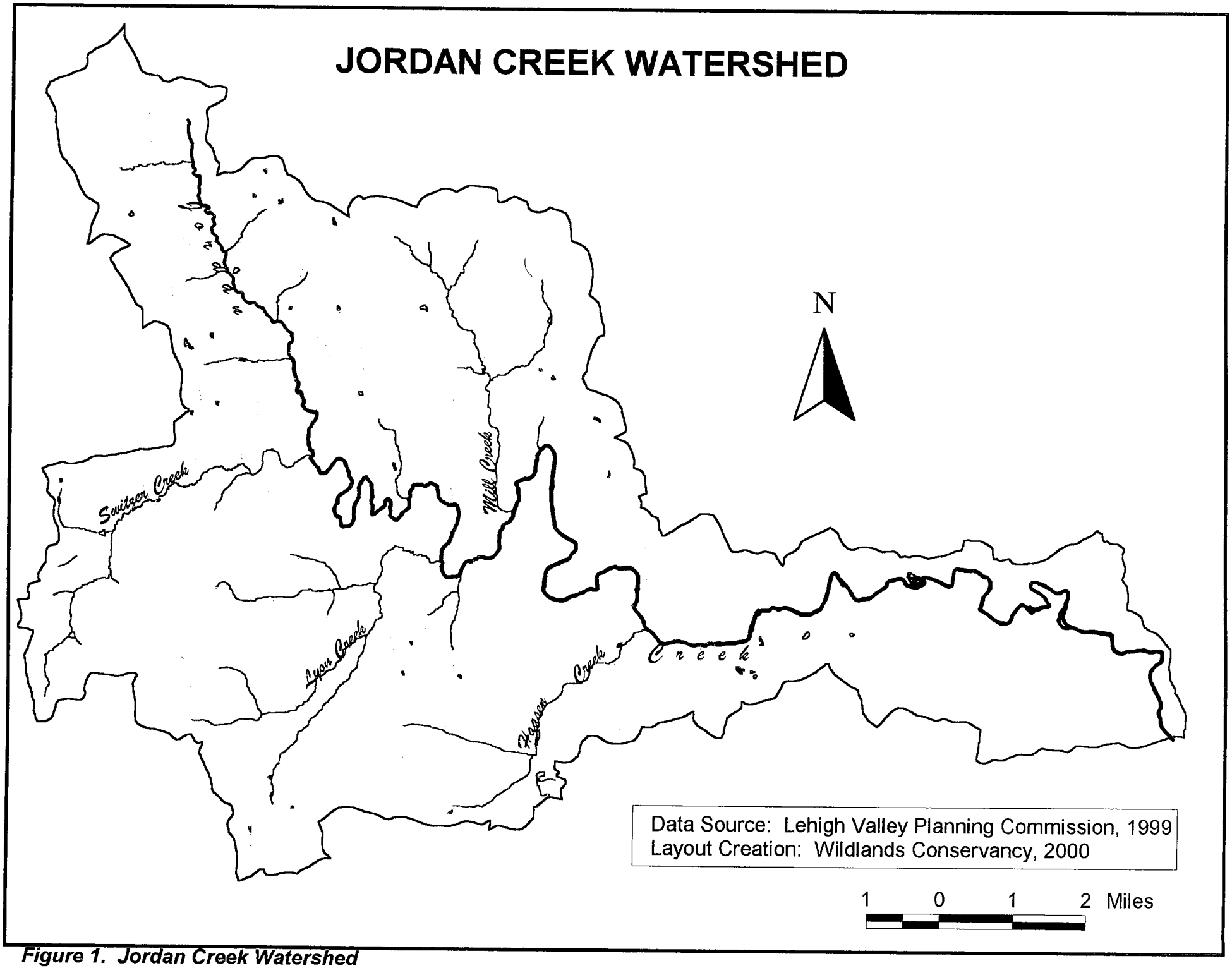


Figure 1. Jordan Creek Watershed

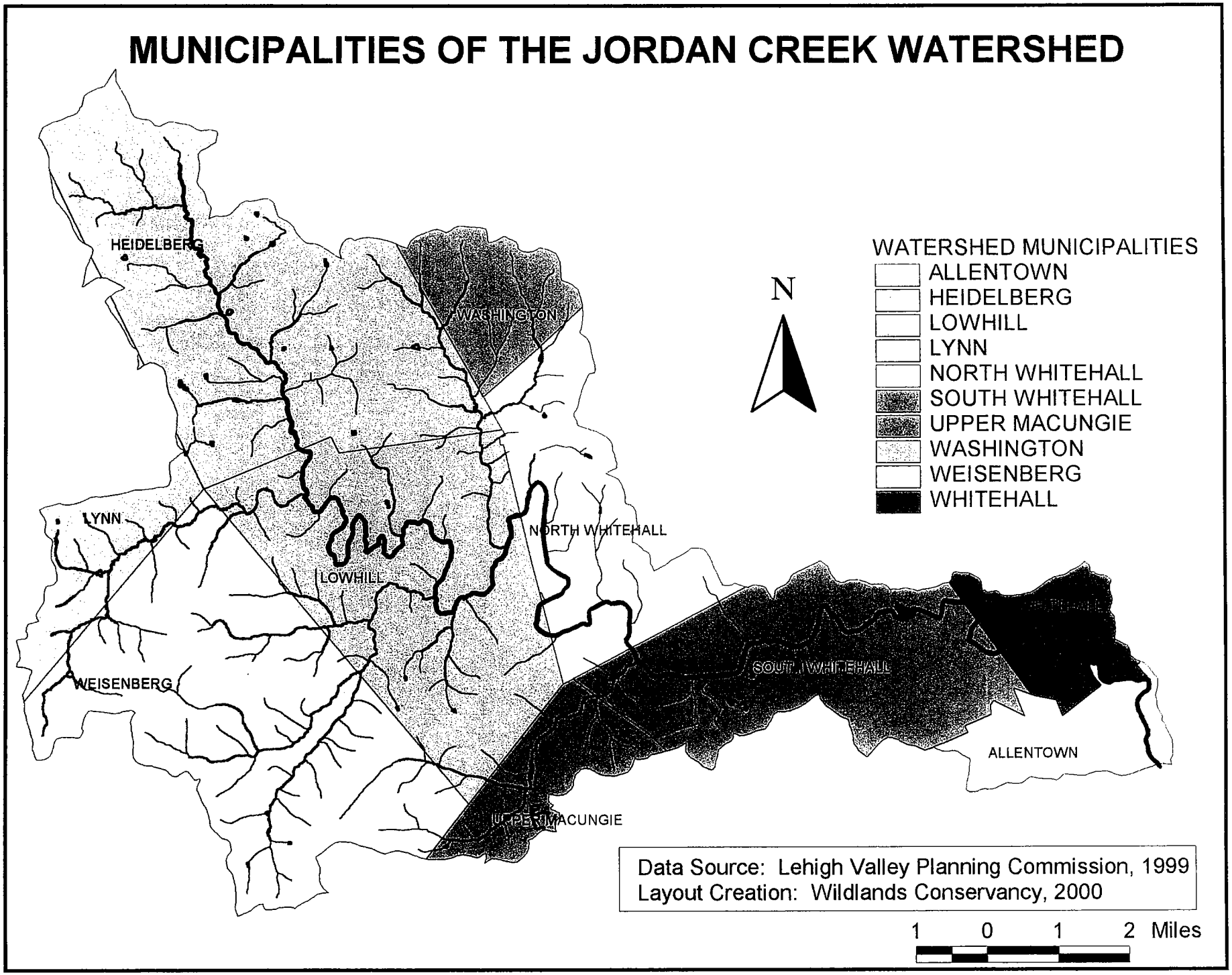


Figure 2. Municipalities of the Jordan Creek Watershed

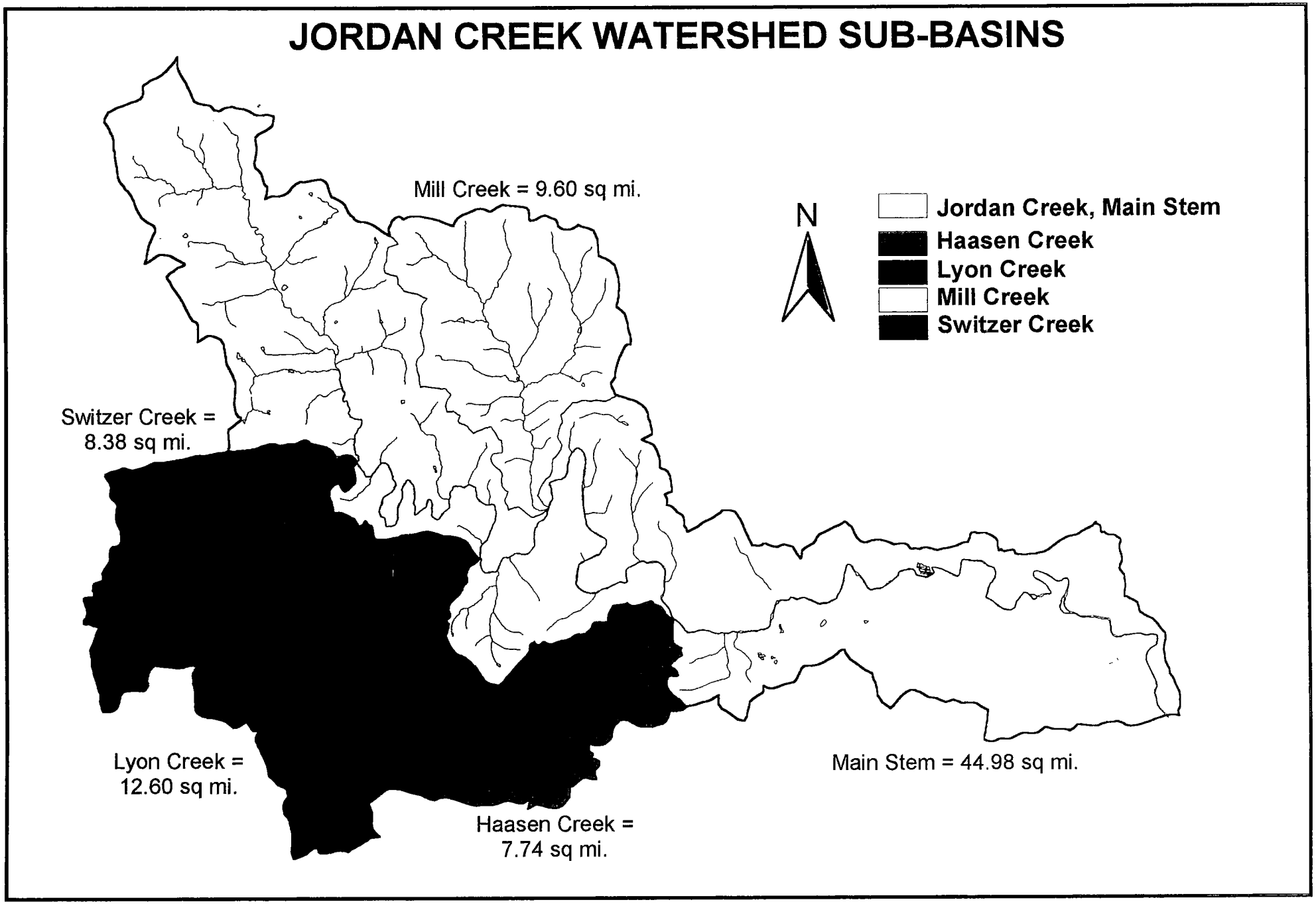


Figure 3. Jordan Creek Watershed Sub-Basins.

Creek forms a tortuous pattern, meaning that it contains several large or exaggerated meanders or bends.

The watershed can be generally divided into three topographic regions. First, mountains and hills with narrowing valleys and moderate slopes characterize the upstream reaches of the watershed. The middle portion of the watershed contains rolling hills, v-shaped to wide valleys, and steep to moderate slopes. Lastly, the downstream reaches, closer to the mouth of the creek, are composed of rolling hills with wide valleys and moderate slopes. Figure 4 is a topographic map of the Jordan Creek watershed.

1.3 Geology

The stratigraphy and structure of bedrock underlying the land surface plays an important role in the physical, chemical and biological interactions of the watershed. The mineral composition of geologic formations determines, in large part, the quality and chemical make-up of both surface and ground waters throughout the watershed. The resulting chemical composition may be a determining factor in what species of flora and fauna live and thrive in the watershed. Factors of geologic structure such as degree of fracturing, folding, or dissolution of bedrock may all be relevant to the quantities of water available for withdrawal by public wells or for irrigation or recreational purposes. The geology of the Jordan Creek watershed is mapped in Figure 5 and listed in Table 2.

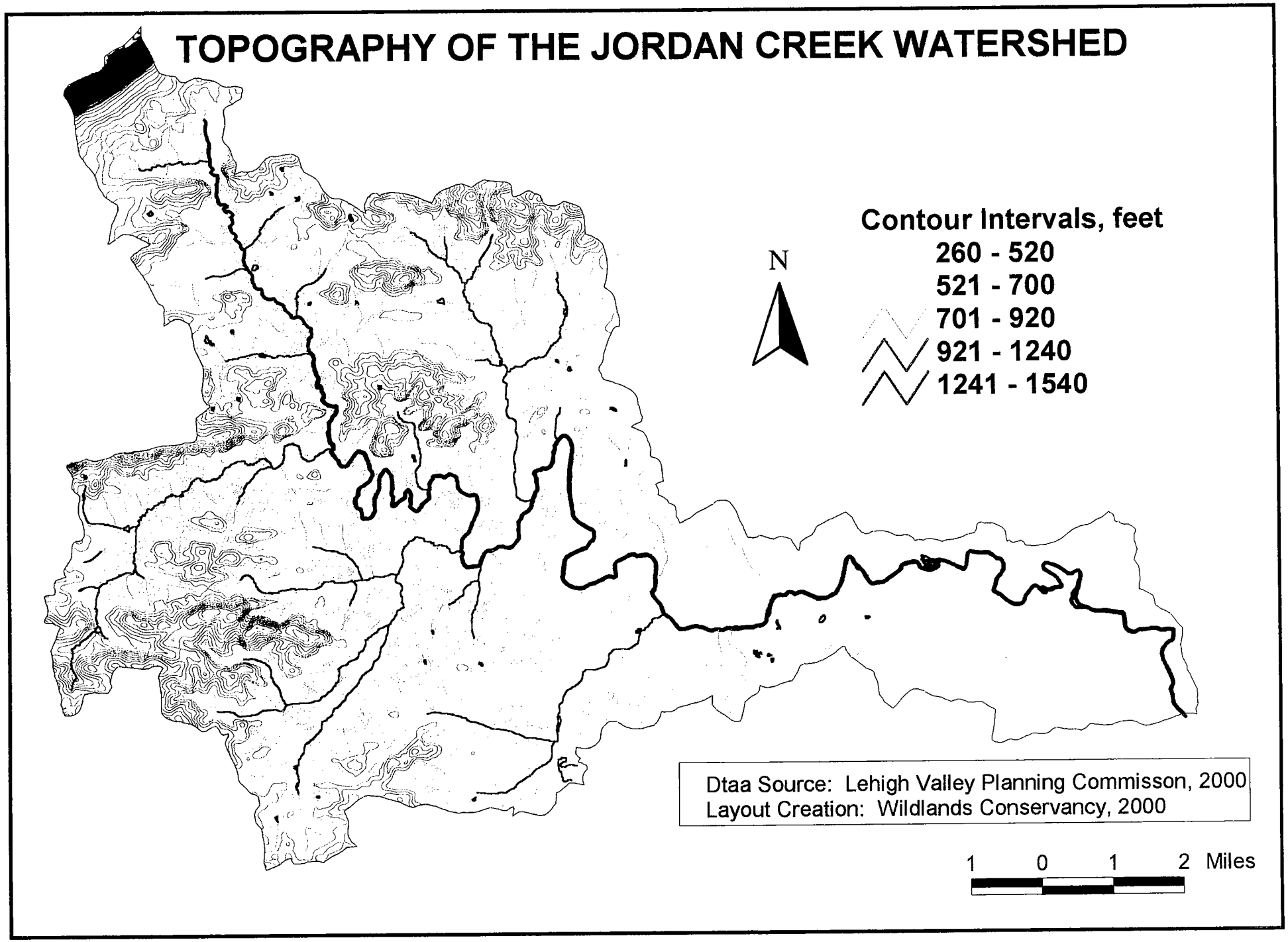


Figure 4. Topography of the Jordan Creek Watershed

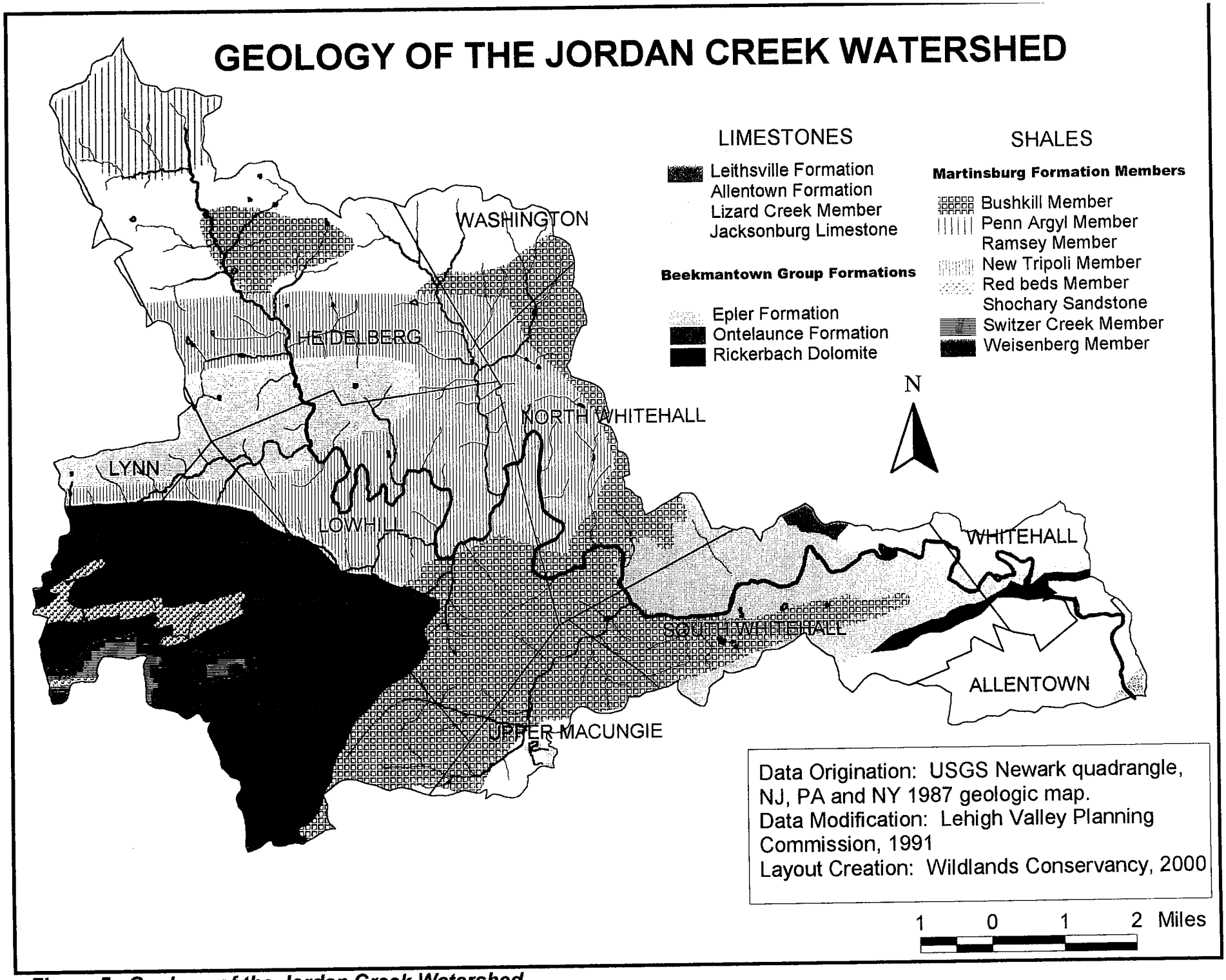


Figure 5. Geology of the Jordan Creek Watershed

Table 2. Bedrock Units of the Jordan Creek Watershed

System	Geologic Unit	Thickness (feet)	Dominant Characteristics
CAMBRIAN	**Allentown Formation**	1,700	typically bluish-gray; alternating light and dark beds
	Leithsville Formation	1,000	medium to dark-gray, crystalline dolomite
ORDOVICIAN	**Jacksonburg Formation**	N/A	dark-colored limestones with variable characteristics
	Martinsburg Formation	N/A	lower part-banded clay slate; Middle part-sandy beds; Upper part-banded like lower part but less sand and beds much thicker
	Bushkill Member		
	Ramsey Member		
	Pen Argyl Member		
	Schochary Sandstone		
	New Tripoli Member		
	Red Beds		
	Switzer Creek Member		
	Weisenberg Member		
	Beckmantown Group	3,950	limestone and alternate calcareous strata
	Epler Formation		
	Ontelaunee Formation		
	Rickenbach Formation		
SILURIAN	**Shawangient Formation**	N/A	contains fragments of lingulid brachiopods, eurypterid remains, and rare Dipleurozoa

The headwaters and middle reaches of the creek are underlain by the Martinsburg Formation, which is characterized by dark gray shale, thin beds of siltstone and sandstone of depths up to 12,000 feet. Slopes along the stream are steep and unstable while surface drainage is good. Ground water yields are an average of 32 gallons a minute, but water quality is poor due to high hydrogen sulfide and iron concentrations (Wood,et al, 1972). After leaving the Martinsburg Formation, the creek is underlain for a few miles by thick beds of laminated light gray limestone of the Beekmantown Group. Bedrock pinnacles and topography of flat to rolling valleys of low relief characterize this area. Ground water yields here are high. The stream then flows for a few miles through the Epler Formation. Medium gray limestone interbedded

with gray dolomite is present here as are sinkholes and caves. The topography is similar to the Beekmantown Group. As the stream nears the confluence with the Little Lehigh Creek it is underlain by gray and impure limestones of the Allentown Formation. This formation has open and steeply dipping fractures that can result in stream flow loss. Sinkholes are also a problem in the areas underlain by this formation (Wood, et al, 1972).

Figure 6. The upper reaches of the Jordan Creek are underlain by the dark gray shales of the Martinsburg Formation.

The geologic formations of the Jordan Creek watershed were all developed during the Cambrian (more than 500 million, but less than 570 million years old) and Ordovician (more than 430 million, but less than 500 million years old) geologic time periods. The Martinsburg, New Tripoli, and Shochary sandstone formations were all developed during the Ordovician time period and underlie the headwaters and mid-section of Jordan Creek; most of Switzer, Mill, and Haasen Creeks; and a small portion of Lyon Creek. The Cambrian formations of the Beekmantown Group and the Allentown and Leithsville limestones and dolomites underlie the lower sections of the Jordan Creek. Table 3 describes the geologic formations found in the watershed.

Table 3. Geologic Formations of the Jordan Creek Watershed

Allentown Formation
Formed during the Cambrian period; composed of broad-banded magnesian limestones; typically bluish-gray in beds 6 to 18 inches thick; alternating light and dark beds are characteristic and caused by varied quantities of carbonaceous matter and a large amount of magnesian carbonate.

Leithsville Formation
Medium to dark-gray, crystalline dolomite, which is light-olive-gray in some places; turns light gray and yellowish-brown when weathered; massively bedded with interbeds of thin shale and dolomitic shale; contains pink to gray mottled chert and dark-gray chert, as well as scattered sand grains; upper part of formation is typically very shaley.

Jacksonburg Formation
A series of dark-colored middle-Ordovician limestones and argillaceous limestones; has variable characters and thickness and is underlain by dolomitic limestones of the Beekmantown Group and the overlying non-calcareous shales of the Martinsburg Formation.

Shawangient Formation
The Lizard Creek member of this formation is located only in the upper northwestern portion of the watershed; contains fragments of lingulid brachiopods, eurypterid remains, and rare Dipleurozoa (a class of jellyfish-like fossils).

Martinsburg Formation
The Martinsburg Formation is best subdivided on a lithologic basis into a lower, a middle and an upper part. The lower part is characteristically a banded clay slate, though there are also thin sandstone beds. The Middle member contains sandy beds as its most typical facies, though some slate beds are also found in it. The uppermost member is banded like the lower, but there is less sand and the individual beds are much thicker.

> Bushkill Member: Lowest member of the Martinsburg Formation, dark-gray, thin-bedded claystone slate; weathers to medium light gray of yellowish brown; contains beds of quartzrose, greywacke siltstone and carbonaceous slate; slate cleavage is dominant; estimated at 4000 feet thick.

Table 3. Continued

Ramsey Member: Middle member of the Martinsburg Formation, consists of alternating beds of light- to medium-gray claystone slate, greywacke siltstone, and fine- to medium- grained greywacke; weathers to yellowish brown; claystone has well-developed slaty cleavage; greywacke broken by poor to good fracture cleavage that grades into flow cleavage.

Pen Argyl Member: Upper member of the Martinsburg Formation, dark gray to blackish claystone slate; weathers to yellowish-brown; thin beds of quartzrose slate and carbonaceous claystone slate; quartzrose beds average one foot thick; slate beds commonly five feet thick; slate cleavage is well developed.

Shochary Sandstone: Middle Ordovician; comprised of shale and calcareous turbidities; sedimentary characteristics.

New Tripoli Member: Middle Ordovician; comprised of shale and calcareous turbidities; sedimentary characteristics.

Red Beds: Dusky red to grayish-yellow and light green mudstone and argillite.

Switzer Creek Member: Conglomeratic graywacke, interbedded with dark green and gray mudstone and shale.

Weisenberg Member: Light olive gray to grayish-olive shale and mudstone to micaceous shale.

Beekmantown Group

The Beekmantown Group consists almost exclusively of limestones and alternating calcareous strata of varying composition and physical properties. High magnesian limestones (dolomites) are predominant, especially in the lower part, but there are many interbedded strata containing a medium or low percentage of magnesium carbonate ($MgCO_3$).

Table 3. Continued

Epler Formation: Thick-bedded; medium to medium-dark gray, finely crystalline limestone; inter bedded with medium-dark gray, finely crystalline dolomite; limestone turns light gray when weathered and dolomite turns yellowish-gray; contains edgewise conglomerate, fossil fragments, and oolitic lenses.

Ontelaunee Formation: Almost singly limestone; mostly dolomitic; extensively quarried; medium-dark gray, finely laminated; turns yellowish-gray when weathered; thick-bedded with dark-gray chert layer at base.

Rickenbach Formation: Medium to dark gray, coarsely crystalline dolomite in lower part; medium to medium light gray, finely crystalline dolomite in upper part; contains chert lenses, beds and nodules

1.4 Rock and Mineral Resources

The rocks and minerals found in the bedrock of the Jordan Creek watershed have historically played a major role in the economy of the region. Limonite iron ore deposits, which worked well in old charcoal and newer anthracite furnaces and produced excellent foundry iron and gun metal, were abundant in the Lehigh Valley and heavily mined between 1910 and 1915. Quarries for non-metal construction aggregates eventually became a major industry for the watershed. These aggregates included crushed stone, sand, gravel, and slag that were used to add strength and bulk to concrete and bituminous mixes, mortars, plasters, etc. Sand and gravel quarries are the main source of aggregate within Pennsylvania, followed closely by carbonate rocks. Construction materials such as building stone were often the by-product of quarries in areas containing some carbonate units. Even more important and abundant within the Jordan Creek watershed are the limestone and dolomite formations. Locally important sources of these materials include the Ontelaunce, Epler, Rickenbach dolomite and Allentown formations.

1.5 Soil Characteristics

Soil characteristics directly influence many natural functions and interactions of a watershed, as well as many activities occurring within and values placed on a watershed by man. For instance, different types of soils allow different rates of precipitation infiltration, thus affecting soil moisture content, groundwater recharge, base flows in creeks, etc. Man may also value one soil type over another because it has more nutrients, making it more favorable for agricultural use, or because the depth of one is more conducive to development than another. The parent materials of a soil type may also lead to significant impacts on water quality. Most of the soil series in the Jordan Creek watershed are formed from weathered limestone. This has a significant impact on water quality, especially on the pH and alkalinity of the system. Water flowing through weathered limestone soils may pick up carbonate ions that contribute to a higher pH and better alkalinity than water flowing through soils derived from other types of bedrock. The majority of the other soil series in the watershed originated from weathered shale, sandstone, and slate. The slope and location of a type of soil are also significant factors. Many of the soils mapped in the Jordan Creek watershed are found on steep slopes and are moderately too highly erodible. Vegetation along the stream banks in these areas is essential in order to minimize the effects of erosion and sedimentation on stream quality. These are just a very few examples of why evaluation of soil characteristics is essential for proper management of a watershed. Figure 7 shows the location of the different soil types in the watershed.

The largest soil series in the Jordan Creek watershed are the Berks-Bedington Complex, the Duffield-Ryder Silt Loam and the Washington Silt Loam. Urban Land is also a predominant classification in the watershed. The main stem of the Jordan Creek has its headwaters in mixtures of the Ladig Gravelly Loam, the Brinkerton-Comly Silt loam, the Comly loam, Buchanan Gravelly Loam and the Beddington-Berks Complex. The majority of the main stem of the Jordan flows through the Berks-Beddington Complex and into the Washington and the Duffield-Ryder Silt Loams and is surrounded by the Urban Land of Allentown as it flows toward its confluence with the Little Lehigh.

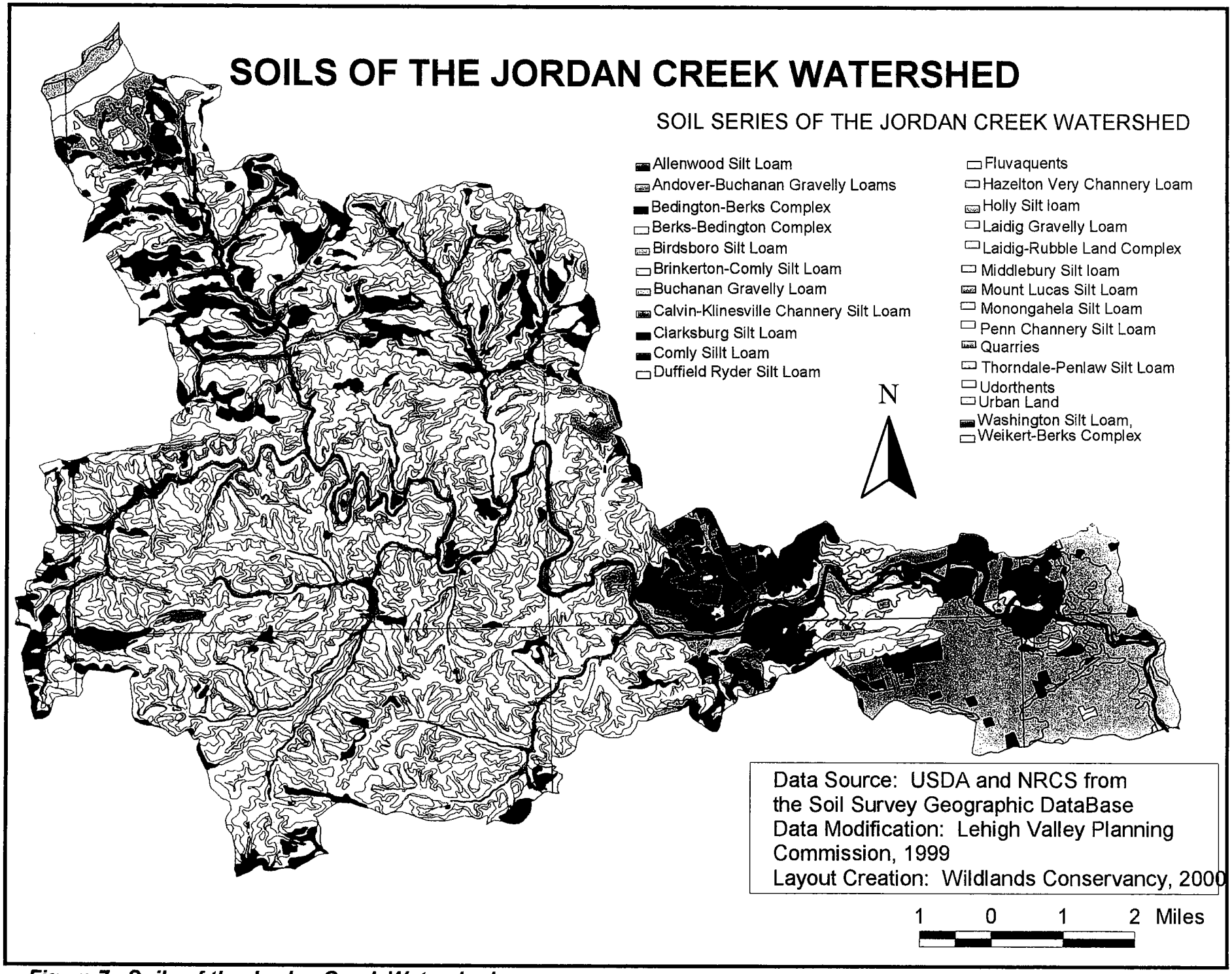


Figure 7. Soils of the Jordan Creek Watershed

Berks-Bedington Complex

The Berks series consists of moderately deep, well-drained soils formed in materials weathered from shale, siltstone and sandstone. Typically these soils have a dark brown channery silt loam surface 10 inches thick. In sequence from the top the upper 7 inches is yellowish-brown channery loam; the next 4 inches is yellowish brown very channery silt loam. The lower 5 inches is strong brown very channery loam. The friable substratum is yellowish-brown very shaly loam. Bedrock is at a depth of 33 inches. The Bedington series consists of very deep, well-drained soils on uplands. They formed in materials weathered from shale, siltstone and sandstone. Typically these soils have a dark brown, channery silt loam surface layer 10 inches thick. The subsoil form 10 to 17 inches is strong brown channery silt loam, from 17 to 35 inches is yellow red channery silt loam and from 35 to 43 inches is yellowish red very channery silt loam. The substratum from 43 to 63 inches is yellowish red extremely channery silt loam.

Duffield-Ryder Silt Loams

The Duffield series consists of very deep and deep, well drained soils on uplands. They formed in material weathered from impure limestone. Typically these soils have a dark grayish brown silt loam surface layer 10 inches thick. The subsoil from 10 to 53 inches is yellowish-brown and brownish-yellow silty clay loam. The substratum from 53 to 60 inches is yellowish-brown shaly silt loam. The Ryder series consists of moderately deep, well-drained soils on uplands. They formed in material weathered from shaly limestone. Typically, these soils have a dark brown silt loam surface layer, 8 inches thick. The subsoil from 8 to 23 inches is yellowish-brown friable silt loam. The substratum from 23 to 33 inches is light olive brown very shaly silt loam. Thin-bedded shaly limestone is at 33 inches.

Washington Silt Loam

The Washington series consists of very deep, well-drained soils on uplands. They formed in glacial till. Typically these soils have a dark yellowish brown loam surface layer 9 inches thick. The strong brown subsoil from 9 to 17 inches is loam and from 17 to 52 inches is clay loam. The substratum from 52 to 72 inches is brownish yellow loam grading to gravelly silt loam with depth. Bedrock is at 72 inches.

Urban Land

Urban land is land mostly covered by streets, parking lots, buildings and other structures of urban areas.

Because agricultural activities comprise the majority of the land uses in the Jordan Creek watershed, it is important to assess soils based on their suitability to agriculture. The soils of the Jordan Creek watershed are broken down into two agricultural classifications, "prime" and "additional" farmland. Prime farmland exists mostly on low gradient slopes and has specific soil characteristics. The soil types that are unique to the prime farmland distinction are usually deep, moderately-to well-drained soils and rate moderate to good in natural fertility of the soil. Many of these soil types exist on flood plains or stream terraces and have high moisture capacities. Because of the location of the Jordan Creek Watershed in relation to Blue Mountain, it is likely that much of this flood plain fertility is due to the nutrients that have

washed out of the soil and down the mountain. Because of their frequent proximity to streams, these soils are often subject to some flooding and, therefore, erosion problems.

The soil types unique to the additional farmland distinction display subtle differences from the soils of the prime farmland distinction. Whereas the prime farmland tends to be on low gradient slopes, the "additional" farmland will exist in depression areas as well as on low gradient slopes. These depression areas make these additional farmland locations more selective as to the crops that can be planted. The additional farmland soils are typically poorly draining soils also found on the flood plains, but with less ability to drain rising waters. In periods of heavier rains, these soils can cause erosion problems for crops, but have fairly good productivity when they have drained for extended periods of time. Additional farmland soils are usually more suitable for pastures because of frequent flooding and poor drainage. Table 4 describes each soil type in the Jordan Creek watershed, including its suitability for agricultural activities.

1.6 Sinkholes

Many of the critical areas of the watershed are a result of underlying carbonate bedrock throughout much of the lower portion of the Jordan. Sinkholes and land subsidence are two typical hazards associated with carbonate bedrock. Both natural and man-made causes including dissolution of soluble rock, underground erosion, compaction of sediments, tectonic movements, mining and fluid extraction are common contributors to their development. Closed depressions are the most common surface feature of these processes. They are typically bowl-shaped, but can be linear and trough-like. Sinkholes form similar to closed depressions and are a surface expression of soil and colluvium that have been transported into voids within the underlying carbonate bedrock. The difference from a closed depression is that sinkholes have a distinct break in the ground surface. Sinkholes can be a major hazard, especially on roadways or when they develop suddenly and without warning to those in the vicinity. The sinkholes of the Jordan Creek watershed identified in the W.G. Kochanov Sinkhole Survey and are mapped in Figure 8.

Table 4. Soil Series in the Jordan Creek Watershed.

Soil Type	Parent Material	General Description
Allenwood Silt Loam	Formed in glacial till derived from shale, siltsrone and sandstone.	Consists of deep, well drained soils on uplands. A water table when present is >6 feet. **Soil productivity is very high.**
Andover-Buchanan Gravelly Loams	The Andover series formed in colluvial material. The Buchanan series formed in colluvium derived from sandstone, siltstone and shale.	Both series consist of deep, poorly drained soils on uplands. **Neither series are suited to cropland.**
Bedington-Berks Complex	This complex formed in materials weathered from shale, siltstone and and sandstone.	The Bedington series consists of very deep, well drained soils on uplands with **high productivity**. The Berks series consists of moderately deep, well drained soils with **moderate productivity.**
Birdsboro Silt Loam	Formed in stream deposits washed from uplands underlain by red sandstone, shale and siltstone.	Consists of deep, well to moderately drained soils on terraces and alluvial fans. **This soil has a productivity that is very high.**
Brinkerton-Comly Silt Loam	The Brinkerton series formed from colluvium. The Comly series formed in material weathered from shale and influenced by glacial, periglacial or colluvial action.	The Brinkerton series consists of very deep, poorly drained soils on uplands with **moderate productivity**. The Comly series consists of deep, well drained soils on uplands with moderate productivity.
Buchanan Gravelly Loam	Formed in colluvium derived from sandstone, siltstone and shale.	Consists of deep, moderately well to somewhat poorly drained soils on uplands. **Soil productivity is moderate.**
Calvin-Klinesville Channery Silt Loam	The Calvin and the Klinesville series were formed in material weathered from shale, siltstone and sandstone.	The Calvin series consists of moderately deep, well drained soils on uplands with low productivity. The Klinesville series consists of shallow, well drained soils on uplands with **very low productivity**.
Clarksburg Silt Loam	Formed in colluvium glacial till or residuum.	Consists of deep, moderately well drained soils on uplands. This soil has **moderate productivity.**

Table 4. Continued.

Comly Silt Loam	Fromed in material weathered from shale and influenced by glacial, periglacial or colluvial action.	Consists of deep, moderately well drained soils on uplands. This soil has **moderate productivity.**
Duffield-Ryder Silt Loam	The Duffield series was formed in material weathered from impure limestone. The Ryder series was formed in material weathered from shaly limestone.	The Duffield series consists of very deep and deep, well drained soils on uplands with **high productivity**. The Ryder series consists of moderately deep, well-drained soils on uplands.
Fluvaquents	Formed in alluvium with a wide range of textures on floodplains.	Consists of very deep, somewhat poorly to very poorly drained soils. Although highly variable, generally the surface layer is a very dark grayish-brown silt to sandy loam.
Hazelton Very Channery Silt Loam	Formed in material weathered from sandstone.	Consists of deep, well-drained soils on upland. Typically, these soils have a dark brown very stony or extreamly stony sandy loam surface layer. The soil has a productivity that is **not suited to cropland.**
Holly Silt Loam	Formed in loamy alluvium on floodplains.	This soil has a **productivity that is moderate**. Consists of deep, very poorly and poorly drained soils. Areas are used for pasture or cropland.
Laidig Gravelly Loam	Series is derived mainly from sandstone and shale.	Soil permeability is slow and available water holding capacity is low. The soil has a **productivity that is moderate**. Series consits of deep, well-drained soils on uplands.
Ladig-Rubble Land Complex	Rubble land is commonly at the base of rock outcrops and some areas are deposits of cobbles, stones and boulders left on mountain sides by glaciation.	This soil has a productivity that is **not suited to cropland.** Permeability iis slow and available water holding capacity is low. Rubble land consists of areas of stones and boulders.
Middlebury Silt Loam	Series is formed in alluvial material.	Permiability is moderate and available water holding capacity is low. The soil has a **productivity that is high**. The series consists of deep, moderately well drained soils on floodplains.

Table 4. Continued.

Mount Lucas Silt Loam	Series formed in old alluvial material.	Permiability is slow and available water holding capacity is medium. The soil has a **productivity that is moderate**. Series consists of very deep, moderately well-drained soils on terraces.
Monongahela Silt Loam	Series formed in old alluvial material.	Perimability is slow and available water holding capacity is medium. The soil has a **productivity that is moderate**. Series consits of deep, moderately well drained soils on terraces.
Penn Channery Silt Loam	The series was formed in materials from red shale, siltstone and fine grained sandstone.	Permiability is moderately slow and availabe water holding capacity is low. The soil has a **productivity that is moderate**. The series consists of moderately deep, well-drained soils on uplands.
Thorndale-Penlaw Silt Loam	The series formed in colluvium weathered from limestone, shale and sandstone.	Permiability is slow and available water holding capacity is medium. The soil has a **productivity that is moderate.** Series consists of very deep, somewhat poorly-drained soils on uplands.
Udorthents	These are deep, nearly level to steep areas of mostly loamy materials placed on soils to provide sites for buildings, roads, recreational facilities and other uses.	The soil has a productivity that is **not suited to cropland.**
Urban Land	Urban land iis land mostly covered by streets, parkinglots, buildings and other structures of urban areas.	The soil has a productivity that is **not suited to cropland.**
Washington Silt Loam	Series formed in glacial till.	Permeability is slow and available water holding capacity is figh. The soil **productivity is very high**. The series consists of deep, well drained soils on uplands.
Weikert-Berks Complex	Soils formed in materials weathered from shale, siltstone and sandstone.	Berks permeability is moderately slow, available water holding capacity is very low and **productivity is moderate**. Weikert permiability is moderate, water holding capacity is very low and **productivity is very low.**

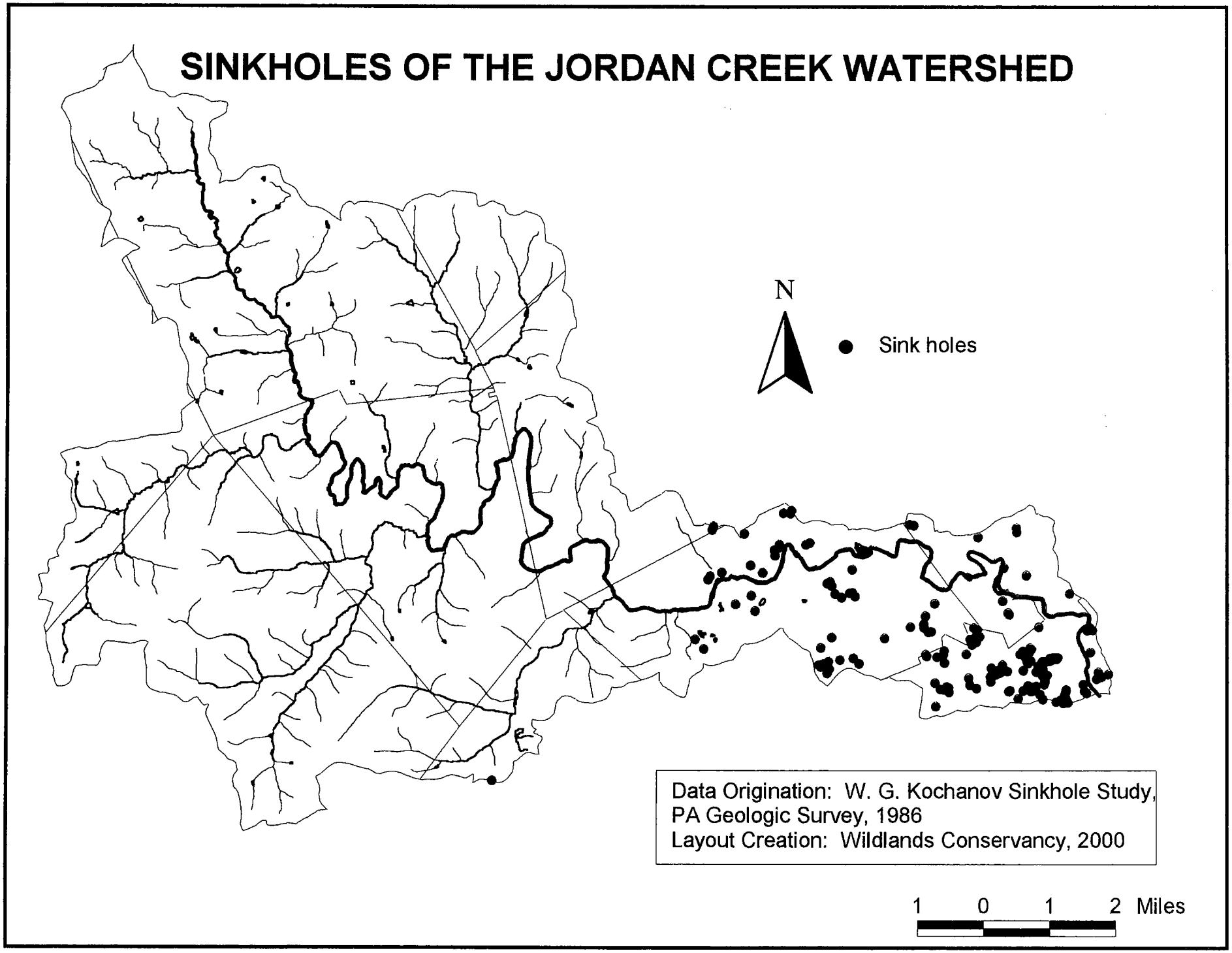


Figure 8. Sinkholes of the Jordan Creek Watershed

2.0 AQUATIC RESOURCES

2.0 AQUATIC RESOURCES

2.1 Water Body Classifications

Waters of the Commonwealth of Pennsylvania are protected by water quality standards based on classified uses of each water body. The Department of Environmental Protection (DEP) uses these standards when regulating discharges. Water quality criteria for the Jordan Creek watershed were developed based on the protected uses defined in Chapter 93 of the Pa. Water Quality Standards, shown in Table 5.

Table 5. Jordan Creek Watershed Chapter 93 Classifications.

Stream Segment	Protected Use	Description
Jordan Creek and all tributaries	Migratory fishery (MF)	Passage, maintenance and propagation of anadromous and catadromous fishes
Jordan Creek (main stem)	Trout stocking fishery (TSF)	Maintenance of stocked trout from 2/15 to 7/31 and maintenance and propagation of additional warm water species
Mill Creek	Cold water fishery (CWF)	Maintenance and propagation of fish (including Salmonidae) and other cold water species
Switzer, Lyon and Haasen Creeks	High-quality cold water fishery (HQ-CWF)	CWF with environmental features requiring special water quality protection

As rural areas of the watershed continue to become more developed as a result of suburban sprawl, continuing conservation efforts will be essential to protecting the integrity of water quality. The effects of economic growth and development on water quality have already been demonstrated on the main stem of Jordan Creek. Here, the use classification of Jordan Creek has already been downgraded from a HQ-CWF to a TSF and MF. The downgrade is a result of increased sedimentation, temperature, and nutrient loading associated with non-point source pollution. Although permitted discharges are regulated such that the receiving waters do not exceed water quality standards based on the above classifications, non-point sources of pollution are currently not monitored and therefore have replaced point discharges as the largest threat to the watershed.

2.2 Water Quality

2.2.1 Review of Existing Water Quality Reports

Evaluating the health of the Jordan Creek greatly depends upon the condition of the Creek prior to the study period. Previous studies provide a comparison for determining if the water quality and habitat conditions are improving or deteriorating. The previous water quality of the Jordan Creek is examined by studies conducted in 1967, 1977, 1985 and 1986.

1967 USGS Water Quality Study
In 1967, in anticipation of the proposed Trexler Dam, the United States Geologic Survey (USGS) studied water quality in the Jordan watershed. Results showed that moderately high flows in Switzer and Lyon Creeks had total phosphate concentrations of 0.82 and 1.7 mg/L respectively, which were high (0.01 mg/L is the standard threshold for unpolluted waters and at 0.10 eutrophication becomes problematic). A sample from tributary streams showed roughly the same concentration of nitrate, all of which were in the range of 8 to 25 mg/L. The high concentrations of phosphates in Switzer and Lyon Creeks are believed to come from farm runoff in stream valleys. Samples analyzed by USGS between June 1972 and July 1973 show that the basin experiences high concentrations of nutrients and chloroform bacteria. Means for nitrite varied from 2.8 mg/L in the upper portions of the Jordan to 4.2 mg/L in Lyon Creek. USGS water quality monitoring data from 1966 to 1975 as been retrieved by Wildlands Conservancy and is analyzed in Appendix E.

1977 Lehigh University Drinking Water Study
In 1977 Lehigh University conducted a sampling program of the Lehigh River and the Jordan Creek that focused on the water quality standards set forth by the 1977 Safe Drinking Water Act. The purpose of the study was to analyze the water for inorganic and organic substances governed by the primary regulations and to evaluate the suitability and treatability of the waters from the above-listed sources for domestic water use. Trace heavy metals analyses were performed on ten different samples. Cadmium and chromium were the only metals to be consistently observed in the water resources studied and no levels in excess of the limitations were observed. Therefore, from a trace metal standpoint all of the waters of the Jordan Creek tested fell within the guidelines for domestic consumption. In addition, trace organic pesticide levels resulted in no detection of any pesticides regulated in the Act. In general, all of the waters of the Jordan Creek were considered to be "of excellent quality for domestic water supply, presenting no special problems for water treatment operations prior to domestic use" (Usinowicz, 1977). Regarding traditional water quality parameters, the Jordan Creek had a mean alkalinity of 44 mg/L (the beneficial range is between 100 and 200 mg/L). In 1977 pH values for the Jordan ranged from 7.9 to 9.3 with a median value of 8.4 (Pa. DEP standards range between 6 and 9) and nitrate values for the Jordan averaged 6.3 mg/L (1mg/L is considered unpolluted and 10 mg/L is the maximum safe drinking level).

1985 Wildlands Conservancy Baseline Study
In 1985 a baseline study of the Jordan Creek was conducted by Wildlands Conservancy. At this time the city of Allentown was relocating a 0.17-mile section of the Jordan Creek as part of

the American Parkway construction project. The purpose of this study was to establish baseline data on the existing creek that could then be used for comparison with future studies on the new channel in order to evaluate the effectiveness of reconstruction methods. An overview of the water quality data shows that pH values were slightly alkaline, ranging from 7.7 to 7.3. The alkalinity and conductivity readings had a similar pattern to water temperatures, and the seasonal trends of alkalinity and conductivity were inverse to that of dissolved oxygen. Dissolved oxygen ranged from 13.6 mg/L to 3.4 mg/L in 1985. The results of these samples show that turbidity and pH had no distinct seasonal patterns. As would be expected, water temperature was higher in fall and spring than in winter. Alkalinity and conductivity also showed higher readings in the fall and spring than in winter. Because colder water can absorb more oxygen, dissolved oxygen levels peaked in the winter samplings.

While conducting this study, researchers noted a fair amount of man-made objects integrated into the substrate of the stream. Objects such as glass, tires and scrap metal were observed frequently while sampling. Another notable observation was the "storm sewer-like" odor that was noted by researchers.

According to the data collected in this base-line study, researchers observed that stream temperature, discharge, turbidity, pH, dissolved oxygen, alkalinity and conductivity levels were generally within the tolerance ranges of the fish and macro-invertebrates surveyed. Researchers concluded that the parameters sampled probably did not provide an abnormally stressful environment for the aquatic fauna within the stretch sampled. The following table is taken from the 1985 Wildlands Conservancy study.

Table 6. Wildlands Conservancy 1985 Water Quality Averages

	Sampling Dates				
Parameter	9/20/84	11/23/84	1/19/85	3/30/85	5/31/85
Water Temperature (°C)	16.10	5.95	1.60	13.85	18.75
Width (m)	12.67	12.90	14.10	14.05	13.53
Mean Depth (m)	0.19	0.20	0.31	0.26	0.24
Mean Velocity (m/sec)	0.06	0.07	0.35	0.24	0.14
Discharge (m^3/sec)	0.14	0.18	1.53	0.89	0.46
Turbidity (NTU)	4.75	9.50	6.45	4.20	4.95
pH	7.10	7.45	7.60	6.90	6.90
Dissolved Oxygen (mg/L)	3.35	11.77	13.60	10.00	8.45
Alkalinity (mg/L $CaCO_3$)	191.50	165.50	65.00	98.00	128.50
Conductivity (μmhos/cm)	615.00	475.00	255.00	320.00	395.00

1986 Pa. DER Drinking Water Study

In 1986 and 1987, the Pa. Department of Environmental Resources-Bureau of Water Quality Management conducted water quality studies on Mill Creek and the main stem of the Jordan Creek. The state water quality standard for nitrate in drinking water is 10 mg/L. This level was exceeded only at the sampling station directly downstream from an industrial waste discharge. Water chemistry data from all other stations revealed elevated levels of fecal bacteria and

nitrates, attributable primarily to agricultural runoff, and secondarily to faulty on-lot septic systems. Siltation of the stream substrate in the upper reaches of the Jordan interferes with colonization of new benthic organisms and limits the availability of fishery habitat. Since there was little earth moving for urban development in the upper watershed, this siltation was most likely attributable to agricultural runoff.

2.2.2 1999 Water Quality Sampling Results and Analysis

Basic water quality data was collected from representative sites throughout the Jordan Creek watershed during the summer of 1999 by Wildlands Conservancy. Monitoring sites included sampling upstream from, downstream from and along each of the four main tributaries and throughout the main stem of the Jordan Creek into Allentown (Figure 9). Water temperature, pH, dissolved oxygen levels, specific conductance, dissolved solids and hardness were the water quality parameters measured by Wildlands Conservancy (Table B1 and B2). Table 7 contains general background information on all of the water quality parameters that were measured in the Jordan Creek. Table B3 summarizes the purposes of testing these parameters. The weekly results were averaged for each location and graphed in order to characterize the conditions along various stretches of the Jordan Creek and its tributaries. The results of these analyses are discussed below.

Water Quality Materials & Methods

Water quality samples were taken once a week for 8 weeks in the summer of 1999. Samples were taken from 14 sampling locations along the main stem of the Jordan Creek as well as one sampling site on each of the tributaries. Each tributary sampling site was approximately within one-half mile of the confluence of the tributary with the Jordan Creek. Water quality parameters were sampled using a Hydrolab DataSonde 3 Probe. The Hydrolab DataSonde 3 Probe was placed in mid-stream at mid-flow and held until pH, dissolved oxygen and turbidity measurements stabilized before a reading was taken.

The Hydrolab DataSonde 3 Probe measures eight water quality parameters. Water temperature was measured with this probe using a thermistor within a range of –5° to 50° C and an accuracy of ± 0.15° C. Specific Conductance was measured with this probe using a 6-electrode cell within a range of 100,000 μmhos/cm and an accuracy of ±1%. Measurements of pH were taken using a glass pH rebuildable or low ionic strength reference electrode sensor within a range of 0 to 14 units and an accuracy of ± 0.2 units. Dissolved oxygen readings were taken with a rebuildable polarographic sensor within a range of 0 to 20 mg/L and an accuracy of ± 0.2 mg/L. Turbidity measurements were taken using an ISO 7027 nephelometric with 880 nm infrared and transmissive correction within a range of 0 to 1000 National Turbidity Units (NTU) and an accuracy of ± 5%.

The remaining water quality parameters of nitrate, ammonia and orthophosphate were sampled and analyzed at Lehigh University. These samples were collected as 1-L samples in 125 mL HCl acid washed High Density Polyethylene (HDPE) Nalgene bottles and kept on ice during transport from the field to the laboratory. The samples were then filtered through pre-rinsed GFF filters and kept at 4° C until they were analyzed within 24 hours. Laboratory analysis of nitrate, ammonia and orthophosphate were performed on a Lachat/Zewellegger

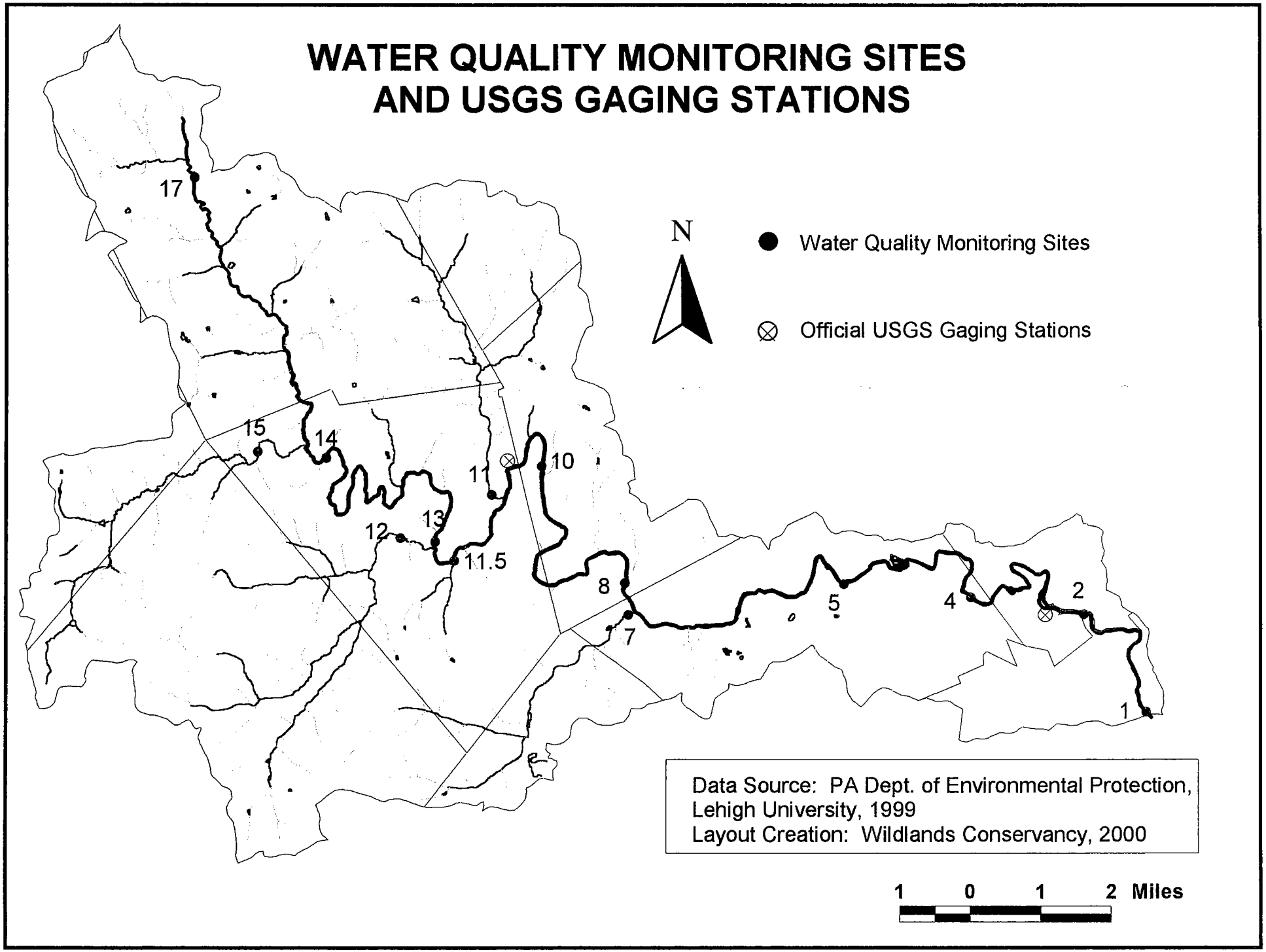


Figure 9. Water Quality Monitoring Sites and USGS Gaging Stations

Table 7. Definitions of Water Quality Parameters

DEFINITION	SOURCES	PURPOSE OF TEST	NORMAL LEVELS
Nitrate			
One of the forms of nitrogen found in aquatic ecosystems; others include ammonia (NH_3) and nitrite (NO_2)	Fertilizer runoff, failing septic systems, animal wastes, decomposing organic matter	High nitrate levels combined with phosphates cause excessive plant and algae growth, a deteriorating process called eutrophication; causes changes in the types of plants and animals in a stream; may lead to low dissolved oxygen; may cause temperature increase	Unpolluted waters normally have less than 1 mg/L, DEP water quality standard is 10 mg/L
Dissolved Oxygen			
A stream with running water will contain more dissolved oxygen than still water; cold water holds more oxygen than warm water	Wastewater from sewage treatment plants, stormwater runoff and failing septic systems	If more oxygen is consumed than produced, some organisms may die due to low levels; spikes in dissolved oxygen may indicate sources of pollution	Trout require at least 7 mg/L dissolved oxygen for unimpaired production; dissolved oxygen levels of at least 4-5 mg/L are needed to support a wide variety of aquatic life

Table 7. Definitions of Water Quality Parameters

DEFINITION	SOURCES	PURPOSE OF TEST	NORMAL LEVELS
pH			
pH indicates acidity or alkalinity; 7 is a neutral measurement; freshwater ranges from 2-12	Dissolved minerals from rocks and soil; acid mine drainage, acid rain, livestock containment areas contribute to acidity; water treatment and sewage plants contribute to alkalinity	Variations in pH affect chemical and biological processes in water; low pH increases availability of metals and other toxics for intake of aquatic life; it is critical to survival, growth and reproduction of fish and macroinvertebrates to mainatain a constant pH	Range from 6.5 to 8.2 is optimal for most organisms; the DEP standard is between 6 and 9
Alkalinity			
Alkalinity is a measure of a stream's ability to neutralize acids	Alkalinity is greatly determined by the type of underlying bedrock and soil; high values may be caused by sewage and livestock waste	Alkalinity is the best measure of a stream's sensitivity to acid inputs; abrupt changes in alkalinity may signify pollution; without neutralizing capacity, any acid added to a stream would cause an immediate change in pH	Alkalinity levels between 100 and 200 mg/L provide ideal buffering within a stream; endurable pH levels may be maintained at this level of alkalinity, and aquatic life may be protected from acidic shock; this occurs when there is a sudden decrease in pH that aquatic life can not rapidly adapt to survival

Table 7. Definitions of Water Quality Parameters

DEFINITION	SOURCES	PURPOSE OF TEST	NORMAL LEVELS
Specific Conductance			
The ability of water to conduct an electrical current; determined by the presence of inorganic dissolved solids	Carbonate bedrocks often yeild high conductivity; discharges to a stream can impact conductivity	Measurements outside normal range for a stream may indicate the presence of a contaminant	U.S. rivers range from 150 to 500 micromhos/cm; conductivity beyond this range may not be suitable for certain fish and macro-invertebrates
Phosphates			
Organic phosphates are associated with living material and can be used by animals; phosphate is an essential nutrient for plant and animal growth.	Wastewater from sewage treatment plants, fertilizer runoff, faulty septic systems, livestock confinement and manure storage facilities	Slight increases may cause numerous undesirable effects: accelerated plant growth, algae blooms, low dissolved oxygen and death of certain aquatic organisms	Phosphate levels below 0.03 mg/L are generally considered to be unpolluted; levels between 0.03 and 0.1 mg/L are sufficient to stimulate plant growth; the critical level for avoiding severe impact is 0.1 mg/L
Temperature			
Temperature is a key determinant of what species can survive in a particular environment	Discharges of coolant and waste waters from industrial or utility plants; runoff from heated surfaces; lack of stream cover to provide shade	Temperature preferences vary widely among species and all species are negatively impacted by rapid fluctuations in temperature	Growth is impaired in Brook Trout at temperatures above 19° C; death will occur above 24° C; desired temperatures depend on the desired use of the water body

auto-analyzer. Alkalinity was measured by Wildlands Conservancy staff using an Orbeco-Hellige Aqua Analyzer 2.

Field data from the Hydrolab DataSonde 3 Probe was immediately recorded on data sheets and later logged in Microsoft Excel for statistical analysis. Other water quality parameters requiring laboratory analysis were recorded and logged following analysis. Field Quality Control (FQC) samples were taken during water quality sampling. At least one random replicate sample was taken during each sampling period. Additional quality control samples, such as split samples and field blanks, were taken to ensure precision of sampling equipment and protocols.

Water Temperature

Temperature governs many biochemical and physiological processes in cold-blooded aquatic organisms because their body temperature is dependent on the surrounding water; thus, water temperature has an important role in determining growth, development and behavioral patterns. Stream insects, for example, often grow and develop more rapidly in warmer portions of a stream or during warmer seasons. Growth rates for algae and fish appear to respond to temperature changes in a similar fashion. The relationship between temperature and growth, development and behavior can be strong enough to affect geographic ranges of some species.

Water temperature is one of the most important factors in determining the distribution of cold water fish species in freshwater streams, due both to direct impacts and to influence on dissolved oxygen concentrations and is influenced by local conditions such as shade, depth, water impoundments and current. Many fish species can tolerate only a limited temperature range. Although temperature preferences vary widely among species, all species are negatively impacted by rapid fluctuations in water temperature.

Life and the reproductive necessities for trout are the target standards for water temperature. Pa. DEP standards dictate that the temperature of a HQ-CWF, such as the Jordan tributaries, must not exceed 19 degrees Celsius (66°F). Above this temperature, growth impairment is likely in Brook Trout. Death of Brook Trout will occur at temperatures above 24°C. Every monitoring site exceeded the temperature water quality standard for a HQ-CWF (Figure B1). Average temperatures in the Jordan watershed ranged from 20.2°C at the headwaters to 26.2°C at site 11.5, downstream from Lyon Creek. The temperature peaked at site 11.5 (26.2°C), and temperatures were high enough to cause death to Brook Trout at sites 14, 13, 12, 11.5, 8 and 4.

Sources of thermal pollution include discharges of coolant and waste waters from industrial or utility plants, runoff from heated surfaces such as pavement and roof tops, and lack of shade-providing stream side vegetation.

Dissolved Oxygen

Higher forms of aquatic life depend on oxygen for survival just as we do. The oxygen concentration of a water body is a dynamic indicator of the balance between oxygen-consuming and -producing processes in a stream at the time of sampling. Dissolved oxygen

(DO) concentrations in a water body can be depleted by processes that consume organic matter or waste. Too much nitrogen and phosphorous entering a water body fuel the explosive growth of floating plant life or algae so extensively that they block out light needed by underwater plant life. Then, when the algae die, they sink to the bottom where their decomposition consumes oxygen. This process is called eutrophication. The ability of a stream to maintain sufficient DO levels in spite of other impacts is dependent on hydraulic properties effecting the rate at which oxygen can be absorbed by the water column from the atmosphere. For example, a stream flowing rapidly over a rocky substrate may cause significant aeration that allows for oxygen to be readily absorbed by the churning water. Whereas a slow sluggish stream flowing over a uniform substrate provides little opportunity for atmospheric absorption, such a stream would recover more slowly in the presence of oxygen-depleting impacts.

A minimum of 7 mg/L DO is required for a HQ-CWF classification of a stream. Below this standard Brook Trout reproduction may be impaired. In the Jordan Creek average DO concentrations ranged from 6.7 mg/L at site 8, just upstream from Haasen Creek to 11.5 mg/L at site 2, prior to the stream's entry into Allentown (Figure B2). Site 8 was the only site with a level below the Pa. DEP HQ-CWF standard. DO levels generally increased from the headwaters to site 11.5, with a significant drop at site 12 (located on Lyon Creek). The level then declined to site 8, located below Kern's Dam. The stagnant waters above the dam in conjunction with an overgrowth of algae probably contributed greatly to the decrease at this site despite the aeration that occurred as water passed over the dam. It is also worthy to note that during dry summer conditions the water is released from the bottom of the dam and thus is not aerated as would be expected. From this site the oxygen level is replenished until reaching the city of Allentown. The level peaks at site 2 located in Jordan Parkway, but then declines again as it flows toward the confluence with the Little Lehigh. Factors contributing to the decline within the city include increased pollution as well as stagnant waters and increased temperatures. Because cold water can hold more oxygen than warm water, a lack of shading in the lower part of the watershed may contribute significantly to a degrading of oxygen levels in the creek during hot summer months.

Specific Conductance

Specific conductance measures the ability of the water to conduct an electrical current and is dependent on the amount of dissolved constituents in the water. Geologic characteristics have a major impact on the specific conductance of a stream. Streams flowing through carbonate bedrocks often yield higher conductivity than those waters flowing over sandstones and shales. The headwaters of the Jordan Creek have a conductance of approximately 90.0 μmhos/cm (Figure B3). The conductance increases with progression downstream to 318.7 μmhos/cm at site 7. Between sites 8 through 15 the average specific conductance is 214.8 μmhos/cm, which is fairly typical for streams throughout the Lehigh Valley. Likely due to the influence of underlying carbonate geology, the conductance increases to 318.7 μmhos/cm at site 7. The conductance spiked at site 4 to 1281.3 μmhos/cm. This spike is not likely to be attributed to natural conditions such as carbonate geology and although a definitive cause has not been identified, a point source may be impacting specific conductance at this site. The conductance recovers slowly, dropping to 774.3 μmhos/cm as the creek winds its way to the mouth in Allentown.

pH

Average pH values for the Jordan Creek and its tributaries ranged from 7.2 to 8.8 through the summer of 1999 (Figure B4). These readings are based on a scale from 0 to 14, with 7 being a neutral reading (neither acidic nor alkaline). Readings above 7 indicate alkaline conditions such as are found in the Jordan watershed. The alkaline condition of the Jordan and its tributaries likely stems from the underlying carbonate geology, which is prevalent throughout the Lehigh Valley. Readings showed a consistent pattern of fluctuation between sites. Although all readings were within the Pa. DEP standard range of 6 to 9, such variance between sites and changes at any one given site over short periods of time may be very stressful for certain species of aquatic organisms. Some organisms are more tolerant of variations and can withstand a wider range of values than others, which may cause a shift in the variety and quantity of organisms found in an ecosystem.

Alkalinity and Hardness

Alkalinity values for the Jordan Creek Watershed range from 18.8 to 223.2 mg/L (Figure B5). The average value for the middle section of the watershed, between sites 15 and 7 is 52.87mg/L. A 223.2 mg/L spike in alkalinity was observed at site 4. The increase at site 4 may be due to natural causes such as a change in the underlying bedrock. As water passes through carbonate geology such as limestone or dolomite, it dissolves minerals that contribute to an increase in alkalinity. Levels of alkalinity between 100 and 200 mg/L are beneficial to aquatic life. At these levels the stream is well buffered against acidic deposition that may cause abrupt and detrimental fluctuations in pH. Although the spike in alkalinity at site 4 is within beneficial ranges, the sharp increase from the previous site indicates that an external factor is entering the stream in this vicinity.

Total hardness and calcium hardness readings within the watershed followed the same basic curve as alkalinity. Total hardness ranged from 30 mg/L near the headwaters to 263 mg/L in the lower part of the watershed. The average value for the middle and upper reaches of the watershed, between sites 15 and 8, was 81.5 mg/L. There was again a dramatic spike at site 4 (326 mg/L) that is unlikely to be due to changes in the bedrock. Calcium hardness ranged from 17.6 mg/L near the headwaters to 142.8 mg/L at site 1 in Allentown. As with total hardness, the highest value (173.6 mg/L) was measured at site 4.

2.2.3 Nutrient Sampling Results and Analysis

An essential part of evaluating and managing the Jordan Creek watershed is determining the areas where non-point source pollution is entering the stream. Once the areas of pollution are identified, finding the source and hence a solution or management practice to control the pollution is possible. Because non-point sources of pollution come from diffuse areas they are often difficult to identify, control and regulate. Since industrial discharges and other point sources of pollution have come under strict regulation with the introduction and evolution of the Clean Water Act, attention has been focused on how to deal with the much larger issue of how to control non-point sources of pollution.

This management plan and others like it will help in this effort by gathering partnerships that can use available resources more effectively to thoroughly identify sources, build support and educate the local communities at all levels. Through partnership and public meetings, management practices can be evaluated to find those that are beneficial both to the environment and the concerned community. In order to better understand the watershed and to identify areas of concern, Wildlands Conservancy worked with students and faculty from Lehigh University to analyze nutrient data from various locations throughout the watershed, as well as to conduct a stream walk of the Jordan Creek. Through this stream walk areas where pollution is entering the stream have been identified using a Global Positioning System (GPS). Data points of these areas have been incorporated to a Geographic Information System (GIS), a computerized spatial database, and have been used for analysis of the watershed and development of the management plan. Data received from these two efforts are being combined to determine those areas most threatened by non-point sources of pollution.

Water samples were collected during five weeks of the summer of 1999 and were analyzed for nutrients including orthophosphate, nitrate and ammonia. High nutrient readings are a key indicator of non-point source pollution. Increased levels of nitrates and phosphates entering the stream may lead to excessive algae growth, which blocks sunlight from reaching more beneficial forms of aquatic plants whose growth or existence may be stunted or terminated as a result. Excessive algae growth may also result in rapid fluctuations in DO and pH in the stream due to the processes of photosynthesis, decomposition and respiration.

Phosphate

Phosphates occur naturally in water as a result of decomposition of organic material and leaching from phosphate-rich bedrock. Orthophosphate (PO_4) was the form of phosphate selected for analysis because it is used in fertilizers that are commonly applied to agricultural fields and lawns, and which frequently are washed into the nearest stream during rain events. The levels of orthophosphate being added to streams from this type of non-point source pollution are much greater than the naturally occurring levels. Jordan Creek results ranged from concentrations of 0.009 to 0.720 mg/L (Figure B6). These levels may seem very low and harmless; however, at levels of only 0.03 mg/L algal growth can be stimulated, leading to degradation of water quality as described above. Concentrations above 0.1 mg/L are considered problematic, whereas levels below 0.03 mg/L are generally considered to be unpolluted or due to natural causes. Five sites within the Jordan Creek watershed were found to have average concentrations above the critical level of 0.1 mg/L. Site 4 showed a dramatic spike in concentration that exceeded 0.7 mg/L. Upon analysis of concentration versus flow data, this spike is thought to be the result of point source pollution. Flow versus concentration data for a less severe spike at site 11 indicates that it is from non-point sources of pollution. Most other sites within the watershed maintained concentrations around 0.03 mg/L.

Nitrate

Nitrate (NO_3) readings in Jordan Creek ranged from less than 4 to greater than 16 mg/L (Figure B7). Unpolluted waters usually have nitrate concentrations less than 1 mg/L. With the exception of site 11 at the mouth of Mill Creek, the average concentration of nitrate from the headwaters to Haasen Creek appears to be approximately 5 mg/L. From Haasen Creek, the nitrate levels appear to increase towards the mouth of the Jordan. Site 11 was the only

location in the watershed that registered levels of nitrate above the drinking water standard of 10 mg/L. The spike at site 11 appears to be the result of non-point sources of pollution. Typical sources of high readings such as this include fertilizer runoff, wastes from failing septic systems and livestock wastes.

Ammonia

Ammonia (NH_4^+) is another form of nitrogen that was analyzed to help identify areas of non-point source pollution. Ammonia is found in very small quantities in natural water. Some sources of ammonia in streams include fertilizer runoff and precipitation. The results of the ammonia analysis showed a great deal of variability from site to site. Concentrations ranged from approximately 0.01 to 0.14 mg/L (Figure B8). The highest levels were observed at the mouths of the Jordan, Lyon, and Switzer Creeks. A gradual increase can be seen in the concentrations of the Jordan as it flows from the headwaters past the confluence with the two aforementioned tributaries. The increased concentration is likely a result of runoff from agricultural fields, which dominate this portion of the watershed. The concentration decreased significantly from site 8 at Kern's Dam to site 5 above Cedar Crest Boulevard. It quickly spiked again at site 4, which is located below both agricultural fields and Geo-Trimet Products Group. More investigation is needed to determine whether the cause of this spike is due to point or non-point sources of pollution. A more intensive study is being conducted by a Lehigh University graduate student to determine the connection between high nutrient levels in the creek and the various land uses that may be contributing to them.

2.2.4 Water Quality Conclusions

The average concentration of parameters examined at the mouth of each tributary have been calculated by Wildlands Conservancy and are list in Table 8. The highest concentration of ammonia was found in Lyon Creek. Mill Creek had the highest levels of Nitrate, Phosphate and Dissolved Solids. Haasen Creek had the highest levels of Alkalinity, Calcium Hardness and Total Harness.

Table 8. Average Concentration (mg/L) at Tributaries and the Jordan Creek

	Switzer	Lyon	Mill	Haasen	Jordan
Ammonia	0.126	0.14	0.05	0.04	0.11
Phosphate	0.05	0.02	0.11	0.03	0.11
Nitrate	4.40	6.30	16.30	6.30	9.20
Dissolved Solids	130.60	148.00	150.60	148.80	495.50
Total Hardness	83.00	88.00	86.00	119.00	263.00
Calcium Hardness	53.20	48.80	52.00	81.80	142.80
Alkalinity	58.3	52.70	40.30	69.80	168.60

The total loads of each water quality parameter examined were calculated by Wildlands Conservancy to determine how many pounds of Ammonia, Phosphate, Nitrate, Total Dissolved Solids, Hardness and Alkalinity were being contributed to the Jordan Creek from its tributaries each day during the summer of 1999 (Table 9). The total load that the Jordan creek adds to

the Little Lehigh Creek was also calculated. Lyon Creek contributes the most ammonia to the Jordan Creek of all the tributaries. Mill Creek contributes the most phosphate and nitrate to the Jordan and Haasen Creek contributes the highest levels of dissolved solids, alkalinity and total and calcium hardness. It should be noted that these calculations are based on data collected only during summer months and that stream flow, and therefore loading, vary monthly.

Table 9. Load (lbs/day) Contributed by Each Tributary and the Jordan Creek

	Switzer	Lyon	Mill	Haasen	Jordan
Ammonia	1.33	2.30	1.36	1.04	16.52
Phosphate	0.56	0.35	2.82	0.80	16.07
Nitrate	46.20	105.10	426.20	129.40	1370.80
Dissolved Solids	1377.70	2497.20	3932.30	4816.80	73747.10
Total Hardness	875.60	1476.90	2245.50	2809.80	39143.30
Calcium Hardness	561.20	819.00	1357.80	1931.40	21253.50
Alkalinity	5920.20	13744.60	35452.24	45604.50	3163232.00

2.3 Macro-invertebrate Sampling

Macro-invertebrates are valuable members of any aquatic habitat and play many roles within an aquatic system. Macro-invertebrates serve as a food source for other organisms in the aquatic system and their community structure can serve as an indicator of water quality conditions. Community structure, qualitative as well as quantitative, can provide information relating to subtle changes in water quality. Macro-invertebrates have a relatively stable nature in the aquatic environment, as they are not highly mobile, other than storm events that can flush an area of macro-invertebrates. Macro-invertebrates can be specifically useful in reflecting past or long-range changes in water quality because of their ability to maintain stable populations under typical conditions and their propensity to remain in a specific area.

Aquatic insects have varying degrees of sensitivity to pollution. Most spend at least several months exposed to the water; some spend a year or more in the immature stage before leaving the water as an adult, and still others never leave the water. Therefore, a period of time exists in their lives when they cannot escape water pollution, if it occurs. Knowledge of which species can tolerate which levels and types of pollution is helpful in the assessment of water pollution factors.

2.3.1 Aquatic Macro-invertebrate Background

Plecoptera

Order Plecoptera, or stone fly nymphs can represent a major part of the community in clean streams, as they are an important part of aquatic food chains. *Plecoptera* comprise a large percentage of the trout diet and therefore, they can be monitored in order to qualitatively interpret the potential health of a stream and its fish populations. Since most nymphs live in the rocky substrate, they are particularly vulnerable to the siltation caused by erosion. Runoff

containing fertilizers, pesticides and various chemicals also poses a water quality threat to stone flies. Adult stages of stone flies are generally poor fliers and therefore are often found in close proximity to the waters edge resting on rocks and other large objects. This lack of flying proficiency makes adult *Plecoptera* also subject to poor water quality conditions. Without the ability to migrate to other streams, impaired water quality will offer few alternatives for stone flies. *Plecoptera* are directly dependant upon *Ephemeroptera* and *Diptera* populations because large parts of Plecoptera diets are comprised of these orders.

Trichoptera

Order Tricoptera, or caddis fly larvae are aquatic and prefer well-oxygenated, fast-flowing streams, but some reside in ponds and temporary pools. The larval stage of caddis flies is the longest stage of their life cycle. The pupal stage usually only lasts two weeks while adults live for a short time, approximately 30 days or less. Most caddis flies are considered very sensitive to pollution. Caddis flies are common bottom fauna in most freshwater lotic (flowing water) and lentic (still water) environments and occur in all substrate types.

Ephemeroptera

Order Ephemeroptera, or mayflies also prefer cooler, well-oxygenated streams and are also very good indicators of water quality. *Ephemeroptera* are the most abundant and typical part of the trout diet. Thus, much like the stone flies, they offer qualitative information about the potential health of fish populations, specifically trout.

Diptera

Immature stages of flies of the Order *Diptera* can be expected in virtually every type of aquatic habitat, and as a group, these flies are the most widely adapted of all aquatic orders. They occur everywhere from mountain streams to petroleum pools to arctic bogs. Adult stages usually only have one or two generations per year and are typically present during the spring or summer. Macro-invertebrates of the Order *Diptera* are usually seen in aquatic habitats, but are not actually in the water most times. They are what are called "water skimmers," skimming on the surface of streams, ponds and lakes. This makes them less susceptible to water pollution.

Coleoptera

In the Order *Coleoptera* water quality is not as restrictive as with other aquatic insects because many water beetles use atmospheric oxygen for respiration. Many aquatic beetle species enter and leave the water at will and many frequent environments that are marginal between terrestrial and aquatic habitats. *Coleoptera* species should not typically be a dominant organism in aquatic habitats. They do, however, make an important part of fish and waterfowl diet. "Riffle beetles" as they are often referred to have many specific adaptations on a species level and thus, generalizations cannot be easily made.

2.3.2 Macro-invertebrate Sampling Results

Macro-invertebrate sampling for the Jordan Creek was conducted at six locations (Figure 10). The first sampling location was located in the headwaters of the Jordan Creek. Site 2 was located upstream of the mouth of Switzer Creek, while site 3 was just downstream of Switzer

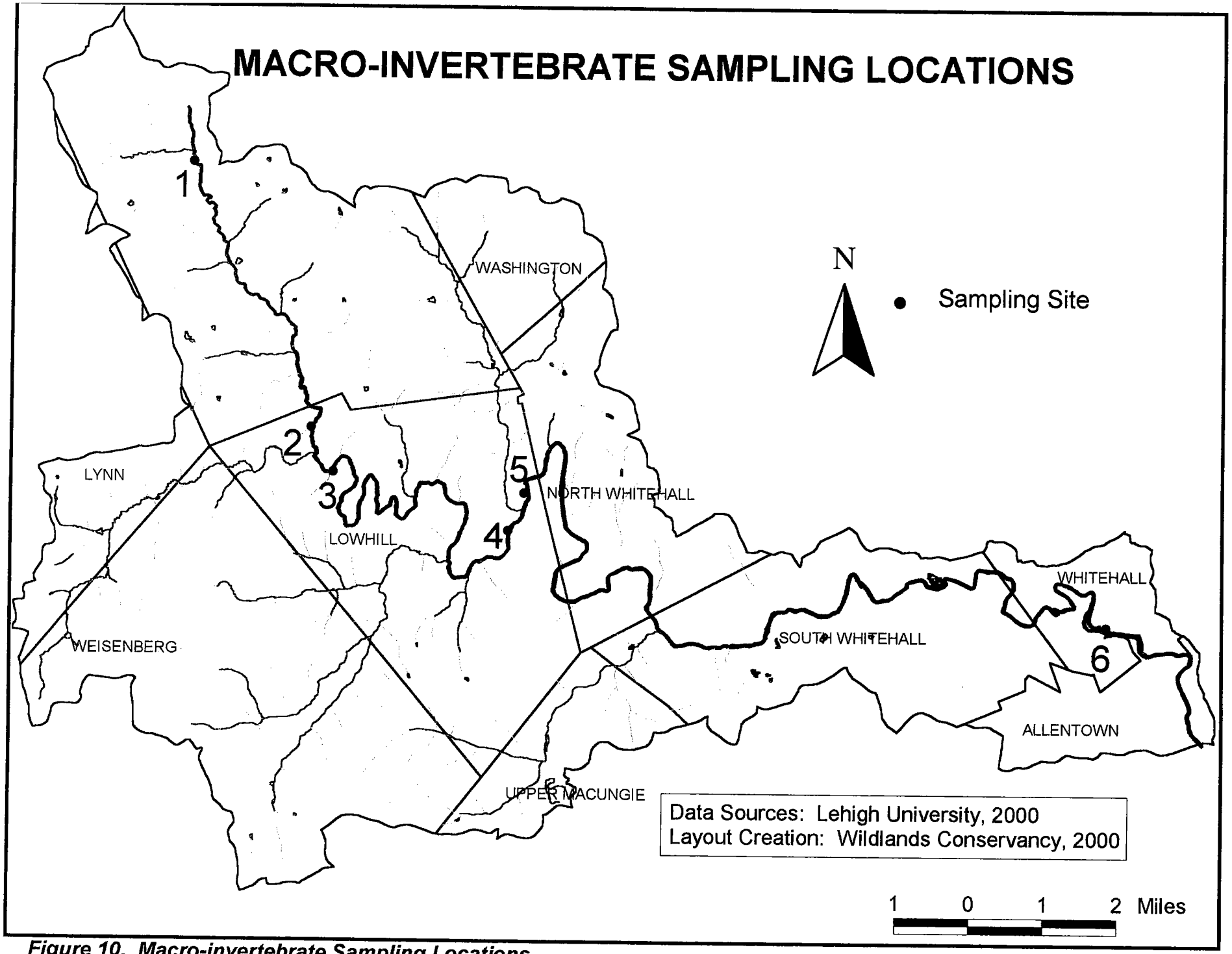


Figure 10. Macro-invertebrate Sampling Locations

Creek at water quality sampling site 14. Macro-invertebrate sampling locations 4 and 5 were designated upstream and downstream of Mill Creek respectively. The sixth macro-invertebrate sampling location was located in Jordan Park in Whitehall Township.

Lehigh University student Kelly Maloney collected macro-invertebrates in the Jordan Creek. The detailed results of the sampling are listed in Appendix C. Once collected and identified, the macro-invertebrates were further classified by their pollution tolerance value using the Environmental Protection Agency's index of pollution tolerance levels. These indices are based on tolerance values established in Klemm, et al 1990.

Overall, the community structures at the sampling sites were relatively consistent in terms of the total number of taxa and the individual EPT Index at each site. The EPT Index stands for the total number of taxa of *Ephemeroptera, Plecoptera, and Trichoptera* that were found. These are used because they are typically known as some of the more intolerant species and serve as a standard for qualitatively measuring water quality. All three orders also comprise a large percentage of the trout diet and thus, have implications as to the quality and availability of trout habitat.

Statistical analysis of the Jordan Creek macro-invertebrate community was conducted on a stream-wide basis as well as by individual sampling locations. The EPT Index for the entire Jordan Creek was 15. This means that of all of the taxa found in the macro-invertebrate sampling, approximately one half are classified as *Ephemeroptera*, *Plecoptera* or *Trichoptera*. Based on the EPT Index found in the Jordan Creek, the water quality would be indicated to be good on a stream-wide basis. However, the EPT Index was made up primarily of *Ephemeroptera* and *Trichoptera*. Because *Plecoptera* are the most sensitive of the three orders, the absence of significant numbers of these could indicate water quality impairments to the stream. The number of individuals of the EPT Index made up 32% of the total number of individuals sampled.

The United States Environmental Protection Agency's Rapid Bio-assessment Protocol Index of Macro-invertebrate Tolerance Levels was used as another more quantitative measure of water quality, (Table C1). Based on this index, 65% of all the macro-invertebrate taxa were classified as having a tolerance rating of excellent, very good or good. These three classifications indicate macro-invertebrates that are typically more sensitive. These three classifications represent a numerical tolerance rating of between 0 and 5. The number of individuals within this low tolerance rating comprised approximately 45% of the total number of individuals sampled. The Index of Macro-invertebrate Tolerance level shows that approximately one half of all the macro-invertebrates in the sample were classified as good, very good or excellent. This would indicate good water quality in the Jordan Creek based on the macro-invertebrate community.

Site 1 in the headwaters of the Jordan Creek contained 17 total Families in the sample, (Figure C1a). The dominant Family at the sample location was *Chironomidae* of the Order *Diptera*. There was more than four times the number of individuals of the Order *Diptera* than any other order found at Site 1, (Figure C1b). Evaluation of the macro-invertebrate community can be done on a family level. The EPT Index for Site 1 was 9 (53%) and approximately 71%

of the total families in the sample had a low tolerance level, equal to 5 or lower. With approximately 75% of all the Families sampled having a tolerance level of 5 or lower, water quality at sampling site 1 could be characterized as favorable to aquatic macro-invertebrate life. Further statistics were also analyzed dependent upon the total number of individuals in the sample. Based on the total number of individuals in the sample, approximately 22% of all macro-invertebrates sampled were within the EPT Index and approximately 39% of all macro-invertebrates sampled had a tolerance rating of 5 or lower.

Site 2 upstream of the mouth of Switzer Creek contained 21 total taxa in the sample, (Figure C2a). *Chironomidae* was also the overwhelmingly dominant family at sample Site 2. There were more than three times as many macro-invertebrates of the Order *Diptera* as there was any other in the sample, (Figure C2b). The EPT Index for that site was 12 (57%) and approximately 67% of the total families in the sample had a low tolerance level, equal to or lower than 5. With 67% of all the families sampled having a tolerance level of 5 or lower, a slight decrease in water quality may occur from site 1 to site 2. Based on the total number of individuals in the sample, approximately 30% of all macro-invertebrates sampled were within the EPT Index and approximately 38% of all macro-invertebrates sampled had a tolerance rating of 5 or lower.

Site 3 downstream of the mouth of Switzer Creek contained 20 total taxa in the sample, (Figure C3a). *Chironomidae* and *Caenidae*, of the Order *Ephemeroptera*, were the dominant families at sample Site 3, (Figure C3b). The EPT Index for that site was 10 (50%) and approximately 65% of the total families in the sample had a low tolerance level, equal to or lower than 5. The decrease in percentage of Families with a tolerance level of 5 or lower indicates a slight downgrade in water quality from site 2 to 3. Based on the total number of individuals in the sample, approximately 46% of all macro-invertebrates sampled were within the EPT Index and approximately 35% of all macro-invertebrates sampled had a tolerance rating of 5 or lower.

Site 4 upstream of the mouth of Mill Creek contained 15 total taxa in the sample, (Figure C4a). *Elmidae* of the Order *Coleoptera* was the dominant family at sample Site 4, (Figure C4b). The EPT Index for that site was 8 (53%) and approximately 60% of the total families in the sample had a low tolerance level, equal to or lower than 5. Based on the total number of individuals in the sample, approximately 41% of all macro-invertebrates sampled were within the EPT Index and approximately 59% of all macro-invertebrates sampled had a tolerance rating of 5 or lower. It is unusual to have a dominant family from the Order *Coleoptera*. However, this site does show the most even distribution among all the sample sites.

Site 5 downstream of the mouth of Mill Creek contained 19 total taxa in the sample, (Figure C5a). *Elmidae* was also the dominant family at sample Site 5. The EPT Index for that site was 9 (47%) and approximately 58% of the total families in the sample had a low tolerance level, equal to or lower than 5. Sampling site 4 displays a decrease in the percentage of families with a low tolerance level, equal to or less than 5, indicating another possible downgrade in water quality. With 63% of the Families sampled having a low tolerance level, there may be a slight increase in water quality from site 4 to site 5. The diversity found at site 5 may also indicate an improvement in water quality. Based on the total number of individuals in the

sample, approximately 27% of all macro-invertebrates sampled were within the EPT Index and approximately 63% of all macro-invertebrates sampled had a tolerance rating of 5 or lower. Once again, this sampling site was unique in the fact that a family from the Order *Coleoptera* was dominant, (Figure C5b).

Site 6 in Jordan Creek Parkway contained 14 total taxa in the sample, (Figure C6a) *Chironomidae,* of the Order *Diptera,* was the dominant family at sample Site 6, (Figure C6b). The EPT Index for that site was 8 (57%) and approximately 71% of the total families in the sample had a low tolerance level, equal to or lower than 5. Of all the Families sampled at site six, 71% had a low tolerance level, equal to or lower than 5. This would indicate that water quality, regarding suitability to macro-invertebrate habitat, in Allentown is similar to the water quality in the headwaters. These conditions would not typically be expected because of the significant differences in the surrounding land uses. It should however be noted that 54% of the macro-invertebrate community at site 6 was made up of *Diptera*, a high-tolerance Order. Based on the total number of individuals in the sample, approximately 28% of all macro-invertebrates sampled were within the EPT Index and approximately 40% of all macro-invertebrates sampled had a tolerance rating of 5 or lower. The sample at Site 6 showed the highest numbers of individuals of *Diptera* and *Trichoptera.* The *Ephemeroptera* species were drastically low however.

Stream-wide statistical analysis was conducted on the Jordan Creek macro-invertebrate data. This stream-wide analysis was approached in two different ways. The data was analyzed based on all of the Orders within the sample (Figure C7) as well as the four most abundant Orders (Figure C8). These four Orders were *Diptera, Ephemeroptera, Coleoptera* and *Trichoptera*. Both of these graphs show trends in the macro-invertebrate community at each sampling site throughout the Jordan Creek. Visual analysis of Figure C8 shows the relationship of the four most abundant Orders of macro-invertebrates in the Jordan Creek. The Order *Diptera* showed a slight increase in individuals sampled from Site 1 to Site 2. There were drastic decreases in numbers of individuals from Site 2 through Site 4 where the numbers of individuals sampled started to increase again. The Order *Ephemeroptera* had a spike in its number of individuals at Site 3 and displayed a fairly consistent community at the other sites. The Order *Coleoptera* showed gradual increases in the number of individuals through Site 4 and then experienced a sharp increase at Site 5 and then falls back at Site 6. The Order *Trichoptera* showed a fairly consistent community through Site 5 and then experienced a spike more than doubling the individuals in any previous sample.

The Jordan Creek macro-invertebrate data was also analyzed based on the Hilsenhoff Index of Pollution Tolerance Levels. Once each species was identified and its pollution tolerance level was determined, each sampling site's Family Biotic Index (FBI) was calculated. This index is a tool that can be further used to determine water quality using the biologic component of the system. The FBI utilizes a series of calculations that factor in the abundance of organisms as well as the individual tolerance values to eventually determine a numerical score for a specific sampling site. That score is then compared to a scale, which allows a water quality rating to be applied to that sampling site. The FBI scale spans from a score of 0 to 10. That scale accounts for seven classifications for water quality based on the biologic component: excellent

(0-3.75), very good (3.76-4.25), good (4.26-5.00), fair (5.01-5.75), fairly poor (5.76-6.50), poor (6.51-7.25), very poor (7.26-10.00).

All six of the Jordan Creek macro-invertebrate sampling sites scored as having fair water quality based on the Hilsenhoff Family Biotic Index: Site 1 (5.516), Site 2 (5.367), Site 3 (5.122), Site 4 (5.175), Site 5 (5.019) and Site 6 (5.569). The Hilsenhoff FBI would support the conclusion that water quality above Switzer Creek, the first tributary to enter the Jordan Creek, is impacted. As the Jordan then flows south and Lyon and Mill Creeks contribute to its flow, water quality improves slightly. As agricultural and urban sources of non-point source pollution accumulate in the flow of the Jordan Creek, water quality shows signs of being impacted again at Sampling Site 6 in Allentown.

2.4 Jordan Creek Fish Surveys

In addition to the chemistry and to the structure of the macro-invertebrate communities of the Jordan Creek, fish populations can also provide valuable information about the state of the creek. There have been a number of fish surveys conducted on various sections of the Jordan Creek. These surveys are summarized here and detailed results are found in Appendix C.

In order to analyze the fish communities identified in the surveys listed below, tolerance ratings for all fish species sampled were obtained from *Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities* (Simon, 1999). This index lists the fish species according to tolerance as "Tolerant" to environmental perturbations, "Intolerant" to a wide range of environmental stresses or "Intermediate". The classification of Intermediate suggests that the fish species is neither intolerant nor tolerant of environmental stresses.

2.4.1 Educational Survey, 1988

One of these surveys was conducted in 1988. The permit was issued to David M. Worden and his assistants of IEP, Inc. The permit was to be used in connection with the operation of Scientific Collector's Permit No. 35, Type III in Lehigh County. This survey sampled four locations in total. The first two sampling sites were in South Whitehall Township just downstream of Cedar Crest Boulevard. Sampling Site 1 was just upstream of GeoTechnical's wastewater treatment plant discharge on the Jordan Creek. The second sampling site was just downstream of the PMI Plant in Allentown. Sampling Site 3 was located on the border of South Whitehall and Whitehall Townships. Sampling Site 4 was located within an aeration impoundment inside the PMI Plant. Samples were taken on two dates in 1988. The first sample was taken on June 29, 1988 and the second sample was taken on October 19, 1988. All four locations were sampled on June 29, 1988. Only two of the locations were sampled on the October 19, 1988 sampling date. The results of this survey are listed in Tables C2 and C3. Sampling on June 29, 1988 resulted in 23 species being sampled between all four sampling locations. Sampling on October 19, 1988 resulted in 17 species being sampled between Sampling Sites one and two.

JUNE 29, 1988 SAMPLING

Sampling Site 1 had 19 species sampled on this date. Using the tolerance ratings contained within "Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities," eight of the 19 species sampled were found to be tolerant. In addition, another ten of those 19 species sampled were found to be intermediate. Only two of those species sampled are listed as intolerant. The dominant species at Sampling Site 1 was the Pumpkinseed Sunfish, which is listed as an intermediate fish species. There was also significant abundance of three other species at Sampling Site 1. Rockbass, an intermediate fish species, Banded Killifish, a tolerant fish species and White Sucker, another tolerant fish species all sampled in numbers slightly less than the dominant Pumpkinseed Sunfish.

Sampling Site 2 had eleven species sampled on this date. Of those eleven species, six are classified as tolerant species and four are classified as intermediate species. Only one of the species sampled is considered intolerant. The dominant species at Sampling Site 2 on this date was the White Sucker, classified as a tolerant fish species.

Sampling Site 3 had eight species sampled on June 29, 1988. Five of those species are listed as tolerant species. The three remaining of those species are listed as intermediate. There were no intolerant species at Sampling Site 3 on this date. The two most abundant fish species were the Pumpkinseed Sunfish, an intermediate fish species and the Banded Killifish, a tolerant fish species.

Sampling Site 4, the site located in the aeration impoundment in the PMI Plant had only five fish species present on the sampling date. Three of those five species are considered tolerant. The other two species are listed as intermediate species. The overwhelmingly dominant species at Sampling Site 4 was the Brown Bullhead, a tolerant fish species.

OCTOBER 19, 1988 SAMPLING

Sampling Site 1 had sixteen species sampled on the second sampling date. Of those species sampled, five are listed as tolerant, ten are listed as intermediate fish species and only one is considered intolerant. The dominant species at this sampling site on this sampling date was the Spottail Shiner, an intermediate fish species.

Sampling Site 2 had twelve species sampled on October 19, 1988. Four of those species sampled are listed as tolerant. Seven of the sampled species are listed as intermediate species and only one species is listed as intolerant. The dominant species at Sampling Site 2 on this sampling date was the Fallfish, an intermediate species.

2.4.2 International Minerals and Chemical Corporation Survey, 1990

Another survey conducted on the Jordan Creek took place on June 12, 1990. The Pennsylvania Department of Environmental Resources (DER) conducted the survey in South Whitehall Township about 1 mile downstream of the Rte. 309 Bridge. The purpose of the survey was to examine potential impacts from International Minerals and Chemical Corporation (IMC). The company manufactured formaldehyde, dimethylolpropionic acid, trimethylolethane and calcium formate. The survey was conducted because of allegations that there had been

groundwater contamination in the vicinity of IMC. The permitted outfall from IMC had exceeded its limits in the past for total suspended solids and biochemical oxygen demand. As a result, a new National Point source Discharge Elimination System (NPDES) Permit was issued to IMC at their outfall.

Two sampling sites were selected for this survey. The first served as a reference site upstream of the IMC outfall. The second site was the impact site just downstream of the IMC outfall. Water Quality data and aquatic macro-invertebrate data was collected at both sampling sites. Fish surveying was conducted at Site 2 only. The results of that survey are listed in Table C4. The fish community was identified to a species level and prioritized by the numbers of individuals present: Rare, only having 1 or 2 individuals, Present, having between 3 and 24 individuals, Common, having between 25 and 99 individuals and Abundant, having greater than 100 individuals.

The fish surveying at Sampling Site 2 resulted in eight species being sampled. Of those eight species, four are classified as tolerant species to environmental stresses and four are classified as intermediate fish species. There were no species that are classified as intolerant to environmental stresses. Unfortunately, this survey did not include any specific enumeration in terms of the fish population present. The dominant species can be inferred from the fact that only one species was classified as an abundant population, the Common Shiner, which is classified as an intermediate species.

2.4.3 Catchable Trout Program Survey, 1990

The Pennsylvania Fish and Boat Commission was requested by Waterways Conservation Officer Fred Mussel to perform a survey on section 502C Switzer Creek, a tributary of Jordan Creek. The sample was collected July 23, 1990. The report for this survey was prepared in June 1993. At the time of the release of the 1992 Chapter 93 Water Quality Classification List, this stretch was listed as a High Quality Cold Water Fishery, Migratory Fisheries. The purpose of this survey was to have this stretch included in the 1991 "Catchable Trout Program" in Fisheries Management Area V.

This survey was conducted and reported on by David A. Arnold for the Pennsylvania Fish and Boat Commission. Three sampling sites were established on section 502C. Water Quality data was collected at all three sampling locations. Fish surveys were conducted at sampling sites 2 and 3 only. There was only one brown trout found between both sampling sites. With the large amount of surrounding public access and low numbers of trout in the stream, this stretch was added to the 1991 "Catchable Trout Program." In-season stocking was added for the 1993 trout season after two consecutive cycles of preseason stocking in 1991 and 1992. This survey recommended continued stocking of catchable trout. The complete listing of all of the fish surveyed through this report on Switzer Creek can be found in Table C5.

The survey sampled a total of 19 species between the two sampling sites. Sampling Site 2 produced twelve species in the sample. Of those species, four are classified as tolerant, seven are considered intermediate and only one is listed as an intolerant species. Because only the presence of fish species and not population numbers were included in this survey, it is

impossible to determine the dominant species at either sampling location. Sampling Site 3 contained seventeen species on the sampling date. Of those species, seven are considered tolerant, nine are classified as intermediate species and only one is listed as intolerant to environmental stresses.

2.4.4 Pittman-Moore, Inc. Fishkill, 1991

The Pennsylvania Department of Environmental Resources conducted another survey on the Jordan Creek in 1991 in South Whitehall and Whitehall Townships. This survey was conducted as a result of a fishkill that occurred on May 17, 1991 just downstream of the Pittman-Moore, Inc. plant. Typically in summer months, the Jordan Creek runs dry upstream of the Pittman-Moore plant. Therefore, the Jordan Creek became comprised primarily of the effluent from the Pittman-Moore plant at the point of the plant. Fish populations were sampled on July 2, 1991 downstream of the Pittman-Moore effluent in order to determine the impact of the plant.

Five sampling sites in total were used in this survey. The first site was upstream of the Pittman-Moore plant, but was dry at the time of the survey. Data was used from a survey conducted at this site earlier in the year on June 17, 1991. The second site was at the outfall from the Pittman-Moore plant. Both of these sites were only sampled for water quality. The remaining three locations were all downstream of the Pittman-Moore plant.

Site 1 was located approximately 150 yards downstream of Pittman-Moore's effluent discharge channel. Site 2 was located at the bridge at Schererville Park, approximately 2 miles downstream of the Pittman-Moore plant. Site 3 was located at Helfrich Spring Bridge, approximately 4 miles downstream of Pittman-Moore. Water Quality, macro-invertebrates and fish were all surveyed at these three locations. This survey concluded that the fishkill was a result of the effluent coming from Pittman-Moore, Inc., as it comprised the majority of the stream flow in the area of the fishkill. It was determined that on the date of the fishkill, Pittman-Moore was in violation of their permitted discharge criteria for total suspended solids and dissolved oxygen. The complete list of fish species sampled can be found in Table C6.

Sampling Site 1 contained fourteen species on the sampling date. Seven of those species are classified as tolerant, six are considered intermediate species and only one is classified as intolerant to environmental stresses. Sampling Site 2 produced twelve fish species on the sampling date. Of that total, nine are considered tolerant to environmental stresses, two are classified as intermediate species and once again only one is considered intolerant to environmental stresses. Sampling Site 3 contained the most species on the sampling date, nineteen. Of those, nine are considered tolerant, six are classified as intermediate species and four have been determined to be intolerant to environmental conditions. This report, like some others discussed also did not contain any specific information about fish populations. Thus, no conclusions can be drawn about dominant species at any of the sampling locations.

2.4.5 Fish Survey Conclusions

Three of the four surveys discussed above were all conducted at the same sampling location in South Whitehall Township. The surveys at this location took place on four different dates from 1988 through 1991. The data at this location suggests there are definite trends in the fish population at this location. The overall number of species at this location decreases from the first sampling date to the second and then decreases significantly in the third sampling date. The fourth sampling shows fish population numbers equal to the first sample. Overall, at this site, the fish population decreased between 1988 and 1990 and then returned to or surpassed their original population levels in 1991 (Figure C9). The first and second sampling dates were actually part of the same survey, but took place on different days in June of 1988. The number of tolerant and intolerant species remains proportional to the number of overall species sampled at all four sampling dates. The number of tolerant species makes up approximately half of the total sample in all four samples, indicating impacted water quality at this site.

Using the information collected about the fish populations on various sections of the Jordan Creek in the past, some conclusions can be drawn about the water quality within the creek. In all of the surveys analyzed, the majority of the species that were sampled are classified as either tolerant species to environmental stresses or intermediate. This means that the fish species most often present in the Jordan Creek can withstand poor water quality either very well or fairly well. Very few of the species sampled in any of these surveys are listed as intolerant to environmental stresses. In addition, when population numbers were provided and dominant species could be identified, there were no dominant species that are classified as intolerant to environmental stresses. Based upon the information generated from the fish surveys conducted on the Jordan Creek it can be concluded that there are many areas on the Jordan Creek that have degraded water quality indicated by the degraded fish populations contained within those stretches.

2.5 Streamwalk Results (Wildlands Conservancy/Lehigh University)

In order to visually assess where non-point source pollution was entering the Jordan Creek, Wildlands Conservancy worked with students and faculty from Lehigh University to conduct a streamwalk. This field data collection was conducted throughout the course of the summer of 1999. During this streamwalk areas where pollution is entering the stream were identified using a using a hand-held Global Positioning System (GPS) unit. Data points of these areas have been incorporated to a Geographic Information System (GIS), a computerized spatial database, and have been used to analyze and identify site-specific impacts to the watershed and to create GIS coverage maps displaying NPS pollution factors. Some of the possible water quality impairment factors that were identified (sinkholes, stormwater discharges, agricultural pollution factors and streamside development) are discussed throughout the report.

2.6 Hydrologic Trends Assessment

Water quality and quantity monitoring data can be used to assess the specific impacts of activities and to identify any significant hydrologic trends within the watershed.

As development progresses within a watershed, the creation of new impervious surfaces and storm sewer systems can decrease opportunities for infiltration and alter the response to rainfall events. Natural watersheds with high infiltration will produce less storm runoff and more groundwater recharge for a rainfall event. The benefit of less runoff is a reduced risk of flooding. The benefit of more groundwater recharge is replenishment of aquifers for water supply and streamflow maintenance during low rainfall periods. Urbanized watersheds exhibit a "flashier" response to rainfall with higher runoff and lower recharge. These characteristics increase risks of flooding and can increase the severity of low rainfall conditions on the creek (i.e. the frequency and duration of dry creek beds).

Land use and land development activities within the Jordan Creek watershed influence surface and ground water quality, quantity and available uses. Water quality and quantity monitoring data can be used to assess the specific impacts of these activities within the watershed. Wildlands Conservancy contracted the Lehigh Valley Planning Commission to conduct an assessment of water quantity monitoring data in order to identify any significant hydrologic trends within the watershed.

The USGS has performed monitoring of Jordan Creek flows dating back to 1945 and official gaging stations are located on the Jordan Creek at Schnecksville and Allentown (Figure 9). The Schnecksville gage monitors the portion of the watershed that is primarily sandstone and siltstone with minor amounts of slate and no limestone or dolomite. Conversely, the Allentown gage is located in the "limestone valley" portion of the watershed. For this study, USGS has prepared an analysis of the gaging station records to determine data for annual stream flow and annual baseflow for each year of record, (Table A1). Baseflow is the portion of stream flow that is associated with the groundwater feeding the stream. The balance of streamflow is associated with storm runoff. Due to some concern about the choice between the available baseflow separation techniques as they relate to the identified trends, Lehigh Valley Planning Commission used three different techniques, the 5-day fixed interval, the sliding interval and the local minimum. As Table 10 illustrates, there is a strong consistency in the trend analysis for the three methods, eliminating this concern. LVPC prepared assessments of the data to identify any long-term trends. Key findings and recommendations based on the trend analyses are listed here and are summarized in Table 10.

Figure 11. United States Geological Survey's stream gage at Geiger Covered Bridge in Schnecksville. This gage has monitored a 53.0 square mile drainage area since 1967.

Key Findings (Source: Lehigh Valley Planning Commission)

- Precipitation, streamflow, baseflow and storm runoff appear to follow cyclical patterns throughout the period of record
- Precipitation as a long-term trend is relatively stable with no appreciable upward or downward trend (Figure A1).
- The amount of precipitation that becomes streamflow is increasing over time (Figure A2).
- The baseflow of the stream is slightly increasing over time (Figure A3).
- The baseflow as a percentage of streamflow is decreasing over time (i.e. streamflow is increasing faster than baseflow) (Figure A4).
- The stormwater portion of streamflow is increasing over time (Figure A5).
- No evidence is provided to suggest that baseflow levels or groundwater levels in the watershed are decreasing over time.

Table 10. Jordan Creek Watershed Hydrologic Trends (by Various Baseflow Separation Methods.) (Source: Lehigh Valley Planning Commission, 2000)

	Baseflow Separation Method		
Schnecksville Gage	5-day Fixed Interval	Sliding Interval	Local Minimum
Streamflow	increasing	increasing	increasing
Baseflow	slightly increasing	slightly increasing	slightly increasing
Baseflow/ Streamflow %	decreasing	decreasing	slightly decreasing
Storm Runoff	increasing	increasing	increasing
Allentown Gage			
Streamflow	increasing	increasing	increasing
Baseflow	slightly increasing	slightly increasing	no trend
Baseflow/ Streamflow %	decreasing	decreasing	decreasing
Storm Runoff	increasing	increasing	increasing

Regarding these findings, the trend of concern is the increase of stormwater over time. This is an expected trend, assuming that land development activities in the watershed are responsible for the increase. This trend means that storm runoff volume on an annual basis is increasing. It does not mean necessarily that peak runoff rates of flooding from stormwater events are increasing. The Lehigh Valley Planning Commission recommends that the trend of increasing stormwater runoff should be met with an increased emphasis, where geology and soils permit, on groundwater recharge through the land development process. Also, periodic re-assessment of identified trends should be performed with increasing years of gage data.

2.7 Stream Flow/Discharge

One of the major concerns for the Jordan Creek is the seasonal loss of water associated with the underlying bedrock. Extensive stretches of both the Jordan Creek and some of its tributaries are prone to running dry during late summer months (Figure 12). This situation can be especially severe during extended drought periods such as the drought of 1999. The average groundwater loss from the Jordan Creek to the Lehigh River through fractures was estimated to be 17 million gallons per day (Wood et al, 1972). Some reports have quoted an average annual loss of ten percent of flows or approximately 26 cubic feet per second (cfs) (Wood et al, 1972).

The Jordan Creek periodically goes dry where the channel is underlain by carbonate geology, which readily develops solution cavities and fractures from the dissolution of minerals by passing water. When the water enters the bedrock it flows mostly through these fractures in a northeastward direction and discharges via springs along the banks of the Lehigh River near Coplay (Wood et al, 1972). During relatively dry summers, especially those preceded by a dry spring, Jordan Creek first begins to go dry in the Stetlersville area. The dry reach lengthens as

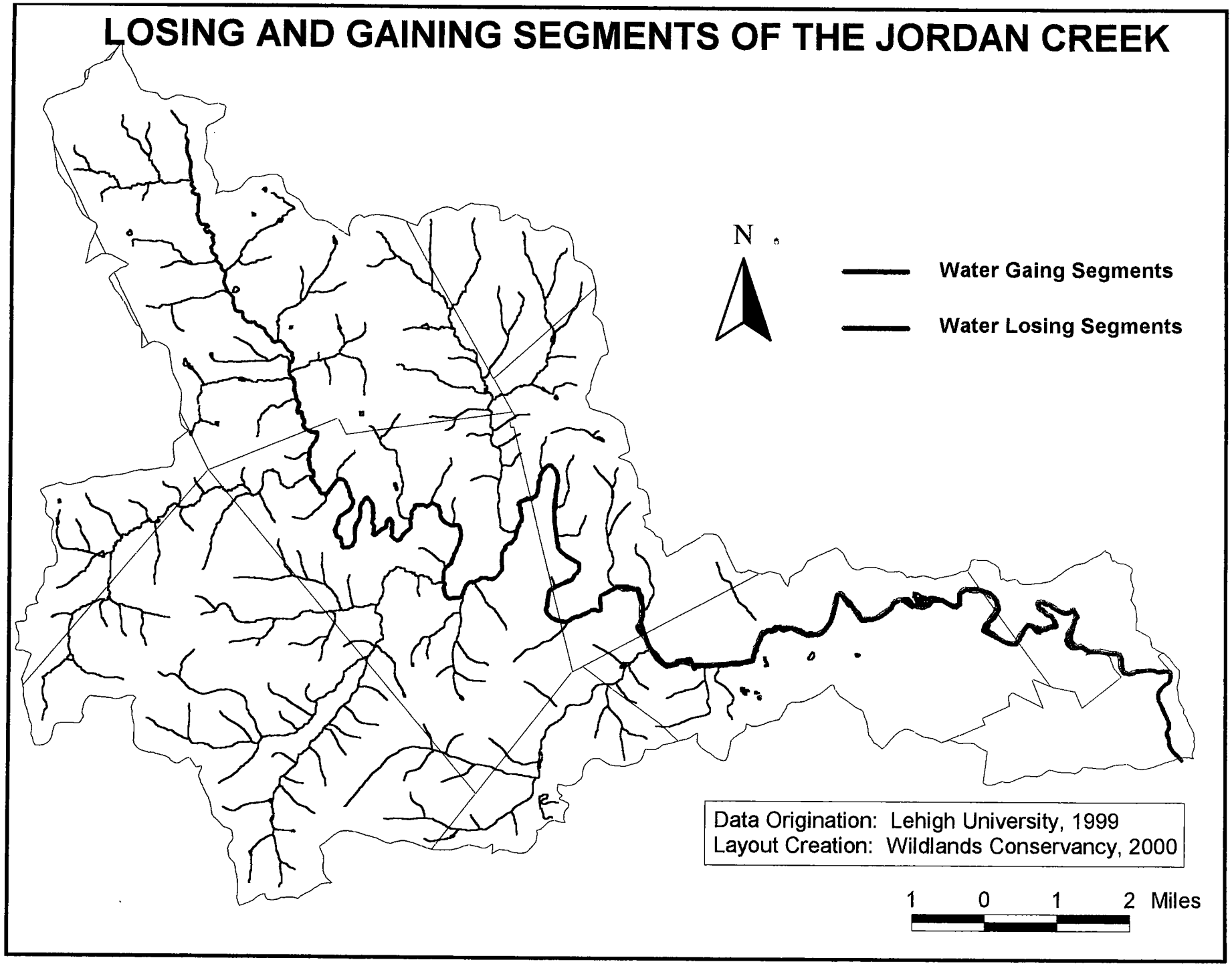


Figure 12. Losing and Gaining Segments of the Jordan Creek

the summer drought continues, until the 8-mile reach between Guthsville and Helfrich Spring becomes totally dry. A flow of several cubic feet per second is maintained for a short reach downstream from the mouth of Haasen Creek, the only major tributary along the water-losing reach. The only other tributaries in the 14.4-square-mile drainage area from Kernsville and the mouth of Haasen Creek to the Allentown gage are several intermittent streams in the Guthsville area; thus, surface runoff from that part of the basin underlain by carbonate rocks is negligible. When flow is available from the upper part of the basin, water is continuously lost along the channel to the underlying carbonate-rock aquifer. Information collected from newspaper articles indicates that periodic dryness in the Jordan Creek has occurred about once every two years since at least 1936 (Wood et al, 1972).

Streamflow records for the oldest continuous-record station, Jordan Creek at Allentown, represent the flow characteristics in the continuously flowing reach of the lower channel. Streamflow records for the more recently established continuous-record station 4518, Jordan Creek at Schnecksville, represent runoff from that part of the basin lying upstream from the water-losing reach. The two losing segments of the stream are from Kernsville to Guthsville and from Stetlersville to Scherersville. The gaining segments include from Guthsville to Stetlersville and from Scherersville to Allentown (Wood et al., 1972). Studies indicate that part of the water lost in a losing reach is regained in the successive gaining reach. The magnitude of the loss is roughly proportional to the flow entering the water-losing reach, with the largest losses occurring at the highest flows (Wood et al, 1972). Part of the water lost from the channel flows northward through the carbonate rocks and is discharged from springs in and along the banks of the Lehigh River near Coplay (Wood et al, 1972).

The areas of the creek that historically run dry suffered unusually long dry spells during the summer of 1999. The creek was dry almost continuously from July 1999 to the beginning of September 1999. Ecologically, the biggest problem associated with the losing stream is that often times the rapidly-lowering water table catches fish by surprise and leaves them stranded in small pools of water that eventually go dry. Typically, these fish either die or are rescued by local residents who relocate them to other waterways with substantial flows. Not only do fish populations suffer, but the entire food chain is compromised starting with the macro-invertebrate population and extending to amphibians, birds, and terrestrial mammals. The native vegetation growing along the stream banks also suffers from the lowered water table, thus increasing the watershed's susceptibility to invasive and non-native vegetation.

2.8 Floodplains

Floodplains are areas of low elevation lying adjacent to stream channels (Figure 13). These low areas are frequently subjected to flooding and therefore should be left in a natural state whenever possible. Disturbance of floodplain areas by construction, clearing of vegetation, filling of wetlands, etc. will result in excessive flooding and negative water quality impacts to the stream, as well as increased potential for property damage. Because it is the natural tendency for streams to migrate and change form over time, any development that takes place within a floodplain may be faced with eroding stream banks, loss of property, and encroachment of the stream to the development within the ensuing years following construction. Improper management of streamside property will also heighten the rate at

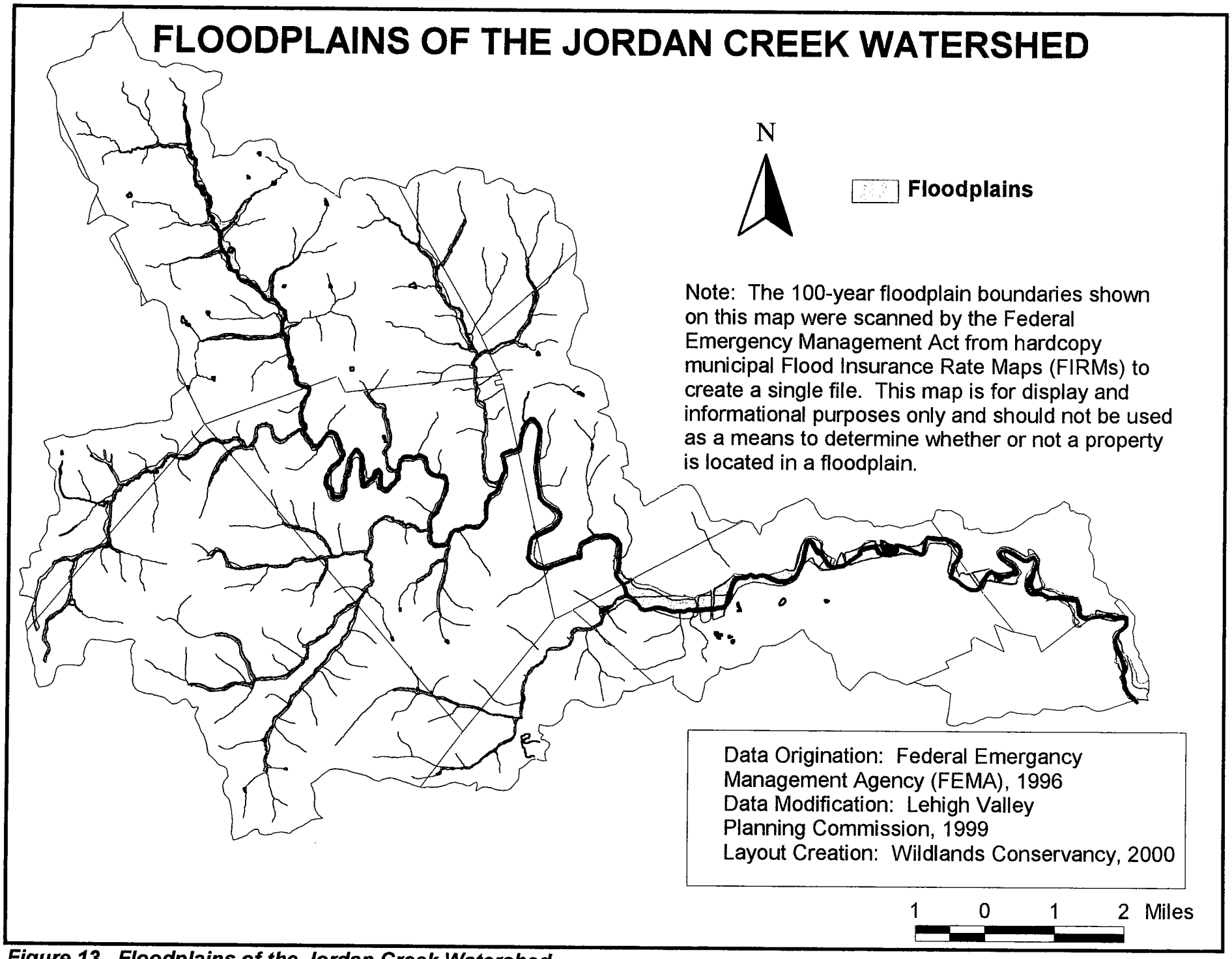


Figure 13. Floodplains of the Jordan Creek Watershed

which erosion and, therefore, loss of property will occur. For developments that have already been established within floodplains, establishing and maintaining a vegetated buffer will greatly reduce erosion rates as well as the impacts that the establishment has on the stream.

The U.S. Department of Urban Housing and Development–Federal Insurance Administration has prepared a Flood Insurance Study for each municipality in the Jordan Creek watershed. Collectively, these studies document the 100-year floodplain within the Jordan Creek watershed. Each of these floodplain studies is available at the Lehigh Valley Planning Commission office and at the respective municipal offices.

Currently within the Jordan Creek floodplain, the land use consists primarily of agriculture, open space and woodlands. Located within the floodplain are various park properties including Lehigh Valley K.O.A., State Game Lands, Trexler-Lehigh County Game Preserve, Fogelsville Pond, Covered Bridge Park, Jordan Creek Parkway, Camp Horseshoe and two sportsman's associations.

There also currently exist many instances of development within the 100-year floodplain in the Jordan Creek watershed. Throughout most of the watershed floodplain development takes the form of scattered residences and encroachments associated with road crossings. In the densely urbanized areas, the natural floodplain has, in many instances, been completely modified by development activities resulting in higher flood damage potential and lesser flood carrying capacity.

Development within the urbanized areas of the watershed is taking place with rules and laws that largely did not exist for the current urbanized areas. The new rules are those established by Pennsylvania Act 166 of 1978, the Floodplain Management Act. Act 166 required municipalities to adopt ordinances to regulate the type and extent of development within floodplain areas. All of the watershed municipalities have enacted ordinances consistent with Act 166. With enforcement of those ordinances, any future floodplain development will be limited to that which would not significantly alter the carrying capacity of the floodplain or be subject to a high damage potential. A result of this has been that developments taking place adjacent to streams have had the floodplain areas dedicated for recreation and open space uses or otherwise been kept free of development (Joint Planning Commission, 1992).

2.9 Flooding/Stormwater

Flash flooding may be another hazard encountered within the watershed. Flash flooding may result from extended periods of heavy rain, such as those associated with tropical storms, or they may result from the spring melt of winter snow and ice accumulations. This is especially a problem in urban areas where the natural floodplains have been so heavily developed and altered that precipitation can not be absorbed by the land, which has been covered by impervious surfaces. Thus, precipitation is quickly carried to the creek. The creek, when unable to hold the additional storm water runoff, overflows not onto natural floodplains, but instead onto residential streets, neighborhoods, and commercial properties. Taking steps to minimize storm water runoff and increase groundwater recharge in urban areas will greatly reduce the impacts and costs associated with flooding. The stormwater discharges to the

Jordan Creek that were identified through the 1999 streamwalk are mapped in Figure 14. The streamwalk identified 27 storm water discharges in total on the main stem of the Jordan Creek. As would be expected, the majority of those are located in the more heavily populated areas of South Whitehall Township, Whitehall Township, and the City of Allentown.

The Pennsylvania Storm Water Management Act, Act 167 of 1978, provides the framework for improved management of the storm runoff impacts associated with the development of land. The purposes of the Act are to encourage the sound planning and management storm runoff, to coordinate the storm water management efforts within each watershed and to encourage the local administration and management of a coordinated storm water management. The difference between at-site runoff control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts. Whereas the objective of typical at-site design would only be to control post-development peak runoff rates to predevelopment levels from the site itself, a watershed-level design would be geared towards maintaining existing peak flow rates in the entire drainage system. Act 167 establishes a process for decision-making. Act 167 is essentially a three-step process of runoff control which involves: documentation of the existing state of storm runoff in the watershed; preparation of a plan to control storm runoff from new development; and the development of priorities for implementation. Act 167 also specifies that a plan must be updated every five years. *The Jordan Creek Watershed—Act 167—Storm Water Management Plan* has been prepared for Lehigh County by the Joint Planning Commission and is available from the Lehigh Valley Planning Commission.

In the southwest corner of Whitehall Township there is an area that has been susceptible to flooding and uncontrolled drainage for many years. A current flooding situation causes significant inflow and infiltration to the sanitary sewer system. As a result, effluent escapes from the system and is transported to the Jordan Creek via storm water. Whitehall Township has engineered and begun construction of a three-phase flood mitigation project. This $600,000 flood mitigation project will eliminate a thirty-year-old flooding problem, including flooding of roadways and homes. The project will eliminate approximately 2000 feet of unrestricted unregulated overland storm water conveyance. These overland flows before this project have caused severe soil erosion for the entire length. Sanitary sewer inflow and infiltration and sewage backup to storm sewers is eliminated as a result (Source: Whitehall Township).

2.10 Wetlands

Wetlands are a long misunderstood and under-appreciated habitats that have been destroyed and filled in for years and continue to be abused around the country. There have been efforts to recognize the ecological benefits of wetlands and to protect them. Specifically, section 404 of the Clean Water Act prohibits unauthorized placement of dredged or fill material into waters of the United States, including most wetlands. The United States Army Corps of Engineers administers this program with EPA oversight. Within Pennsylvania, The Pa. DEP has jurisdiction for the protection of wetlands and stream encroachments under Chapter 105 of the Dam Safety and Encroachment Act of 1978 (Jeffries, 1990).

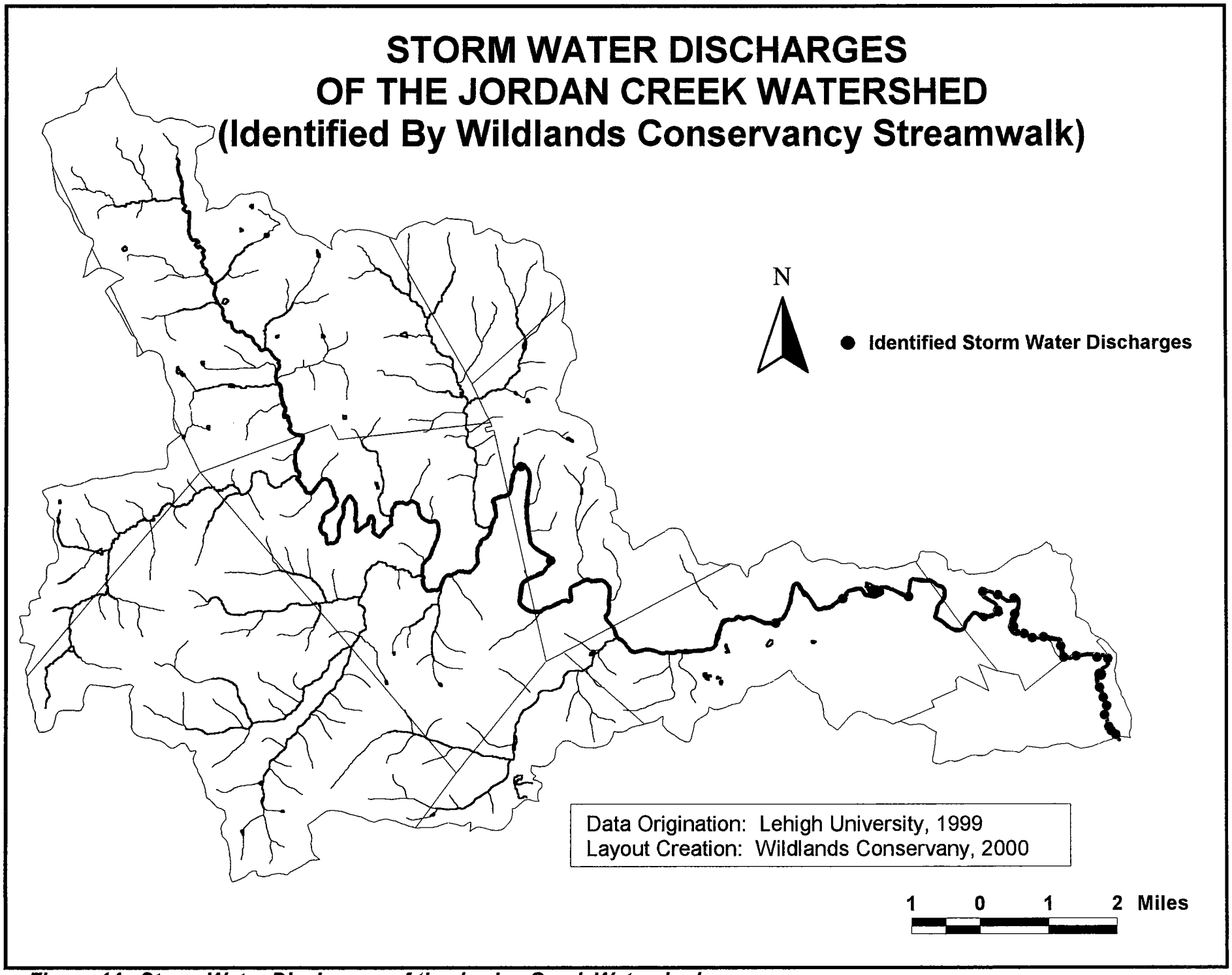


Figure 14. Storm Water Discharges of the Jordan Creek Watershed

When the United States was settled there were 215 million acres of wetlands, but as of the mid-1970's there was only 99 million of those acres remained (Jeffries, 1990). Wetlands, as defined by the U.S. Fish and Wildlife Service, are "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have at least one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (water-adapted plants), (2) the substrate is predominantly undrained hydric soil and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year." (www.usfws.gov).

Wetland destruction results not only in the loss of the wetland functions described, but also in the loss of unique and diverse wetland habitats and species.

There are 438 acres of wetlands throughout the Jordan Creek watershed (Figure 15). Most of the wetlands are located in low areas surrounding the creek. There are 164 acres of Riverine wetlands, 141.7 acres of Palustrine Open Water wetlands, 89 acres of Palustrine Forested, 23.4 acres of Lacustrine, 15.2 acres of Palustrine Emergent and 4.6 acres of Palustrine Scrub-Shrub wetlands. Wetlands are an important part of the watershed because they provide a crucial link between land and water habitats. Many species of birds and amphibians are especially dependent on these areas. Wetlands also occasionally serve as homes to threatened or endangered species of flora and fauna.

It is also critical to preserve wetlands, as their potential to store large amounts of water helps moderate stream flows during both storm events and droughts. Storm water runoff accumulates in wetlands, where it is retained until peak stream flows have passed, and it is then released slowly to the stream. This natural wetland function can help to minimize the extent and duration of peak discharge rates. Chemical and biological processes that occur in wetlands also help to transform deleterious substances like pesticides into less harmful forms for the environment. In addition, wetlands help reduce soil runoff and prevent pollution. Even the best erosion and sedimentation practices allow some soil to leave the field with runoff. Plants in wetlands help slow the movement of water, allowing sediment to drop out. Nutrients such as phosphorus, which cling to the soil, are deposited in the wetland where they can be used by the plants.

Five major wetland classification systems exist: Marine, Estuarine, Lacustrine, Palustrine and Riverine. Within these major classifications, there are sub-systems, classes and subclasses to further define the wetland. Marine and Estuarine wetlands are not contained within the Jordan Creek watershed. Marine wetlands are all wetlands and deepwater habitats that exist within a channel except when water-containing ocean-derived salts are present and if the wetland is dominated trees or shrubs (Nebel, 1998). Estuarine Wetlands are deepwater tidal habitats adjacent to tidal wetlands that are semi-enclosed by land but have open, partly obstructed or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (Nebel, 1998). Lacustrine, Palustrine and Riverine wetlands are found in the Jordan Creek watershed. Information about these wetland types is located in Table 11.

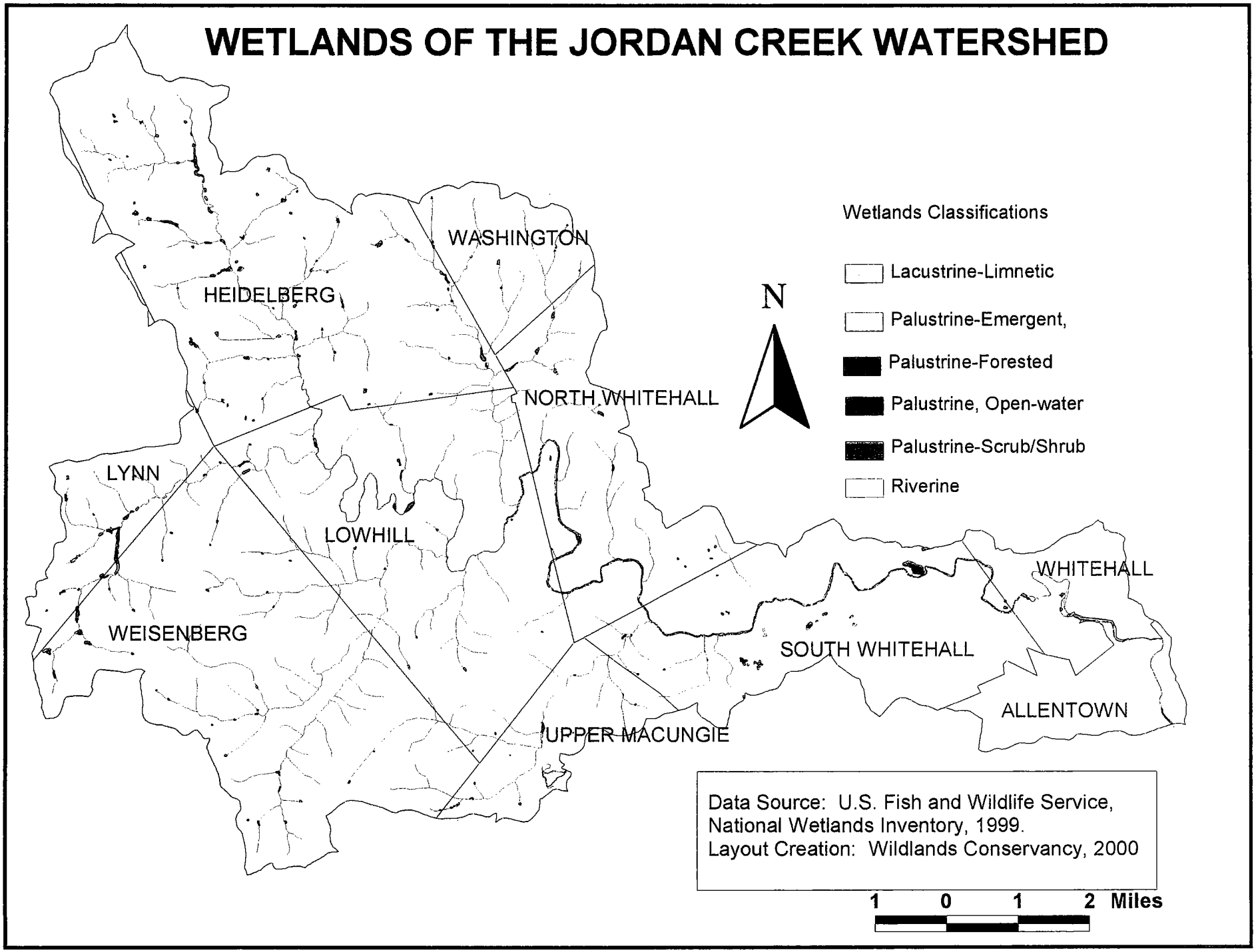


Figure 15. Wetlands of the Jordan Creek Watershed

Table 11. Wetland Systems of the Jordan Creek Watershed

Lacustrine-Limnetic, Open Water, Excavated: The Lacustrine System includes all wetlands and deepwater habitats that are situated in a topographic depression or a damned river channel and lack trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30 percent area coverage. The total area of these wetlands must exceed 20 acres. The classification of Open-water refers to the fact that the wetland vegetation exists mostly on or below the surface of the water for most of the growing season.

Palustrine-Emergent, Narrow-leaved, Temporary: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Emergent wetland class is characterized by erect, rooted, herbaceous hydrophytes excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by narrow-leaved perennial plants. Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season.

Palustrine-Emergent, Narrow-leaved, Seasonal: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Emergent wetland class is characterized by erect, rooted, herbaceous hydrophytes excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by narrow-leaved perennial plants. Surface water is present for extended periods especially early in the growing season, but is absent by the end of the season in most years.

Palustrine-Emergent, Narrow-leaved, Seasonal-Saturated: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Emergent wetland class is characterized by erect, rooted, herbaceous hydrophytes excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by narrow-leaved perennial plants. The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present.

Table 11. Continued

Palustrine-Forested, Broad-leaved, Deciduos: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Class Forested Wetland is characterized by woody vegetation that is 6 m tall or taller. Dominant trees typical of Broadleaved Deciduous Wetlands, which are represented throughout the United States, are most common in the South and East.

Palustrine-Forested, Broad-leaved, Deciduos-Temporary: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Class Forested Wetland is characterized by woody vegetation that is 6 m tall or taller. Dominant trees typical of Broadleaved Deciduous Wetlands, which are represented throughout the United States, are most common in the South and East. Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season.

Palustrine-Forested, Broad-leaved, Deciduos-Seasonal: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Class Forested Wetland is characterized by woody vegetation that is 6 m tall or taller. Dominant trees typical of Broadleaved Deciduous Wetlands, which are represented throughout the United States, are most common in the South and East. Surface water is present for extended periods especially early in the growing season, but is absent by the end of the season in most years.

Palustrine, Open-water, Permanent: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The classification of Open-water refers to the fact that the wetland vegetation exists mostly on or below the surface of the water for most of the growing season. Water will cover the land in this system throughout the year in all years. Vegetation is composed of obligate hydrophytes.

Table 11. Continued

Palustrine, Open-water, Artificial: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The classification of Open-water refers to the fact that the wetland vegetation exists mostly on or below the surface of the water for most of the growing season. The amount and duration of flooding is controlled by means of pumps or siphons in combination with dikes or dams. The vegetation growing on these areas cannot be considered a reliable indicator of water regime.

Palustrine, Open-water, Intermittenly Exposed: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The classification of Open-water refers to the fact that the wetland vegetation exists mostly on or below the surface of the water for most of the growing season. Surface water is present throughout the year except in years of extreme drought.

Palustrine, Open-water, Excavated: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The classification of Open-water refers to the fact that the wetland vegetation exists mostly on or below the surface of the water for most of the growing season.

Palustrine-Scrub/Shrub-Emergent, Narrow-leaved, Temporary: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Class Scrub/Shrub includes areas dominated by woody vegetation less than 6 m tall. The species include true shrubs, young trees and trees or shrubs that are small or stunted because of environmental conditions. The Emergent wetland class is characterized by erect, rooted, herbaceous hydrophytes excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by narrow-leaved perennial plants. Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season.

Table 11. Continued

Palustrine-Scrub/Shrub, Broad-leaved, Deciduos, Emergent: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Class Scrub/Shrub includes areas dominated by woody vegetation less than 6 m tall. The species include true shrubs, young trees and trees or shrubs that are small or stunted because of environmental conditions. Dominant trees typical of Broadleaved Deciduous Wetlands, which are represented throughout the United States, are most common in the South and East. The Emergent wetland class is characterized by erect, rooted, herbaceous hydrophytes excluding mosses and lichens. This vegetation is present for most of the growing season in most years.

Palustrine-Scrub/Shrub, Broad-leaved, Deciduos, Temporary: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. The Class Scrub/Shrub includes areas dominated by woody vegetation less than 6 m tall. The species include true shrubs, young trees and trees or shrubs that are small or stunted because of environmental conditions. Dominant trees typical of Broadleaved Deciduous Wetlands, which are represented throughout the United States, are most common in the South and East. Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season.

Riverine, Lower Perennial-Open Water: The Riverine System includes all wetlands and deepwater habitats contained within a channel. The Lower Perennial subsystem is characterized by low gradient and slow water velocity. There is no tidal influence and some water flows throughout the year. The substrate consists mainly of sand and mud. There is usually a well developed flood plain along these systems. The classification of Open-water refers to the fact that the wetland vegetation exists mostly on or below the surface of the water for most of the growing season.

Riverine, Upper Perennial-Open Water: The Riverine System includes all wetlands and deepwater habitats contained within a channel. The Upper Perennial subsystem is characterized by higher gradient and fast water velocity. There is no tidal influence and some water flows throughout the year. The substrate consists of rock, cobbles or gravel with occasional patches of sand. There is usually very little floodplain development along these systems. The classification of Open-water refers to the fact that the wetland vegetation exists mostly on or below the surface of the water for most of the growing season.

2.11 Water Supply

Lehigh Valley Planning Commission has developed a Wellhead Protection Implementation Program in an effort to preserve and prevent contamination of public water supply and the health risks that may be associated with contamination. Threats to our water supplies include improper or faulty septic systems, injection wells, storage tanks, industries, land application of sewage sludge, superfund sites and countless others. As part of their Wellhead Protection Implementation Program, the LVPC identified as many of these threats as possible within the watershed area. By examining the areas surrounding the wells for the presence of any identified threats, the risk to that well can then be assessed based on the types and proximity of threats to the wellhead.

Nearly 92 percent, or 48,149 acres, of the Jordan Creek watershed is not serviced by community water supply and residences in these areas therefore rely on individual wells for their water supply (Figure 16). Thorough and frequent analysis of water samples from high-risk wells, as well as proper management of local threats, is important. For those wells that are not currently at risk, steps can be taken to ensure that they remain unpolluted. Within a model ordinance prepared by the LVPC, a three-zone protection area surrounding wells is proposed. Each zone within the protection area would carry different regulations. The three areas are referred to in the model ordinance as *wellhead protection areas (WHPAs) 1,2 and 3*. Wellhead protection area 1 (WHPA 1) is a relatively small radius of 100 to 400 feet surrounding the well and is alternately referred to as the wellhead zone. *Wellhead protection area 2 (WHPA 2)* is usually larger than the wellhead zone and reflects the area surrounding the well that is influenced by the pumping of the source. This area is referred to as the zone of diversion. Physically, this area is the land surface from which water is drawn into the well through pumping. *Wellhead protection area 3 (WHPA 3)* is the land surface that drains to the well based on topography. WHPA 3 is also referred to as the zone of contribution (Joint Planning Commission, 1996). WHPA 1 carries the most stringent regulations. Progressing outward from the wellhead, WHPAs 2 and 3 would support a decreasing degree of regulations. Regulations would mostly involve limitations to the types of activities and land uses that are permitted within the given zone (Joint Planning Commission, 1996). By applying such restrictions, the potential exposure of the water supply to any hazardous substances should be greatly reduced. The proposed wellhead protection areas within the Jordan Creek watershed are shown in Figure 17.

2.12 Groundwater Recharge Areas

Protecting groundwater resources is an environmental problem of particular public concern because so many people derive their domestic water supplies from groundwater. The residency time for groundwater aquifers is often measured in hundreds to thousands of years; therefore, once aquifers are damaged by pollutants, it may be difficult or impossible to reclaim them for continued use. Aquifers are also very important because approximately 30 percent of the stream flow in the United States is supplied by groundwater that emerges as springs or other seepages along the stream channel (Keller, 1988). This phenomenon, known as base flow, is responsible for the low flow or dry season flow of most perennial streams. Therefore, maintaining high-quality groundwater is important in maintaining good quality stream flow.

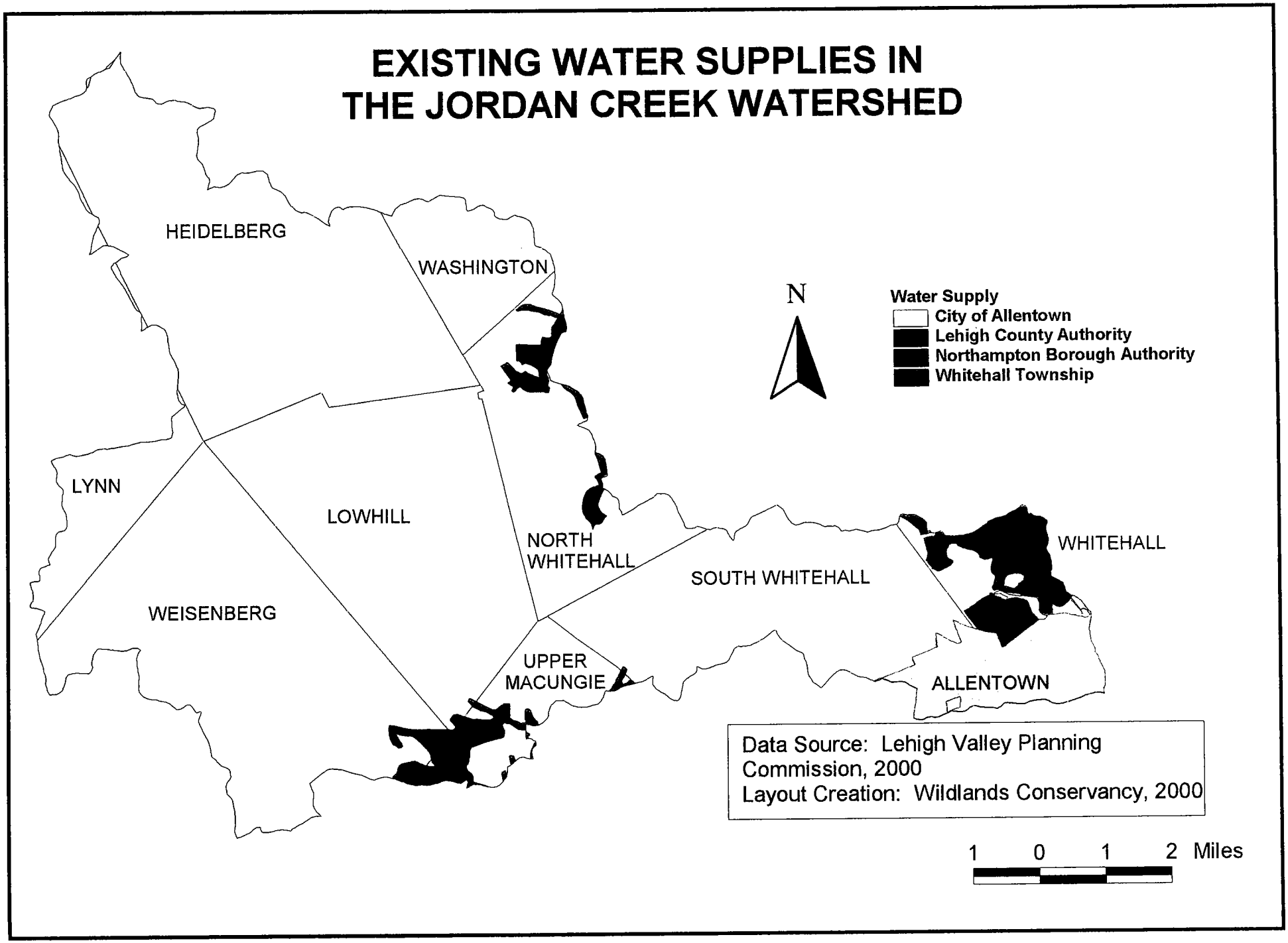


Figure 16. Existing Community Water Supplies

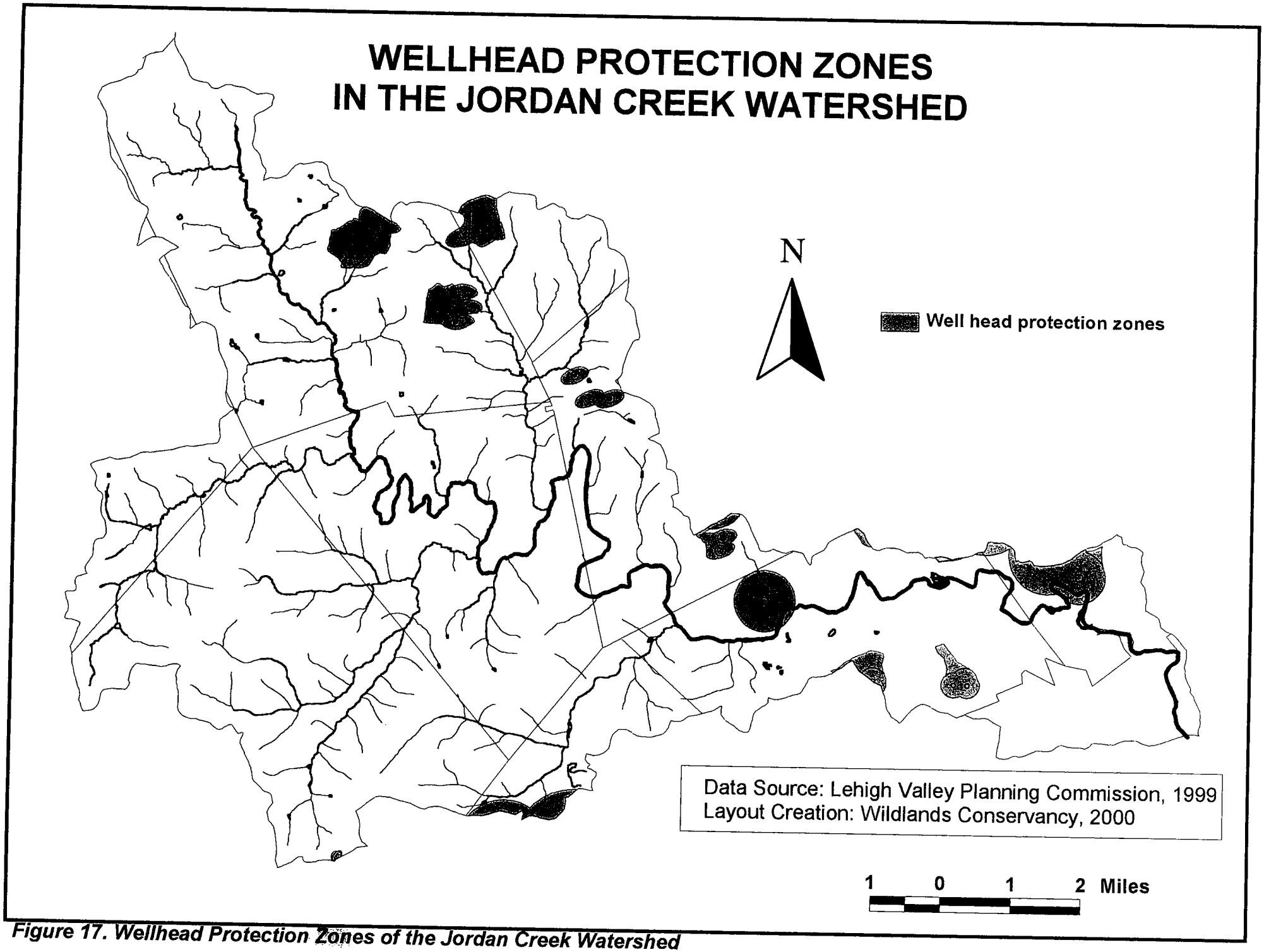


Figure 17. Wellhead Protection Zones of the Jordan Creek Watershed

Open spaces (woodlands, vacant lands, parks, cemeteries, etc.) found throughout the watershed are valuable for more than just their recreational, aesthetic, and habitat benefits. These areas also provide the necessary ground area for precipitation to infiltrate to the ground water table. By preserving open spaces we will be protecting our ground water resources. Since a stream is actually the surface water expression of the groundwater table, by preserving groundwater recharge areas, the flow of the stream will be sustained, especially during the dry summer months when the Jordan and some of its tributaries occasionally run dry. Not only are large open spaces such as the State Game Lands critical recharge areas, but so are smaller spaces such as city and municipal parks. City parklands are particularly important because pervious surfaces are so scarce in an urban environment, making it extremely difficult to prevent or mitigate flooding and to protect and maintain adequate groundwater supplies.

According to *Water Resources of Lehigh County, PA. Report #31, 1972*, from the Department of Environmental Resources and written by Charles Wood and others, ground water yields approach 200 gallons per minute, but turbidity is a common ground water problem. Ground water in the permeable carbonate rocks is more susceptible to widespread pollution than is the ground water in the less permeable non-carbonate rocks. In 1972 there was ample evidence of mild to gross pollution of ground water by domestic wastes in all communities having on-lot sewage disposal systems (Wood et al, 1972). Pollution that reaches the water table by infiltration tends to remain near the top of the zone of saturation in the aquifer as it migrates toward points of discharge. Wastes that have been introduced by means of waste-disposal wells may follow deeper routes to the points of discharge, undergoing negligible decomposition during their movement. Pollutants that reach the water table in most of the carbonate-rock area in the Jordan basin will eventually discharge into springs and seeps along the Lehigh River (Wood et al, 1972).

2.13 National Pollutant Discharge Elimination Strategy (NPDES) Permits

The Federal Clean Water Act and the Pennsylvania Clean Streams law requires wastewater dischargers to have a permit establishing pollution limits and specifying monitoring and reporting requirements. The federal Clean Water Act requires states to issue National Pollutant Discharge Elimination Strategy (NPDES) permits to any person or municipality wanting to discharge wastewater into the states' waters. NPDES permits regulate household and industrial wastes that are collected in sewers and treated at municipal wastewater treatment plants. Permits also regulate industrial point sources and concentrated animal feeding operations that discharge directly into receiving waters.

Permits regulate discharges with the goals of protecting public health and aquatic life and assuring that every facility treats wastewater. To achieve these ends, permits include the following terms and conditions: site-specific (or effluent) limits; standard and site-specific management; and compliance monitoring and reporting requirements. When and if regulated facilities fail to comply with the provisions of their permits, they may be subject to enforcement actions. DEP and EPA use a variety of techniques to monitor permittees' compliance status, including on-site inspections and review of data submitted by permittees. The NPDES permit is generally valid for a period of five years. Operators and locations with current NPDES

permits are listed in Table 12 and are shown in Figure 18. The types of regulated pollutants are:

Conventional Pollutants are contained in the sanitary waster of households, businesses and industries. These pollutants include human wastes, ground-up food from sink disposals and laundry and bath waters. Conventional pollutants include:

Fecal Coliform-These bacteria are found in the digestive tracts of humans and animals; their presence in water indicates the potential presence of pathogenic organisms.

Oil and Grease-These organic substances may include hydrocarbons, fats, oils, waxes and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process.

Toxic Pollutants are particularly harmful to animal or plant life. They are primarily grouped into organics (including pesticides, solvents, polychlorinated biphenyls (PBCs) and metals (including lead, silver, mercury, copper, chromium, zinc, nickel and cadmium).

Non-conventional Pollutants are any additional substances that are not conventional or toxic that may require regulation. These include nutrients such as nitrogen and phosphorous.

Table 12. NPDES Permits in the Jordan Creek Watershed

Operator	Receiving Stream	Location	Discharge Type
Allen Product Company	Jordan	2050 Pope Road, Allentown	Industrial Waste
GEO-TRIMET Products Group	Jordan	2409 N. Cedar Crest Blvd., Allentown	Industrial Waste
Kernsville Elementary School	Jordan	5051 Kernsville Road, Orefield	Sewage
KidsPeace	Jordan	5300 KidsPeace Drive, Orefield	Sewage
Parkland School District	Jordan	2700 N. Cedar Crest Blvd., Allentown	Sewage
Trexler-Lehigh Game Preserve	Jordan	5150 Game Preserve Road, Schnecksville	Sewage
Lehigh Carbon Community College	Jordan	4525 Education Park Drive, Schnecksville	Sewage
Heidelberg Heights	Mill	Germansville, Heidelberg Township	Sewage
Weisenberg Elementary School	Lyon	2665 Golden T Road, Kutztown	Sewage
Private Residential Discharge	Jordan	Not Available	Sewage
Private Residential Discharge	Jordan	Not Available	Sewage
Private Residential Discharge	Jordan	Not Available	Sewage
Private Residential Discharge	Jordan	Not Available	Sewage

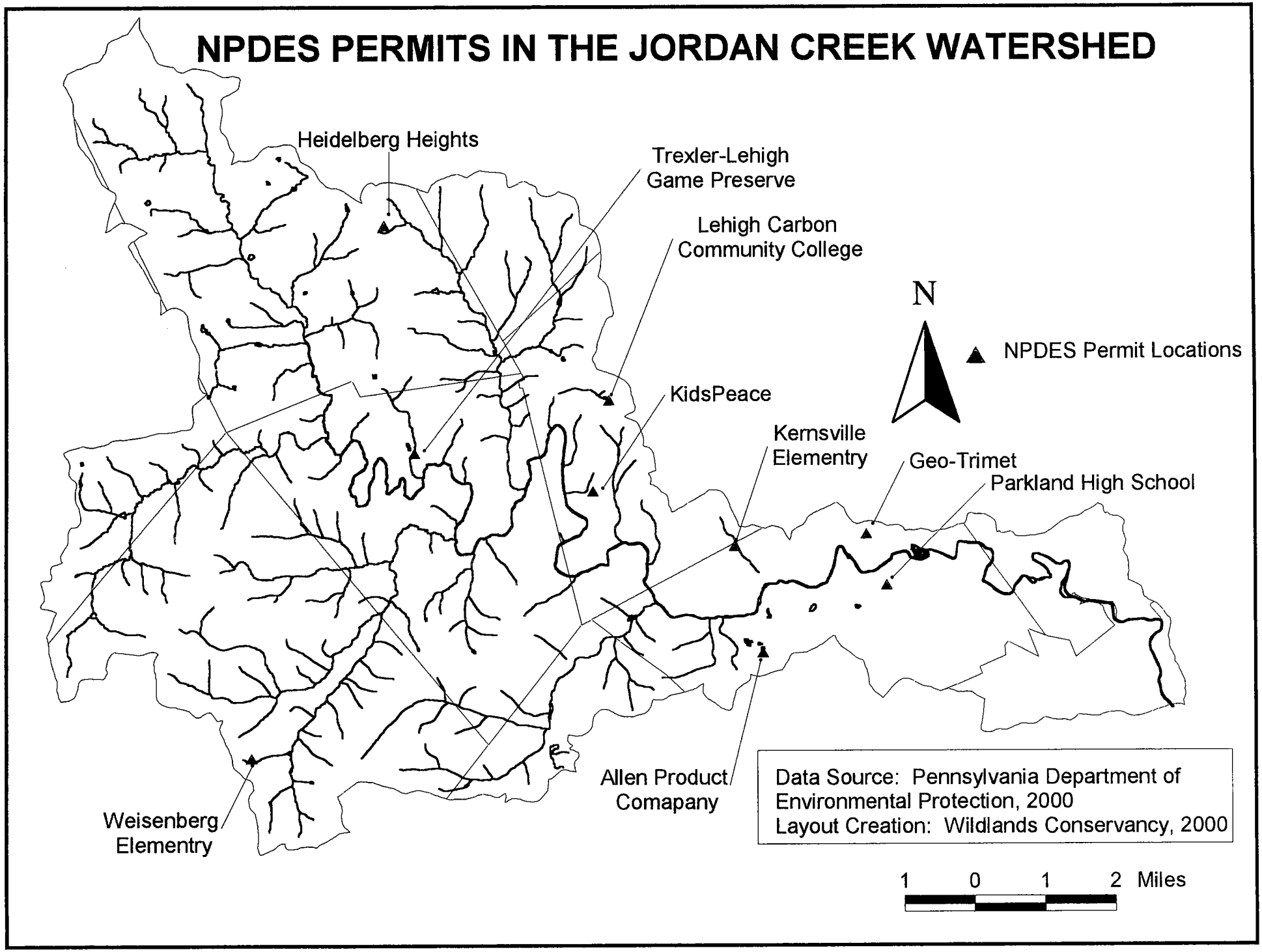


Figure 49. NPDES Permits in the Jordan Creek Watershed

3.0 BIOLOGICAL RESOURCES

3.0 BIOLOGICAL RESOURCES

3.1 Flora

The headwaters of the watershed, along the ridge of Blue Mountain, consist of a mixed species, mixed age forest dominated by Chestnut, Scarlet, and Upland Pin Oak. Blueberry and Allegheny Blackberry dominate the understory shrubs at the top of Blue Mountain.

Down the mountain, stands of Birch can be observed colonizing disturbed openings in the forest. Mountain Laurel exists in sporadic clusters on the higher slopes of the mountain. Big Tooth Aspen are also present on these slopes. There were occurrences of Norway Maple, an invasive, exotic species, on the mountain.

The lower slopes of the mountain consist of a mixed age, mixed species hardwood stand. Prevalent species include White, Black and Scarlet Oaks, Shagbark Hickory, Red Maple, Beech, and Tulip Poplar. Eastern White Pine can be observed scattered throughout the lower mountain slopes. Regeneration in the understory is composed mainly of oaks.

Extensions of the mountain forest are present in non-continuous stands along the base of the mountain and contain many of the same species. Red Maples seem to be colonizing abandoned fields around the headwaters. Multiflora Rose is invading the forest understory and stream banks near the headwaters of the creek.

At the confluence of the Jordan and Switzer Creek, Eastern Hemlocks dominate the north-facing slopes at the entrance to KOA Campgrounds. Characteristic vegetation along the upper Switzer Creek includes mixed hardwood forests were dominated by Beech. Other abundant species included Shagbark Hickory, White Oak, Black Cherry, and Ash. A few scattered Scotch Pines were also present along the upper portions of Switzer Creek. Tartarian Honeysuckle, a highly invasive species, has completely over-run the understory along Switzer Creek. Russian Olive is also an undesirable invasive shrub and is encroaching into the understory and especially prominent in the Game Preserve.

Mixed forests along Lyon Creek are vegetated predominantly with Shagbark Hickory, Beech, Red Maple, and Ash. Other notable species found along this tributary include Witch Hazel, Black Cherry, Apple, and White Oak. Allegheny Black Berry and Russian Olive are colonizing in disturbed areas with sunlight exposure.

Forested regions along Haasen Creek support a wide variety of species composition. Willows and Cucumber trees are present in low areas near the creek. Other species found throughout the Haasen Creek drainage basin included Hemlocks, Ash, Black Cherry, Sugar Maples, White Oaks, Black Oaks, Shagbark Hickory, and Beech. More sparsely distributed are occurrences of Sycamore.

A wooded area along the Jordan, above the dam at Covered Bridge Park, reveals a sycamore- and oak-dominated forest. Black and White Oaks are the prevalent species. Also abundant are Green Ash and Silver and Red Maple. Individual occurrences of American Hornbeam and

Cherry were spotted. The understory contains Sumac and Allegheny Blackberry. Tartarian Honeysuckle is also beginning to invade the floodplain in this area.

The last significant forested area surveyed was Jordan Park. This site contains a hardwood forest of mixed ages and species. Species composition consists predominantly of Sycamore and Ash, but also contains large numbers of Black and White Oaks, Sugar Maple and Beech. There are also single or scattered occurrences of Elm, Black Walnut and White Mulberry. Regeneration in the understory consists mostly of Beech.

3.1.1 Riparian Buffers

Riparian buffers are vegetated zones of protection located along streams or rivers. Riparian buffers serve several very important functions for the health and protection of the creek as described below:

Figure 19. Much of the upper half of the watershed contains substantial riparian vegetation, protecting the Jordan Creek against non-point source pollution.

Food Source: Stream bank vegetation provides food and energy for aquatic insects when leaves, woody debris and seeds fall into the stream. Preserving buffers to maintain an aquatic insect food source is important, as these insects are critical links in the food chain.

Habitat: Stream bank vegetation provides habitat not only for terrestrial life, but also for aquatic life. Overhanging branches and fallen logs from trees often provide much needed

shelter to protect fish from predators. In addition, deep pools are frequently created when stream banks are scoured below the root mass of vegetation, which holds the upper stream bank in place. These pools are the preferred habitat of fish as the water is cooler and they have protection from the overhanging bank and vegetation. Macro-invertebrates also use the vegetation for habitat purposes. Many insects build homes out of detritus that enters the stream from the surrounding buffer zone.

Temperature Moderation: The establishment of riparian buffers is a key to the fight against thermal pollution. Buffers shade the stream from sunlight and therefore help to keep water temperatures below levels that are detrimental to the life, growth and reproduction of coldwater fishes. Maintaining buffers in urban areas is extremely important because they can help mitigate the negative impact of storm water runoff from heated surfaces such as paved roads, parking lots, sidewalks, and roofs.

Stream Bank Stabilization: The roots of vegetation act as an anchor for the soil and hold soil particles together to help resist erosion. When located along a stream, the roots will help preserve the structural integrity of the stream bank and prevent accelerated rates of erosion and scouring of the banks.

Sediment and Nutrient Reduction: The extensive root system of vegetated buffers helps prevent sediment and nutrients contained in storm water runoff and overland flow from entering the stream. The roots and vegetation impede the flow of runoff, slowing down the water and allowing sediments to drop out and be deposited on the floodplain. Riparian buffers also reduce nutrient loading in the creek. Once deposited in the riparian zone, these nutrients are available for uptake by the vegetation, which needs nutrients to grow. Plants in a forest community play a major role in the retention of nutrient elements and a natural forest can be extremely efficient in conserving its mineral elements. In the nitrogen cycle the tissues of dead plants and animals is decomposed to ammonia or ammonium ions, which are then acted on by nitrifying bacteria to produce nitrates, the form in which nitrogen is usually assimilated by plants. If there are not enough plants present near a waterway, nitrate ions are not held in the soil and eventually enter the stream. As a side effect, the stream polluted with nitrates supports an algal bloom, which blocks sunlight from reaching more beneficial forms of aquatic plants. Excessive algal growth may result in rapid dissolved oxygen and pH fluctuations in the stream due to the processes of photosynthesis, decomposition and respiration.

3.1.2 Invasive and Exotic Vegetation

Hundreds of plant species have been relocated by humans from their native ranges to new areas. Many of the exotic plants that have been introduced, either by accident or by intention, have been beneficial and ecologically benign. But a small percentage have run rampant. Gaining a foothold first in areas disturbed by human activities, these species then move into natural areas where they have not only driven out indigenous species but in the worst cases radically altered the ecosystems they have invaded.

A native plant is one that occurred within the state before settlement by Europeans. Native plants include ferns and clubmosses; grasses, sedges, rushes, and their kin; flowering

perennials; annuals; biennials and the woody trees, shrubs and vines. There are over 2100 native plant species known in Pennsylvania (Pa. DCNR, 1998). An introduced or "exotic" plant is one that has been brought in and becomes established. In 1998 there were 1300 species of exotic plants in Pennsylvania (Pa. DCNR, 1998). That is 37% of Pennsylvania's total plant flora, and more introduced plants are identified every year. An "invasive" plant not only becomes established, but spreads aggressively into new areas and environments. Some native plants are aggressive in disturbed areas, but most invasive plants are introduced from other continents, leaving behind pests, diseases, predators and natural controls.
Species that have flourished and spread on their own only after people transported them across barriers they could not otherwise surmount (such as oceans, mountain ranges and deserts) are considered non-natives or exotics. In many areas these plants have overwhelmed the native plants and animals. These species are considered invasive. Exotic species are responsible for most damaging invasions, but a far smaller number of natives also have invaded and degraded new habitats (Marinelli, 1996). Invasives reproduce rapidly and can form stands that exclude nearly all other plants. In the process they damage natural areas, altering ecosystem processes, displacing native species, hybridizing with natives and changing their genetic makeup and supporting other non-native plants, animals and pathogens (Marinelli, 1996).

A number of invasive and exotic species have been identified within the watershed. These species present a threat to the abundance and diversity of native vegetation within the watershed. Invasive species usually establish themselves first in disturbed areas and then quickly spread across the surrounding landscape. Some species that have been identified within the Jordan watershed include Multiflora rose, found near the headwaters; Russian and Autumn olive and Tartarian honeysuckle, predominantly found spanning the mid-sections of the watershed; and purple loosestrife, found mostly near the mouth of the Jordan.
Some invasive species in the region, such as Norway maples, release toxins to the soil that inhibit growth and reproduction of native species. Invasive trees are often overlooked because they do not have the dense vine or shrub form typical of exotics. The threat of the Norway maple in many regions is unnoticed because most trees are still saplings. However, by the time these saplings mature, the forested land will be composed almost exclusively of Norway Maple. Even invasive trees do not provide adequate protection from erosion. These trees prevent the establishment of an herbaceous or shrub layer, leaving much of the soil bare and subject to erosion. The Norway maple is no longer recommended, but a large demand still exists and it continues to be used on a widespread basis (Andropogon Associates, 1991).

In forested areas, trees such as Norway Maple (*Acer platanoides*) grow into the canopy, as do vines like Japanese honeysuckle (*Lonicera japonica*), where they shade out or topple trees. In wetlands in the northern third of the United States and southern Canada, purple loosestrife (*Lythrum salicaria*) forms large, dense strands, eliminating the open water areas that waterfowl require and elsewhere displacing native plants that feed and shelter wildlife.

Invasive and exotic species are a major environmental threat to many naturally vegetated regions. Many natural lands, which are becoming more frequently disturbed and fragmented, are increasingly susceptible to invasive and exotic species. When introduced to a new region, invasive vegetation spreads rapidly, overtaking the native habitat. The introduction of just a

few invasive species is sufficient to severely limit the diversity of a natural system, especially if that system is also stressed by other environmental factors. Limiting vegetative diversity ultimately limits wildlife diversity, as birds and animals require different vegetative species for cover and food (Andropogon Associates, 1991).

Invasive species were abundantly and widely distributed when they were believed to be quick solutions to erosion problems. These invasive exotics have shallow root systems that spread quickly to provide ground cover for bare slopes. However, these roots do not effectively stabilize soil, and stream banks continue to erode (Andropogon Associates, 1991).

Exotic species threaten the ecology of naturally vegetated areas, as they do not provide proper food and habitat for native wildlife. For example, if an aquatic macro-invertebrate did not evolve feeding on Norway maple, it will not be edible to that species now. Therefore, that macro-invertebrate species may relocate or be wiped out of the stream entirely, if it cannot find the feeding material on which it evolved eating. Since macro-invertebrates, diatoms and other microorganisms are basic building blocks in the food chain, a loss of them could disrupt the ecology within the riparian habitat.

Invasive species are a severe problem because there are no means of effectively controlling their spread. Many invasive species are spread very rapidly over great distances by animal and bird dispersal. The only means of control is to eliminate as many existing plants as possible and restrict planting of new species (Andropogon Associates, 1991). No species that is proven to be or even suspected of being a successful invader should be planted.

Table 13. Invasive Exotic Species Found in the Jordan Creek Watershed

COMMON NAME	SCIENTIFIC NAME
Trees	
Norway Maple	*Acer pltanides*
Norway Spruce	*Picea glauca*
Russian Olive	*Eleangnus angustifolia*
Autumn Olive	*Eleangnus umbellatus*
Shrubs and Small Trees	
Tartarian Honeysuckle	*Lonicera tatarica*
Multiflora Rose	*Rosa Multiflora*
Vines	
Japanese Honeysuckle	*Lonicera japonica*
Herbaceous Plants	
Purple Loosestrife	*Lythrum salicaria*
Japanese Knotweed	*Polygonum cuspidatum*
Canada Thistle	*Cirsium altissimum*
Timothy grass	*Phleum pratense*
Crabgrasses	*Digitaria sanguinalis*
Quackgrass	*Elytrigia repens*

3.2 Fauna

3.2.1 Aquatic Macro-invertebrates

Macro-invertebrate sampling was conducted by Kelly Maloney from Lehigh University in the summer of 1999 and analyzed by Wildlands Conservancy. Table 14 lists the Families found in the Jordan Creek and statistical analysis is examined in Section 2.2.4 of this Management Plan and in Appendix C.

Table 14. Macro-invertebrates of the Jordan Creek Watershed

ORDER	COMMON NAME	FAMILY
Coleoptera	Water Beetles	Psephenidae
		Gyrinidae
		Elmidae
Ephemeroptera	Mayflies	Ephemerellidae
		Heptagenidae
		Baetidae
		Leptophlebidae
		Caenidae
		Tricorythidae
Plecoptera	Stoneflies	Perlidae
		Perlodidae
Trichoptera	Caddisflies	Hydropyschidae
		Hydroptilidae
		Philopotamidae
		Limnephilidae
		Glossosomatidae
		Uenoidae
		Helicopsychidae
Diptera	True Flies	Chironomidae
		Ceratopogonidae
		Tipuliidae
Odonata	Dragon/Damsel Flies	Gomphidae
		Coenagriondae
Hemiptera	True Bugs	Veliidae
		Gerridae
Megaloptera	Black Flies	Corydalidae
		Sialidae

Table 14. Continued

Mollusca	Clams	Bivalvia
Gastropoda	Slugs/Snails	Gastropoda
Annelida	Worms	Oligachaeta Hirudinea

3.2.2 Fish

There have been numerous fish surveys conducted throughout the Jordan Creek watershed. Table 15 lists the common and scientific names of each species that has been identified between 1988 and 1990. A detailed analysis of these fish surveys is located in section 2.2.4 of this report. Figure 20 shows the sections of the Jordan Creek that are currently stocked with brown, brook and rainbow trout by the Pennsylvania Fish and Boat Commission.

Table 15. Fish of the Jordan Creek and its Tributaries (Source: Pennsylvania Fish and Boat Commission)

COMMON NAME	SCIENTIFIC NAME
American Eel	*Anguilla rostrata*
Blacknose Dace	*Rhinichthys artratulus*
Bluegill	*Lepomis macrochirus*
Bluntnose Minnow	*Pimephales notatus*
Brown Bullhead	*Ictalurus nebulosus*
Brown Trout	*Salmo trutta*
Common Carp	*Cyprinus carpio*
Common Goldfish	*Carassius auratus*
Comely Shiner	*Notropis ameonus*
Common Shiner	*Notropis cornutus*
Creek Chub	*Semotilus atromaculatus*
Cutlips Minnow	*Exoglossum maxillingua*
Fallfish	*Semotilus corporalis*
Green Sunfish	*Lepomis cyanellus*
Golden Shiner	*Notemigonas crysoleucas*
Johnny Darter	*Etheostoma nigrum*
Largemouth Bass	*Mirropterus salmoides*
Longnose Dace	*Rhinichthys cataractae*
Margined Madtom	*Noturus insignis*
Pumpkinseed	*Lepomis macrochirus*
Rainbow Trout	*Salmo gairdneri*
Redbreast Sunfish	*Lepomis macrochirus*
Redfin Pickerel	*Esox americanus americanus*
Rock Bass	*Ambloplites rupellus*
Rosyface Shiner	*Notropis rubellus*

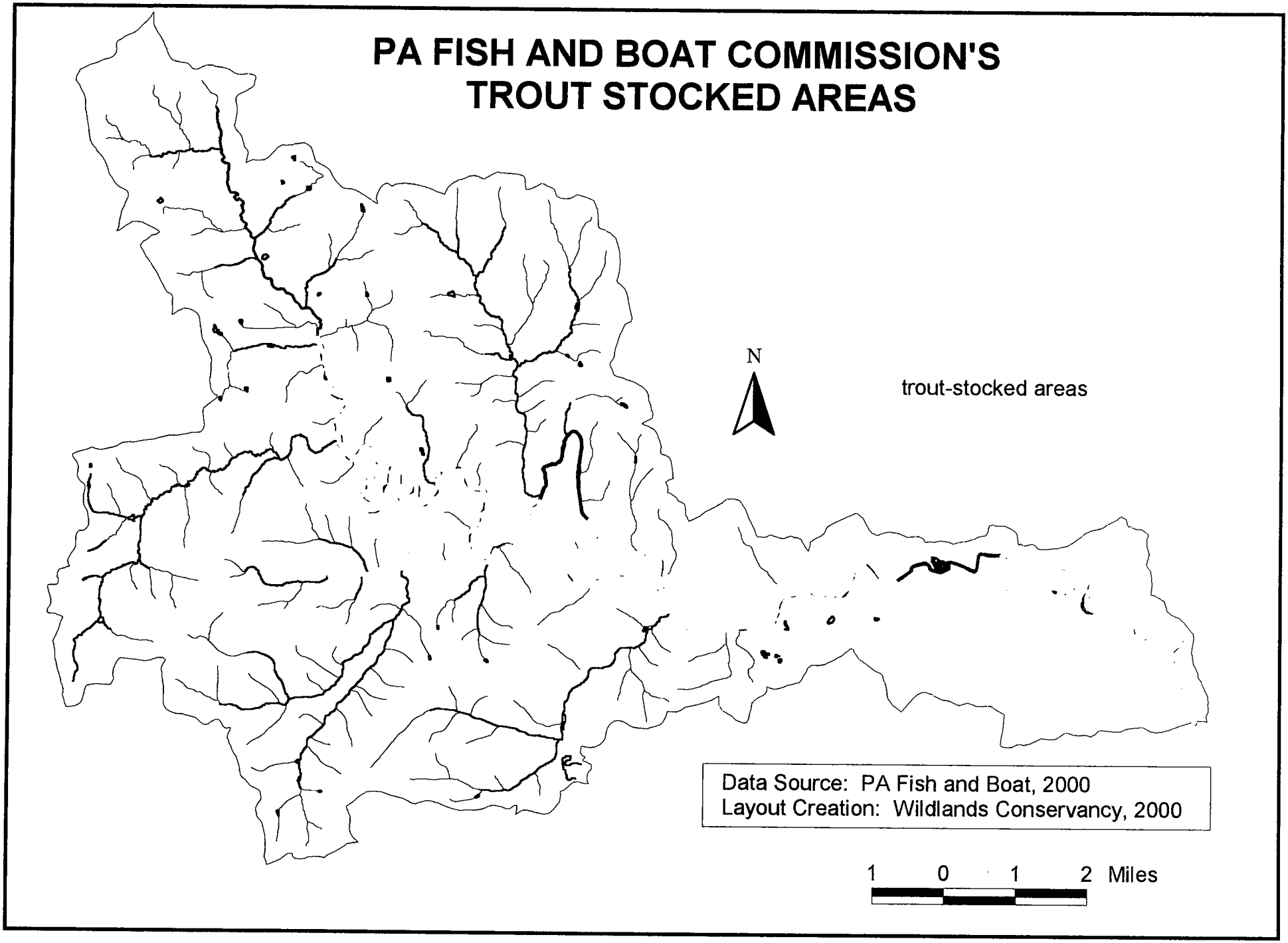


Figure 20. Trout-stocked Sections of the Jordan Creek

Table 15. Continued

Satinfin Shiner	*Notropis analostanus*
Shield Darter	*Percina peltata*
Slimy Sculpin	*Cottus cognatus*
Smallmouth Bass	*Micropterus dolomieui*
Spotfin Shiner	*Notropis spilopterus*
Spottail Shiner	*Notropis hudsonius*
Tessellated Darter	*Etheostoma olmstedi*
White Sucker	*Catostomus commersoni*

3.2.3 Amphibians and Reptiles

Wildlands Conservancy, with assistance from the Pennsylvania Game Commission, has produced the following list of amphibians and reptiles likely to be found in the Jordan Creek watershed. This list is based primarily on species reports from the Pa. Game Commission and was expanded upon through the use of *National Audubon Society's Field Guide* by Wildlands Conservancy staff. These reptiles and amphibians are representative of those found in northeastern Pennsylvania and is not an exhaustive herpetological inventory.

Table 16. Amphibians and Reptiles of the Jordan Creek Watershed
(Data Source: Wildlands Conservancy and Pennsylvania Game Commission)

COMMON NAME	SCIENTIFIC NAME
American Toad	*Bufo americanus*
Black Rat Snake	*Elaphe obsoleta*
Bullfrog	*Rana catesbiana*
Common Garter Snake	*Thamnophis sirtalis*
Copperhead	*Agkistrodon mokasen*
Eastern Box Turtle	*Terrapene carolina*
Eastern Red-spotted Newt	*Notophthalmus viviescens*
Eastern Ribbon Snake	*Thamnophis sauritus*
Fowlers Toad	*Bufo fowleri*
Grey Tree Frog	*Hyla versicolor*
Green Frog	*Rana clamitans melanota*
Longtail Salamander	*Eurycea longicauda*
Milk Snake	*Lampropeltis triangulum*
Northern Brown Snake	*Storeria dehayi*
Northern Dusky Salamander	*Desmognathus fuscus*
Northern Leopard Frog	*Rana pipiens*
Northern Red Salamander	*Psuedotriton rubber*
Northern Red-bellied Snake	*Storeria occipitomaculata*
Northern Slimy Salamander	*Plethodon glutinosus*
Northern Spring Salamander	*Gyrinophilus porpheritirus*

Table 16. Continued

Northern Two-lined Salamander	*Eurycea bislineata*
Northern Water Snake	*Nerodia sipedon*
Northern Black Racer	*Coluber constrictor*
Painted Turtle	*Chrysemys picta*
Pickerel Frog	*Rana palustris*
Rat Snake	*Elaphe obsoleta*
Red-backed Salamander	*Diadophis edwardsil*
Snapping Turtle	*Plethadon cinereus*
Ringneck Snake	*Chelydra serpentina*
Spotted Salamander	*Ambystoma maculatum*
Spotted Turtle	*Clemmys guttata*
Spring Peeper	*Pseudacris crucifer*
Stinkpot	*Sternotherus odoratus*
Wood Frog	*Rana sylvatica*
Wood Turtle	*Clemmys insculpta*

3.2.4 Birds

The Pennsylvania Game Commission provided information to Wildlands Conservancy regarding the birds and mammals present in State Game Lands 205, which is situated in the center of the watershed. It is assumed that other natural areas of the watershed would have similar species of birds due to the close proximity and similar vegetative communities. The information provided by the Pa. Game Commission was enhanced by Wildlands Conservancy staff with the aid of *National Audubon Society's Field Guide*. This list is not known to be an exhaustive inventory of all watershed birds. It is a listing of birds that have been identified in the watershed or have similar habitats to those of the watershed.

Table 17. Birds of the Jordan Creek Watershed
(Data Source: Wildlands Conservancy and Pennsylvania Game Commission)

COMMON NAME	SCIENTIFIC NAME
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Carduelis tristis*
American Kestrel "Sparrow Hawk"	*Falco sparverius*
American Robin	*Turdus migratorius*
American Tree Sparrow	*Spizella arborea*
American Woodcock	*Scalopax minor*
Bank Swallow	*Riparia riparia*
Barn Owl	*Tyto alba*
Barn Swallow	*Hirunda rustica*
Barred Owl	*Strix varia*
Belted Kingfisher	*Ceryle alcyon*

Table 17. Continued

Black-capped Chickadee	*Parus atricapillus*
Blue Jay	*Cyanocitta cristata*
Brown Creeper	*Certhia Americana*
Brown Thrasher	*Toxostoma rufum*
Brown-headed Cowbird	*Molthrus ater*
Canada Goose	*Branta canadensis*
Carolina Wren	*Thryothorus ludovicianus*
Chimney Swift	*Chaetura pelagica*
Chipping Sparrow	*Spizella passerina*
Cliff Swallow	*Hirundo pyrrhonota*
Common Grackle	*Quiscalus quiscula*
Cooper's Hawk	*Accipiter cooperii*
Dark-eyed Junco	*Junco hyemalis*
Downy Woodpecker	*Picoides pubescens*
Eastern Bluebird	*Sialia sialis*
Eastern Meadowlark	*Sturnella magna*
Eastern Screech Owl	*Otus asio*
European Starling	*Sturnus vulgaris*
Evening Grosbeak	*Coccothraustes vespertinus*
Field Sparrow	*Spizella pusilla*
Gray Catbird	*Dumetella carolinensis*
Great Blue Heron	*Ardea herodias*
Great Horned Owl	*Bubo virginianus*
Green Heron	*Butorides virescens*
Hairy Woodpecker	*Picoides villosus*
House Finch	*Carpodacus mexicanus*
House Sparrow	*Passer domesticus*
House Wren	*Troglodytes aedon*
Indigo Bunting	*Passerina cyanea*
Kill Deer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Mourning Dove	*Zenaida macroura*
Northern Cardinal	*Cardinalis cardinalis*
Northern Flicker	*Colaptes auratus*
Northern Harrier "Marsh Hawk"	*Circus cyaneus*
Northern Mocking Bird	*Mimus polyglottos*
Northern Oriole	*Icterus galbula*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Osprey	*Pandion haliaetus*
Pileated Woodpecker	*Dryocopus pileatus*
Purple Finch	*Carpodacus purpureus*
Purple Martin	*Progne subis*
Red-breasted Nuthatch	*Sitta canadensis*

Table 17. Continued

Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Black Bird	*Agelaius phoeniceus*
Ring-necked Pheasant	*Phasianus colchicus*
Rock Dove	*Columba livia*
Ruby-throated Hummingbird	*Archilochus colubris*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Scarlet Tanager	*Piranga olivacea*
Sharp-shinned Hawk	*Accipiter striatus*
Song Sparrow	*Melospiza melodia*
Tree Swallow	*Tachycineta bicolor*
Tufted Titmouse	*Parus bicolor*
Turkey Vulture	*Cathartes aura*
White-breasted Nuthatch	*Sitta carolinensis*
White-throated Sparrow	*Zonotrichia albicollis*
Wild Turkey	*Meleagris gallopavo*
Wood Ducks	*Aix sponsa*
Wood Thrush	*Hylocichla mustelina*

3.2.5 Mammals

This list of mammals was again produced through the same process as the herpetological and avian inventories, in conjunction with the Pa. Game Commission and Wildlands Conservancy. This list is not known to be exhaustive.

Table 18. Mammals of the Jordan Creek Watershed
(Data Source: Wildlands Conservancy and Pennsylvania Game Commission)

COMMON NAME	SCIENTIFIC NAME
Big Brown Bat	*Eptesicus fuscus*
Black Bear	*Ursus americanus*
Bobcat	*Felis rufus*
Coyote	*Canis latrans*
Eastern Chipmunk	*Tamias striatus*
Eastern Cottontail	*Sylvilagus floridanus*
Eastern Mole	*Sylvilagus aquaticus*
Eastern Pipistrelle	*Pipistrellus subflavus*
Gray Fox	*Urocyon cinereoargenteus*
Gray Squirrel	*Sciurus carolinensis*
Hoary Bat	*Lasiurus cinereus*
House Mouse	*Mus musculus*

Table 18. Continued

Little Brown Bat	*Myotis lucifugus*
Long-tailed Weasel	*Mustela frenata*
Meadow Vole	*Microtus pennsylvanicus*
Mink	*Mustela vison*
Muskrat	*Ondatra zibethicus*
Porcupine	*Erethizon dorsatum*
Raccoon	*Procyon lotor*
Red Fox	*Vulpes vulpes*
Red Squirrel	*Tamiasciurus*
Short-tailed Shrew	*Blarina brevicauda*
Silver-haired Bat	*Lasionycteris noctivagans*
Southern Flying Squirrel	*Glaucomys volans*
Striped Skunk	*Mephitis mephitis*
Virginia Opossum	*Didelphis virginiana*
White-footed Mouse	*Peromyscus leucopus*
White-tailed Deer	*Odocoileus virginianus*
Woodchuck "Groundhog"	*Marmota monax*
Woodland Vole	*Microtus pinetorum*

3.3 Species of Special Concern

There are a number of extant and historical species of flora and fauna located within the Jordan Creek watershed. Extant species have been observed as recently as 1993 and historical species were most recently observed in 1958. In order to protect these species and prevent exploitation of them, the locations of the species may not be provided within this document. However, the information can be obtained for protective and preservation purposes from Pennsylvania Natural Diversity Index (PNDI), a cooperative project of the Department of Conservation and Natural Resources, The Nature Conservancy, and the Western Pennsylvania Conservancy. Explanations of all of the possible global and state ranks can be found in Table 19.

Common Name: **Western Hairy Rock-Cress**
Scientific Name: *Arabis hirsuta*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S2-Imperiled in the state because of rarity or because of some factors making it especially vulnerable to extirpation from the state.
Date Last Observed: 1991

Common Name: **Brown Sedge**
Scientific Name: *Carex buxbaumi*
Global Rank: G5-Secure-Common, typically widespread and abundant.

TABLE 19. Pa. Natural Diversity Index Classifications

BASIC GLOBAL RANK CODES AND DEFINITIONS

GX **Presumed Extinct** – Believed to be extinct throughout its range. Not located despite intensive searches of historic sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

GH **Possibly Extinct** – Known from only historical occurrences. Still some hope of rediscovery.

G1 **Critically Imperiled** – Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or stream miles (<10).

G2 **Imperiled** – Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000) or acres (2,000 to 10,000) or stream miles (10 to 50).

G3 **Vulnerable** – Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.

G4 **Apparently Secure** – Uncommon but not rare, and usually widespread. Possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.

G5 **Secure** – Common, typically widespread and abundant. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

STATE RANK CODES AND DEFINITIONS

SX **Extirpated** – Element is believed to be extirpated from the "state" (or province or other subnational unit).

SH **Historical** – Element occurred historically in the state (with expectation that it may be rediscovered), perhaps having not been verified in the past 20 years, and suspected to be still extant. Naturally, an Element would become SH without such a 20-year delay if the only known occurrences in a state were destroyed or if it had been extensively and

Table 19. Continued

unsuccessfully looked for. Upon verification of an extant occurrence, SH-ranked Elements would typically receive an S1 rank. The SH rank should be reserved for Elements for which some effort has been made to relocate occurrences, rather than simply ranking all Elements not known from verified extant occurrences with this rank.

S1 **Critically Imperiled** – Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. Typically 5 or fewer occurrences or very few remaining individuals or acres.

S2 **Imperiled** – Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. Typically 6 to 20 occurrences or few remaining individuals or acres.

S3 **Vulnerable** – Vulnerable in the state either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences.

S4 **Apparently Secure** – Uncommon but not rare, and usually widespread in the state. Usually more than 100 occurrences.

S5 **Secure** – Demonstrably widespread, abundant, and secure in the state, and essentially ineradicable under present conditions.

S? **Unranked** – State rank is not yet assessed.

SU **Unrankable** – Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. NOTE: Whenever possible, the most likely rank is assigned and a question mark added (e.g., S2?) to express uncertainty, or a range rank (e.g., S2S3) is used to delineate the limits (range) of uncertainty.

S#S# **Range Rank** – A numeric range rank (e.g., S2S3) is used to indicate the range of uncertainty about the exact status of the Element. Ranges cannot skip more than one rank (e.g., SU should be used rather than S1S4).

State Rank: S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.
Date Last observed: 1992

Common Name: **A Gay-Feather**
Scientific Name: *Liatris scariosa var nieuwlaandii*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S2-Imperiled in the state because of rarity or because of some factors making it especially vulnerable to extirpation from the state.
Date Last Observed: 1991

Common Name: **Winged Loosestrife**
Scientific Name: *Lythrum alatum*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.
Date Last Observed: 1993

Common Name: **Mead's Sedge**
Scientific Name: *Carex meadii*
Global Rank: G4-Apparently Secure-Uncommon but not rare, and usually widespread. Possibly cause for long-term concern. G5-Secure-Common, typically widespread.
State Rank: S2-Imperiled in the state because of rarity or because of some factors making it especially vulnerable to extirpation from the state.
Date Last Observed: unknown

Common Name: **Schweinitz's Flatsedge**
Scientific Name: *Cyperus schweinitzii*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.
Date Last Observed: 1948

Common Name: **Slender Cotton Grass**
Scientific Name: *Eriophorum gracile*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.
Date Last Observed: 1948

Common Name: **Lupine**
Scientific Name: *Lupinus perenis*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S2-Imperiled in the state because of rarity or because of some factors making it especially vulnerable to extirpation from the state.

S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.
Date Last Observed: 1926

Common Name: **Golden Club**
Scientific Name: *Orontium aquaticum*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S2-Imperiled in the state because of rarity or because of some factors making it especially vulnerable to extirpation from the state.
S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.

Common Name: **Whitlow Wort**
Scientific Name: *Paronychia fastigiata v. nuttalli*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.
Date Last Observed: 1951

Common Name: **Tuckerman's Pondweed**
Scientific Name: *Potamogeton confervoides*
Global Rank: G3-Vulnerable-Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction. G4-Apparently Secure-Uncommon but not rare, and usually widespread. Possibly cause for long-term concern.
State Rank: S2-Imperiled in the state because of rarity or because of some factors making it especially vulnerable to extirpation from the state.
Date Last Observed: 1878

Common Name: **Virginia Rose**
Scientific Name: *Rosa virginiana*
Global Rank: G5-Secure-Common, typically widespread and abundant.
State Rank: SU-Unrankable-Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
Date Last Observed: 1951

Common Name: **Wiry Witchgrass**
Scientific Name: *Pancium flexile*
Global Rank: G4-Apparently Secure-Uncommon but not rare, and usually widespread. Possibly cause for long-term concern. G5-Secure-Common, typically widespread.
State Rank: S3-Vulnerable in the state either because rare and uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation.
Date Last Observed: 1921

3.4 Important Natural Areas

3.4.1 Protected Habitats

State Game Lands 217, on the south side of Blue Mountain, form the most northwestern portion of the watershed. These 442 acres of biologically rich habitat provide natural protection to the headwaters of the Jordan Creek. The Conrad Raker Conservation Area, an environmental field station for Muhlenberg College, is a 40-acre wooded tract in Germansville. This sanctuary is used by biology classes for field study and a section of the Jordan Creek within the preserve provides added opportunity for aquatic biology studies. Muhlenberg students and teachers also conduct research on various aspects of plant and animal biology. Centrally located in the watershed is State Game Lands 205, containing 1303 acres of wildlife habitat and open space preservation and the Trexler-Lehigh Game Preserve, which protects 1066 acres. Closer to the mouth of the Jordan is a protected habitat area owned by a local industry. The property is located adjacent to the creek and abuts Route 29 (Cedar Crest Boulevard). Species that have been reported at the site include fox, turkey, deer and coyote.

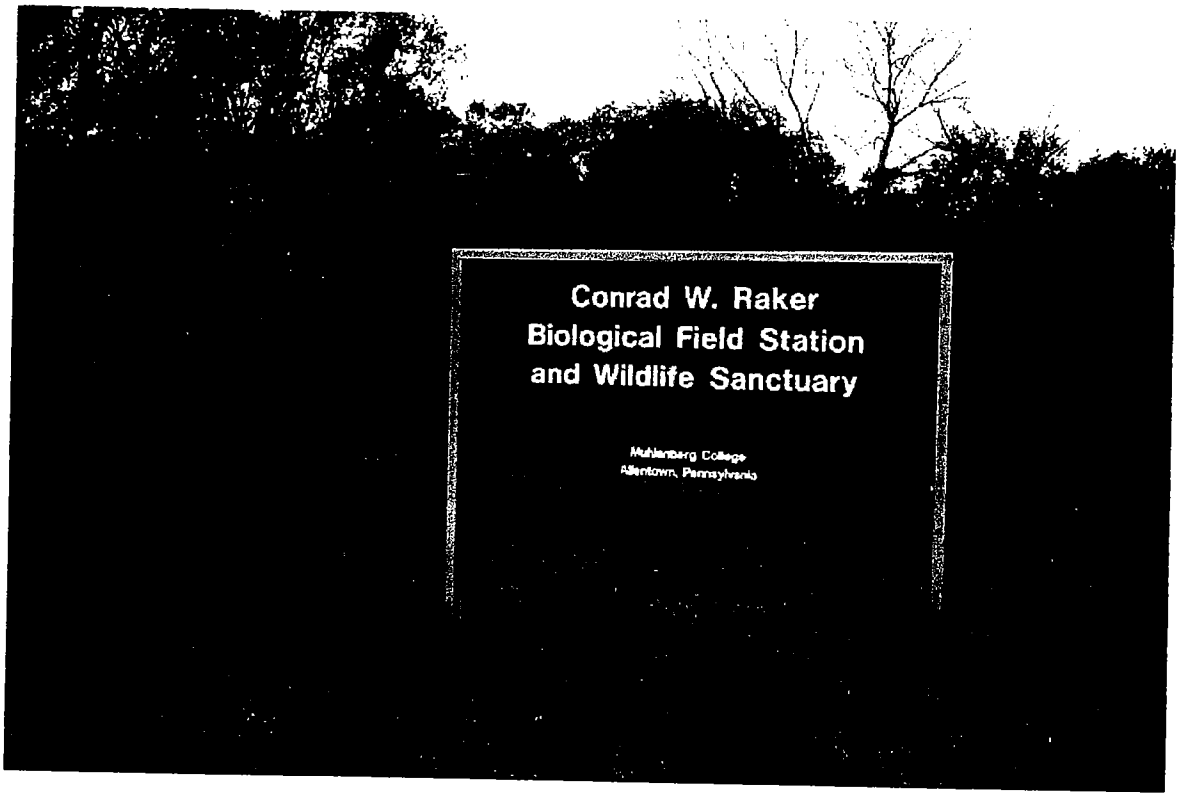


Figure 21. The Conrad W. Raker Sanctuary is maintained by Muhlenberg College and is located in Heidelberg Township.

Figure 22. State Game Lands 205, in Lowhill Township, are accessible from Route 100.

3.4.2 Important Natural Areas

Listed below are the sites of statewide significance for protection of biological diversity. These areas are shown in Figure 23 and were identified in a report, *A Natural Areas Inventory of Lehigh and Northampton Counties, Pennsylvania*, prepared by the staff of the Pennsylvania Science Office of the Nature Conservancy and are available from the Lehigh Valley Planning Commission.

Helfrich Springs Cave—This site is a cave formed in limestone and dolomite. A single individual of a G4 S2S3 (refer to Table 19) animal species was found here in 1998. The rear portion of the cave serves as a hibernaculum for several species of bats.

Jordan Creek Slopes—This locally significant site is a relatively diverse second growth forest. Along with its plant diversity the site is significant for the many types of habitat it supports including streams, seeps, lakeshore, forest and boulder fields

Jordan Valley Marsh—This site supports a fair quality population of Pa.-Endangered sedge species. Succession is a potential threat. (Succession is the change in species that occupy a given area, with some species invading and becoming more numerous while others decline in population and disappear.)

Trexler Hollow—A roadside outcrop of Martinsburg shale supports two plant species of concern. Further surveys are recommended to determine if the populations of these species are more widespread in this area. Roadside herbicide spraying is a potential threat to the species of concern at this site.

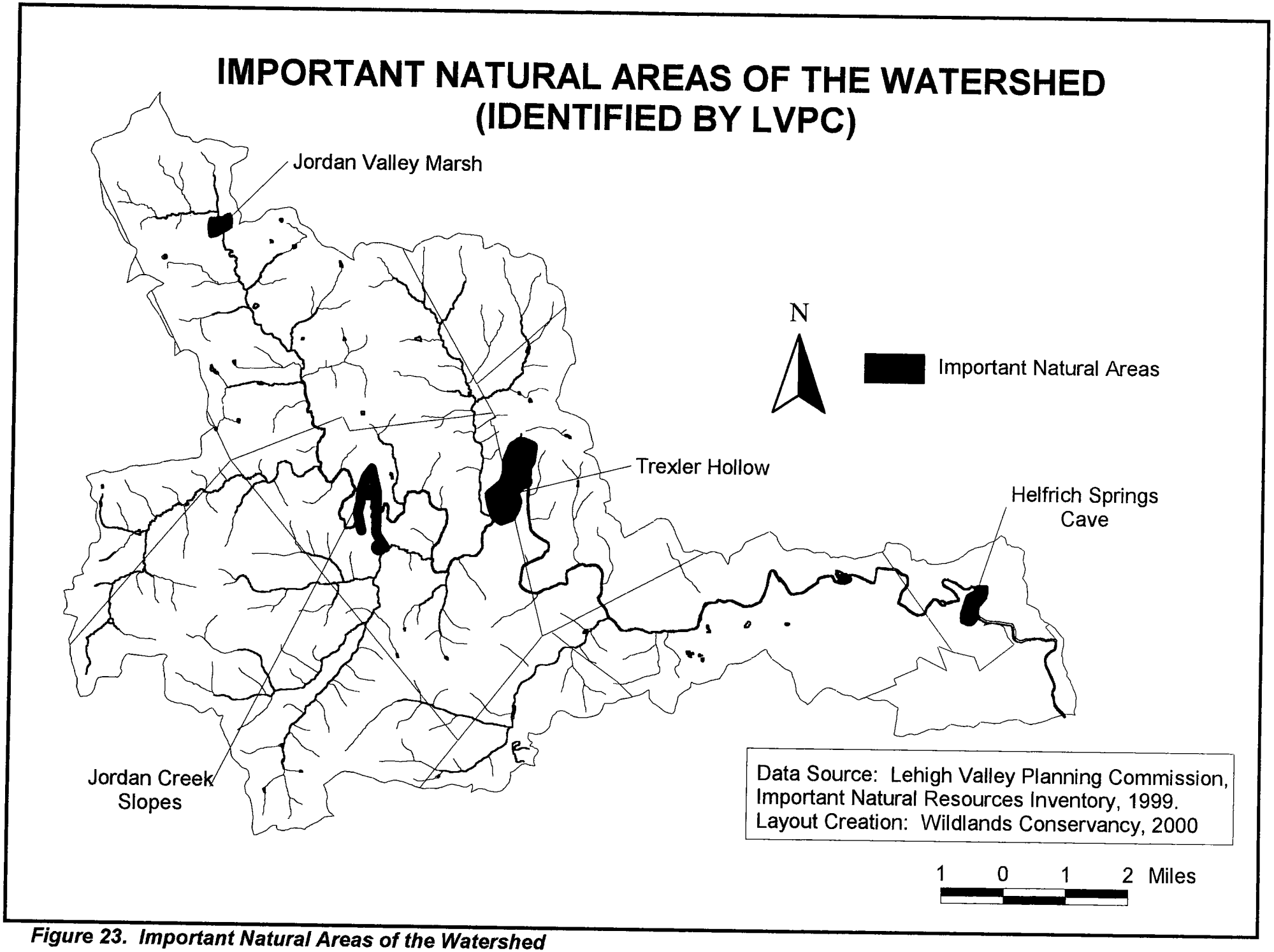


Figure 23. Important Natural Areas of the Watershed

4.0 CULTURAL RESOURCES

4.0 CULTURAL RESOURCES

4.1 Historical Review

The Jordan Creek watershed has a long and rich history, from Native Americans to European Settlement, throughout the Ages of Agriculture and Industry and into the Contemporary Era. The historical events of the region have shaped both its landscape and its residents of today. The economic development of the watershed is unique, inventive and diversified.

4.1.1 Native American History

When the first Europeans appeared in the Middle Atlantic area, Indians of the Algonquian language occupied the Delaware River Valley. They called themselves *Lenni-Lenape*, signifying "the real people" or "the original people", with a connotation of superiority and special destiny (Klein, 1973). The English later gave these Indians the name "Delawares." According to Delaware legend, they had migrated eastward from the Pacific Coast and, in alliance with the Iroquois, had driven out the earlier inhabitants of the New York-Pennsylvania region, the Eries and the Monongahela (Klein, 1973). The Lenni-Lenape made their home from the Allegheny Mountains to the Atlantic Ocean. The Lenni-Lenape divided into the Wolf tribe, or *Minsi*, who lived along the eastern ridges of the mountains; the Turtle tribe, or *Unamis*, who hunted and farmed in the lower Delaware valley; and the Turkey tribe, or *Unalachtigos*, who occupied the area between Delaware Bay and the Atlantic Ocean (Klein, 1973).

The Lenni-Lenape possessed a civilization with developed concepts and procedures of government, religion, education, social responsibility, morality and personal honor (Soderlund, 1985). Although Indian chiefs or "kings" as the Europeans called them, nominally ruled the tribes, they governed more by consensus than by edict (Soderlund, 1985). The whole tribe often met in council, the chief in the center, surrounded by elders, young warriors, women and in the outermost circle, children. William Penn remarked "how powerful kings are, yet how they move by the breath of their people" (Soderlund, 1985). The Indians had the rudiments of representative government and developed procedures for policy making, diplomacy, declaring war, making peace and handling personal misconduct (Soderlund, 1985).

Although the Delawares had no religion in the European sense of a contrived theology; they based their lives on certain beliefs about their creator and the expectancy of judgment in an afterlife. The Indians had phrased the ideal of the Golden Rule long before they ever heard of the Bible, and found no difficulty accepting many Christian concepts (Klein, 1973).

These people contributed much to the early colonists. They shared their knowledge of agriculture and introduced Europeans to such crops as potatoes, corn, beans, squash, tomatoes and tobacco. They provided the pelts for colonial ventures in the fur trade. They eased access to the interior of Pennsylvania not only by their canoes, but by a network of well-defined Indian paths, so numerous and well placed that many of the routes still serve their original purpose, functioning as modern day highways. Their language, through unwritten, lives on in hundreds of picturesque names for countries, towns, mountains and rivers.

4.1.2 Early Settlement, 1681-1763

In 1681, William Penn became the largest single landowner in the world through a grant from the British government. The territory measured about 54,000 square miles or 35 million acres overall (Eckhart, 1992). The province contained about 2000 white inhabitants comprised primarily of English, Dutch and Swedes. In 1682, Penn visited his province for the first time and instituted a government, planned the city of Philadelphia and laid the foundation for the Commonwealth. English and Welsh Quakers were the first immigrants. In 1701, a Charter of Pennsylvania was issued which remained in effect until the drafting of the State Constitution in 1776. William Penn had three sons, Thomas, Richard and John, who succeeded him as heirs.

As early as 1715 immigrants began to inhabit the Lehigh Valley region. Following rivers, creeks and Native American trails, they located along the banks of streams or near springs. As settlement continued, immigrants selected readily accessible and obviously fertile sites near a fresh water supply (Fletcher, 1950). By 1738, families of similar religions began to settle in the same areas. The Lutheran of Reformed Churches, being the vast majority, settled in the area now occupied by North Whitehall Township. Settlement in Upper Macungie Township was also established by 1743 (Eckhart, 1992).

Next to the family of William Penn, the largest owner of property was William Allen, a London barrister who came to Philadelphia and later became Chief Justice of the colony (Joint Planning Commission, 1963). This ground owned by William Allen was retained as a private hunting area. On the west bank of the Jordan Creek he erected a log cabin as a hunting and fishing lodge for friends and family. Northwest from Allen's region, not far from the Jordan Creek, Lynford Lardner of Philadelphia owned a stone house called Grouse Hall. This region of the Lehigh Valley contained many other cabins, speculating the advantage for trade and milling in the location (Joint Planning Commission, 1963). In 1762 this region, within the forks where Jordan Creek and Little Lehigh Creek join, became the foundation of what is now known as Allentown.

4.1.3 Age of Agriculture, 1763-1830

Between 1763 and 1790, the German population had proliferated in the Lehigh Valley region. This changing proportion of Germans and Scotch-Irish was partially due to the difference of attitudes toward the soil of the valley. The Germans were drawn to the limestone soils, which resembled those of Europe (Joint Planning Commission, 1963). The German's farming nature was reflected in their care of the soil and their livestock. They practiced basic methods of crop rotation and burned and spread limestone and spread cattle manure in order to maximize fertilizer for the land.

Until the completion of the Lehigh Canal in 1829 the population growth rate in the Lehigh County area continued to increase. In 1800, the region contained 25,197 people. By 1830, the population almost doubled to 50,880. Allentown alone grew from 573 people in 1800 to 710 in 1810. Most of this population growth occurred in farmlands as opposed to the cities (Joint Planning Commission, 1963).

Between 1790 and 1830 an explosion of villages also occurred that included East Texas, Dillingersville, Ballietsville, Guthsville, Egypt, Saegersville, Lehigh Gap, Lynnville and New Tripoli. Villages often contained a post office, tavern, hotel and a church as well as a mill and tannery.

4.1.4 Challenge of Industry, 1830-1890

The Industrial Revolution replaced craft production in homes and small shops with mass-production in the factories. The Industrial Revolution also increased agricultural production through improvements in farm machinery, quicker and safer means of transportation and research in better methods of farming, pest control, crops, animals and marketing techniques. These improvements elevated farmer's standards of living. Quarrying of slate, mining of anthracite, iron and zinc and the building of canals and railroads introduced new types of people, new ideas and new problems into the Lehigh Valley.

The Lehigh Valley alone was a rich mineral resource for iron, zinc, slate and limestone. Three types of ore existed in the valley. Limonite, also known as "brown ore" was the most common and found in such regions as the small, steep valleys east, southeast and northeast of Hellertown, Fogelsville, Guthsville and Ironton. With the development of mining, came the process of smelting. The Lehigh Valley's furnaces were small, had water wheels to provide power and used charcoal for fuel. Expansion was limited due to the expense of charcoal and availability of skilled labor and timber resources (Joint Planning Commission, 1963). At the same time, roads were beginning to deteriorate. The horse driven wagon trains carrying ore turned the roads into dust in the summer and mud slicks in the winter (Joint Planning Commission, 1963).

With the discovery of zinc oxide made from ore and the completion of the Lehigh Canal, the slate industry began to rise (Joint Planning Commission, 1963). Large deposits of slate were found in a belt along the southern base of the Blue Mountain from the Delaware Water Gap to the western border of Lehigh County. Smaller amounts of slate were found in North Whitehall, South Whitehall and Lowhill townships.

As the mining industry grew, railroad production began to soar. This enabled communication and transportation of materials between major cities. With the spread of railroads in the valley, manufacturers increased exponentially, as did the number of people employed in manufacturing (Joint Planning Commission, 1963).

By 1890, the valley contained 1248 manufacturing establishments and had a well-diversified economy (Joint Planning Commission, 1963). The output of the flour and gristmills was second only to iron and steel in terms of total product (Joint Planning Commission, 1963). The gristmills were not large employers of men and women because they used improved machinery. These mills were located along streams such as the Perkiomen, the Hosensack, the Jordan and the Bushkill. This enabled them to send their produce to market down the canal and over the railroads.

In the act of improving the communication and trade, the telegraph entered the Lehigh Valley region in 1848. One of the large companies organized in 1876 became known as the Lehigh Telegraph Company. This company operated primarily in Lehigh County and its offices were in areas such as Macungie, East Texas, Emmaus, Allentown, Fogelsville, Trexlertown, Kraussdale, Ironton, Neffs, Schnecksville, Siegersville, Saegersville, Lynnville, New Tripoli, Slatedale and Slatington.

As manufacturing increased and transportation and communication improved during Industrial Revolution, the agriculture community began to benefit. The transportation improvements provided farmers with new markets outside the valley and the newer farming techniques and equipment increased production yields per acre of new varieties of crops.

During the time of social revolution, years 1830 to 1890, there was a division into two periods, politically due to the Civil War. Before the war, agrarian forces held all control over the local government. After the war, railroads, mining and manufacturing held greater political influence (Joint Planning Commission, 1963).

Physical features of the Lehigh Valley region were altered in the midst of the Industrial Revolution. The rural areas showed the least change. There telegraph poles and wires lined many roads and constantly trains passed through almost every part of the region. The farms and rural villages appeared to have become more prosperous as better machinery and produce lay in the fields (Fletcher, 1950).

On the other hand, towns and boroughs were completely transformed. Industry and manufacturing dominated the boroughs that had once been small towns. These areas had no protection against the power of development (Eckhart, 1992). Houses were small and often overcrowded. Noise, smoke and smells from the factory were part of daily life. Often piles of slag or other refuse bordered the residential areas. Factory wastes usually went into rivers and streams, which consequently became polluted. Narrow and poorly maintained streets were inadequate for the increase in traffic resulting from business and industry (Eckhart, 1992). Water systems and volunteer fire companies fell short of the needs of an expanding population (Eckhart, 1992). Very few parks or public recreation services existed. Sanitation including sewage disposal were considered to be each family's responsibility. And most boroughs had little to no hospital services. These boroughs were tools to profit-making with little regard for the health, safety, or general welfare of the people (Eckhart, 1992).

The physical development of Allentown was due primarily to its location between the Little Lehigh and the Jordan (Joint Planning Commission, 1963). This placement enabled it to be involved in a movement of industry and commerce. The Allentown fairgrounds were west of the Jordan; the Allentown Iron Works and Allentown Rolling Mills were located between the Jordan and the Lehigh in the north.

4.1.5 Contemporary Age 1890-1960

Between 1890 and 1960 the population of Lehigh and Northampton counties increased from 160,851 to 428,948 (Eckhart, 1992). Part of this was due to the increase of births over deaths.

Though another major contributor was the large influx of immigrants from Ireland, England and Italy. This pattern of population growth caused the division of the region into a few cities and many townships and boroughs, each, which was politically independent of the others (Eckhart, 1992). The age of agriculture had produced most of the townships. The age of industry had given rise to most of the boroughs. Many of these boroughs arose due to quarrying, manufacturing or railroading.

This diversified and changing economy had effects on industries too within the Lehigh Valley. The discovery that cement was less expensive than slate for construction caused the decline of the slate industry (Joint Planning Commission, 1963). The number of slate companies in the Lehigh County in 1919 was 27 and by the year 1959 had decreased to two (Joint Planning Commission, 1963). Despite the declined production in a number of industries, the economy continued to expand. This was evident in the invention of the internal combustion engine, which made motorized transportation possible.

During these years, there was a continuation of scientific and technological advances, which changed conditions of life. Electricity, oil, steel, cement, chemical, and other products were developed. Labor-saving machinery provided people with more free time and education and recreation services became a greater role in the lives of people.

4.2 Economic Development History

4.2.1 Agriculture

"During the period from 1840 to 1940," writes S.W. Fletcher in the second volume of *Pennsylvania Agriculture and Country Life*, "Pennsylvania agriculture was transformed gradually from a simple and largely self-sufficing occupation and way of life into a capitalistic, scientific and highly commercial enterprise." Most of this development occurred after 1890.

In terms of relative importance to the economy of the Lehigh Valley region, after 1890 agriculture declined. Between 1910 and 1959 the number of farm operators in Lehigh and Northampton counties diminished from 6860 to 2749 (Joint Planning Commission, 1963). Over the same span of years the amount of land in farms decreased from approximately 85% of the area of the two counties to 60% (Joint Planning Commission, 1963).

Yet agriculture continued to be one of the principal industries affecting the development of the region. One reason for this lay in the willingness of farmers to accept technological improvements for increasing the efficiency of production and raising standards of living. Around the turn of the century the silo began to make an appearance. About the time of the First World War the Model T Ford gave farmers an improved means of locomotion. After 1920 labor-saving devices such as tractors, milking machines and brooders came into increasing use. By the end of the Second World War most farms in the region were supplied with telephones, electricity, and modern household appliances. The majority had at least one tractor larger than a garden tractor. Most farmers possessed trucks. Improved equipment meant that a farmer could till more land in less time than his ancestors had found possible. In 1910 the average sizes of farms in Lehigh and Northampton counties were respectively 58.2

and 54.0 acres. By 1959 the average sizes of farms in the two counties had risen respectively to 99.9 and 102.9 acres (Joint Planning Commission, 1963).

Also, farmers learned to apply methods of scientific farming. In the Lehigh Valley region this meant increased yields of crops on which farmers principally depended for cash income. Among these were corn, wheat, potatoes, dairy products, fruits, vegetables, poultry, and poultry products. In time, the farmers became small businessmen with considerable investments in land, buildings, and equipment. Upkeep and replenishing of their capital necessitated a continual reliance on government and an industrialized economy. Farmers in Lehigh and Northampton counties were brought increasingly into contact with governmental agencies and programs (Joint Planning Commission, 1963).

On the national front the next 50 years saw a proliferation of agricultural programs that offered various sorts of benefits to farmers but, at the same time, subjected them to greater governmental controls. The administration of Theodore Roosevelt concentrated on soil and forest conservation. That of Woodrow Wilson emphasized education of farmers in scientific methods of agriculture. In 1914 the Smith-Lever Act was passed, which aided the establishment of a system of county agents and farm bureaus to demonstrate improved methods for tilling the soil, rotating crops, using fertilizers, controlling pests, preserving the soil, and selecting seeds. About the time of the First World War the organization of farm bureaus on state and national lines produced the most powerful agricultural pressure group in the country, the American Farm Bureau Federation (Joint Planning Commission, 1963). In the 1920's the A.F.B.F. and other groups assisted the farmer in obtaining a variety of laws favorable to agriculture, especially laws encouraging the formation of cooperatives. Although the cooperative movement had its origin in the late 19th century, the decades of the 1920's and 1930's mark its greatest period of growth (Joint Planning Commission, 1963).

Again, in the nation as a whole the period of depression beginning in 1929 saw still further increases in government aid to agriculture. Farmers received improved facilities for credit, support for parity prices, crop insurance, rural electrification, and marking aids. These and other programs appeared in the administration of Franklin D. Roosevelt and were in revised forms continued through the administrations of Harry S. Truman and Dwight D. Eisenhower respectively. Farm credit banks and federal agents for administering production and marketing controls and other programs appeared in the region (Joint Planning Commission, 1963).

In general, farmers in Lehigh County opposed these programs. The county obtained farm bureaus; and in the 1920's and 1930's the farmers in the region organized a number of cooperatives for insurance, marketing, and purchasing. Among the largest of these were the Lehigh Valley Cooperative Farmers and the Farm Bureau Cooperative Association of Lehigh County and the Lehigh Valley Egg Producers Cooperative Association. However, the cooperatives were not forced on the farmers by government. Cooperatives represented a voluntary effort to obtain services that would have been too costly to obtain by other means (Joint Planning Commission, 1963). But respect to the agricultural policies of the New Deal, the farmers of the valley took a different attitude. Subsidies, production and marketing controls, and other programs of direct governmental aid and regulation were of less benefit to the farmers of southeastern Pennsylvania than they were to those of the Midwestern and

western section of the United States (Joint Planning Commission, 1963). The Rural Electrification Administration never appeared in the Lehigh Valley region. Many farmers refused to apply for subsidies.

The family farm remained the basic unit of production. A few large commercial farms appeared, for example, the Trexler Farms in Lehigh County. The Trexler farms were another enterprise of General Trexler, who started them in 1901 with the purchase of large tracts of land in Lowhill and North Whitehall townships. In 1905 he planted about 300 acres to peach and apple trees. Three years later he set aside a thousand acres as a refuge for deer, buffalo and elk. This tract became known as "Trexler's Deer Park" – later, as Trexler's Game Preserve. In ensuing years Trexler added to his agricultural holdings, so that by 1933 he possessed about 2000 acres of fruit trees, a poultry farm, a trout hatchery and two other farms. These farms were known as Trexlertown and Springwood and aggregated about 2700 acres, most of which were planted in potatoes, vegetables and hay and provided for raising prize-winning horses and Jersey cattle (Joint Planning Commission, 1963).

Yet, for the most part, large farms such as the properties of General Trexler occupied a small proportion of the total land in farms in the Lehigh Valley region. A more pronounced trend was that of farming non-owned land, because farmers were often able to rent land more easily than they could afford to buy it. Although the number of farmers in the region was severely reduced, farming as a way of life was preserved for the several thousand families who were responsible for the major part of the agricultural production of the region.

4.2.2 Utilities

Utilities became known as a group of industries and services that were awarded special privileges and strict regulation. The growth of various utilities in the Lehigh Valley region presents great contrasts (Joint Planning Commission, 1963). Water supply and sewage disposal remained decentralized. Communications and power displayed rapid trends toward a high degree of centralization. The abundance of water supply in the region principally accounts for the decentralization of supply (Joint Planning Commission, 1963). In rural areas water supply still came from a private well on each establishment. In urban areas, the municipalities controlled the supply. Private companies were the original controllers of water but as the population grew and the concern for clean water grew, the supply of water became a public affair (Joint Planning Commission, 1963). After the Civil War many municipalities took over the responsibility for providing their inhabitants with fresh water. This trend continued, until by the First World War most cities and boroughs in the Lehigh Valley region had municipal water systems. Then, as suburban populations continued to expand, municipalities had to extend their facilities. After the Second World War, as suburbs expanded into the townships surrounding cities, municipal governments began furnishing water by sale or contract to outlying areas. The growth of sewage disposal parallels that of the water supply, except that a demand for municipal sewage systems did not develop until people began to understand the nature of contamination and its relation to disease (Somerset Publishers, 1996).

In the domain of the telegraph the process of consolidation was largely completed by 1890. Western Union joined most parts of the county, including the Lehigh Valley. In the telephone

industry consolidation came more slowly. The period before the First World War was marked by considerable competition among small companies. Many merchants had to install the telephones of several companies in order to communicate with all parts of the Valley (Joint Planning Commission, 1963). For many years after the First World War three principal companies remained in operation in the valley, the Bell, the Keystone and the Lehigh (one of the enterprises of General Trexler). By 1930 the three had merged into the Bell system, of which General Trexler was the director.

By contrast with water and sewage disposal, communications and power remained in private hands and became highly centralized. In the 1880's, when electricity was first commercially used, small companies were necessary because the direct current employed could be transmitted only over short distances (Joint Planning Commission, 1963). With the introduction of alternating current in the 1890's the chief technological obstacle to large-scale operations was removed. Small companies that had formed in most of the urban and industrial areas of the region rapidly merged.

In the central and southern parts of the region a similar process gave control over electric power to the Pennsylvania Power and Light Company. First, the Bethlehem Electric Light and the Allentown Electric Light and Power companies absorbed or put out of business most other electrical companies in their respective areas. These companies eventually merged and reorganized into the Lehigh Valley Light and Power Company. Finally, in 1920 the Lehigh Valley Light and Power Company and several other large companies in Pennsylvania were merged to form the Pennsylvania Power and Light Company.

The physical properties of the utility companies helped change the landscape of the valley (Joint Planning Commission, 1963). The companies had office buildings and manufacturing and storage facilities. Gas storage tanks existed in the cities and reservoirs for water became larger and more numerous. In 1927 Pennsylvania Power and Light completed construction of the 23-story PP&L building at Ninth and Hamilton streets in Allentown, providing the area with its only skyscraper. Also, the pipes and lines for carrying services to the people and to industry spread over the valley. Gas and water mains and sewer pipes were installed, repaired and improved. In the several decades before the First World War masses of telephone and telegraph poles and wires appeared in urban areas. In 1914 Allentown began experimenting with underground conduits. The extension of underground wires, together with improvements in poles and cables and stricter controls over routing, helped to reduce confusion and gradually many poles and wires disappeared from densely populated areas (Joint Planning Commission, 1963).

4.2.3 Transportation

Stiff competition among several sorts of transportation accompanied the economic growth of the region. As a result, travel by water dwindled and came to an end; transportation by rail reached a peak and then declined; the use of highways steadily increased; and the public began to accept travel by air (Joint Planning Commission, 1963).

By 1890 commerce on the canals had for several decades been deteriorating. Yet, the final demise was delayed until well after the First World War. One reason for this lay in the insistence of state governments that the canal companies maintain their properties. The Lehigh Valley Railroad Company was unable to relinquish its responsibility for the Morris Canal to the State of New Jersey until 1922. The Lehigh Coal and Navigation Company was even less fortunate. In most years from 1890 to 1930 the company operated the canals at a loss (Joint Planning Commission, 1963). During these years coal tonnage on the Lehigh canal declined from 356,639 to 91,227 (Joint Planning Commission, 1963). Finally, in 1923 the Lehigh Valley and the Reading jointly purchased from the Thomas Iron Company the Ironton Railroad.

The renovation of equipment and the expansion of physical facilities continued. Between 1916 and 1919 the Philadelphia and Reading buried the famous iron bridge of Catasauqua and Fogelsville under a huge fill, on which heavier rails were laid (Joint Planning Commission, 1963). Freight and passenger stations, roundhouses, bridges and other structures were enlarged and improved. Between 1910 and 1929 air brakes and automatic signals came into general use. The 1920's saw the utilization of crossroad ties, audible-visible crossing alarms and industrial departments for enticing industries to local rights of way (Eckhart, 1992).

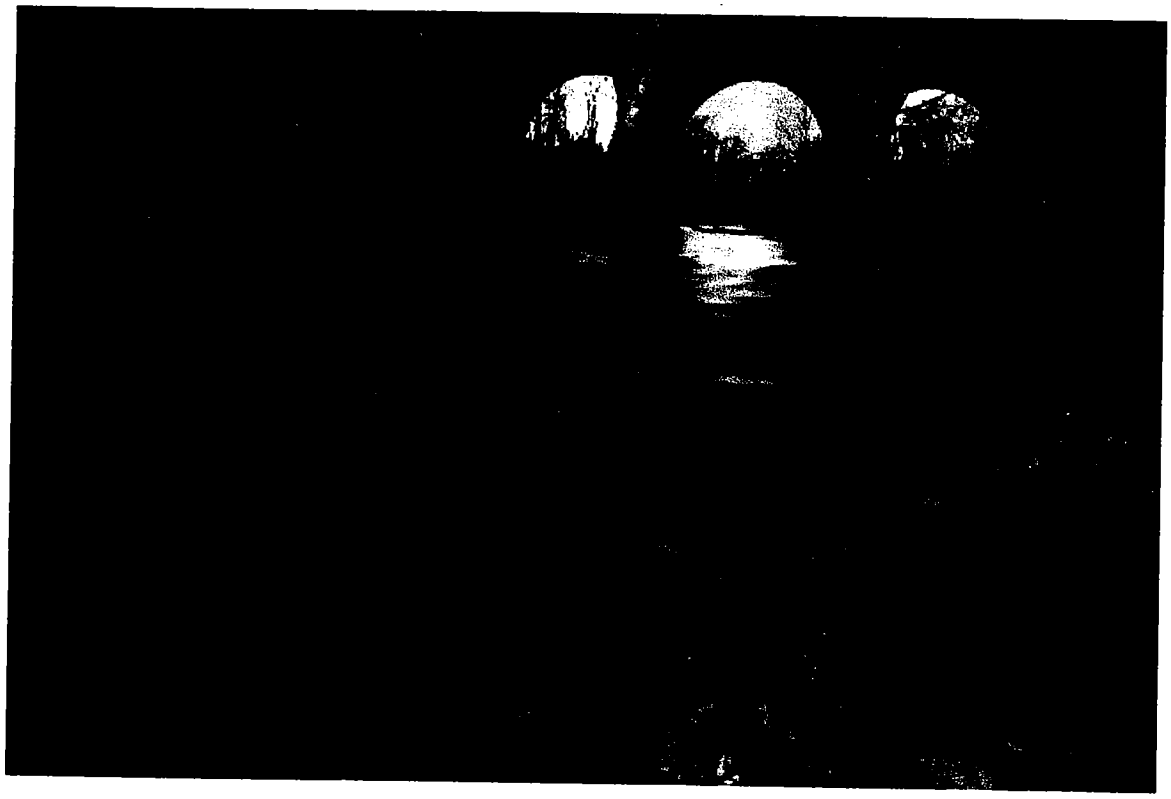


Figure 24. A stone arched railroad bridge in South Whitehall Township is a reminder of the transportation and architectural history of the Jordan Creek watershed.

The automobile appeared in the valley around the turn of the century. At first the inhabitants considered it a novelty. In 1903 the Pennsylvania Department of Highways was organized and began constructing macadam roads. During the same period boroughs and cities began extensive programs of street improvements. In 1916 the federal government entered the field of highway construction by making available to the states grants of money in exchange for a certain measure of control. In 1921 the federal system of highways was created. The aim was a network of arterial routes connecting the Lehigh Valley region, namely, U.S. 611, U.S. 309, U.S. 22, and U.S. 222 (Joint Planning Commission, 1963). These routes did not always use the beds of the old turnpikes. Heavy construction equipment eliminated many curves and cut through hills. Steel and concrete bridges replaced the covered wooden structures. In many places the new roads bypassed farms and villages serviced by the old routes. Away from the main highways, farm-to-market roads were also improved. Throughout the 1930's and 1940's the hard surfacing of rural roads continued. By 1959 only 517 of the 1611 commercial farms in Lehigh and Northampton counties were located along dirt or unimproved roads (Joint Planning Commission, 1963).

4.3 Archeological Resources

Occasional floods, especially those of 1841 and 1962, as well as heavier traffic necessitated much building and rebuilding of bridges. By 1890 most of the railroad bridges consisted of iron trusses on stone or wood foundations. The increased use of the pitched roof led to adoption of the term "covered bridge" to describe such a structure, although from the point of view of engineering design several sorts of covered bridges already existed. Private bridges, some covered and some uncovered, were set at various points across all of the tributaries to the Lehigh River. The Jordan Creek watershed has several historic and architecturally significant covered bridges constructed in the mid-1800s. Another site of archaeological importance is an Indian bake oven located in Trexler's Game Preserve that was chiseled out of solid rock. The oven was slated to become a shrine to the Lenni-Lenape Indians. Figure 25 and Table 20 show the watershed landmarks that are listed on the National Register of Historic Sites.

Table 20. Properties on the National Register of Historic Places
(Source: PA Historical & Museum Commission, Bureau of Historic Preservation)

Name	Address
Lehigh County Prison	4th & Linden Streets, Allentown
Bridge	SR4028 – over branch of Jordan Creek
Frantz's Bridge	SR4025 – over Jordan Creek
Geiger's Covered Bridge	Old Packhouse Rd., North Whitehall
Rex Covered Bridge	Jordan Road, North Whitehall
Schlicher's Bridge	Game Preserve Rd., North Whitehall
Manasses Guth Covered Bridge	Lapp Road, South Whitehall
Wehr Covered Bridge	Wehr Mill Road, South Whitehall
Dent Hardware Company	1101 3rd St., Whitehall
Helfrich's Springs Grist Mill	Mickley Pike & Lenhart Rd., Whitehall

Source: Lehigh Valley Planning Commission, 1997

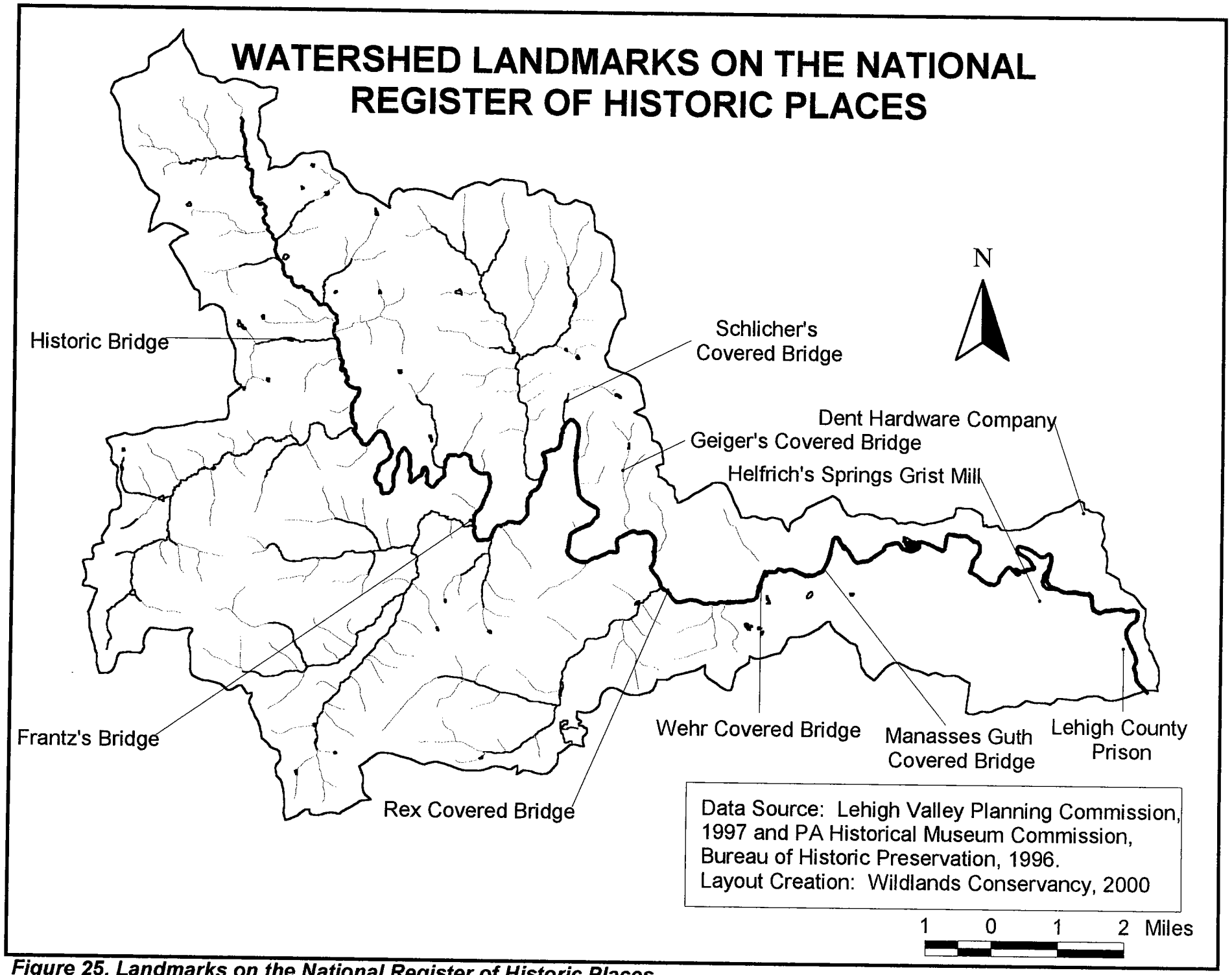


Figure 25. Landmarks on the National Register of Historic Places

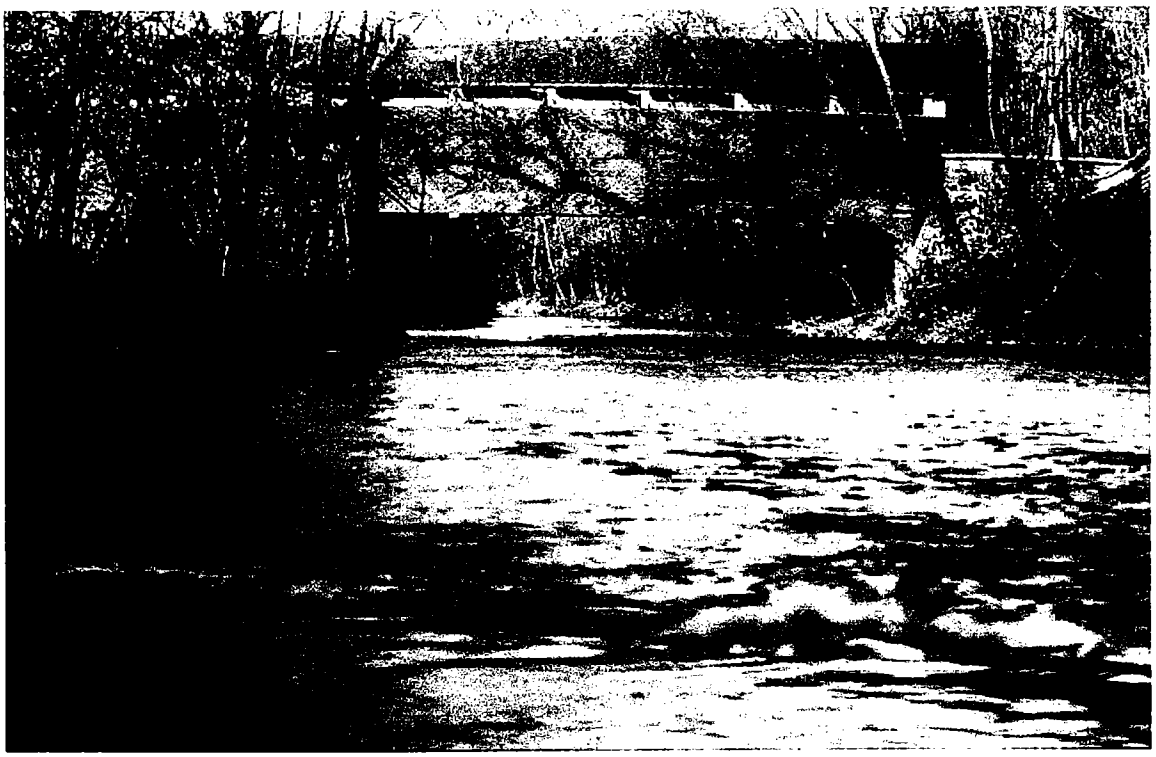


Figure 26. Manasses Guth Covered Bridge is one of the watershed's historic landmarks and is located on the east end of Covered Bridge Park in South Whitehall.

4.4 Recreational Resources

4.4.1 Existing Watershed Recreational Resources

The Jordan Creek watershed contains significant recreational resources, from state game lands to municipal parks, totaling 3383 acres or approximately 6 percent of the watershed. There are 1744 acres of state game lands in the watershed dedicated to conservation, where residents can hunt, fish, horseback ride, etc. The entirety of State Game Lands 205 is located within the watershed and consists of 1303 acres of woodlands and open space in Lowhill Township. In addition to Game Lands 205, 442 acres of State Game Lands 217 are also located within the watershed in Heidelberg Township. These acres of preserved land are in the most northwestern part of the watershed and provide natural protection to the headwaters of the Jordan Creek. The game lands play a vital role in providing a wildlife habitat, migratory corridor, natural zone of protection and recreation for the headwaters and mid-stream reaches of the Jordan Creek. These game lands are managed through the Southeast Office of the Pa. Game Commission.

The Trexler-Lehigh Game Preserve is 1066 acres and is bordered on the west, north and east by the Jordan Creek. The preserve contains a 25-acre children's petting zoo, along with numerous exhibits of both native Pennsylvania species and exotic animals of Africa, Australia

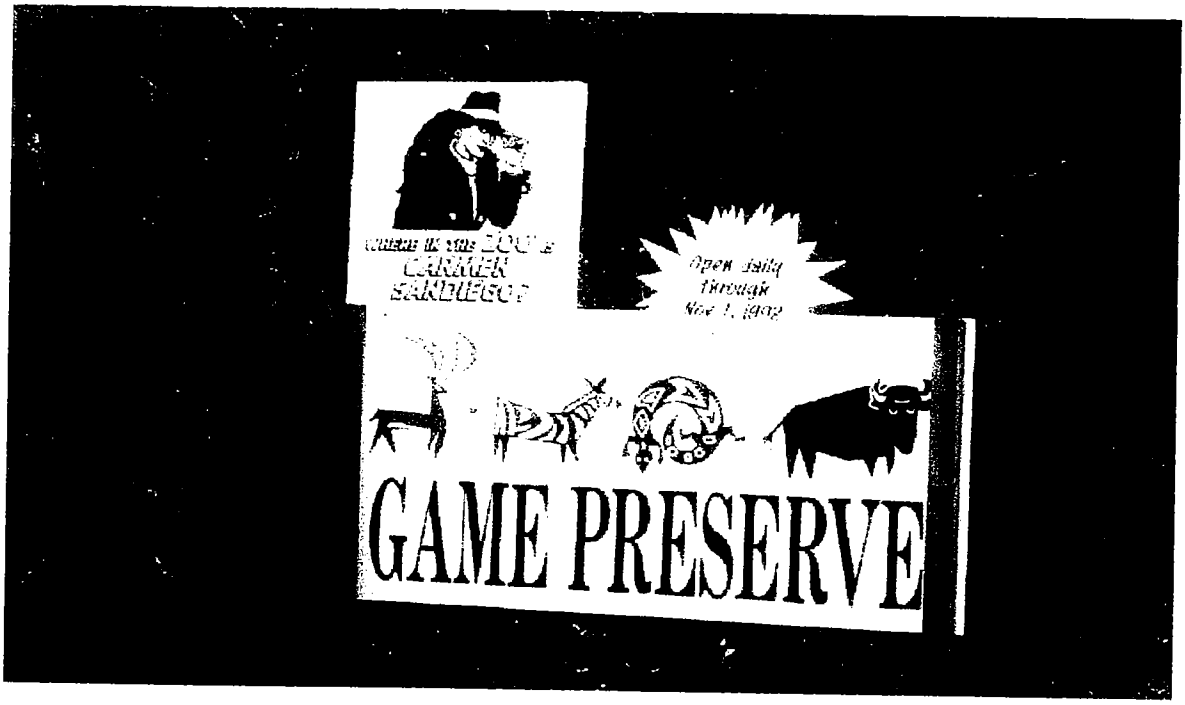


Figure 27. The Trexler-Lehigh Game Preserve is located in Lowhill and North Whitehall.

Figure 28. The Jordan Creek as it flows through the Trexler-Lehigh Game Preserve. The Game Preserve, along with State Game Lands 205 provides a significant zone of protection to the middle reaches of the Jordan Creek watershed.

and Asia. The Game Preserve provides educational experiences for the Lehigh Valley and is popular for both elementary school field trips and family outings. Covered Bridge Park in South Whitehall is 106 acres of parkland along the Jordan Creek. The park contains several soccer and baseball fields and basketball courts and picnic areas. The park is also utilized by local fishermen and is bound by two historic covered bridges; Wehr's Bridge on the west and Guth's Bridge on the east end. Jordan Park is approximately 14.2 acres located in Whitehall Township and boarders approximately 4771 feet of the Jordan Creek. The park is relatively developed and contains a swimming pool and several basketball courts and baseball fields. Throughout Jordan Park the creek is channelized by stonewalls and there is very little riparian vegetative cover. The Jordan Creek Parkway is another significant watershed recreational facility that surrounds an approximately 12,698-foot reach of the Jordan Creek. This park contains several tennis courts and is used extensively by fishermen, hikers, runners and mountain bikers. The Jordan Creek Parkway has many intact riparian areas and is kept in a natural-type environment.

Figure 29. Wehr Covered Bridge is a historic landmark in the west end of Covered Bridge Park

Figure 30. Wehr Dam is directly upstream from Wher Bridge and is used for fishing and recreation by local residents.

These three municipal parks, Jordan Park, Covered Bridge Park and Jordan Creek Parkway are large, popular recreation areas, frequented by thousands of people. Natural and environmentally responsible management of these parks would provide two benefits. First, restoring to or enhancing natural riparian corridors would provide significant water quality and habitat improvements. These benefits could potentially be quite significant, given the size of the parks and the lengths of the creek sections they surround. Secondly, because these parks are so popular with watershed residents, natural streamside management practices, perhaps combined with educational signage/information, could encourage good stream stewardship among park users.

Figure 31. Large stretches of recreational lands along the Jordan Creek, such as this section in Jordan Park, have been channelized and are void of riparian vegetation. This type of management can increase risks of non-point source pollution and flooding.

Figure 32. Also in Jordan Park, a more natural and environmentally responsible approach to creek-side recreational land management can be observed. Along this section of the park, wildlife can be observed and the Jordan is offered some protection from non-point source pollution and flooding.

These features are key natural and recreational areas of the watershed. Some of the activities popular at these sites include fishing, walking/hiking, bird and wildlife observation, wading, and picnicking. Easy access to such recreational areas may provide for a higher quality of life throughout the watershed in comparison to surrounding areas where suburban sprawl is consuming more and more natural areas that once were used for both active and passive recreational activities. It is essential to maintain and properly manage these areas, both to ensure continued recreational opportunities and to provide protection for the delicate environment of the Jordan Creek. Figure 33 identifies parks and recreational areas of the watershed.

Table 21. Existing Parks and Outdoor Recreational Lands, 1995.
(Source: Assessment Department for Lehigh County)

Municipality	Acres	Percentage
Allentown	1638	14
Heidelberg Township	1674	11
Lowhill Township	1534	17
Lynn Township	2668	10
North Whitehall Township	1847	10
South Whitehall Township	553	5
Upper Macungie Township	427	3
Washington Township	2127	14
Weisenberg Township	44	<1
Whitehall Township	694	8

(Note: These figures are based on the entire areas of the municipalities, not just the portions in the watershed)

Table 22. Major Year-Round Recreational Facilities in the Jordan Creek Watershed

Facility	Uses
Allentown Fairground/ Agricultural Hall	Tradeshows, Exhibits, Concerts, Plays
Allentown Art Museum	Exhibits, Special Events
Lehigh County Velodrome	Bicycle Racing Events
PA Stage Company	Professional Theater Events
Symphony Hall	Home of Allentown Symphony Orchestra, Ballets, Concerts

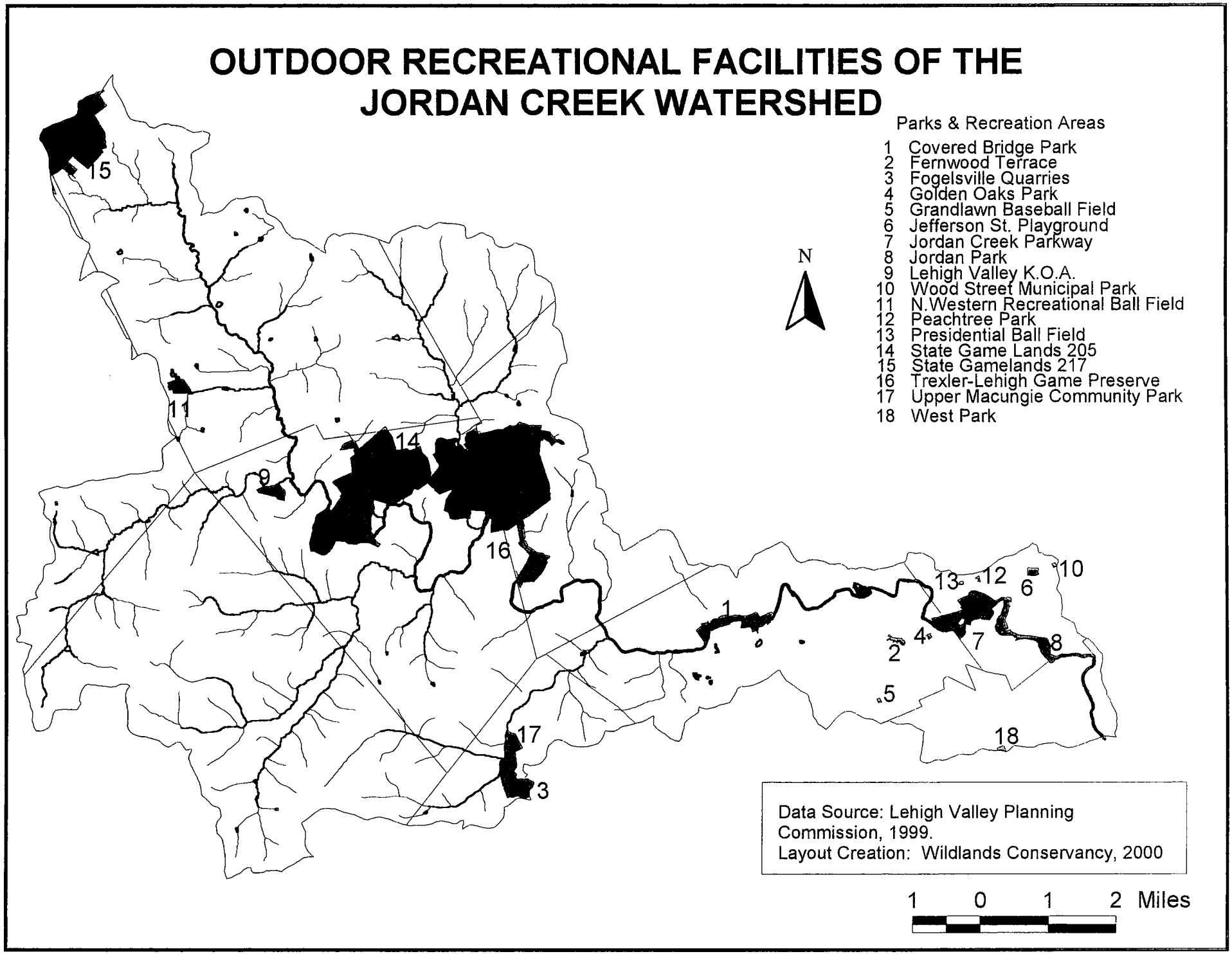


Figure 33. Outdoor Recreational Facilities of the Jordan Creek Watershed

4.4.2 Jordan Creek Watershed Bike Rides

Throughout the Lehigh Valley, there is a listing of bike rides on various streets and paths. These rides are designed on roads and paths conducive to bicycle riding. This means that account has been taken to stay off of busy roads and steep, hilly roads as much as possible. The Lehigh Valley Wheelmen Association has catalogued these rides in the Lehigh Valley. The Joint Planning Commission of Lehigh-Northampton Counties has compiled a visual listing of these rides. A complete map of all of these rides within the Lehigh Valley is available by contacting: Lehigh Wheelmen Association, P.O. Box 356, Bethlehem, PA 18016.

Specifically, there are five of these rides that either exist within the Jordan Creek watershed or in some way cross or travel next to the tributaries of the Jordan Creek. Directions are listed below.

Covered Bridges: Ride 1 – This ride is 2.1 miles long and encircles the Jordan Creek. This ride starts in the parking lot at Covered Bridge Park. From the parking lot, the ride crosses Wehr's Bridge traveling north and continues along River Road as it travels east immediately along-side the Jordan Creek. The ride then turns right onto Lapp Road and crosses Guth's Bridge. The ride then turns right again onto Iron Bridge Road and follows along the Jordan all the way back to the parking lot where it began.

Covered Bridges: Ride 2 – This ride is 6.3 miles long forming a larger loop around the Jordan Creek. This ride is actually upstream of Ride 1 through Covered Bridge Park. It also starts in the parking lot at Covered Bridge Park and crosses Wehr's Bridge. Once across the bridge, the ride turns left onto Limekiln Road, crosses under the Pennsylvania Turnpike and continues to Route 309. The ride makes a right onto Route 309 and then left onto Terrace Road. It follows Terrace Road until it turns left onto Thompson Street and then and immediate right onto Hoffmansville Road. Follow Hoffmansville Road until Kerns Dam. At Kerns Dam the ride turns left onto Jordan Road and travels immediately next to the Jordan Creek. The ride follows along on Jordan Road across Route 309 and back under the Pennsylvania Turnpike. This road then turns into Huckleberry Road. It then turns left onto Wehr Mill Road, continuing until it returns to the parking lot at Covered Bridge Park.

Covered Bridges: Ride 3 – This ride is the longest of the Covered Bridges rides at 19.3 miles. This ride allows the rider to see an extensive amount of the Jordan Creek, crossing it numerous times and traveling next to it for extended amounts of time. It also begins at the parking lot in Covered Bridge Park. Ride 3 is then exactly the same as Ride 2 until it gets to Kerns Dam. At Kerns Dam the ride turns right onto Jordan Road, crossing the Jordan Creek at Rex's Bridge, another unnamed crossing and Geiger's Bridge until the ride reaches Orchard Road. It then turns left onto Orchard Road, travels around Lehigh Carbon Community College and runs into Route 309 where it turns left. The ride then continues on Route 309 for a short distance, making a left onto Game Preserve Road. It then stays extremely close to the Jordan Creek, crossing it once at Schlicher's Bridge. The ride continues on Game Preserve Road until Weidasville Road, where it turns left and

continues to Kernsville Road. The ride then makes a left turn onto Township Line Road and then another left onto Haasadhill Road. On Haasadhill Road, the ride follows the Haasen Creek until it flows into the Jordan Creek, where the ride turns right onto Jordan Road. From this point the directions are the same as Ride 2 from the Kerns Dam section to the end.

Allentown & NW – This ride is 16.2 miles long, approaching Jordan Creek from the south in Allentown. It starts at the Cedar Beach parking lot on the corner of Ott Street and Parkway Blvd. It follows Parkway Blvd. West until it makes a right onto Springhouse Road. It continues along Springhouse Road across Tilghman Street and under Route 22. It then turns left onto Crackersport Road where it then turns left onto Bulldog Drive. The ride then continues through South Whitehall Township to Ridgeview Road, where it turns left and then a quick right onto Housman Road. The ride then continues until it makes a left onto Chapmans Road. It then turns again onto Blue Bran Road and continues for a while, traveling next to the Jordan Creek until Kerns Dam. The ride then turns right onto Hoffmansville Road, traveling east to Thompson Road. It turns left onto Thompson and then a quick right onto Terrace Road. It continues until it turns left onto Lime Kiln Road. It follows along until it makes a left onto River Road. It continues on River road until Lapp Road, where it turns left. The ride then crosses the Jordan at Guth's Bridge onto Iron Bridge Road until Cedar Crest Boulevard. It turns right onto Cedar Crest for a short distance until Minnick Road, where it makes a left. It follows Minnick until it turns into Albright Avenue. It then makes a right onto Whitehall Avenue and follows along until it turns left onto Ott Street and back down to the parking lot at Cedar Beach.

Fogelsville – This ride is 11.6 miles long, crossing two tributaries of the Jordan Creek, Haasen Creek and Lyon Creek. This ride starts at the quarry on Moyer Road along Route 100 just south of Hilltop Road. The ride travels north along Moyer Road until it makes a left onto Wertman Street. It then continues on Wertman Street until it reaches a right turn at Seipstown Road, continuing and crossing Lyon Creek. It then makes a right turn onto Golden Key Road and then after a short distance makes another right turn onto Lyon Valley Road. The ride then continues for a short distance longer until it makes another right turn onto Boger Stadt Road. It follows Boger Stadt Road until it makes a right turn onto Claussville Road and then an immediate left onto Short Road and back to Seipstwon Road, where it turns left. The ride then continues along Seipstown Road until a left turn onto Moyer Road, which returns the ride to its beginning.

4.4.3 Possible Future Recreational Resources

The Jordan Creek watershed needs a long-term action plan for park and open space acquisition and development. Priority should be given to lands along the Jordan Creek because of the potential habitat and water quality benefits, along with educational opportunities, that could result from streamside land management. It is recommended that sites should be targeted in the range of 70-100 acres or larger that afford a variety of recreation possibilities. Cooperative arrangements within municipalities should be given preference because they allow county dollars to purchase even more acreage. Cooperative

arrangements also may result in the local units of government assuming development and maintenance responsibilities for some of the new parks.

An approximately 20-acre area along Martin Luther King Boulevard in Allentown surrounds the Jordan-Little Lehigh-Trout Creek (a tributary to the Little Lehigh) confluence. This land is currently owned by the city of Allentown, is vacant and littered with trash. This area could be an ideal site for public recreation. Natural-setting recreation is nearly non-existent in the city and would likely be welcomed by Allentown residents. This site could provide environmental education opportunities. The area also has significant historical education opportunities. Because the land surrounds the mouths of three creeks, it was very likely once an area of significant Native American activity. The area contains an abandoned railroad bridge over the Jordan-Little Lehigh confluence (which could be renovated into a scenic walkway) and was once the site of Allentown's garbage incinerator (the area has been locally termed "incinerator park"). These features could be incorporated into an industrial history exhibit and a Native American exhibit.

Figure 34. The land surrounding the confluence of the Jordan Creek with the Little Lehigh Creek is currently owned by the city of Allentown and is a potential future recreational area.

Along the Jordan Creek, in the area between the Jordan Creek Parkway (at Mauch Chunk Road) and the Pennsylvania Turnpike, mostly in South Whitehall Township, is a scenic segment of the Jordan Creek Valley. This area presently remains relatively natural, despite development pressure to the north and south of the stream. The area contains a mixture of farm fields and woodlots and the floodplain is wide in several areas. The county's two oldest

houses-the Troxel House and the Guth House, the historic Iron Bridge and two covered bridges are found along this segment of the Jordan. This stretch of the Jordan is suitable for a wide variety of active and passive recreation uses. There are many flat areas that can be used for turf field sports and the creek offers fishing. The linear nature of the creek valley lends itself to the development of a trail system. South Whitehall Township could be a partner in the acquisition since the township has expressed interest in increasing the size of Covered Bridge Park.

While acquiring lands to develop parks and recreational areas is a priority, conservation and open space lands should not be ignored, especially if the opportunity to acquire some outstanding natural areas arises. The use of easements should be considered where outright acquisition is too expensive, not workable or perhaps not necessary. Easements could be used as connectors between major parks or open space areas associated with residential subdivisions. Easements can be used as a method to preserve critical natural areas where public access is of secondary concern.

4.5 Transportation

The Jordan Creek watershed possesses a wide variety of land uses and is unique in its change in dominant land uses throughout the watershed. This variation of land uses directly affects the transportation system within the watershed (Figure 35). Rural areas tend to be dominated by automobile traffic on smaller roadways servicing residences, farms and small businesses. Suburban areas demand larger roads with similar service to residences and businesses, but a greater access to major roadways for long distance travel. Urban areas tend to need similar access to residences and businesses, but greater intra-city public transportation outlets.

The northern part of the watershed is dominated by agriculture land use. A lower density of people in this agricultural area is a main reason that the majority of the roads in this area are smaller roads servicing transportation between farms and homes. As mentioned above, the two major roadways in this area are Route 100 and Route 309, which run north and south in the western and central parts of the watershed respectively. Both of these roads are predominantly two lane roads with some areas of four lane wide roadway. These roadways are not express highways, instead possessing frequent lights and businesses.

The southern part of the watershed is more suburban surrounding Allentown and then urban within Allentown. This suburban and urban nature to the southern part of the watershed creates two relationships with the transportation within the watershed. Because this area surrounded the city of Allentown, more major roads were constructed through this area. These major roads have made this area more attractive to residents and therefore have brought increased development to the area. Increased development has placed added pressure on large highways such as Route 22 and Route 78, which are the major roadways in the area running east and west. As a result of this increased pressure, major improvements on both of these roads have recently taken place. While these improvements have not always take place within the Jordan Creek watershed, the pressure that is placed on these roads by residents and businesses of the watershed directly correlates to the need for these improvements.

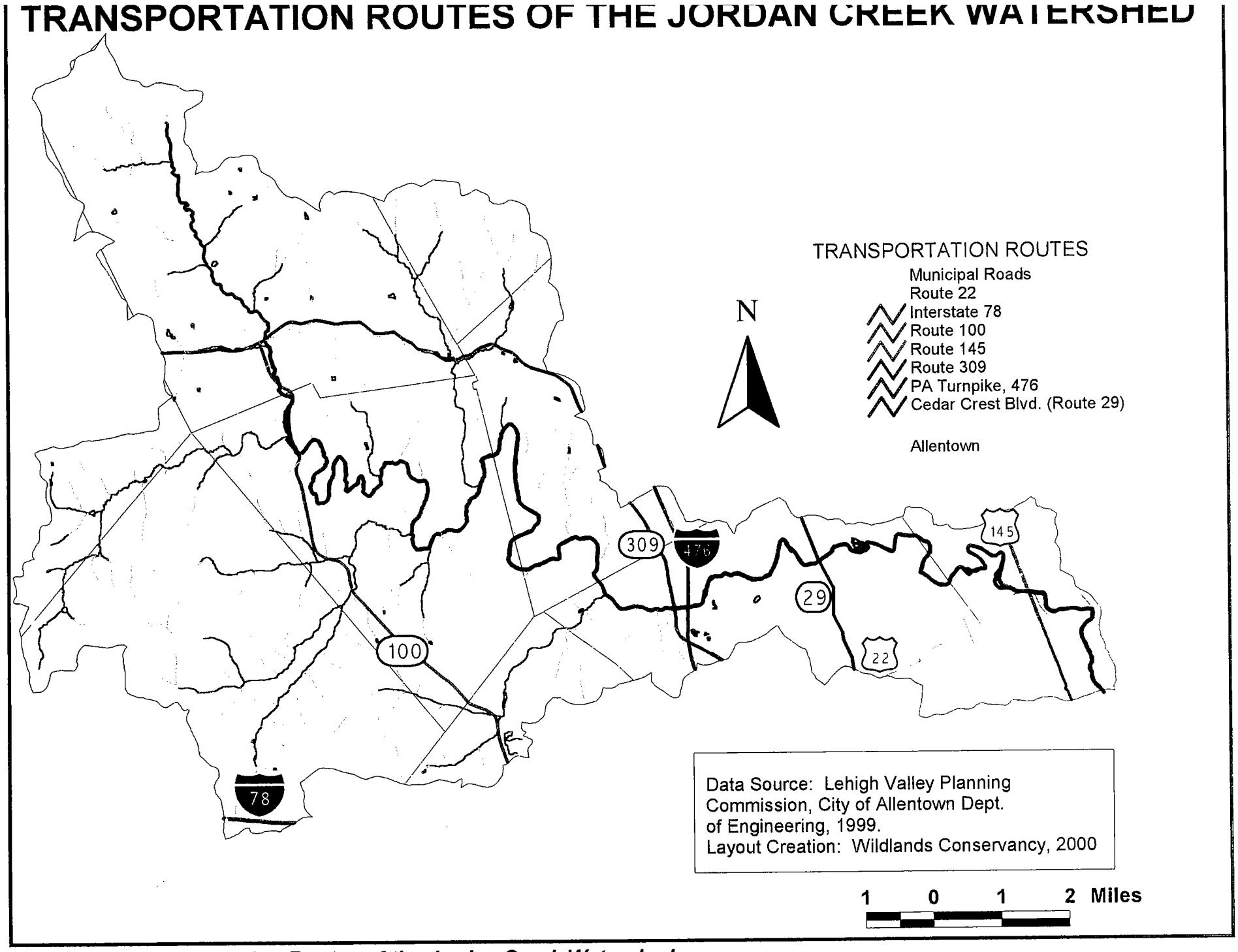


Figure 35. Transportation Routes of the Jordan Creek Watershed

Other major roadways of the watershed are Routes 29 and 145, which service the southeastern part of the watershed running north and south. Route 29 is a two-lane road, which essentially connects more rural areas north of Allentown and south of Allentown. Route 145 or MacArthur Road is a four lane high way with frequent traffic lights that runs from the center of Allentown north through the watershed. Route 476, the Northeast Extension of the Pa. Turnpike runs through the central part of the watershed and is an express highway used primarily for long distance travel. It is the only toll road in the watershed.

4.6 Demographic/Economic Profile

The Jordan Creek watershed is composed of a diverse range of socio-economic conditions. The upper two-thirds of the watershed is predominantly rural in nature, while the lower one-third is a combination of parks and urban land. The city of Allentown provides employment opportunity for those living in rural areas of the watershed not engaged in agricultural production. The scenic country landscape and fertile soils combined with city opportunities for work and leisure make the Jordan Creek Watershed a desirable place to live.

The populations of the municipalities in the Jordan Creek watershed have all increased from 1980 to 1990. All municipalities were expected to continue this growth trend through the year 2000. Major population growth was expected to occur within North Whitehall and South Whitehall Townships through the 1990s (US Department of Commerce, Bureau of the Census; forecasts by the Lehigh Valley Planning Commission).

Table 23. Population in the Municipalities of the Jordan Creek Watershed
(Note that only portions of these municipalities are in the Jordan Creek watershed)

Municipality	1990	2000(estimated)
City of Allentown	105,301	105,014
Heidelberg Township	3250	3937
Lowhill Township	1602	1979
Lynn Township	3220	4181
North Whitehall Township	10,827	12,104
South Whitehall Township	18,261	19,345
Upper Macungie Township	8757	10,693
Washington Township	6356	7028
Weisenberg Township	3246	3976
Whitehall Township	22,779	23,994

Source: Lehigh Valley Planning Commission, 1997

Five public school districts including Northern Lehigh, Northwestern Lehigh, Parkland, Whitehall-Coplay, and Allentown serve the watershed. Of all the school districts within the Lehigh Valley, Northwestern Lehigh, which serves Heidelberg, Lowhill, Lynn and Weisenberg Townships, experienced the greatest percent increase in student population between 1980 and 1990 (Lehigh Valley Planning Commission, 1997).

The employment forecast shows that the services industry was expected to receive the most increase since 1990 (Lehigh Valley Planning Commission, 1997). In 1994 the services industry employed more people in the Lehigh Valley than any other industry sector, followed by manufacturing and retail trade. According to the Planning Commission, Lehigh Valley Hospital, Lucent Technologies and Air Products & Chemicals are major employers of the watershed (Table 25).

Table 24. Average Income and Poverty Status in 1989.
(Source: US Department of Commerce, Bureau of the Census)

Municipality	Household Income, $	Per Capita Income, $	% Persons Below Poverty Level
Allentown	25,983	12,822	12.9
Heildelberg Township	34,871	12,828	2.7
Lowhill Township	39,628	15,818	3.0
Lynn Township	37,639	14,370	3.2
North Whitehall	40,175	16,299	3.4
South Whitehall	43,968	20,404	1.8
Upper Macungie	41,594	18,679	3.9
Washington Township	36,093	14,042	4.3
Weisenberg Township	44,337	19,314	3.3
Whitehall Township	33,214	14,959	5.2

Table 25. Largest Employers of Residents of the Jordan Creek Watershed
(Source: Eastern Pennsylvania Business Journal)

Employer	Employees	Type of Business
Lehigh Valley Hospital Center	5024	Acute-care Hospital
Lucent Technologies	4260	Electronics
Air Products & Chemicals	4000	Gas and Chemical Products
Bethlehem Steel Corporation	3200	Steel Manufacturer
St. Luke's Hospital	2536	Acute-care Hospitals
Lehigh County	2050	County Government
Mack Trucks Incorporated	1850	Vehicle Manufacturer
Wood Company	1778	Food Service
PPL Corporation	1690	Electric Utility
Allentown School District	1650	Public Schools

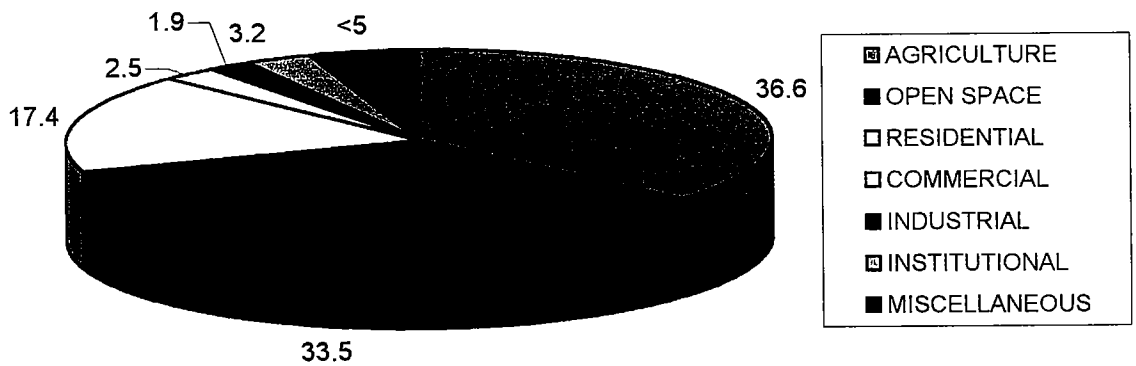
5.0 WATERSHED ISSUES

5.0 LAND USE AND NON-POINT SOURCE POLLUTION

5.1 Land Use

In the upper reach of the Jordan Creek watershed, west of State Highway 309, agriculture is the main land use. Other land uses in this reach include rural residential, State Game Lands, forested areas, open areas and the Trexler-Lehigh County Game Preserve (Figure 36 and Table 26). In the lower reach, east of State Highway 309, urban and residential areas are dominant land uses. Commercial and industrial land uses make up a small land use category. A limestone quarry, municipal parks, agricultural land and forested areas complete the land uses.

Table 26. Percent Land Use in the Jordan Creek Watershed



Agriculture is the dominant land use, occupying more than 36% of the land in the watershed (Figure 37). The second largest land use in the watershed is the 33.5% dedicated to open space and conservation (Figure 38). Approximately 17% of the land in the watershed is residential in use. The remaining land uses are all less than 5% each and include commercial, industrial, institutional, impervious surfaces, quarries and utility/transportation. Rural agricultural and conservation land is located in the north and west parts of the watershed. The urban center of Allentown is in the east and consists primarily of residential and commercial land uses.

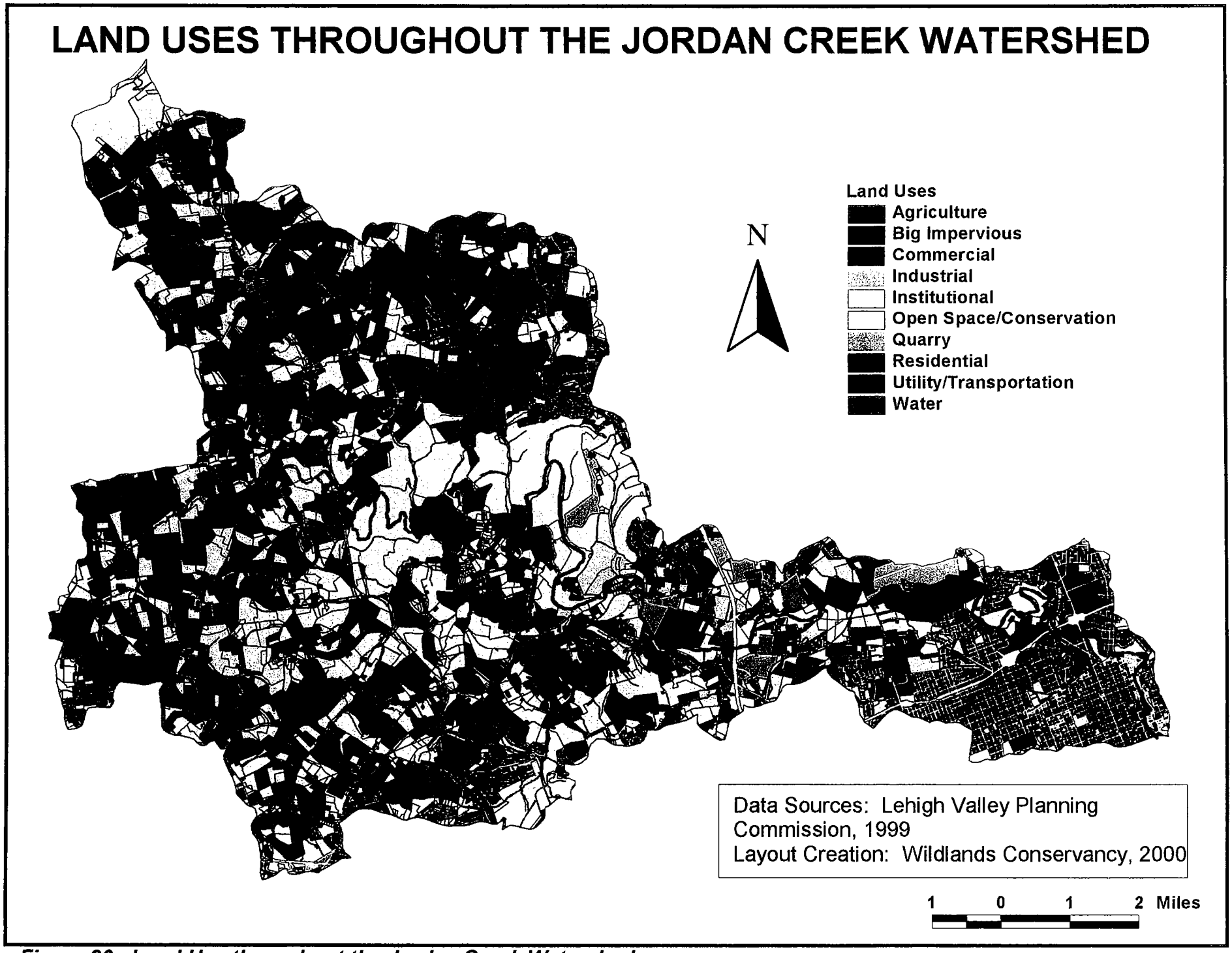


Figure 36. Land Use throughout the Jordan Creek Watershed

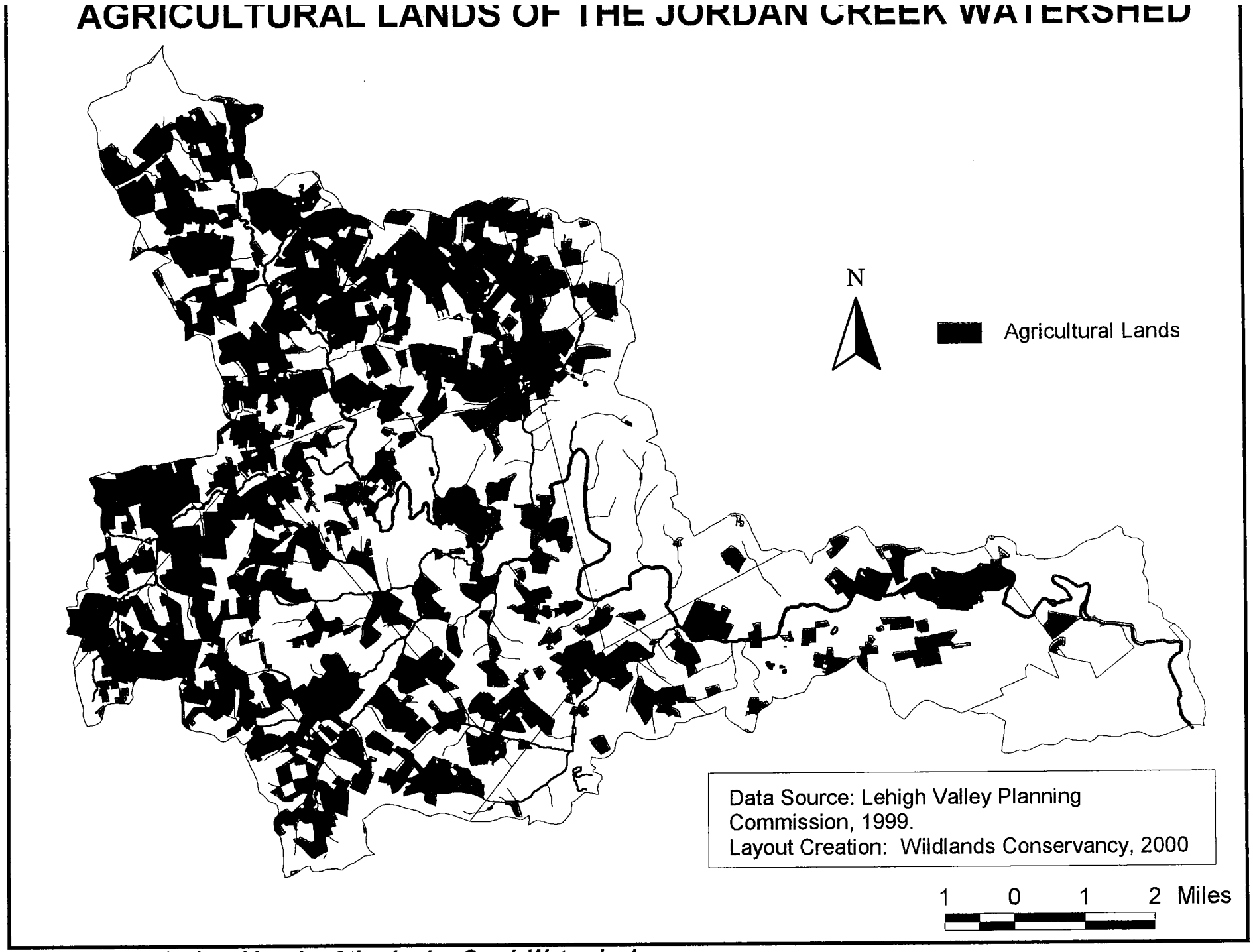


Figure 37. Agricultural Lands of the Jordan Creek Watershed

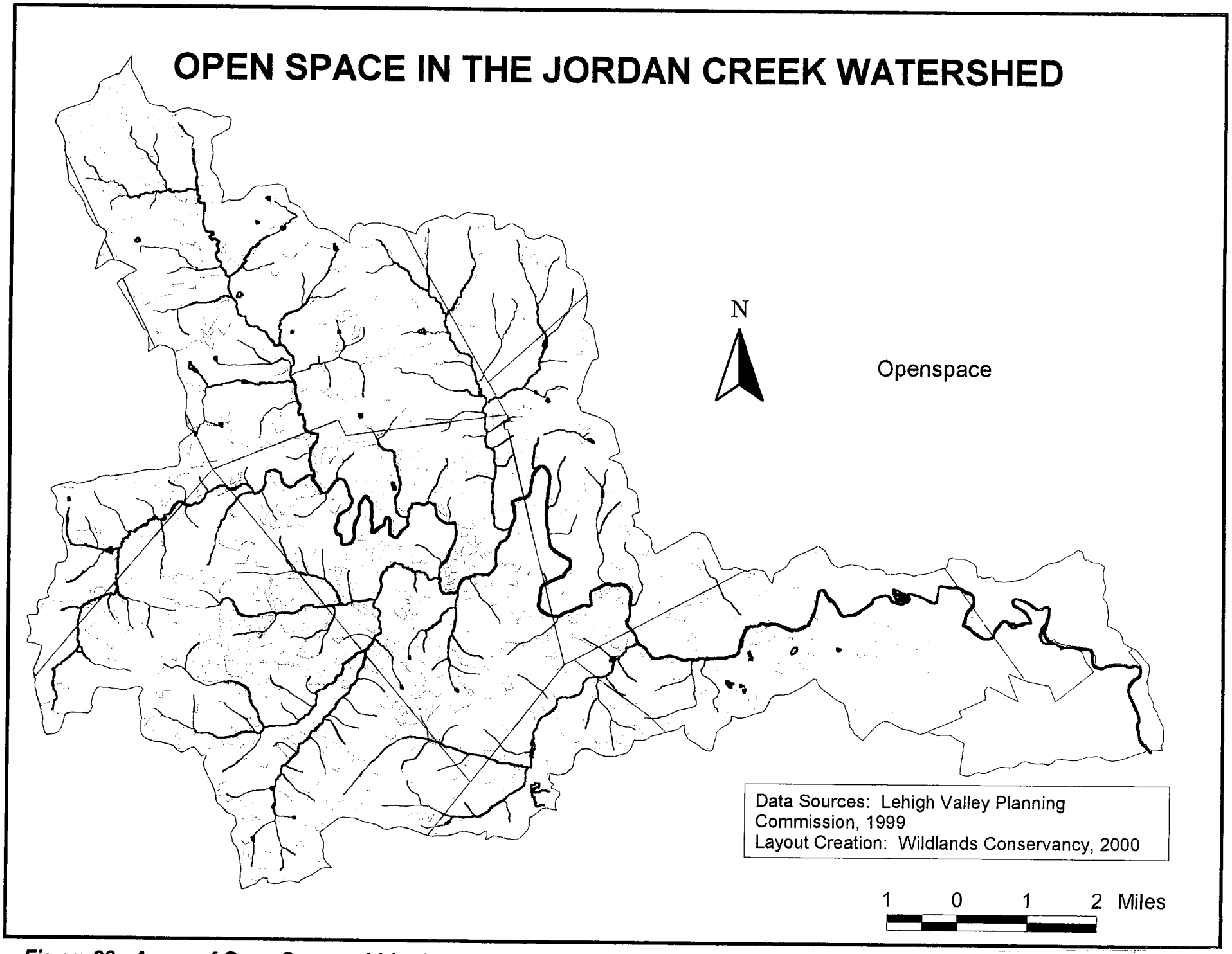


Figure 38 Areas of Open Space within the Jordan Creek

Table 27. 1995 Existing Land Use (in Acres) by Municipality

Municipality	Residential	Commercial/Industrial/ Warehousing	Agricultural/ Vacant
City of Allentown	3361	1718	963
Heidelberg Township	1877	82	11,444
Lowhill Township	1489	40	5292
Lynn Township	2399	122	19,820
North Whitehall	4062	540	10,554
South Whitehall	3007	1327	4456
Upper Macungie	2770	1945	9642
Washington Township	2891	311	9184
Weisenberg Township	2575	97	13,712
Whitehall Township	2081	1485	2636

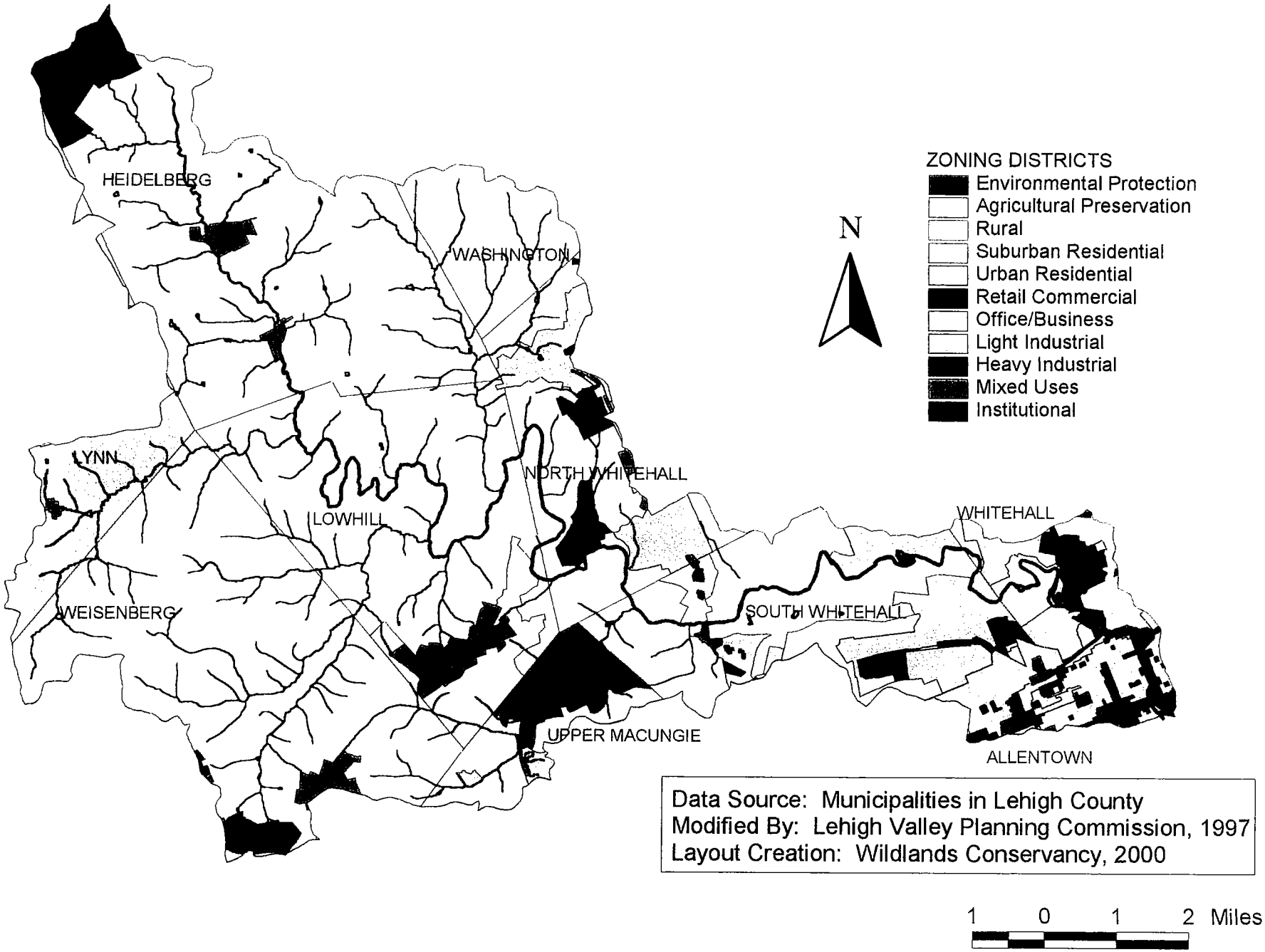
(Note: These figures reflect the entire area of the municipalities, not just portions in the watershed)
Source: Lehigh Valley Planning Commission, 1997

5.1.1 Zoning

Based on the municipal zoning throughout the Jordan Creek watershed, agriculture, open space and residential land uses will continue to dominate the major part of the watershed upstream of South Whitehall Township (Figure 39). In the lower portion of the watershed, more urbanized land uses dominate the zoning. On a land use percentage basis, agriculture and residential land uses represent the dominant land use types of concern for water quality purposes. Trends identified for these land uses should be priorities for addressing with pollutant management strategies. The remaining land uses will only be small percentages of the watershed in the near future. Of these, the predominant land use of concern is industrial and the potential for point source discharges of contaminants. Measures to mitigate the potential adverse impacts of land use activities on water quality should focus on the preliminary trends identified herein and the specific impacts of future residential and industrial development and continuing agricultural use. The status of developments within the Jordan Creek watershed are mapped in Figure 40. Zoning is an important control of the type of development and redevelopment that occurs in the watershed and there are several types of zoning practices that can protect land and water resources, including:

- Cluster development--constructing dwellings close together to preserve open space
- Down-zoning--changing an established zone to require a lower density
- Conditional zoning--allowing certain activities only under specified conditions that protect water resources
- Overlay zoning--placing additional zoning requirements on an area that is already zoned for a specific activity of use; through the use of resource overlay zoning, high pollution activities can be controlled in sensitive areas
- Open space preservation--protecting open space and buffer zones near water bodies, i.e. greenways or riparian corridors

ZONING DISTRICTS IN THE JORDAN CREEK WATERSHED



Data Source: Municipalities in Lehigh County
Modified By: Lehigh Valley Planning Commission, 1997
Layout Creation: Wildlands Conservancy, 2000

Figure 30 Zoning Districts in the Jordan Creek Watershed

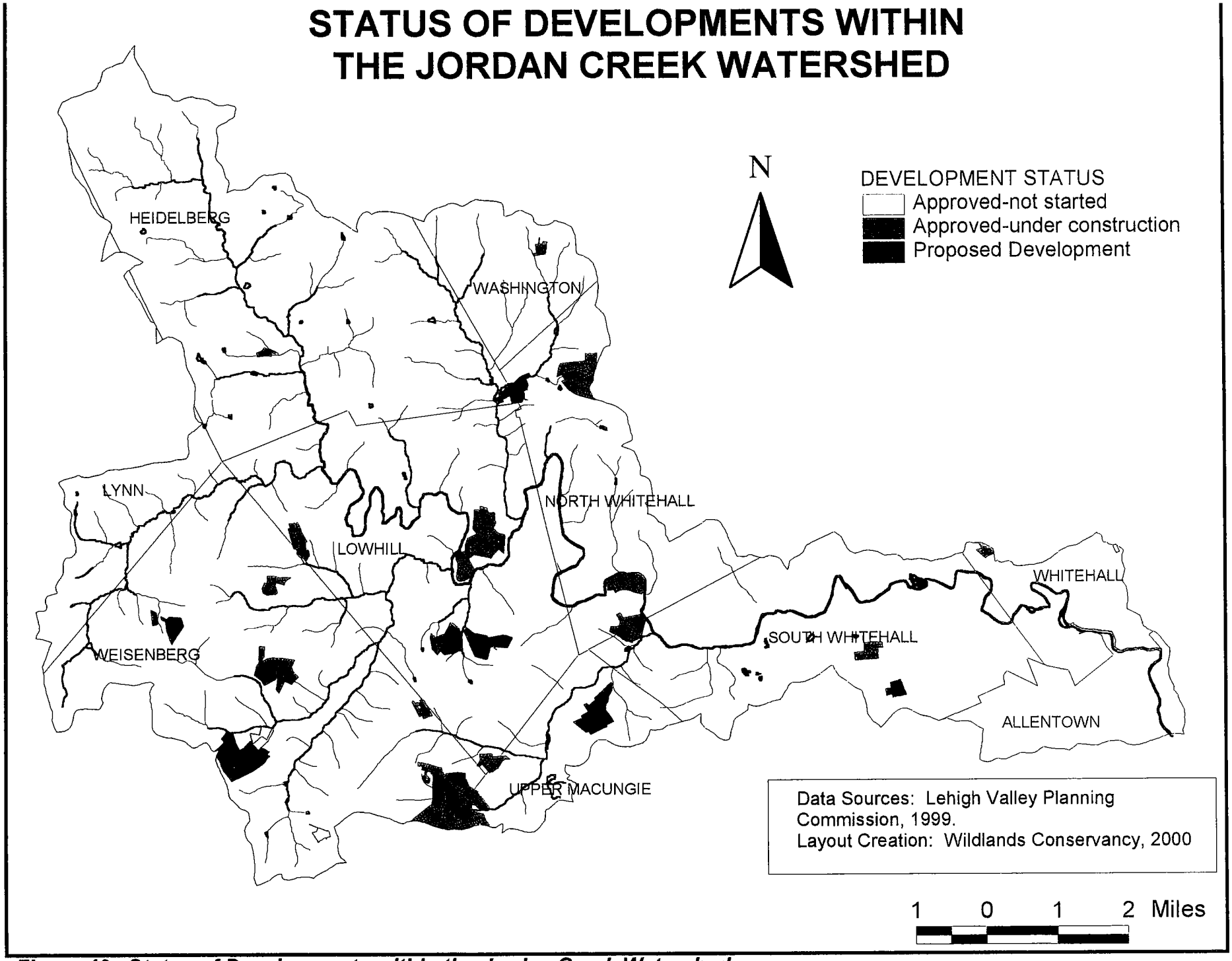


Figure 40. Status of Developments within the Jordan Creek Watershed

5.1.2 Agricultural Land Conservation Easements

Of the 19,282 acres of agricultural land in the Jordan Creek watershed, 4348 acres, or 22.5 percent is protected with a conservation easement (Figure 41). A conservation easement is a legal agreement between a landowner and a land trust (a private, nonprofit conservation organization) or government agency that permanently limits a property's uses in order to protect its conservation values.

A landowner also retains many rights associated with that land. When a landowner sells or donates a conservation easement to a land trust, the owner permanently forfeits some of those rights. For example, a landowner might give up the right to build additional residences, while retaining the right to grow crops. Future owners of the land will also be bound by the easements terms.

The conservation easement is written in a legal agreement that is tailored to protect the land's conservation values and meet the financial and personal needs of the landowner. An easement designed to protect wildlife habitat might prohibit development of any kind, for example, while one on a farm might allow continued farming and the building of additional agricultural structures, but prohibit subdivision.

The land trust takes on the responsibility and legal right to enforce the easement. If a future owner or someone else violates the easement the land trust will work to have the violation corrected.

5.1.3 Land Use and Water Quality (Source: Lehigh Valley Planning Commission)

A distinct relationship exists between land use and water quality. Knowledge of this relationship is necessary for both land use planning purposes and protection of water resources. Wildlands Conservancy contracted the Lehigh Valley Planning Commission (LVPC) to conduct analysis of the correlation between the water quality data collected by the Conservancy and existing land use in the Jordan Creek watershed. The method used by the Lehigh Valley Planning Commission to prepare their assessment was to determine the percent of a given land use associated with a monitoring point, the associated water quality data by parameter at the monitoring point and compare that relationship to the other monitoring points throughout the watershed. The final product was an assessment of percent land use versus water quality to identify any strong linkages and helps determine if any land use measures needed to protect water quality. The purpose of the study is to identify whether any clear relationship exists between the monitored water quality in the creek and the land use pattern within the watershed. The impact of watershed geology on water quality is also evaluated. The key findings based on the assessment are listed below and are summarized in Table 28.

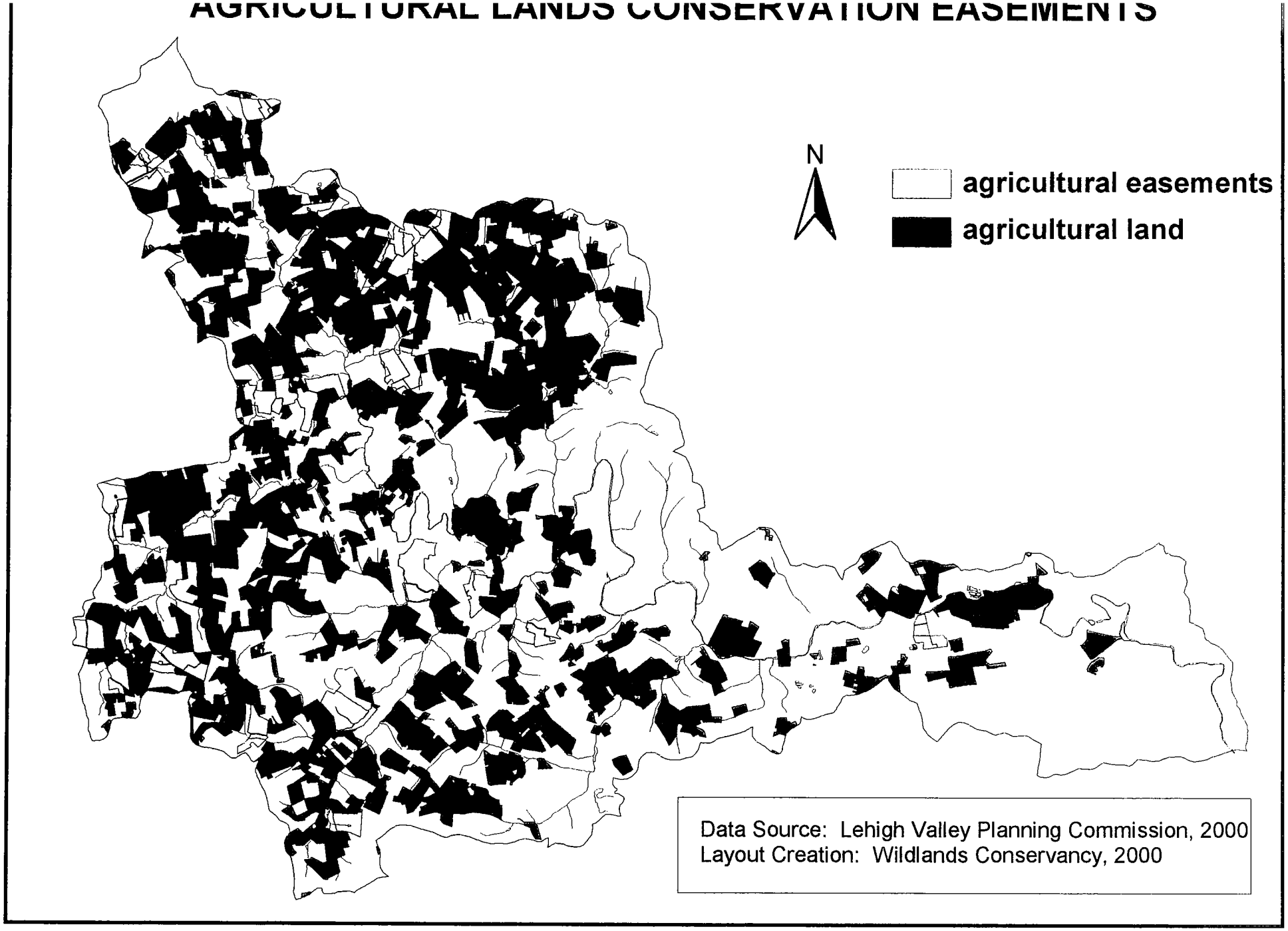


Figure 41. Agricultural Land Conservation Easements

Table 28. Jordan Creek Watershed Land Use and Geology Water Quality Trends
(Source: Lehigh Valley Planning Commission)

Parameters	Land Use Type Open Space	Agriculture	Residential	Industrial	Commercial	Institutional	Transporation	Geology Limestone
Alkalinity								Increase
Ammonia		Decrease	Increase	Increase	Increase	Increase	Increase	Increase
Ca^+ Hardness			Increase					Increase
Conductivity			Increase				Increase	Increase
Dissolved O_2								
Nitrate	Decrease	Increase			Increase			
pH								
Phosphate	Decrease	Decrease	Increase	Increase		Increase		
TDS			Increase	Increase		Increase	Increase	Increase
H_2O Temperature		Decrease		Increase	Increase	Increase		
Total Hardness			Increase			Increase	Increase	Increase

Key Findings:

- Significant trends, both increases and decreases between land use and water quality, were identified for alkalinity, ammonia, calcium hardness, conductivity, nitrates, phosphates, total dissolved solids, temperature, total hardness and turbidity.

- All seven of the land use types within the watershed would appear to have significant water quality trends for certain water quality parameters. The land use types include open space, agricultural, residential, industrial, commercial, institutional and transportation.

- Limestone has a very significant impact on the water quality in the Jordan Creek. Six of the water quality parameters have an increasing correlation with limestone. Alkalinity, ammonia, calcium hardness, conductivity, total dissolved solids and total hardness display this trend with limestone.

- Trends identified for residential, commercial and open space land uses may be used with more confidence than trends for other land use types because they have a larger range of land use by percentage by sampling site.

- All "developed" land uses exhibit a strong correlation with limestone in terms of increasing land use percentage with increasing limestone in the drainage area. Agriculture has the opposite correlation with limestone.

- Agricultural and residential land uses represent the dominant future land uses in the watershed based on zoning.

Improperly or inadequately controlled land use activities can greatly impact both surface water quality and aquatic life. The severity of the impacts depends on the physical and chemical characteristics of the receiving water, the properties of the pollutants involved and both the intensity and nature of the land use activity.

The types of pollutants generated vary with land use activity. Typically, a single pollutant seldom occurs individually. For example, sewage waste is a biodegradable organic substance that contains nutrients and may also contain pathogenic organisms or heavy metals. The combination of pollutants can have serious effects on water quality and aquatic life. However, the full impacts of combined pollutants are often difficult to determine.

Knowledge of the relationship between land use and water quality is necessary for both land use planning purposes and protection of water resources. By knowing the types of water pollution threats and associated land use activities, it may be possible to determine a more preferable location for any given activity. Further, implementation of appropriate management programs for existing activities can minimize any water quality degradation or even improve existing water quality.

For the Jordan Creek watershed, agriculture and open space dominate the upstream areas and "developed" land uses dominate the downstream areas. As the water quality monitoring progresses downstream, the agricultural and open space land uses typically give way to increasing residential, commercial, industrial, institutional and transportation land uses. A major contributor of water quality, however, is watershed geology and specifically the presence or absence of limestone. Surface water and ground water in limestone areas would be expected to have elevated concentrations of hardness and alkalinity due to the solution of carbonate bedrock. Other water quality parameters such as conductivity, pH and total dissolved solids may also be affected by the presence of limestone. The limestone areas are located at the downstream portion of the Jordan Creek watershed. Monitoring point 8 is located essentially in the center of the watershed and has only a very small fraction of drainage area in limestone. Monitoring points 1 through 7 have significant limestone. Points 10 through 17 have no limestone in their drainage areas. According the LVPC, the key challenge in the assessment of land use/water quality trends for the Jordan Creek watershed is to separate trends caused by lands use from trends caused by geology. For this reason, water quality trends were evaluated with respect to limestone percentage of drainage area as well as land use percentage. Further, for each land use, possible trends were evaluated looking at all water quality data and also looking at the monitoring points not affected by limestone. Trends were only considered valid if they appeared using all data and only non-limestone monitoring point data.

Limestone has a very significant impact on water quality in the Jordan Creek watershed. Six parameters have an increasing correlation with limestone. For these six parameters, the identified trends with land use should be used cautiously because of the difficulty of screening out the limestone impact from the correlations. The trends for open space, agriculture and residential land uses may be more reliable since they have a wider range of occurrence throughout the watershed. For industrial, commercial, institutional and transportation, the correlations will be more sensitive to isolated water quality problems such as improperly controlled construction site runoff or other individual properties discharging contaminants. All identified trends should be viewed as generalized and preliminary trends subject to further investigation (Lehigh Valley Planning Commission, 2000).

5.2 Non-Point Source Pollution

Non-point source (NPS) pollution is the Nation's largest source of water quality impairment. NPS pollution occurs when rainfall, snowmelt or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes or coastal waters or introduces them into the ground water. NPS pollution is widespread because it can occur any time activities disturb the land or water. Agriculture, forestry, grazing, septic systems, recreation, urban runoff, construction, physical changes to stream channels and habitat degradation are some potential sources of NPS pollution.

Over the past 25 years, Pennsylvania has made significant strides toward reducing and eliminating pollution from industrial and municipal wastewater discharges. By 1998 only 3.4 percent of surface water quality impairments in Pennsylvania could be attributed to point sources (www.dep.state.pa.us). The remaining 96 percent is linked to non-point sources—

abandoned mines, agriculture, urban runoff, failed septic systems and air deposition—and must be managed comprehensively to achieve meaningful and lasting results (www.dep.state.pa.us).

The latest National Water Quality Inventory indicates that agriculture is the leading contributor to water quality impairments, degrading 60 percent of the impaired river miles and half of the impaired lake acreage in the United States (www.dep.state.pa.us). The most common NPS pollutants are sediment and nutrients. These wash into water bodies from agricultural land, small and medium-sized animal feeding operations, construction sites and other areas of disturbance. Other common NPS pollutants include pesticides, pathogens (bacteria and viruses), salts, oil, grease, toxic chemicals and heavy metals. Each year the United States spends millions of dollars to restore and protect the areas damaged by NPS pollutants.

Pollutants originating from non-point sources can impair water quality in many ways.

Drinking Water
Excessive NPS pollutants may increase the cost of treating surface water for potable or industrial use. High concentrations of nitrates can cause an existing water supply to be abandoned or require extensive treatment. Toxic chemicals, bacteria and viruses in water supplies may require increased levels of treatment resulting in higher costs. High concentrations of suspended solids can increase the amount of sedimentation, which, in turn, reduces the effective storage capacity of lakes and water supply reservoirs. Increased nutrients can create a suitable habitat for aquatic plants, which can lead to other problems.

Fisheries and Wildlife
Toxic chemicals and low oxygen levels can result in changes in aquatic community structures and fish kills. Eutrophication can result in changes in the floral community, which, in turn, influence the fish and invertebrate community structures. Flow variation, removal of riparian vegetation and channelization can change the physical habitat of fish and invertebrates while sediment deposition can cover aquatic food supplies and breeding sites. The Jordan Creek was once classified by the Pennsylvania Department of Environmental Protection as a high quality-cold water fishery (HQ-CWF). However, as previously discussed, the Jordan Creek was downgraded to a migratory fishery and a trout-stocking fishery.

Recreation
Increased nutrients stimulate aquatic plant growth, which can make water bodies less desirable for swimming, boating, hunting and fishing. Bacterial concentrations often exceed recommended levels, thereby limiting water contact sports and aquatic uses. Dissolved, suspended and settleable materials can create unaesthetic conditions of watercolor and clarity and can result in decreased productivity through limitation of the euphotic zone (the well-lit surface waters) in lakes.

Agriculture and Industry
Salinity can result in decreased crop yield and changes in soil structure. High nutrient concentrations can result in excessive aquatic plant growth in supply and receiving reservoirs and distribution canals. Clogging of irrigation pumps and reduction of distribution canal

capacity results from such excessive plant growth. Excessive sediment can cause operational problems for some irrigation systems. Elevated bacterial concentrations and toxic contamination may be detrimental for livestock watering and may constrain application to crops which are consumed raw or are sensitive to the specific toxins.

5.3 Agricultural Non-point Source Pollution

Agriculture is the dominant land use in the Jordan Creek watershed, occupying nearly 37 percent of the study area. For this reason, significant attention is given to the effects agricultural activities can have on water quality and agricultural best management practices.

Areas of the Jordan Creek watershed have become "polluted" in the sense that they are saturated with more nutrients than can be absorbed by the crops as they grow. The nutrients move into waterways by trickling underground or in surface runoff during storms. As a result, the waters of the Jordan Creek have become over-fertilized, or eutrophic. When too much nitrogen and phosphorus enter the creek they fuel the explosive growth of floating plant life, or algae, so extensively that they cloud the water and block out light needed by underwater plant life. When the algae die, they sink to the bottom where their decomposition consumes oxygen. Many parts of the Jordan Creek have become so low in oxygen they are harmful to fish and other aquatic life. Common sources of agricultural pollution include:

Sediment: row-crop land, stream banks devoid of well-established riparian areas or where livestock have access, gullies or other areas with high erosion rates.

Nitrogen: heavily fertilized cropland, animal confinement areas or improperly designed animal waste storage systems, fields on which manure is applied.

Phosphorus: heavily fertilized cropland, animal confinement areas or improperly designed animal waste storage systems, fields on which manure is applied. (Municipal sewage treatment plants are also potential sources.)

5.3.1 Managing Agricultural Non-point Source Pollution

Agricultural activities that cause NPS pollution include confined animal facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting and harvesting. The major agricultural NPS pollutants that result from these activities are sediment, nutrients, pathogens, pesticides and salts. Agricultural activities also can damage habitat and stream channels. Agricultural impacts on surface water and ground water can be minimized by properly managing activities that can cause NPS pollution.

Managing Sedimentation

Sedimentation occurs when wind or water runoff carries soil particles from an area, such as a farm field or construction sites, and transports them to a water body, such as a stream or lake. Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic plants; covers fish spawning areas and food supplies; and clogs the gills of fish. In addition, other pollutants like phosphorus, pathogens and heavy metals are often attached to

the soil particles and wind up in water bodies with the sediment. Farmers and ranchers can reduce erosion and sedimentation by applying management measures to control the volume and flow rate of runoff water, keep the soil in place and reduce soil transport.

Managing Nutrients

Nutrients such as phosphorus, nitrogen and potassium in the form of fertilizers, manure, sludge, irrigation water, legumes and crop residues are applied to enhance production. When they are applied in excess of plant needs, nutrients can wash into aquatic ecosystems where they can cause excessive plant growth, which creates a foul smell and taste in drinking water and kills fish. Farmers can implement nutrient management plans that help maintain high yields and save money on the use of fertilizers while reducing NPS pollution.

Managing Confined Animal Facilities

By confining animals to areas or lots, farmers can efficiently feed and maintain livestock. However, these confined areas become major sources of animal waste. Runoff from poorly managed facilities can carry pathogens (bacteria and viruses), nutrients and oxygen-demanding substances that cause major water quality problems. Ground water can also be contaminated by seepage. Discharges can be limited by storing and managing facility wastewater runoff with an appropriate waste management system.

Managing Irrigation

Irrigation water is applied to supplement natural precipitation or to protect crops against freezing or wilting. Inefficient irrigation can cause water quality problems. Excessive irrigation can concentrate pesticides, nutrients, disease-carrying microorganisms and salts--all of which impact water quality--in the top layer of soil. Farmers can reduce NPS pollution from irrigation by improving water use efficiency. Actual crop needs can be measured with a variety of equipment.

Managing Pesticides

Pesticides, herbicides and fungicides are used to kill pests and control the growth of weeds and fungus. These chemicals can enter and contaminate water through direct application, runoff, wind transport and atmospheric deposition. They can kill fish and wildlife, poison food sources and destroy the habitat that animals use for protective cover. To reduce NPS contamination from pesticides, people can apply Integrated Pest Management (IPM) techniques based on the specific soils, climate, pest history and crop for a particular field. IPM helps limit pesticide use and manages necessary applications to minimize pesticide movement from the field.

Managing Livestock Grazing

Overgrazing exposes soils, increases erosion, encourages invasion by undesirable plants, destroys fish habitat and reduces the infiltration of sediment necessary for building stream banks, wet meadows and floodplains. To reduce the impacts of grazing on water quality, farmers can adjust grazing intensity, keep livestock out of sensitive areas, provide alternative sources of water and shade and re-vegetate rangeland and pastureland.

5.3.2 Agricultural Best Management Practices

Methods of cleaning up land runoff fall into two categories: keeping nutrients from entering the water or putting fewer nutrients on the land initially. Known as *best management practices* (BMPs), the techniques range from farming with less fertilizer to planting seed directly into existing vegetation, a practice that avoids plowing and disrupting the soil and also reduces runoff. Other BMPs involve storing manure in concrete or steel pits, altering farm slopes to retard runoff, fencing cattle from streams so they don't pollute the water and cause stream bank erosion and planting winter cover crops to take up excess fertilizer left in the soil after the main harvest.

Some BMPs show great promise for controlling nutrients and sediment contributed by agriculture. Research and field tests at the University of Maryland's Wye Experiment Station, for example, show potential for controlling nitrogen by sowing fields in winter cover crops like rye and wheat. On many soils, the largest pulses of nitrogen leaving fields are not in the spring when fertilizer is applied, but in winter, as the leftover residues of crops decay or manure is spread when no plants are growing to take it up. Cover crops can absorb the bulk of this runoff. Plowed back into the spring, they can substitute for part of a farmer's purchase of commercial fertilizer (Horton, 1991).

There are a large number of best management practices that can be used by farmers to mitigate the effects of non-point source pollution in the Jordan Creek watershed.

Agri-chemical Handling Facility (AHF)
The AHF is a permanent structure with an impervious surface to provide an environmentally safe area for handling of on-farm agri-chemicals, such as pesticides and fertilizers that are used in spraying operations of cropland. This practice provides for the containment and isolation of spillage from on-farm agri-chemical mixing, loading, unloading and rinsing operations in order to minimize pollution of the soil, water, air plant or plant or animal resources.

Barnyard Runoff Control
The collection and reduction of runoff water and agricultural wastes from barnyards, feedlots and other outdoor livestock concentration areas for storage or treatment to improve water quality.

Contour Buffer Strips
Contour buffer strips are strips of perennial vegetation alternated with wider cultivated strips, farmed on the contour. These strips of permanent vegetation slow runoff and trap sediment. This practice is most effective when used with other conservation practices such as conservation tillage and crop rotation.

Contour Farming
Contour farming is preparing the soil, planting, cultivating and harvesting crops around a hill nearly on the level, rather than up and down the hill. Crop rows on the contour form hundreds of small dams to slow runoff.

Contour Stripcropping
Contour stripcropping is a system of growing crops in approximately even width strips or bands on the contour to reduce soil erosion. The crops are arranged so that a strip of meadow or close growing crop is alternated with a strip of rowcrop, or alternating strips of high and low residue-producing crops.

Cover Crops
A cover crop is a crop of close-growing grasses, legumes or small grains grown to control soil erosion during periods when the major crops do not furnish enough cover. Cover crops are often seeded in the fall to protect the soil until the next spring's planting of major crops, and may add organic matter to the soil and trap excess plant nutrients.

Crop Rotation
Crop rotation is growing various crops on the same piece of land—often changing the crops year by year. This practice may include alternating row crop production from a high residue-producing crop such as corn to a low residue-producing crop like soybeans. Crop rotations work best with other conservation practices such as conservation tillage, strip cropping, contouring and grassed waterways.

Critical Area Planting

Planting vegetation on highly erodible or critically eroding areas in order to stabilize the soil, reduce damage from sediment and runoff to downstream areas and improve wildlife habitat and visual resources.

Diversion
A diversion channel is a channel and ridge similar to a terrace that diverts excess runoff from an area for use or safe disposal in another area. A diversion might be used to divert water from a feedlot, cropland, an active gully or farm buildings.

Field Borders
A field border is a band or strip of perennial vegetation, usually grass or legumes, next to cropland on the outside of a field. Field borders reduce erosion on end rows and also function as turn areas for farm machinery.

Filter Strips
Filter strips are strips of vegetation a minimum of 15 to 25 feet wide that remove sediment, organic matter and other pollutants from runoff. They can be used on cropland next to streams, ponds and lakes or other areas to reduce sediment loads that could reach waterways.

Forest Stand Improvement
Apply to stands of forest trees where quality can be improved through thinning, pruning, and releasing describable seedlings and young trees.

Grassed Waterways
Grassed waterways are areas planted with grass where water usually concentrates as it runs off a field. Grass in the waterway slows the water and guides it off the field, significantly reducing gully erosion.

Heavy Use Protection
Protecting heavily used areas by establishing vegetative cover, by surfacing with suitable materials, or by installing needed structures. The purpose of this practice is to stabilize urban, recreation or agricultural facility areas frequently and intensely used by people, animals or vehicles.

Mortality Composting Facility
A facility for the composting of the normal daily mortalities from a poultry or livestock operation. This facility is designed to biologically treat animal carcasses by composting and to protect the environment by stabilizing nutrients, destroying pathogens and producing low odor, humus-like material which is useful as a fertilizer substitute and soil amendment.

Nutrient Management
Nutrient management involves applying the correct amount and form of plant nutrients for optimum yield and minimum impact on water quality. Practicing strong nutrient management reduces input costs and protects water quality by preventing over-application of commercial fertilizers and/or animal manure.

Pesticide Management
Pest management involves having an expert "scout" crops and recommending that farmers apply pesticides only when concentrations surpass a certain threshold. While sometimes this means spraying more than usual, it often saves considerably on pesticide application.

Pasture/Grazing Management
A planned grazing system is two or more grazing units rotated, or alternately rested, and grazed in a planned sequence. This practice improves grazing efficiency. Rotational grazing systems conserve water resources, enhance wildlife habitat and reduce soil erosion while improving water quality.

Roof Runoff Management
A facility for collecting, controlling and disposing of runoff water from roofs. This practice prevents roof runoff water from flowing across animal concentration waste areas, roads and alleys and to reduce pollution and erosion, improve water quality, prevent flooding, improve drainage and protect the environment.

Residue Management
Residue farming leaves a planned level of the past year's crop residue on the soil surface after planting. Often referred to as conservation tillage, this cropping system leaves at least 30% groundcover after planting. Methods of leaving more residue include using high residue-producing crops, waiting until spring for tillage operations, reducing the number of tillage

passes, planting cover crops, driving more slowly on tillage operations and applying no-till techniques.

Spring Development
Improving springs and seeps by excavating, cleaning, capping or providing collection and storage facilities. The purpose of this practice is mainly to improve the distribution and/or quality of water, or to increase the quantity of water for livestock or wildlife and also to obtain water for irrigation if water is available in a suitable quantity and quality.

Streambank Fencing/Protection
Stream protection involves protecting a stream by excluding livestock and establishing buffer zones or vegetation to filter runoff. Fencing prevents cattle from trampling banks, destroying vegetation and stirring up sediment in the streambed. A buffer zone of vegetation along the stream bank filters runoff and may also absorb excess nutrients and chemicals.

Stripcropping
Growing crops in approximately even width strips or bands. The crops are arranged so that a strip of meadow or close growing crop is alternated with a strip of row crop, or alternating strips of higher and low. Apply to cropland subject to erosion or soil movement that constitutes a pollution hazard.

Structure for Water Control
A structure in an irrigation, drainage or other water management system that conveys water, controls the direction or rate of flow or maintains a desired water surface elevation. The purpose of this structure is to control the stage, discharge, distribution, delivery or direction of the flow of water in open channels or water use areas. Also used for water quality control and to protect fish and wildlife and other natural resources.

Subsurface Drainage
A conduit such as a tile, pipe, or tubing installed beneath the ground surface to collect and/or convey drainage water. This practice improves the soil environment for vegetative growth by regulating the water table and ground water flow.

Terraces
Terraces reduce the rate of runoff and allow soil particles to settle out. The resulting cleaner water is then carried off the field in a non-erosive manner. Terraces are most effective when used in combination with other practices such as crop residue management, contour farming, crop rotations and field borders. Terracing reduces sediment pollution of lakes and streams.

Tree Plantings
Planting trees to establish a stand of trees can be an effective conservation measure in open areas or sparse woodlands where soils are adapted to hardwood forests. Establishing forests—or retaining them where they exist between farms and waterways—appears to do a remarkable job of improving polluted runoff, including the elusive subsurface flows of nitrogen in groundwater (www.epa.gov).

Trough
A trough or tank, with needed devices for water control and wastewater disposal, installed to provide drinking water for livestock. This practice allows for the desired protection of vegetative cover through proper distribution of grazing or through better grassland management.

Underground Outlet
A conduit is installed beneath the surface of the ground to collect surface water and convey it to a suitable outlet. This practice disposes of excess water from terraces, diversions, subsurface drains, surface drains, spillways from dams or roof downspouts without causing damage by erosion or flooding.

Waste Stacking Pad
A stabilized area for the temporary storage and handling of solid manure or other stackable agricultural wastes.

Water and Sediment Control Basins
Water and sediment control basins are short earthen dams built across the slope and minor drainage ways. Basins trap sediment, reduce gully erosion, and reform the land surface.

5.3.3 Elements of a Successful Agricultural NPS Pollution Control Program

The Rural Clean Water Program (RCWP) is a major source of practical information on how to conduct a successful NPS control project. An RCWP evaluation, conducted during 1991 and 1992 by the National Water Quality Evaluation Project (NWQEP) at North Carolina State University, compiled elements that are considered to be essential to the success of an agricultural NPS pollution control program (Coffey, 1992). The participation of landowners, the accurate definition of the most critical areas and the implementation of nutrient management techniques are the three elements of a model project identified in the study.

Landowner Participation: It has been demonstrated that the better landowners understood the project purposes, the more willing they were to participate. One recurring theme was that repeated landowner contact was necessary to obtain high rates of participation. Information/education programs that involved the larger rural community as well as the actual users of the water resources tended to be more successful. The project that obtained the highest level (essentially 100%) of landowner participation did so by getting the local dairy cooperative to levy a penalty on the price paid for milk to dairy farmers who scored below a given level on a conservation/management rating scale.

Defining Critical Areas: Treating critical areas is the best NPS control strategy at the watershed level. Criteria used to identify the critical areas contributing most to water resource impairments generally include erosion rate, proximity to watercourses and animal unit concentration. Several project experiences suggest that particular attention must be given to certain management practices, including tillage operations and nutrient and pesticide management. The ability to identify critical areas and management practices successfully also

increases the cost effectiveness of the entire project and the overall success in improving water quality in the impaired resource (Coffey, 1992).

The critical area approach is important for two reasons. First, for budgeting purposes, it is far more cost effective to focus treatment on the most intense sources. Second, ranking areas for treatment should allow the opportunity to produce the greatest water quality changes in the shortest possible timeframe. Experiences from the RCWP support these general conclusions, reaffirming the belief that targeting is the key to NPS control (Coffey, 1992).

Nutrient Management:
In projects where animal unit densities are high relative to crop nutrient needs, and/or where soil and topographic characteristics are conducive to rapid nutrient flushing, an efficient nutrient management program appears to be a prerequisite to improved water quality (Coffey, 1992).

Changes in nutrient management directed at improving water quality often involve recommendations that differ from traditional farming practices. Traditionally, the use of commercial fertilizers in conjunction with animal wastes is often viewed as insurance. The experience of the RCWP, however, shows that educating producers while providing soil and manure testing services, assessments of crop nutrient needs, specific recommendations for application rates and guidance on optimal timing, can significantly reduce excess nutrient applications. A mass balance approach to agricultural nutrient management is very important when the objective is water quality (Coffey, 1992). This includes calculating farm-level nutrient budgets in terms of waste, legume fixation, nutrient cycling within the production system and nutrient outputs.

5.4 Urban/Suburban Non-point Source Pollution

During urbanization, pervious spaces, including vegetated cover and open forested areas, are converted to land uses that usually have increased areas of impervious surface, resulting in increased runoff volumes and pollutant loadings. Urbanization typically results in changes to the physical, chemical and biological characteristics of a watershed. Vegetative cover is stripped from the land and cut-and-fill activities that enhance the development potential of the land occur. For example, natural depressions that temporarily pond water are graded to uniform slopes, increasing the volume of runoff during a storm event (www.epa.gov). As population density increases, there is a corresponding increase in pollutant loadings generated from human activities. These pollutants typically enter surface waters via runoff without undergoing treatment.

As watersheds are converted from natural and agricultural areas to urban developments, changes in land use and hydrology can trigger a corresponding flow of adjustments that occur downstream. Because of more efficient delivery systems that are part of the urban development infrastructure (i.e. curbs, gutters and storm sewer systems), an increased volume of stormwater runoff reaches receiving streams more quickly and with greater velocity (www.epa.gov). This increased runoff can cause severe degradation, including stream

channel erosion, sedimentation, flooding, physical destruction of biota and loss of stream and riparian habitat (www.epa.gov).

The pressures of urbanization are stressing the watershed, particularly in the townships of Whitehall, South Whitehall and Allentown. Changes in land use along the banks of the Jordan Creek have accompanied this population growth. Figure 41 identifies urbanized land uses along the Jordan Creek. Environmentally responsible streamside management of these areas is critical to protecting and improving the quality of the Jordan Creek.

5.4.1 Effects of Urban Areas on Runoff

Increased Runoff

The porous and varied terrain of natural landscapes like forests, wetlands and grasslands trap rainwater and snowmelt and allow it to slowly filter into the ground. Runoff tends to reach receiving waters gradually. In contrast, nonporous urban landscapes like roads, bridges, parking lots and buildings do not let runoff slowly percolate into the ground. Water remains above the surface, accumulates and runs off in large amounts.

Cities install storm sewer systems that quickly channel this runoff from roads and other impervious surfaces. Runoff gathers speed once it enters the storm sewer system. When it leaves the system and enters into a stream, large volumes of quickly flowing runoff erode stream banks, damage streamside vegetation and widen streamside channels. In turn, this will result in lower water depths during non-storm periods, higher than normal water levels during wet weather periods, increased sediment loads and higher water temperatures. Native fish and other aquatic life cannot survive in urban streams severely impacted by urban runoff.

Increased Pollutant Loads

Urbanization also increases the variety and amount of pollutants transported to receiving waters: sediment from development and new construction; oil, grease and toxic chemicals from automobiles; nutrients and pesticides from turf management and gardening; viruses and bacteria from failing septic systems; road salts and heavy metals. These are examples of pollutants generated in urban areas. Sediments and solids constitute the largest volume of pollutant loads to receiving waters in urban areas.

When runoff enters storm drains, it carries many of these pollutants with it. Increased pollutant loads can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies and make recreational areas unsafe.

5.4.2 Sewage Treatment

In many instances, as people move from rural to urban or urbanizing areas, construction of city sewage systems and wastewater treatment facilities has not kept pace with growth. As a result, the individual septic-tank disposal system, long used in rural areas not connected to sewer systems, continues to be an important method of sewage disposal in outlying areas of cities. Nearly 88 percent, or 46,247 acres, of the Jordan Creek watershed is not serviced by municipal wastewater treatment facilities (Figure 43) and residences in these un-sewered

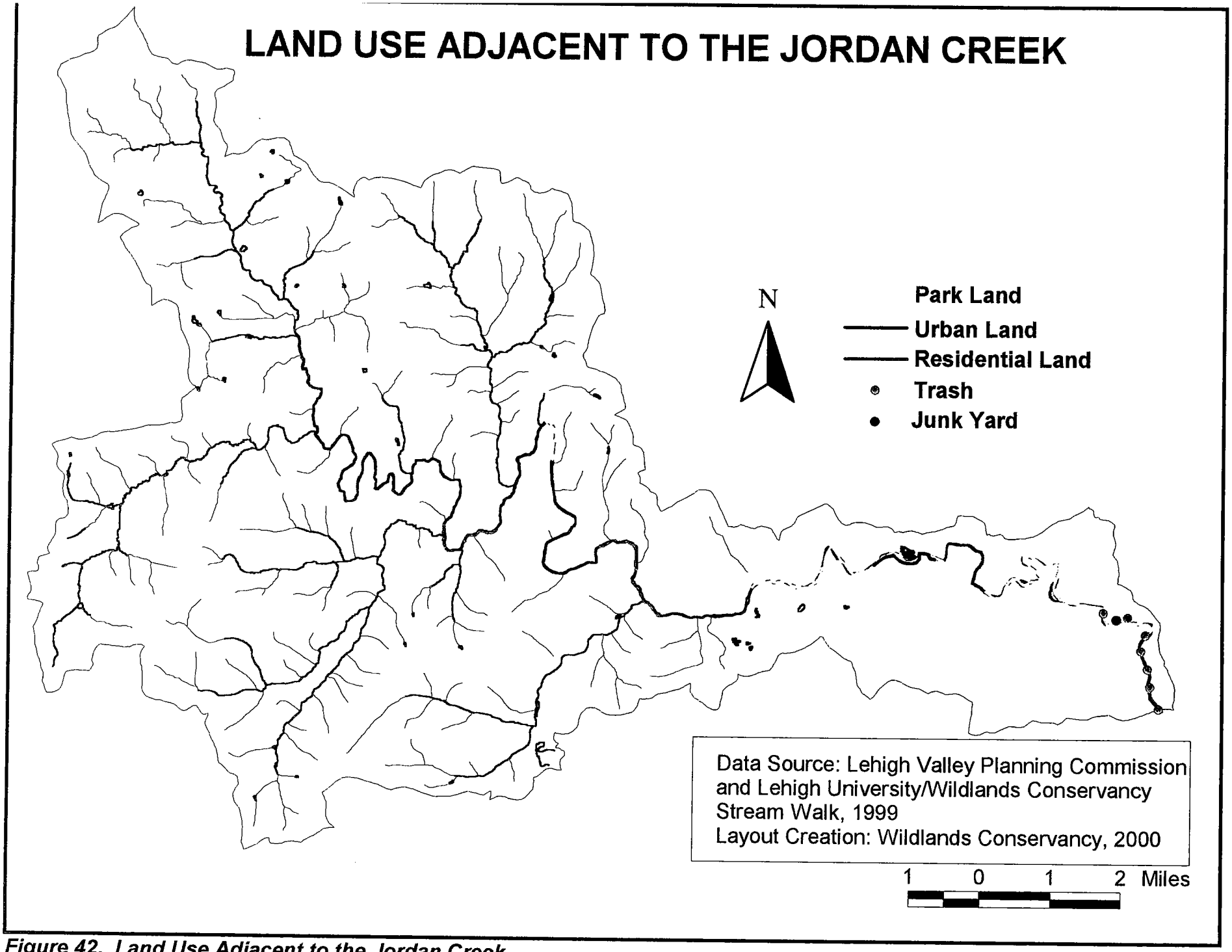


Figure 42. Land Use Adjacent to the Jordan Creek

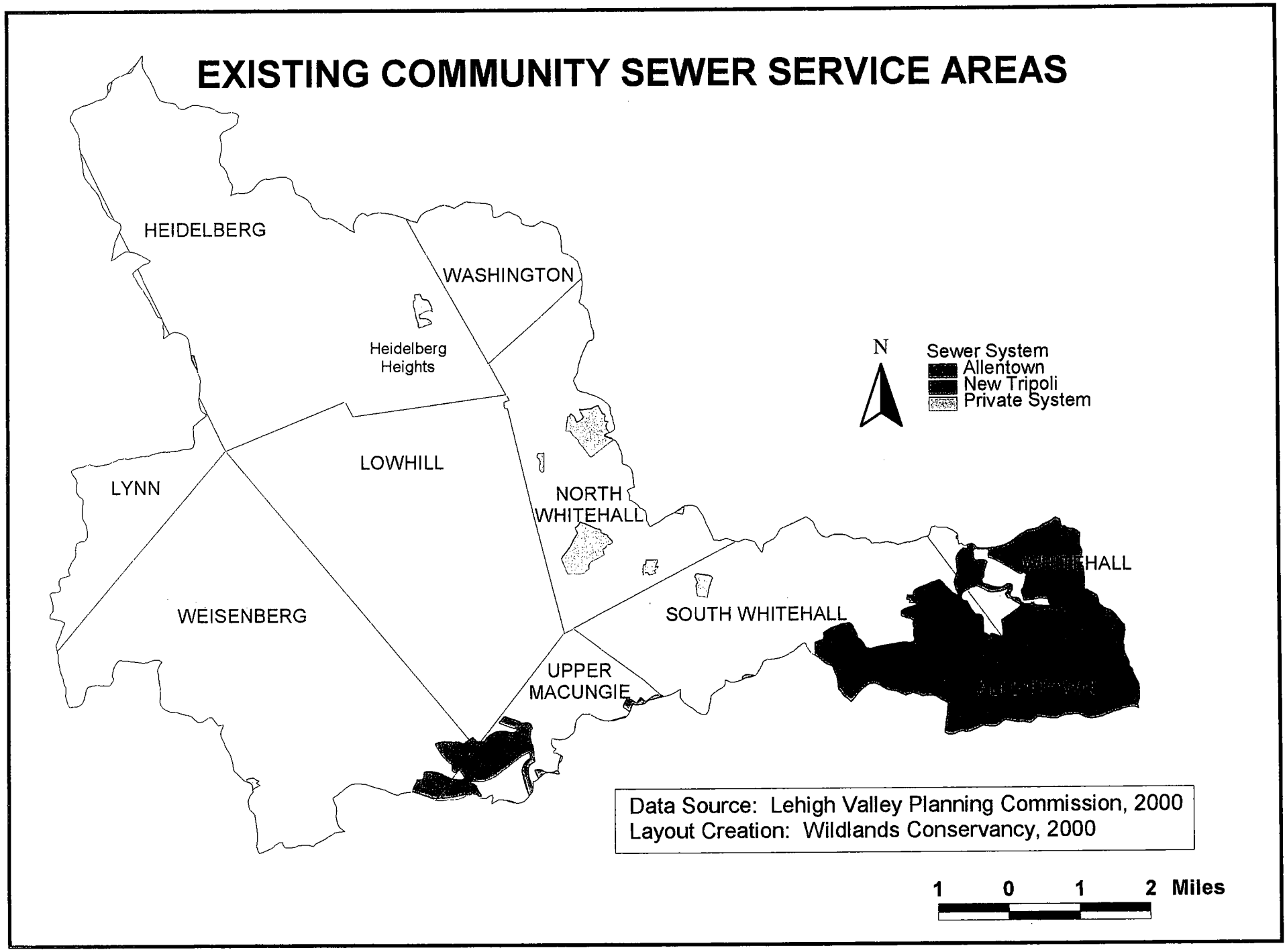


Figure 43. Existing Community Sewer Service Areas

areas therefore depend on septic systems. Improperly functioning septic systems are a major source of stream and groundwater contamination. Figure 44 shows the areas identified by the Joint Planning Commission as potential on-site sewage disposal problem areas based on municipal on-site system repair data, soils assessments for on-site disposal, lot sizes and as documented in sewage facilities plans of the Joint Planning Commission and municipalities.

A septic system tank is designed to separate solids from liquid, biochemically digest and store organic matter through a period of detention, and allow the clarified liquid to discharge into the drain field (absorption field), a system of piping through which the treated sewage may seep into the surrounding soil. As the wastewater moves through the soil the natural processes of oxidation and filtering further treat it. By the time the water reaches and freshwater supply, it should be safe for other uses. Sewage absorption may fail for several reasons. The most common cause are failure to pump out the septic tank when it is full of solids and poor soil drainage, which allows the effluent to rise to the surface in wet weather. When a septic tank absorption field does fail, serious pollution of groundwater and surface water may result.

Sewer authorities in the watershed include Lehigh County Authority (LCA), New Tripoli, the City of Allentown, South Whitehall and the Coplay-Whitehall Sewer Authorities. Approximately 561 acres of the watershed are serviced by privately owned and operated sewer systems and only 6 acres of the watershed are serviced by the New Tripoli sewer system. There are 5753 acres of the sewered watershed remaining. LCA operates the systems shown in Upper Macungie and Weisenberg Townships and has taken ownership of the Heidelberg Heights plant. The Coplay-Whitehall Sewer Authority operates the systems shown in Whitehall and South Whitehall Township operates the system shown in South Whitehall. The waste from all of these areas is eventually received by the City of Allentown.

5.5 Watershed Remediation

5.5.1 Agricultural Pollution (Identified by Wildlands Conservancy Streamwalk)

Figure 45 identifies potential water quality problems related to agriculture in the Jordan Creek. Severe stream bank erosion occurs primarily along the main stem near the headwaters in Heidelberg Township, where the Jordan crosses between Lowhill and North Whitehall and through the western part of South Whitehall. In total 12 sites were identified by the streamwalk on the main stem of the Jordan Creek. They were located in various townships in the watershed as stated above: two in Heidelberg Township, two in Lowhill Township, three in North Whitehall Township, four in South Whitehall Township, and one in the City of Allentown.

Sediment accumulation was identified primarily where the Jordan crosses between Lowhill and North Whitehall, through the western portion of South Whitehall and in Whitehall and Allentown. The streamwalk specifically identified seven locations where unusual amounts of sediment were accumulating in the main stem of the Jordan Creek: two in Lowhill Township, two in South Whitehall Township, one in Whitehall Township, and two in the City of Allentown. Agricultural activities are located directly adjacent to the Jordan and its tributaries at the headwaters in Heidelberg Township. Domesticated animals have been identified wading in the Jordan approximately 3 miles from the headwaters in Heidelberg Township and six miles from

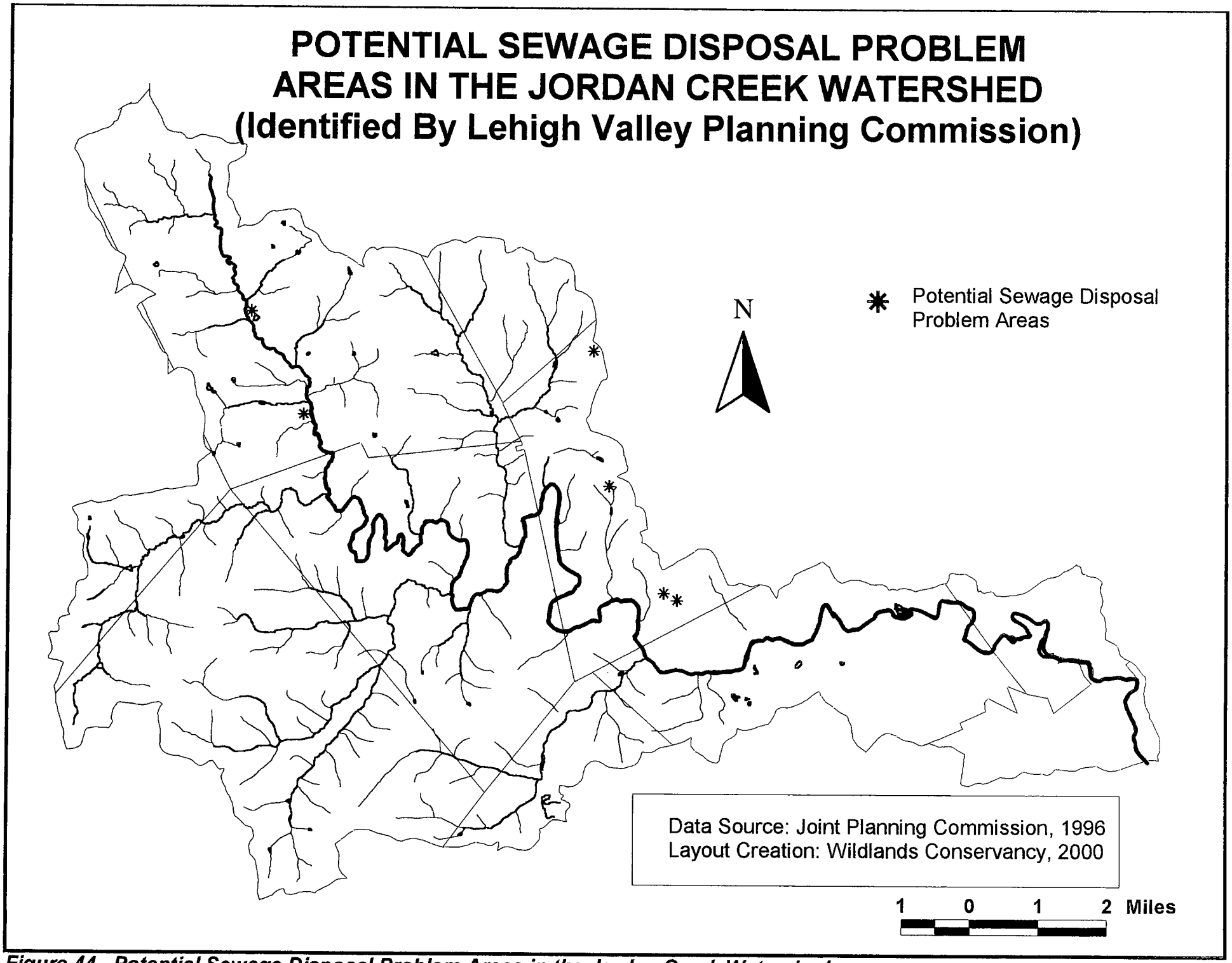


Figure 44. Potential Sewage Disposal Problem Areas in the Jordan Creek Watershed

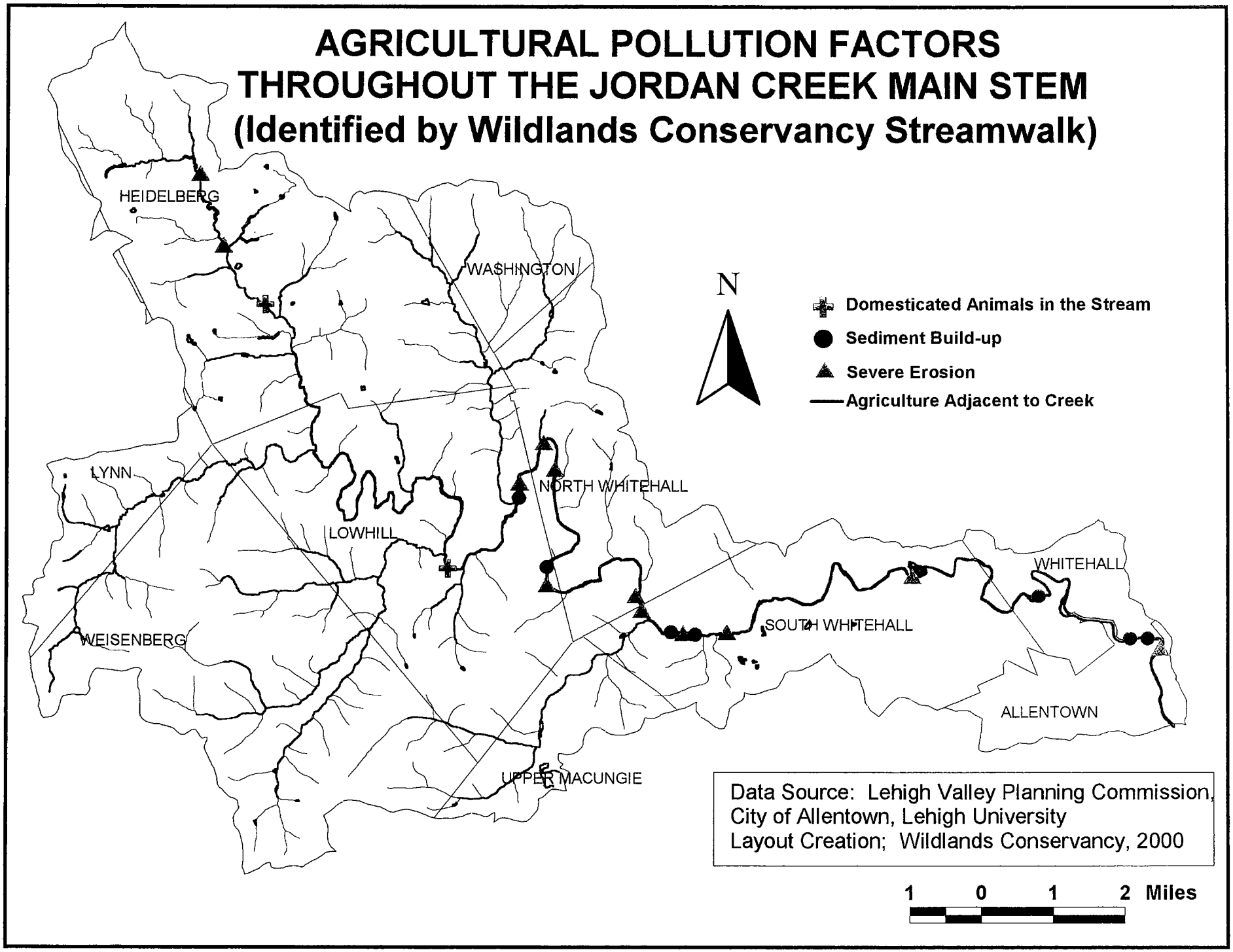


Figure 45. Agricultural Pollution Factors throughout the Jordan Creek

the headwaters in Lowhill Township. In total, the streamwalk identified two instances of livestock having direct access to the stream on the main stem of the Jordan Creek. Streamside fencing and cattle crossings are agricultural best management practices that could be utilized to minimize the impacts these animals are having on the Jordan Creek.

5.5.2 Agricultural Areas in Need of Remediation (Identified by NRCS)

According to the United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) information of 1998, there were 320 farms in the Jordan Creek watershed. Of those farms, 246 are considered cash grain operations, 33 grow potatoes, 25 are classified as livestock farms, and 16 grow fruits and vegetables. Approximately 150 farmers operate this list of 320 farms within the Jordan Creek watershed.

The USDA NRCS Office has prepared a list of the farms that have contacted that office and expressed and interest in addressing agricultural non-point source pollution and implementing agricultural Best Management Practices. This list is contained within this document and more specific information can be obtained from the USDA NRCS. Table 29 highlights specifically the individual improvements appropriate on each farm listed. These estimates were made by that office between 1993 and 2000 and are subject to change due to fair market values of materials, the installation of specific devices and new technology. The total estimate for work that needs to be done within the Jordan Creek watershed currently totals $700,099. This total estimate accounts only for work on farms that have contacted the NRCS office and have had site visits and estimates performed. The farms on this list are numbered due to privacy issues for each individual farmer. The specific addresses for each farm are held by the NRCS office, but are not for public knowledge. Definitions of the Best Management Practices recommended by NRCS are listed in section 5.3.2 of this document.

Table 29. Projected Remediation Needs of Watershed Farms

Name	Agri-Chemical Handling Facility	Barnyard Runoff Control	Critical Area Planting	Diversion	Filter Strip	Forest Stand Improvement	Grassed Waterway	Heavy Use Protection	Mortality Composting Facility	Nutrient Management	Pasture/Grazing Management	Roof Runoff Mgmt.	Spring Development	Streambank Fencing/Protection	Stripcropping	Structure for Water Control	Subsurface Drainage	Terrace	Trough	Underground Outlet	Waste Stacking Pad	Estimated Cost of Farm Projects
Farm 1	X		X			X	X		X	X	X				X			X			X	$47,222.00
Farm 2							X	X	X	X	X	X		X	X				X		X	$41,758.00
Farm 3		X						X		X	X	X		X					X		X	$35,375.00
Farm 4		X	X					X		X	X	X		X					X		X	$34,945.00
Farm 5		X	X					X		X	X	X		X					X		X	$34,300.00
Farm 6					X	X	X			X	X	X		X	X			X	X			$31,958.00

Table 29. Continued

Name	Agri-Chemical Handling Facility	Barnyard Runoff Control	Critical Area Planting	Diversion	Filter Strip	Forest Stand Improvement	Grassed Waterway	Heavy Use Protection	Mortality Composting Facility	Nutrient Management	Pasture/Grazing Management	Roof Runoff Mgmt.	Spring Development	Streambank Fencing/Protection	Stripcropping	Structure for Water Control	Subsurface Drainage	Terrace	Trough	Underground Outlet	Waste Stacking Pad	Estimated Cost of Farm Projects
Farm 7			X	X						X	X		X					X	X		X	$31,050.00
Farm 8			X									X		X	X		X				X	$28,477.00
Farm 9		X	X			X	X	X	X	X	X	X		X	X				X		X	$26,226.00
Farm 10									X	X	X										X	$26,100.00
Farm 11			X	X		X	X	X							X							$24,459.00
Farm 12	X						X								X		X					$23,004.00
Farm 13							X	X							X	X	X			X		$22,434.00
Farm 14						X	X	X														$22,260.00
Farm 15						X				X	X	X		X					X	X	X	$21,510.00
Farm 16			X			X	X			X	X			X					X		X	$20,880.00
Farm 17										X	X	X		X	X				X		X	$20,452.00
Farm 18						X	X	X														$19,560.00
Farm 19						X	X	X			X				X							$18,108.00
Farm 20	X					X		X				X										$16,960.00
Farm 21						X		X		X	X			X	X							$15,410.00
Farm 22	X						X															$10,210.00
Farm 23	X																					$10,000.00
Farm 24	X																					$10,000.00
Farm 25						X		X														$9,936.00
Farm 26			X			X	X	X	X	X		X			X							$7,980.00
Farm 27						X			X	X		X		X					X			$7,350.00
Farm 28									X	X		X										$6,000.00
Farm 29							X			X	X	X			X							$5,056.00
Farm 30										X	X			X					X		X	$4,900.00
Farm 31				X			X											X				$4,830.00
Farm 32										X	X		X								X	$4,700.00
Farm 33						X				X	X										X	$4,431.00
Farm 34						X				X	X	X										$4,357.00
Farm 35										X	X			X					X			$4,340.00
Farm 36							X		X	X												$4,260.00
Farm 37			X			X				X	X				X							$4,169.00
Farm 38										X	X										X	$4,000.00

Table 29. Continued

Name	Agri-Chemical Handling Facility	Barnyard Runoff Control	Critical Area Planting	Diversion	Filter Strip	Forest Stand Improvement	Grassed Waterway	Heavy Use Protection	Mortality Composting Facility	Nutrient Management	Pasture/Grazing Management	Roof Runoff Mgmt.	Spring Development	Streambank Fencing/Protection	Stripcropping	Structure for Water Control	Subsurface Drainage	Terrace	Trough	Underground Outlet	Waste Stacking Pad	Estimated Cost of Farm Projects
Farm 39						X																$3,840.00
Farm 40									X	X												$3,000.00
Farm 41									X	X												$3,000.00
Farm 42							X								X							$2,926.00
Farm 43							X								X							$2,916.00
Farm 44						X				X	X											$2,780.00
Farm 45				X		X	X							X	X		X					$2,420.00
Farm 46										X	X											$2,250.00
Farm 47															X							$1,495.00
Farm 48							X															$1,050.00
Farm 49										X	X											$1,025.00
Farm 50										X	X											$1,025.00
Farm 51										X	X											$1,025.00
Farm 52						X																$840.00
Farm 53										X	X											$500.00
Farm 54										X	X											$500.00
Farm 55					X																	$300.00
Farm 56			X																			$240.00

Total Cost $700,099.00

Table 29 is not a comprehensive list, it only contains information from farmers who have shown an interest in these programs and have voluntarily contacted NRCS. Other farms requiring similar improvements may exist in the Jordan Creek watershed. Interested farmers may contact NRCS or Wildlands Conservancy for further information about how to get involved.

The Natural Resources Conservation Service provided Wildlands Conservancy a map of the locations of these farms. That map contained 127 of the 320 farms in the Jordan Creek watershed. That map provides information as to the farms' locations within the sub-watersheds of Jordan Creek: 20 farms within Switzer Creek, 28 farms within Lyon Creek, 14

farms within Mill Creek, 13 farms within Haasen Creek, and 66 farms within the watershed of the main stem of Jordan Creek.

5.5.3 Current Remediation Projects

Heidelberg Heights:
The Lehigh County Authority (LCA) has been addressing a challenging waste water issue in Heidelberg Heights. In 1998, the LCA took ownership of and operating responsibilities for a failing, private waste water system serving approximately 140 customers in Heidelberg Heights, Heidelberg Township. This system went through a series of design and permitting phases to bring the plant back on-line. The plant is now on-line and fully operational.

Lehigh County Authority's first step once the plant was acquired was to begin an aggressive program to identify areas within the lines of the system that had leaks and were allowing additional flow into the system. This additional flow came mostly in the form of rainwater. After several rounds of flow monitoring and televising over the next year, LCA identified areas of significant infiltration in the main lines. Subsequent repairs took place, but heavy rains in early 2000 indicated that the infiltration problems had migrated to other areas of the system. Further monitoring by the LCA pinpointed the location of the infiltration and the nature of the infiltration. LCA has repaired a portion of those areas and is prepared to contract for the rehabilitation of the remaining areas. LCA needs only the funding necessary to repair these remaining areas.

Properly functioning and maintained sewage treatment facilities can have little or no impact upon water quality. Aging sewage lines are in need of constant repair and maintenance. As development increases and more homes are connected to sewage lines, the pressure placed upon these lines will increase. This added pressure will make the proper maintenance of those lines an even more important issue.

Route 309/Old Packhouse Road Construction:
New road construction is being planned in North Whitehall Township and there is significant concern about the environmental impacts that will result. The scope of the proposed project includes Route 309 from south of Shankweiler Road to Old Packhouse Road and a realignment of Old Packhouse Road. Route 309 is a regional arterial highway connecting southern Lehigh County with northern parts of the county. The segment between Orefield and Schnecksville has seen continued growth, with Lehigh Carbon Community College, KidsPeace and Lehigh Career and Technology institute located along the corridor. Township officials expect continued growth and development both within North Whitehall Township and in municipalities to the north. The major work involved in the project is the relocation of Old Packhouse Road through a currently undisturbed, forested area. Proposed plans for the rebuilding of this road have been designed to minimize environmental impacts by reducing the amount of disturbance to steep slopes and wetlands. After new construction is complete (currently slated to begin in 2002), most of existing Old Packhouse Road will be converted into a passive recreation area for public use. Based on current design plans, the proposed road construction will impact approximately 9.4 acres of woodlands, 6.6 acres of open fields and 1.1 acres of overgrown fields along an unnamed tributary to the Jordan Creek (Summit

Environmental Consulting, 2000). According to Summit Environmental Consulting, the final project design will be completed by 2001 and North Whitehall Township has expressed a commitment to exploring options that would reduce the environmental impacts associated with the relocation project.

Forested lands and open space are increasingly rare in the lower portion of the watershed. Any measures that could reduce the impacts to the natural areas surrounding this construction project should be taken in order to protect the water quality, habitat and scenic benefits they currently provide.

Novak Sanitary Landfill

The Novak Sanitary Landfill (NSL) is located in South Whitehall Township on the south side of Orefield Road and west of Lapp Road. The NSL site is approximately 65 acres in size, but only a portion of the site was utilized for land filling. There are four disposal areas at NSL collectively covering approximately 34 acres. The site is located in a developing area where rural agricultural land is being converted to residential communities and is above the 100-year floodplain. The NSL is a sanitary landfill that received municipal, commercial and industrial solid waste and construction debris. Waste disposal reportedly commenced in the mid-1950s and the last major disposal area was substantially filled as of late 1988.

The detection of volatile organic compounds in an adjacent property owner's well led to a US EPA site inspection in June 1985. In November 1985, the site received a hazardous ranking system score and subsequently was nominated for inclusion on the National Priorities List. The listing was finalized on October 4, 1989 (Geraghty, 1992).

The potential of community and residential wells in the vicinity of the site to be affected by constituent concentrations was studied during the Remedial Investigation, which was performed by Geraghty & Miller, Inc. during the period from mid-1989 to mid-1991. Community supply wells were not found to be affected by constituents from the site. All but one residential well, an on-site well that is generally not used for domestic purposes, exhibited constituent concentrations less than state Water Supply Criteria and federal Maximum Contaminant Levels (MCLs). Slight alteration of ground-water quality was found to be primarily restricted to on-site wells and wells immediately southwest and southeast of the site. The constituents of concern in the affected wells include volatile organic compounds; however, semi-volatile organic compounds and metals were also detected. Off-site residential wells north, north-east and west of the site have not been affected by constituents from the site. No effects of the NSL on the Jordan Creek were detected during the Remedial Investigation. The findings of the investigation also indicate that the non-ground water environmental media at the site, with the exception of the leachate seep areas, have been minimally affected by activities at the NSL. Constituent concentrations associated with on-site soils, as well as ambient air quality, are representative of off-site or "background" conditions.

6.0 MANAGEMENT OPTIONS

6.0 MANAGEMENT OPTIONS

Watersheds are natural boundaries that bind water resources together. They do not conform to municipal or state lines. Water resource problems must be solved within an ecological system—the watershed; and they must be solved locally by people with an interest in the watershed. Locally managed and monitored watershed improvement projects are essential to preserving, protecting and enhancing the water resources of the Jordan Creek watershed.

GOAL 1. IMPROVE WATER QUALITY IN THE JORDAN CREEK AND ITS TRIBUTARIES

Objective 1.1 Abate Agricultural Non-Point Source Pollution

Recommendation: Apply Best Management Practices to Keep Agricultural Pollutants Out of Waterways.

Recommendation: Apply Best Management Practices to Reduce Nutrients Being Applied to Agricultural Land.

Recommendation: Apply Appropriate Best Management Practices to the Agricultural Lands Along the Jordan Creek that Have Been Identified through the Wildlands Conservancy Streamwalk.

- Plant riparian buffers on the farms that have been identified as significant sources of erosion and sedimentation.
- Construct cattle crossings and streamside fences on farms where animals have been found with unrestricted access to waterways.

Recommendation: Make Funding Available and Apply the Best Management Practices to the Farms of the Jordan Creek Watershed that have been Identified by the Natural Resource Conservation District.

► NRCS has identified 56 farms in the Jordan Creek watershed and has prescribed 245 best management practices be implemented on these farms. The estimated total cost of these implementation projects is $700,099. The identified farms, associated best management techniques and estimated costs are listed here.

Projected Remediation Needs of Watershed Farms

Name	Agri-Chemical Handling Facility	Barnyard Runoff Control	Critical Area Planting	Diversion	Filter Strip	Forest Stand Improvement	Grassed Waterway	Heavy Use Protection	Mortality Composting Facility	Nutrient Management	Pasture/Grazing Management	Roof Runoff Mgmt.	Spring Development	Streambank Fencing/Protection	Stripcropping	Structure for Water Control	Subsurface Drainage	Terrace	Trough	Underground Outlet	Waste Stacking Pad	Estimated Cost of Farm Projects
Farm 1	X		X			X	X		X	X	X				X			X			X	$47,222.00
Farm 2							X	X	X	X	X	X		X	X				X		X	$41,758.00
Farm 3		X						X		X	X	X		X					X		X	$35,375.00
Farm 4		X	X					X		X	X	X		X					X		X	$34,945.00
Farm 5		X	X					X		X	X	X		X					X		X	$34,300.00
Farm 6					X	X	X			X	X	X		X	X			X	X			$31,958.00
Farm 7			X	X						X	X		X					X	X		X	$31,050.00
Farm 8			X									X		X	X		X				X	$28,477.00
Farm 9		X	X			X	X	X	X	X	X	X		X	X				X		X	$26,226.00
Farm 10									X	X	X										X	$26,100.00
Farm 11			X	X		X	X	X							X							$24,459.00
Farm 12	X						X								X		X					$23,004.00
Farm 13							X	X							X	X	X			X		$22,434.00
Farm 14						X	X	X														$22,260.00
Farm 15						X				X	X	X		X					X	X	X	$21,510.00
Farm 16			X			X	X			X	X			X					X		X	$20,880.00
Farm 17										X	X	X		X	X				X		X	$20,452.00
Farm 18						X	X	X														$19,560.00
Farm 19						X	X	X			X				X							$18,108.00
Farm 20	X					X		X				X										$16,960.00
Farm 21						X		X		X	X			X	X							$15,410.00
Farm 22	X						X															$10,210.00
Farm 23	X																					$10,000.00
Farm 24	X																					$10,000.00
Farm 25						X		X														$9,936.00
Farm 26			X			X	X	X	X	X		X			X							$7,980.00
Farm 27						X			X	X		X		X					X			$7,350.00
Farm 28									X	X		X										$6,000.00
Farm 29							X			X	X	X			X							$5,056.00
Farm 30										X	X			X					X		X	$4,900.00
Farm 31				X			X											X				$4,830.00
Farm 32										X	X		X								X	$4,700.00

Name	Agri-Chemical Handling Facility	Barnyard Runoff Control	Critical Area Planting	Diversion	Filter Strip	Forest Stand Improvement	Grassed Waterway	Heavy Use Protection	Mortality Composting Facility	Nutrient Management	Pasture/Grazing Management	Roof Runoff Mgmt.	Spring Development	Streambank Fencing/Protection	Stripcropping	Structure for Water Control	Subsurface Drainage	Terrace	Trough	Underground Outlet	Waste Stacking Pad	Estimated Cost of Farm Projects
Farm 33						X				X	X										X	$4,431.00
Farm 34						X				X	X	X										$4,357.00
Farm 35										X	X			X					X			$4,340.00
Farm 36							X		X	X												$4,260.00
Farm 37			X			X				X	X				X							$4,169.00
Farm 38										X	X										X	$4,000.00
Farm 39						X																$3,840.00
Farm 40									X	X												$3,000.00
Farm 41									X	X												$3,000.00
Farm 42							X								X							$2,926.00
Farm 43							X								X							$2,916.00
Farm 44						X				X	X											$2,780.00
Farm 45				X		X	X							X	X		X					$2,420.00
Farm 46										X	X											$2,250.00
Farm 47															X							$1,495.00
Farm 48							X															$1,050.00
Farm 49										X	X											$1,025.00
Farm 50										X	X											$1,025.00
Farm 51										X	X											$1,025.00
Farm 52						X																$840.00
Farm 53										X	X											$500.00
Farm 54										X	X											$500.00
Farm 55					X																	$300.00
Farm 56			X																			$240.00
																						Total Cost
Totals	**6**	**4**	**11**	**4**	**2**	**21**	**20**	**14**	**10**	**34**	**29**	**15**	**2**	**15**	**18**	**1**	**4**	**4**	**13**	**2**	**16**	**$700,099.00**

Objective 1.2 Control Urban Non-Point Source Pollution

Recommendation: Utilize Non-structural Methods to Control Urban Runoff.

⇒ *Land use controls may be necessary along with structural measures in order for a jurisdiction to meet its water quality goals.*

►Land use controls can be a cost-effective means to control urban runoff. They have a maintenance cost/multiple use advantage over structural BMPs in many cases and should be employed in redevelopment situations where appropriate.

►Strategies for implementing land use controls may include limits on impervious surfaces, encouragement for the preservation of open space, and promotion of cluster development.

►The use of nonstructural best management practices for controlling urban non-point source pollution can also be required as a condition of development approval.

►Use public rights-of way as an opportunity for runoff controls such as wet ponds, vegetated swales or meandering vegetated channels. This would include the use of land under bridges and overpasses, the median strips of roads and highways, and the exit ramp rights-of-way off major roads.

►Use zoning to control the type of development or redevelopment allowed within community boundaries. Examples of zoning controls that can be used to protect water resources include:

- cluster development: constructing dwellings close together to preserve open space
- down-zoning: changing an established zone to require a lower density
- conditional zoning: allowing certain activities only under specified conditions that protect water resources
- overlay zoning: placing additional zoning requirements on an area that is already zoned for a specific activity of use; through the use of resource overlay zoning, high pollution activities can be controlled in sensitive areas
- open space preservation: protecting open space and buffer zones near water bodies, i.e. greenways or riparian corridors

Recommendation: Utilize Structural Runoff Controls for Highly Urbanized Areas.

⇒ *In areas where impervious materials cover almost one hundred percent of the surface, conventional BMPs requiring large amounts of land and good soil conditions are usually not feasible. These types of BMPs include dry ponds, wet ponds, constructed wetlands and various sorts of infiltration devices.*

►On sites where standard BMPs are not feasible, consider the use of unconventional or innovative BMPs sometimes known as "ultra-urban" BMPs. These systems are designed to function by gravity flow between components. They include:

- Sand filtration systems
- Underground sand filters consisting of multiple chambers
- Surface sand filters such as double trench systems
- Peat/sand filtration systems

Recommendation: Make Funding Available to Ensure the Proper Maintenance and Operation of Sewage Treatment Facilities within the Jordan Creek Watershed.

►Funding should be made available to abate rainwater infiltration into the Heidelberg Heights sewage treatment facility lines.

►Funding should be made available to access current sewage collection systems in order to reduce leakage and infiltration.

Recommendation: Encourage Municipalities to Adopt Sewage Management Programs for Areas with High Potential for On-lot Systems.

Recommendation: Promote Proper Operation and Maintenance Practices for On-lot Septic Systems.

Recommendation: Provide Educational Opportunities for Owners of On-lot Septic Systems.

Recommendation: Provide Funding to Conduct Workshops for On-lot Septic System Owners About Proper Maintenance and Cleaning Procedures.

Recommendation: Provide In-stream Habitat Improvements to the Jordan Creek and its Tributaries Where Necessary.

Recommendation: Replace Improper Stream Devices Such as Gabion Baskets in the Jordan Creek and its Tributaries.

Recommendation: Remove Unused Low-head Run-of-the-River Dams in the Jordan Creek Watershed.

Recommendation: Remove the Following Abandoned Railroad Structures Along the Lower Section of the Jordan Creek:

- The abandoned Lehigh Valley Railroad station piers, which is located immediately downstream of the Hamilton Street Bridge.
- The abandoned Lehigh Valley Railroad Bridge (on the Jordan Loop), which is located upstream of the Linden Street Bridge.

⇒ *Removal of these two structures within the Jordan Creek will greatly reduce the collection of debris at these structures (thus eliminating the damming effect and reducing flooding) and therefore, improving the flow characteristics of the creek during both small and large flow events.*

Recommendation: Provide Stabilization and Habitat Improvement in the Lehigh County Game Preserve Along the Half-mile Reach of the Jordan Creek Downstream from the Mill Creek Confluence.

Objective 1.3 Revise Storm Water Management Practices

⇒ *In addition to protecting the Jordan Creek, reducing frequency and magnitude of flood damage is a major concern to the watershed. Rapid population growth and increased development have led to the disturbance and alteration of the Jordan Creek watershed and floodplains. While flooding is a natural event, alteration of the watershed has increased both the frequency of and the damage caused by flooding. Minimizing the adverse impacts of flooding occurrences is a realistic goal.*

►Best Management Practices for controlling stormwater quantity and quality should be implemented. Properly managing the quality of stormwater runoff is equally as important as managing the quantity of runoff and is strongly advised. Following BMPs for stormwater quality and quantity management would:

- Protect Jordan Creek from the damaging impacts of stormwater runoff directly entering the stream,
- Improve water quality of Jordan Creek by improving quality of stormwater discharges
- Reduce frequency and magnitude of flooding events, and
- Minimize potential flood damage and cost.

Recommendation: Direct Discharges from Storm Drains to Jordan Creek Should be Avoided at All Cost. Also, Permeable Surfaces Should be Preserved Whenever Possible, as they Will Absorb Overland Flow, thus Distributing the Peak Discharge Over a Greater Length of Time at a Lower Stream Height.

Figure 47. There are many storm water discharges, such as this one directly behind Central Catholic High School in Allentown, that run directly into the Jordan Creek.

Recommendation: Storm Water Runoff Should be Converted to Sheet Flow Over a Porous Medium or Channeled to an Infiltration Structure, Such as a Sedimentation Pond or Trench that Directs Runoff into the Ground Rather than Directly into the Jordan Creek. Directing Water through or Over a Porous Medium that is Naturally Vegetated Would Not Only Increase Infiltration, but Also Filter Out Pollutants and Cool the Water Before it Enters the Creek. This Process Would Greatly Reduce Non-point Source Pollution and Thermal Pollution Typically caused by stormwater runoff. If Natural Areas are Not Available for Stormwater Management Purposes, Infiltration Structures are Recommended.

Recommendation: Promote and Implement Storm Runoff Volume and Rate Controls as described in the Lehigh Valley Planning Commission's Act 167 Storm Water Management Plan, May 1992.

Recommendation: Implement the Recommendations Listed in the Appendix of the Lehigh Valley Planning Commission's Act 167 Storm Water Management Plan, May 1992.

Recommendation: Implement the Stormwater Best Management Practices Prescribed in the City of Allentown's *MS4 Non-point Discharge Elimination Strategy Best Management Practices*. Some of these Practices Include:

- Replace existing open throated city inlets.
- Maintain and inspect detention basins.
- Implement regular street sweeping and leaf removal.
- Clean stormwater inlets and catchment basins.
- Monitor and control pollutants from permitted sites.

- Clean-up snow dump sites.
- Review BMPs on an annual basis.

⇒ *In order for best management practices to be successful in the long term, they must be re-evaluated to see if they are still effective, need modification, need updating, etc. Consideration must also be given to adding new BMPs or possibly deleting nonproductive BMPs.*

Objective 1.4 Riparian Buffer Restoration and Establishment

⇒ *Riparian buffers perform many functions that protect water quality and aquatic life. Riparian corridors provide:*

Recommendation: Devising or Adopting an Ordinance Such as the "Riparian Corridor Conservation District, 1995" Created by the Montgomery County Planning Commission is an Excellent Way to Approach Restoration of Riparian Buffers.

Recommendation: Provide Educational Programs and Opportunities for Land Owners to Learn About the Benefits of Riparian Buffers and How they Improve Water Quality.

Recommendation: Provide Technical Assistance to Land Owners for Dealing with Riparian Issues and Encourage Voluntary Planting of Streamside Vegetation.

Recommendation: Use Public Lands to Demonstrate Proper Riparian Buffer Management.

Objective 1.5 Increase Public Involvement in Non-Point Source Pollution Control

Recommendation: Expand Opportunities for Public Involvement in Non-point Source Control.

⇒ *Over the past 25 years, communities have played an important role in addressing non-point source (NPS) pollution, the Nation's leading source of water quality problems.*

►Coordinate with federal, state and local environmental programs and initiatives to increase the success of community-based NPS control efforts.

►To learn about and help control NPS pollution, local citizens should contact the community-based organizations and environmental agencies in their area. These groups often have information about how citizens can get involved in NPS control activities.

Recommendation: Expand Volunteer Monitoring.

Recommendation: Provide Resources and Technical Assistance to the Retired Senior Volunteer Program (RSVP) and the Environmental Alliance for Senior Involvement (EASI) Monitoring Programs.

Recommendation: Work with the Lehigh Valley Water Suppliers to Provide Educational Materials About Water Conservation.

Recommendation: Provide Assistance to the Lehigh Valley Water Suppliers Web Site.

►Organize local groups of volunteers of all skill levels to gather water quality data. This information can help the government agencies understand the magnitude of NPS pollution. More than 500 active volunteer monitoring groups currently operate throughout the United States.

Recommendation: Promote Ecological Restoration Projects.

►Provide ecological restoration opportunities for the public to help out with a wide variety of projects, such as tree planting and bank stabilization in both urban and rural areas. Restoration efforts should focus on degraded waters or habitats that have significant economic or ecological value.

Recommendation: Increase Educational Activities.

►Integrate NPS pollution curricula into classroom activities. The U.S. Environmental Protection Agency (EPA), federal and state agencies, private groups and nonprofit organizations offer area educators a wide variety of materials.

►Students can start on an NPS control project in the primary grades and carry their work through to the intermediate and secondary levels.

Recommendation: Conserve Water.

►Using technologies that limit water use in the bathroom, kitchen, laundry room, lawn, driveway and garden can reduce the demand on existing water supplies and limit the amount of water runoff. Government agencies, utilities and hardware stores have information about products that help households conserve water.

Recommendation: Manage Household Water.

⇒ *Learning to limit NPS pollution at the household level can reduce the overall impacts of NPS pollution on water quality.*

►Households can irrigate during cooler hours of the day, limit fertilizer applications to lawns and gardens and properly store chemicals to reduce runoff and keep runoff clean.

►Households can replace impervious surfaces with more porous materials.

Recommendation: Work with Lehigh County Hazardous Waste Program to Promote and Publicize their Household Hazardous Waste Disposal Program.

► Chemicals and oils should not be poured into sewers, where they can result in major water quality problems.

►Pet wastes, a significant source of nutrient contamination, should be disposed of properly.

Recommendation: Increase Involvement in Public Meetings and Hearings.

⇒ *Decisions made during public hearings on stormwater permitting and town planning can determine a community's capability to manage NPS pollution over the long term. Laws or regulations may require federal, state or local agencies to hold public hearings when permits are issued or when town plans are formed. Notices about hearings often appear in the newspaper or in government office buildings.*

Recommendation: Form Community Organizations.

►Form community organizations to protect local natural resources. These community-based groups provide citizens with information about upcoming environmental events in their watershed, such as ecological restoration, volunteer monitoring and public meetings.

Recommendation: Provide Funding and Technical Assistance to Organize a Jordan Creek Watershed Association.

⇒ *Watershed-level associations are particularly effective in addressing a wide range of NPS pollution problems.*

GOAL 2. PRESERVE AND PROTECT SIGNIFICANT AND VALUABLE LAND RESOURCES

Objective 2.1 Preserve Farmland and Open Space

⇒ *The Jordan Creek watershed is home to both fertile farmland and critical open spaces. Preserving these valuable resources should be a top priority and many government programs and land trusts exist to provide assistance for preservation activities.*

Recommendation: Utilize the Following Conservation Techniques to Preserve Farmland and Critical Open Space.

- Agricultural Conservation Easement—a permanent legal agreement between a landowner and a governmental agency or nonprofit land trust that stipulates that the land must always be available for agricultural use

- Agricultural Security Areas—participating farmers are entitled to special consideration from local and state governing bodies, thus encouraging the continuing use of the land for productive agricultural purposes.

- Bargain Sale—sale of land or an easement to a nonprofit land trust, a governmental agency or a municipality at a negotiated price less than the fair market value. Seller may obtain certain tax advantages in such a transaction.

- Conservation Easement—the same as an agricultural easement, but emphasis may also be on open space, historic and scenic values and wildlife conservation, as well as on the protected farmland. Landowners may obtain certain tax advantages in such a transaction.

- Clean and Green—a law allowing farmers and landowners to be assessed and taxed on the actual-use value of the land as opposed to the highest-and-best use.

- Limited Development—a concept where a farmer/landowner develops a relatively small portion of his/her land while preserving the major portion by means of a donation of land or conservation easement.

- Purchase of Development Rights (PDR)—the acquisition of the right to develop a landowner's land by a public corporation, government agency or nonprofit trust. Once development rights are sold, a conservation easement is placed on the property.

- Transfer of Development Rights (TDR)—a program in which local governments have the authority to provide for the transfer of development rights from one portion of the community to another portion of the community.

Recommendation: Municipal and County Governments Should Designate Funds to be Used to Purchase Development Rights From Interested Landowners Who Own Property Either Immediately Adjacent the Jordan and its Tributaries or Adjacent to Preserved Farms and Parkland in Order to Create Large Continuous Blocks of Preserved Land.

Recommendation: Municipal and County Governments Should Work Directly with Wildlands Conservancy to Educate Landowners About Land Preservation Options.

► In order to benefit from financial assistance programs for farmland and open space preservation, it is critical to improve communication between the agricultural and land owning community and the appropriate agencies to find the sources of funding for acquisition and preservation of these valuable resources.

Recommendation: Wildlands Conservancy, the Bureau of Farmland Protection and the Land Trust Alliance Should Make Information About Farmland Preservation to Watershed Land Owners.

Recommendation: Protect or Acquire Areas Identified by the Lehigh Valley Planning Commission in their Study of Important Natural Areas:

- Helfrich Springs Cave
- Jordan Creek Slopes

- Jordan Valley Marsh
- Trexler Hollow

Recommendation: Support the Reuse and Revitalization of "Brown Fields" in the Jordan Creek Watershed.

Objective 2.2 Preserve Wetlands

⇒ *Wetlands are a very sensitive part of the ecosystem and perform many functions that benefit the Jordan Corridor. Most of the wetlands within the Jordan watershed are small in size and are therefore often overlooked during development planning. Studies in recent years have found that wetlands are a critical part of the ecosystem that, if managed properly, can provide many benefits for the community.*

Recommendation: Preserve and/or Protect the Wetlands of the Jordan Creek Watershed.

Recommendation: Municipalities Should Implement Wetland Buffer Ordinances.

►Better compliance with wetland regulations is needed to protect these highly sensitive areas. Regulations currently exist to protect wetlands from construction and development. Once a wetland is lost or destroyed, it is gone forever. "No net loss" practices, which require the construction of new wetlands to replace those that have been destroyed, are not sufficient to preserve the benefits that were originally provided. Artificial wetlands often do not have the same hydrologic properties and vegetative species of the destroyed wetland, thus limiting the functions of the new wetland and not achieving the objectives of the "no net loss" philosophy.

Recommendation: Gain Support to Save Wetlands From Development by Educating the Community on the Benefits they Provide.

Recommendation: Wetlands Should be Incorporated into Development Plans as Scenic or Passive Recreational Space and Special Care Should be Devoted to Ensure that the Natural Functions of the Wetland are Not Disturbed.

Objective 2.3 Revise Municipal Ordinances

⇒ *The creation or adoption of ordinances structured to encourage stewardship of watershed resources, protect wellhead areas, and limit land uses and activities within stream corridors and floodplains, would make great strides toward achieving the goal of preserving valuable stream resources. These ordinances would serve to preserve such resources as water supplies, wooded regions, wildlife, and aquatic habitats.*

Recommendation: Adopting an Riparian Buffer Ordinance Similar to the "Riparian Corridor Conservation District, 1995" Prepared by the Montgomery County Planning Commission, Should be a Top Priority Among Municipalities.

Recommendation: This Riparian Ordinance is Preferred and Recommended Over Revisions of Current Floodplain Provisions as it Provides Better Protection for the Narrow Floodplains of the Jordan that are Already Overdeveloped. This Ordinance Would Apply Regulations to Enhance and Preserve Vegetative Buffers Along the Creek. The Ordinance Achieves this Objective by Creating a Zoning Overlay District Based on Forest Service Calculations.

Recommendation: Other Types of Buffer Ordinances to Consider Include Fixed Widths and Separate Zoning Districts. If a Fixed Buffer Ordinance is Desired, a Minimum of 50 Feet is Recommended, with the Potential to be Expanded if Critical Areas Extend Beyond those 50 Feet. The Forest Service Standard for Buffer Zones is Presently Set at 75 Feet.

Recommendation: Implement Sinkhole Ordinances in Watershed Municipalities Such as the Lehigh Valley Planning Commission's Model Sinkhole Ordinance.

Recommendation: Adopting an Ordinance to Protect Groundwater Supplies Such as the "Wellhead Protection Model Ordinance" Prepared by LVPC is Strongly Advised. A Wellhead Protection Ordinance is Highly Recommended for the Purpose of Protecting Groundwater Supplies. Locating Sufficient Public Water Supplies is Becoming Increasingly Difficult as More Aquifers are Being Contaminated as a Result of Population Growth and Development. The Potential for Well Contamination and Possible Loss of an Aquifer would be Greatly Reduced by the Adoption of Provisions Similar to Those Contained in the "Wellhead Protection Model Ordinance."

Recommendation: A Cooperative Effort Among Municipalities is Encouraged to Devise a Common Ordinance(s) to Preserve Jordan Creek Resources. Such an Effort would be More Beneficial and Efficient than Each Municipality Working Individually. Common Ordinances would be Easier to Implement and Enforce than Several Different Ones Throughout the Watershed.

Recommendation: Provide Municipal Officials with Educational Workshops and Programs Concerning Environmentally-beneficial Zoning and Ordinances.

Recommendation: Municipalities Should Adopt Environmentally-beneficial Ordinances.

GOAL 3. DOCUMENT WATER QUALITY AND BIOLOGICAL CHARACTERISTICS

⇒ *Maintaining records of the condition of the stream corridor habitat and the vegetative, aquatic and wildlife species present in the corridor is essential to recognizing and assessing threats that may disrupt the balance of the watershed.*

Objective 3.1 Conduct Water Quality Sampling and Analysis.

Recommendation: Wildlands Conservancy, Volunteer Organizations, Educational Institutions and Other Watershed Interest Groups or Individuals should Combine Efforts to Continue Water Sampling and Analysis of the Jordan Creek on a Regular Basis to:

- Identify problem areas on which to focus remediation
- Monitor and document changes in overall health of the watershed while providing background information for future studies and projects
- Note adjustments that should be made in management practices

Recommendation: Stream walks should also be Preformed Annually through a Cooperative Effort as Mentioned Above in Order to Monitor Physical Changes within the Watershed Such as Sedimentation, Stream Sank Stabilization and Vegetative Cover.

Objective 3.2 Conduct Biological Monitoring.

⇒ *Maintaining records of the condition of the stream corridor habitat and the vegetative, aquatic, and wildlife species present within the corridor, is essential in recognizing and assessing threats that may disrupt the balance of the ecosystem.*

Recommendation: Working with Area Watershed Groups and Educational Institutions, Conduct Needed Research on the Flora and Fauna of the Jordan Creek Watershed, i.e., Mammal, Bird, Fish, Macro-invertebrate and Native Tree/Shrub and Wildflower Inventories.

Recommendation: Stewardship or Stream Watch Programs Staffed by Volunteers Could Survey or Maintain Stream Corridor Vegetation. Educational Youth Programs Could Also Accomplish This.

Recommendation: Provide Resources, Equipment and Expertise for Area School Districts, Colleges and Watershed Groups Interested in Conducting Monitoring on the Jordan Creek and its Tributaries.

Recommendation: Encourage Inventories of Vegetative Communities to:

- Identify native and non-native plant species
- Identify where invasive or exotic species are overtaking native vegetation
- Identify where riparian buffers are present and absent

Recommendation: Conduct Periodic Macro-invertebrate Sampling to:

- Provide additional support for water quality monitoring data
- Assess the diversity and abundance of aquatic life serving as the base of the food chain

Recommendation: A Cooperative Effort should be Developed to Inventory the Watershed to Locate and Identify the Presence of any Threatened or Endangered Species of Flora and Fauna.

Objective 3.3 Provide Efficient Data Management and Distribution.

⇒ *A central clearinghouse for data acquired on the Jordan Creek, through professional and volunteer monitoring and inventory efforts, could greatly improve public awareness and communication between key conservation groups.*

⇒ *With the formation of a central database, a concerned individual would know the appropriate contact for reporting or investigating important information. This would ease information distribution and management decision-making because information collected by various organizations would all be in one location. This location could also be used as a site for meetings concerning ventures that impact the creek.*

Recommendation: Enable Lehigh University to Display, Store and Facilitate the Retrieval of Environmental Information on the Jordan Creek. This Information Could be Stored in the Lehigh Earth Observatory Environmental Database.

Recommendation: Make this Management Plan Document Available to Local Libraries, Universities and Watershed Groups.

Recommendation: Create a Website that Would House an Up-to-Date Version of the Jordan Creek Watershed Management Plan and Progress being Made on its Implementation, Upcoming Projects and Events, Recreational Opportunities, Historic Sites of Interest and Pertinent Water Quality and Environmental Information.

Recommendation: Develop a System for Entering and Displaying Data on the Internet. This Would Provide an Excellent and Efficient Means of Improving Communication and Providing Easy Access to Data by Almost any Interested Party.

GOAL 4. INCREASE AND ENHANCE WATERSHED RECREATIONAL OPPORTUNITIES

⇒ *Increasing population in the municipalities means there is a greater need for recreational opportunities. Outdoor recreation is not only a valuable public resource, it can also serve to increase awareness of the need for open space and environmental conservation.*

Objective 4.1 Implement Rails-to-Trails Conversion Projects.

Recommendation: Support Existing and Potential Watershed Rails-to-Trails Projects. Rail-to-Trail Projects, Largely Funded with Federal Assistance, are Becoming Increasingly Popular. When Properly Constructed, Such Pathways Improve Water Quality and Encourage

Biodiversity by Cleaning Up Land and Creating Green Space. With Appropriate Planning, these Projects Also Educate and Encourage Cultural Preservation.

Recommendation: Conduct a Feasibility Study to Assess the Extent of Abandoned Rail Lines, the Possibilities of Linking the Lines, and the Costs Associated with Acquiring the Necessary Lands or Easements and Converting and Maintaining them as Usable Trails.

Recommendation: Examine the Economic Benefits of Rails-to-Trails Projects. Converting Abandoned Rail Lines within the Watershed to Trails and Greenways Would be an Excellent Means of Stimulating Local Economy and Providing the Community with Diverse Opportunities for Exercise and Recreation. Economic Benefits for Communities Include:

- The possibility of increased local tax revenues due to increased property values,
- Stronger support of recreation-oriented business due to spending by trail users on related activities,
- New opportunities for business and commercial activities such as restaurants and bike and ski rental shops, and
- Greenways along trails that can reduce public expenditures by lowering flood and other natural hazard costs.

Recommendation: Educational Signs Posted Along the Greenway Trails or the Riparian Buffer can Enhance the Experience of Using the Greenway While Providing Information about Ecology, Natural History and Conservation.

Objective 4.2 Improve and Expand Watershed Recreational Facilities.

Recommendation: Municipal Parks Should Serve as Models Demonstrating Land Management Practices that Protect Natural Resources. The Parks Could Distribute Informational Pamphlets Relating to River Conservation and Best Management Practices, or Set Up Informational Displays

Recommendation: Conduct Studies of Existing Streamside Parks in the Watershed in Order to Guide Future Environmental Improvements in these Parks. Parks Bordering the Jordan Creek that are in Need of Environmental Improvements/Restoration Include: Covered Bridge Park in South Whitehall, Jordan Park in Allentown and Jordan Creek Parkway in Whitehall.

Figure 48. Channelized stretches of the Jordan Creek in Covered Bridge Park are lined with gabion baskets and void of riparian vegetation.

Figure 49. The Jordan Creek is lined with long stonewalls through Jordan Park in Allentown. This park is void of streamside vegetation and most stream banks are planted with grass and mowed to the creek edges.

Recommendation: A Feasibility Study Should be Conducted to Determine the Possibility of Creating a Recreational Area Along Martin Luther King Boulevard in Allentown, Near the Jordan-Little Lehigh Confluence.

Recommendation: Land in the Jordan Creek Watershed that is Owned by the City of Allentown Should be maintained in a Natural, Environmentally-beneficial State.

Recommendation: Working with State, County and Local Recreational Agencies, form a Watershed Recreation Task Group to Coordinate Planning for and Development and Operation of Recreational Facilities within the Watershed.

Recommendation: Re-establish or Improve Riparian Corridors through Watershed Recreational Areas.

Recommendation: Examine the Feasibility of Linking Recreational Areas Along the Jordan Creek with Riparian Corridors through Easement or Acquisition.

Recommendation: Examine the Feasibility of Expanding State Game Lands 205 through Additional Land Acquisition.

Objective 4.3 Clean Up the Stream Corridors within the Watershed.

⇒ *Areas within the Jordan Creek corridor are littered with trash. A clean creek corridor is aesthetically pleasing, scenic and attractive, and is more inviting to recreational users than a creek that is uncared for.*

Figure 50. Many of the banks of the Jordan Creek are littered with trash in the city of Allentown.

Recommendation: Provide Central Catholic High School with the Financial and Technical Assistance Necessary to Study and Clean-up the Jordan Creek.

Recommendation: The Scattered Trash Should be Picked Up on a Regular Basis and Prevention Measures put in Place. Major Clean-up Efforts are Needed Along the Jordan Creek Throughout the City of Allentown.

Recommendation: "No Littering/Dumping" Signs Warning People of Significant Monetary Fines Should be Posted Throughout the Watershed, Especially In the City of Allentown.

Recommendation: Develop Strong Public Education Programs. Encouraging Residents to Use the Waterways Responsibly and Feel a Sense of Ownership will Help to Prevent Careless Littering.

Recommendation: Use Cleanup Activities to Aid Educational Efforts; Use Education Programs to Promote Cleanup. Cleanup Efforts Involve Volunteers and Develop Public Commitment, Thus Stimulating Future Stream Conservation Efforts. Promotional and Education Projects Should be Undertaken Before Cleanup Events Take Place. Clean-up Activities by Community and School Groups Should be Publicly Recognized.

Figure 51. As the Jordan Creek flows through Allentown and into the Little Lehigh, it is increasingly degraded with urban trash.

Recommendation: Municipalities should sponsor public river corridor cleanup days, which also provide an opportunity for education. After the more extensive initial cleanups, maintenance could be provided by regular (perhaps yearly) cleanup days or by offering sponsorships similar to roadside maintenance programs.

Recommendation: The Business Community can Spearhead Regular Cleanup Activities by Donating Advertising and Employee Time. Cleanup Efforts Should Also Encourage Joint Voluntary Public-Private Efforts for Trash Removal.

Recommendation: Provide Access to the Jordan Creek and its Tributaries for Recreational Activities.

GOAL 5. PRESERVE HISTORICAL RESOURCES

⇒ *The historic resources of the Jordan Creek watershed are unique and valuable. Preservation must therefore become a more integral part of public and private decision-making.*

Objective 5.1 Identify and Preserve Regionally and Nationally Significant Historic Sites and Landscapes within and Related to the Jordan Creek Watershed.

Recommendation: Support Watershed Heritage Tourism and Program Development

Recommendation: Working with Lehigh County Historical Society and the Pennsylvania Historic Museum Commission, Create and Maintain a Collection of Historical Documents, Photographs, Paintings, etc. of the Jordan Creek and its Watershed.

Recommendation: Working with Lehigh County Historical Society and the Pennsylvania Historic Museum Commission, Publish Heritage Resource Publications that Focus on the Important Role that the Jordan Creek Played in the Development of Lehigh County, Pennsylvania and the Nation.

Recommendation: Create Brochures and Conduct Tours of Historic Covered Bridges and Landmarks in the Watershed in Order to Raise Community Awareness of the Historical and Environmental Significance of the Jordan Creek.

Recommendation: Conduct a Systematic Survey of the Watershed and Surrounding Area to Identify and List Potential National Registry Sites and Structures.

► The criteria used to evaluate a site or structure for inclusion in the National Register of Historic Places state that a site/structure must have:

- an association with events that have shaped history;
- an association with a significant person;
- possession of "distinctive characteristics" from a certain type of construction or time period, the work of a master, or high artistic value; or
- yielding or potential yielding of information.

Recommendation: Provide Assistance to the Bureau for Historic Preservation to Offer Ongoing Training Workshops on Getting Properties Listed on the National Register of Historic Places and Applying for State Grants and Administering Local Historic Districts.

Objective 5.2 Educate Residents of the Watershed About its Heritage and Value.

⇒ *The following recommendations were provided by the Pennsylvania Historical Museum Commission.*

Recommendation: Bring Heritage Alive for Children.

- Work with the Secretary of Education and others to see that Pennsylvania history, historic preservation and archeology are expanded in school curriculums.

- Provide workshops and challenge grants for teachers. Work with partners to launch a new workshop series for teachers focusing on Pennsylvania history and heritage related topics. Initiate a small grant program to encourage teachers to develop new heritage education materials.

- Work with middle schools, high schools and community colleges to interest students at these levels in history preservation. Specific ideas to be explored include internships, preservation-related job fairs and expansion of Pennsylvania History Day programs in collaboration with the Pennsylvania Council for Social Studies and Penn State University.

Recommendation: Get the Preservation Message Out.

- Develop a clear message about the importance of history and preservation to the state's citizens, economy and quality of life. Specific elements to emphasize include the unique role Pennsylvania has played in our nation's history, how preservation of the heritage contributes to the state's economy and the importance of understanding our diverse heritage in an increasingly multicultural society.

- Design and implement a campaign to get the preservation message out. Major elements can be media campaigns, expansion of the historical marker program and working with the Pennsylvania Department of Transportation to promote history exhibits at highway welcome centers.

- Maximize the public benefit of federal and state mandated historic preservation and archaeological compliance projects by building public education activities into every project.

Recommendation: Reach Out to Elected Officials and Key Professionals in the Public and Private Sector.

- Provide more educational materials and events directed at state and local officials, including making presentations at annual conferences and events they attend, inviting them to workshops designed specifically for them and providing briefings on request.

- Provide more educational materials and events directed at public and private sector professionals involved in law, planning, real estate and land development. Create technical assistance materials and offer workshops directed at these professionals.

- Develop a leadership institute for historic preservation. This will be directed at leaders in preservation non-profits, historical societies, heritage parks and other organizations and individuals interested in building their expertise in preservation practice.

Objective 5.3 Build Better Communities Through Preservation.

⇒ *The following recommendations were provided by the Pennsylvania Historical Museum Commission.*

Recommendation: Strengthen and Expand Preservation Planning at the Local and Regional Levels.

- Support getting more historical and archeological resources inventoried, protected and incorporated into local comprehensive plans and zoning ordinances. Expand the Certified Local Government Program and increase financial and technical assistance.

- Develop model ordinances, design guidelines and prepare case studies to support preservation and sound land use planning.

- Work to strengthen local and regional planning legislation at the state level. This includes working with business, civic and environmental organizations to promote sound planning and regional cooperation and making changes to the Municipalities Planning Code. It would also include taking steps to clarify and simplify the historic designation process at the local level and recommend legislative change if necessary.

Recommendation: Expand the Use of Preservation as an Economic Development Strategy.

- Maximize use of existing programs like Keystone Opportunity Zones and Community Development Block Grants to revitalize historic communities. Work in close collaboration with state and local governments, businesses and community development corporations to encourage communities to apply for designation and funding under these programs.

- Work with a wide range of state and local partners to develop heritage tourism potential in communities across the watershed.

- Continue to support studies on the economic impacts of preservation and get the findings out into the communities.

- Promote flexible building code interpretation and streamlining of local approval processes to facilitate rehabilitation of historic properties.

- Promote the use of federal tax credits, state and federal grants and T-21 transportation enhancement funds to revitalize historic communities by providing information and assistance regarding applying for funds.

Recommendation: Make Technical Assistance More Available and Useful to Citizens and Local Governments.

- Develop user-friendly technical assistance materials. This will include establishing a clearing-house of information on preservation-related grants, incentives, techniques, regulations, contractors and consultants.

- Develop a technical assistance outreach program. This will include outreach efforts directed at historic property owners, non-profit organizations and local governments.

- Put state and local historical resource data on a Geographic Information System (GIS) available via the Internet. This will provide important information for individuals, local governments and the development community during planning and development decisions.

GOAL 6. INCREASE ENVIRONMENTAL AWARENESS, KNOWLEDGE, SKILLS AND STEWARDSHIP COMMITMENT AMONG THOSE LIVING IN THE JORDAN CREEK WATERSHED.

⇒ *Inform residents, business owners, recreational users and others about the need for protection. Widespread and increased awareness is one of the most important factors contributing to the success of natural resource protection programs. In order to be successful, education programs must include homeowners and residents, commercial landowners, developers, public agencies and young people.*

Objective 6.1 Provide Environmental, Heritage and Cultural Education Opportunities for School Groups, the General Public and Local Government and Business Leaders that will Provide:

- an understanding that those who live and work in the Jordan Creek Watershed are an inseparable part of its ecosystem and whatever humans do or do not do will alter the health of the watershed;

- a basic knowledge of the natural laws which govern the environment of the Jordan Creek watershed; of the skills needed to solve its environmental problems; and recognition of each individual's responsibility to find solutions to the environmental problems of the watershed;

- the development of a stewardship ethic that leads to the conservation of the Jordan Creek watershed's natural, historical and cultural heritage and to the correction and prevention of environmental degradation in the watershed.

Recommendation: Create and Support the Efforts of a Jordan Creek Watershed Citizen's Organization.

Recommendation: Provide Educational Programming that Will Familiarize All Members of the Jordan Creek Watershed Community with Best Management Practices (BMPs) for General Stream Care.

Recommendation: Document the Entire Length of the Jordan Creek and its Tributaries Using V0ideo, Photos and Written Descriptions of Significant Sites for Use in Planning and Educational Efforts.

Recommendation: Develop Books, Brochures, Guides, Videos, Tours, etc. that Will be used to Promote Public Awareness of the Natural, Recreational and Heritage Resources of the Jordan Creek Watershed and of the Efforts Underway for the Implementation of this Plan.

Recommendation: Develop and Post Educational Signs at Critical Sites Along the Creek at Key Locations Such as Stream Crossings and Recreational Sites Throughout the Watershed to Increase Public Awareness of Threats to the Jordan.

Recommendation: Post Signs at Every Major Stream Crossing Identifying the Name of the Water Body.

Objective 6.2 Hold Frequent and Well-Advertised Public Forums.

Recommendation: Articles and Editorials in Local Newspapers Should be Developed with a Focus on Public Relations and Public Stewardship of the Jordan Creek.

Recommendation: In Addition to School Curricula, Ongoing Efforts Should Include a Regular Environmental Newsletter or a Column in Local Newspapers.

Recommendation: Periodic Efforts Might Include Occasional Seminars on Environmental Topics Affecting the Jordan Creek. Programs on Topics Like Best Management Practices Could be Open to the Public and Presented at Area Educational Institutions. Coverage and Advertisement of these Programs in Local Newspapers could Improve Public Attendance.

Recommendation: Promote the Formation of Environmental Advisory Councils in each of the Watershed Municipalities. These Councils Would Become Advocates for the Jordan Creek, its Tributaries and the Natural Resources of the Watershed and Would Promote Environmental Responsible Municipal Planning and Decision-Making.

Recommendation: Work With the Penn State Cooperative Extension and NRCS to Promote Education of Farms About Best Management Practices.

⇒ *Education leads to increased awareness and awareness leads to increased involvement. Municipalities can take advantage of the interest raised through education programs by developing subsequent stewardship programs. With coordination and oversight from public agencies, land owners and other residents can be encouraged to adopt some of the tasks recommended by this management plan.*

7.0 CONCLUSION

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The Jordan Creek is a 31.3 mile-long tributary to the Little Lehigh Creek and has an 82.3 square-mile watershed located within the townships of Heidelberg, Washington, Lynn, Weisenberg, Lowhill, North Whitehall, Upper Macungie, South Whitehall, Whitehall and the City of Allentown. The creek has four main tributaries: Switzer, Lyon, Haasen and Mill Creeks.

Wildlands Conservancy received a Pennsylvania Rivers Conservation Program Planning Grant for the Jordan Creek. A study of the Jordan Creek and the preparation and publication of a comprehensive Jordan Creek Watershed Conservation Plan were the intended outcomes of the project. The Pennsylvania Rivers Conservation Program was created by the Pennsylvania Department of Conservation and Natural Resources (DCNR). The objective of the program is to conserve, restore and enhance Pennsylvania's rivers through partnership, education, awareness and stewardship.

This conservation plan has identified the historical, cultural, natural and physical resources in the watershed, characterizes the water quality and aquatic life of the stream and has identified problem areas in the watershed. The plan also contains recommendations for conservation and preservation of the Jordan Creek based on information collected as part of this project and on input from public hearings and informational meetings with municipalities and the watershed community.

The Jordan Creek watershed and its resources have been treasured by many since the first Native Americans and European immigrants discovered the region. Through the years, population growth and associated development have altered portions of the watershed. Future growth of the watershed will put increased pressure on the remaining resources. How municipalities choose to handle these pressures will impact not only the health of the watershed, but also the well-being of its residents.

The challenge for communities of the watershed will be to conduct development in an ecologically sound and responsible manner, minimizing urban sprawl and its impacts. Restoring riparian buffers along the Jordan Creek and protecting those that are currently intact is critical to conserving watershed resources and improving water quality and habitat.

The keys to achieving the goals of this project are education and communication. Knowledgeable citizens and groups must form watershed organizations and continue to educate property owners, businesses and political leaders on the issues raised in this report. Communication between property owners and institutions must be established in order for the watershed to benefit from conservation and preservation programs as well as the efficient use of its resources.

This management plan should be used as a tool to build partnerships and as a guide to develop concerted efforts for future preservation, protection and enhancement of the resources of the Jordan Creek watershed.

JORDAN CREEK PROJECTS AND PARTNERS

Project Description	Potential Partners
Establish a Jordan Creek watershed organization.	watershed residents, Wildlands Conservancy
Work to secure funding and implement the Agricultural Best Management Practices needed in the Jordan Creek watershed as identified by NRCS.	NRCS, Wildlands Conservancy, Penn State Cooperative Extension
Work with municipalities to develop and adopt ordinances structured to encourage watershed stewardship.	Municipalities, LVPC, Wildlands Conservancy
Examine the feasibility of establishing a connective greenway along the Jordan Creek.	Wildlands Conservancy, LVPC, DCNR, municipalities
Implement the recommendations of the Lehigh Valley Planning Commission described in their Act 167 Jordan Creek Watershed Stormwater Management Plan.	municipalities, LVPC Wildlands Conservancy
Establish riparian buffers where needed/desired throughout the watershed.	Wildlands Conservancy, municipalities, watershed residents
Provide in-stream habitat improvements to the Jordan Creek and its tributaries.	Wildlands Conservancy, PFBC
Remove or breach unused dams throughout the watershed.	Wildlands Conservancy, PFBC, DCNR, DEP
Develop an on-going water quality and biological monitoring program in the Jordan Creek watershed.	Wildlands Conservancy, DEP, RSVP, EASI, watershed residents

Make this management document available to the public and to educational institutions via the internet and house copies of the plan in local libraries.	Wildlands Conservancy, Lehigh University, local libraries
Provide technical assistance and educational opportunities to municipalities, elected officials and watershed citizens regarding management of the Jordan Creek.	Wildlands Conservancy
Develop a comprehensive restoration plan for the Jordan Creek corridor in Covered Bridge Park.	Wildlands Conservancy, South Whitehall Township, DCNR
Work to place historically significant properties on the National Register of Historic Places and develop watershed tourism activities and related resources.	Lehigh County Historical Society, municipalities, watershed residents
Establish a systematic stream corridor clean-up program and develop a plan to address the littering and dumping occurring throughout the City of Allentown.	Municipalities, school groups, watershed residents, Wildlands Conservancy

DEP—Department of Environmental Protection
DCNR—Department of Conservation and Natural Resources
EASI—Environmental Alliance for Senior Involvement
PFBC—Pa. Fish and Boat Commission
LVPC—Lehigh Valley Planning Commission
RSVP—Retired Senior Volunteer Program
NRCS—Natural Resources Conservation Service

WORKS CITED

Andropogen and Associates. "Invasive Exotics". Landscape Management & Restoration manual. 1991.

Arnold, David A. Switzer Creek (502C) Section 02. Pa. Fish and Boat Commission Comments and Recommendations. 1993.

Coffey, Steven W. et al. "Elements of a Model Program for NPS Pollution Control". Proceedings of the National RCWP Symposium, 1992. pp 361-374.

Eckert, Thomas D. The History of Carbon Co. Vol. 1. 1992.

Encyclopedia of Pennsylvania: Somerset Publishers, Inc. 2nd ed. Vol. 1. 1982.

Fletcher, Stevenson Whitcomb. Pennsylvania Agriculture and Country Life 1640-1840. Harrisburg, Pa.: The Pennsylvania State College Pennsylvania Historical and Museum Commission, 1950.

Fletcher, Stevenson Whitcomb. Pennsylvania Agriculture and Country Life 1840-1940. Harrisburg, Pa.: The Pennsylvania State College Pennsylvania Historical and Museum Commission, 1955.

Geraghty and Miller, Inc. Remedial Investigation Report, Novak Sanitary Landfill, South Whitehall Township, Pennsylvania. Prepared for Novak RI/FS PRP Group. June 1992.

History of the Lehigh Valley Region. JPC-Lehigh-Northampton Counties, 1963.

Horton, Tom. Turning the Tide: Saving the Chesapeake Bay. Washington, D.C.: Island Press. 1991.

Jeffries, Michael and Derek Mills. Freshwater Ecology: Principles and Applications. New York: John Wiley & Sons, 1990.

Joint Planning Commission Lehigh-Northampton counties. Jordan Creek Watershed – Act 167 – Storm Water Management Plan. May 1992.

Joint Planning Commission Lehigh-Northampton Counties. Lehigh-Northampton Counties Wellhead Protection Implementation Program. February 1996.

Klein, Phillips and Ari Hoogenboon. A History of Pennsylvania. University Park, Pa.: The Penn State University Press, 1973.

Klemm, D. J. et al. "Macro-invertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters." EPA/600/4-90-03.

Kupsky, Ed and John Wilkes, Jr. Aquatic Chemical and Biological Investigation 7/2/91 Jordan Creek, South Whitehall Township, Lehigh County. Department of Environmental Resources. 1991.

Lehigh Valley Planning Commission (for the Wildlands Conservancy). Jordan Creek Watershed Hydrologic Trends Assessment. April 2000.

Lehigh Valley Planning Commission (for Wildlands Conservancy). Jordan Creek Watershed Land Use/Water Quality Assessment. July 2000.

Nebel, Beurard J. and Richard T. Wright. Environmental Science: Sixth Edition. Upper Saddle River, NJ: Prentice Hall, 1998.

Pennsylvania Science Office of the Nature Conservancy. A Natural Areas Inventory of Lehigh and Northampton Counties, Pennsylvania. 1999.

Randall, John M. and Janet Marinelli. Invasive Plants: Weeds of the Global Garden. Brooklyn, NY: Brooklyn Botanic Garden, Inc., 1996.

Schubert, Steve T. Aquatic Biology Investigation Jordan Creek Lehigh County. Commonwealth of Pennsylvania Environmental Resources: 1991.

Simon, Thomas P. Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press. 1999.

Soderlund, Jean R. William Penn and the Founding of Pennsylvania 1680 - 1684. Philadelphia , PA: University of Philadelphia Press, 1983.

U.S. Fish and Wildlife Service. National Wetlands Inventory. www.usfws.gov.

Usinowicz, P. J. et al. "Water Quality of the Lehigh and Jordan Creek". Lehigh University. Bethlehem, Pennsylvania. 1977.

Wood, Charles R., et al. Water Resources of Lehigh County Pa. Water Resource Report 31: Pa. Geological Survey, Harrisburg: 1972.

Worden, David M. Fisheries Data from Jordan Creek. Commonwealth of Pennsylvania, Pennsylvania Fish Commission. Harrisburg, PA: 1988.

www.dep.state.pa.us

www.epa.gov

www.usda.gov

www.usgs.gov

Jordan Creek Public Hearing Transcript – December 14, 2000

Chris Kocher (CK): The Jordan Creek Watershed Conservation Management Plan was produced by Wildlands Conservancy with the cooperation of a host of partners. So many municipalities, individuals, watershed organizations and entities have been involved in this particular process. It would not have been possible without their assistance and guidance. This is the fourth of our public forums. This is actually the final public forum that we're going to have on this particular management document. The goal of tonight's meeting is to officially present the plan and then also to again hope for comments on the plan and really get some feedback as to the different sections of the plan. Abigail is going to go through the executive summary and the recommendations that are listed within the plan and ask for comments from the watershed community about the plan. Our aim is to have the document submitted to Harrisburg by December 31 which is only a few days away. With the holidays coming and things like that, we are really rushed for time, but we're looking for comments and feedback about this particular document. Just so you know a little bit about the process that we still need to go through, we are obviously having this meeting tonight. This meeting is being taped. We have to make a transcript of all that is said tonight and incorporate it into the plan. The organization, Wildlands Conservancy, will pass a resolution supporting the plan. That will get put into the project as well as any resolutions passed by municipalities. All that information will be put together and shipped out to Harrisburg by the 31st. You now know a little bit of our timeline and the deadline of the 31st. Again, tonight is designed to gain more input and insight into the Jordan Creek. We are working to preserve, protect, and enhance the resource, and, by the amount of people here this evening and the familiar faces that I see, obviously there are other people interested in this resource and interested in the process we went through.

CK: I will introduce Abigail now, and she is going to go through the executive summary. Does everyone here have a copy of the executive summary? We passed this out at the last meeting. Abigail is going to take us through the executive summary and also talk about some of the recommendations that are listed within. Then we will open the meeting for questions and comments that you may have on the plan or the process.

Abigail Pattishall (AP): Thanks for coming. I'm going to briefly go through the executive summary, give you a little bit of background on the Jordan Creek. I will tell you what we did, what's in the plan, and then we'll finish up by going through the recommendations made by Wildlands Conservancy for the Jordan Creek. Then we will open it up to you guys if you have any questions or comments or any suggestions. To begin with, the Jordan Creek is about 32 miles long. It goes through nine townships and ends up in the city of Allentown where it flows into the Little Lehigh Creek. The entire Jordan Creek watershed is about eighty-three square miles. It has four main tributaries, Switzer Creek, Haasen Creek, Mill Creek, and Lyon Creek. As Chris explained to you, Wildlands Conservancy has gone for DCNR Rivers Conservation funding. What prompted us to do that was the fact that the Jordan Creek has been

listed on the Pennsylvania Rivers high-priority water body list. The other thing was that the Jordan Creek has been downgraded from the status that it had held, and it's now considered just a trout-stocked fishery instead of a high-quality cold-water fishery like it once was. So those two things in conjunction prompted us to take a look at the Jordan Creek.

AP: Chris talked to you about the registry a little bit. I'm going to tell you what's in the plan. We looked at general characteristics of the watershed. We looked at the geology – what kind of soils – were in the watershed, the length of the tributaries, the size of the watershed, the topography, the geology, so all those things are categorized in the first section of the management plan called "physical resources." Then we looked at "aquatic resources." Chapter 93 qualifications were listed -- the main stem of the Jordan Creek as a trout-stocked fishery. The four tributaries, again Mill Creek, Lyon Creek, Switzer Creek, and Haasen Creek are all considered high-quality cold-water fisheries. Part of the aquatic resources section of that report is a study that was actually contracted to the Lehigh Valley Planning Commission. They looked at land use, how it is changing in the watershed, and how it is affecting water quality. They also looked at rates of precipitation, rates of baseflow and some streamflow – how those were changing. These two topics make a pretty decent-sized section of that report.

AP: The next part was section three and that was "biological resources." There we looked at the riparian habitat or streamside habitat. We looked at all the plants that are in the watershed. We identified any invasive plants, any exotic plants. Then we looked at all the animals in the Jordan Creek watershed. We started with the macro-invertebrates. Some students from Lehigh University were working towards their graduate degrees studied macro-invertebrates in the Jordan Creek and in the tributaries. Then we used those to get further inside and take a look at quantities. We also catalogued fish surveys that had been done on the Jordan Creek in the last twenty years, so those give us background information on how the Jordan Creek and its tributaries are changing over the last decade or so. We worked with the Pennsylvania Game Commission to catalogue birds and mammals. Amphibians and reptiles also are in the watershed. We did that mostly through inventories of state game lands, since state game lands occupy a rather large part of the central watershed. We took those inventories and applied them to the rest of the watershed.

AP: Section four is titled "cultural resources." One of the cultural resources we looked at was recreation in the watershed. There are quite a few recreational resources in the Jordan Creek watershed – state game lands, Trexler Game Preserve. North Whitehall, South Whitehall, and Whitehall Townships all have pretty significant township parks. Where were recreational spots lacking in the watershed? We made some recommendations about center city Allentown and found some spots that are owned by the township and might be able to be turned into recreational parks. We also talked about using public recreation as an example for good streamside management, basically looking at the opportunity the municipality has to show everyone who uses these recreational resources how to manage streamside property, how to manage a riparian buffer, how to improve water quality – things like that. So that's a pretty good

chunk of section four of this report – improving and expanding recreational resources. We also looked at the demographic, the economics profile. The upper two-thirds of the Jordan Creek watershed are very rural in nature. Thirty-six percent of the watershed is agricultural land, and another 35% is open space. So the Jordan Creek upper two-thirds, about the first twenty-five miles, is very rural in nature, and as it's going down through Heidelberg, through Lowhill Township, it moves into South Whitehall and then the city of Allentown where it becomes increasingly urban.

AP: Another thing we did was look at water quality. We took a good long, hard look at water quality, and previously existing water-quality studies – I think our earliest one that we took a good look at was from Lehigh University in 1977. We did our own water-quality work in the summers of 1998 and 1999, again in conjunction with Lehigh University. What we found were high levels of nutrients, high levels of non-point-source pollution, increased sedimentation, high levels of phosphates, ammonia, nitrates, and also increased sedimentation. So, primarily, effects of non-point-source runoff are due to everything from increased development to agricultural land, to water and the causes of pollution that start coming into the watershed as the Jordan Creek flows toward South Whitehall Township and the city of Allentown. Also, temperature is a pretty big factor in the Jordan Creek watershed. Areas that we monitored exceeded water-quality temperature standards.

AP: Land use – we went through it a little bit. Thirty-six percent of land use is agriculture. Thirty-five percent is open space. That's followed by about 13% that's rural and urban. The rest of the land uses are less than 5% -- transportation, parking lots, things like that. Again, it's primarily agriculture and open space. As I said before, the Conservancy has contracted with the Lehigh Valley Planning Commission to do a very in-depth analysis of the way land use is changing in the watershed and how that's affecting water quality. That's also in section five of the report.

AP: Our final section was the management options, and this is where we are really looking for input from municipalities and the general public. We came up with six main recommendations. The first one was to abate agricultural non-point-source pollution. What we did there was list a whole bunch of funding opportunities and a whole bunch of best management practices that can be applied to farms in the rural areas of the watershed to improve water quality. Our second recommendation was to abate urban non-point-source pollution. Again, we kind of did the same thing. We looked at all the best management practices that can be applied further down in the watershed – in Allentown, in Whitehall and South Whitehall – to prevent runoff, to prevent thermal pollution, to prevent sedimentation. That pretty much sums up our second recommendation. Our third recommendation was, what we are doing now, to increase public involvement in non-point-source pollution control. One of our recommendations about the Jordan Creek concerns not currently having a watershed association, a group of concerned citizens getting together and forming it through coming to public meetings, creating informed newspaper articles, just trying to get the word out to the general public about non-point-source pollution. It's a pretty big goal.

AP: We also want to continue to document water quality and the biological characteristics of the Jordan Creek. Obviously, that tells us what is going on, if there are any problems, so we do want to try to continue those efforts – through the Conservancy, through local universities. Goal five was to increase the recreational opportunities in the watershed. I had talked about that a little bit. There are municipal-owned lands – in Allentown, especially -- that we really feel would make pretty significant contributions to the Allentown residents if they were turned into very natural-based recreational areas. Also, there are a couple of municipal parks in the watershed that could be managed in a more natural way. So that's another set of recommendations. Then, in conjunction with preserving recreational resources, we also want to preserve historical resources. The Jordan Creek watershed has some pretty significant history, starting with the early settlers. The Lehigh Valley as a whole has played a pretty big role in industrial development. So we want to tie all those things together with recreation and educational opportunities to try and really preserve the historical resources which are really significant in the Jordan Creek watershed. So part of what we did in this study was to identify every spot in the Jordan Creek watershed that you either could be or currently is a Pennsylvania historic landmark.

AP: Our final recommendation is to increase environmental awareness and stewardship of the watershed which, as I said, is accomplished through all those things – through citizens involved in the water quality, through natural management of recreational resources, through the preservation of open space and the preservation of farmland, school programs, holding public meetings. That's a real big concern of ours. We want to see the Jordan Creek as a real viable resource – which is pretty much the point of our plan. I think everyone here has a plan. Does anyone have questions or comments?

CK: As you can see, a lot of work and time has been put into this management document. Hopefully, it will serve as a really good guide for future work on the Jordan Creek. I would just like to take a minute and introduce the president of Wildlands Conservancy, Tom Kerr, who has joined us this evening, and he will say a few words.

Tom Kerr (TK): Hi. I just wanted to say thanks to the staff for tonight's presentation. Wildlands Conservancy, if you don't know, is a non-profit corporation, and you might wonder what our mandate is, why are we doing this work. Why do we stick our nose into this thing? The answer is sort of complicated, but it is interesting. We're not a corporation, we're not a business, we're not an educational institution. We're everything, which is all the things that they aren't, and, because of that, we're able to do things that they can't. Our motto, as a matter of fact, is 'we're part of what works," and we like to thank that we are, in a way, sort of a moral compass for the environment. That doesn't mean we're the second coming or the Messiah here, but we do have access to some things. We have enthusiasm and interest, which is sometimes the thing that really means a lot. We spend a lot of time on education – doing education, but we're not really an educational institution. What we're trying to get people to understand is where the problems are. We have some answers, as suggested here in the plan. It is not rocket science, exactly. I doubt you'll read anything in this that nobody's ever heard of before, but what we've done is to put this information together in

a way that people can go from here and make some changes. They won't all happen. Where's the money, where's the time? – but it's folks like you who are willing to come and listen, maybe get something from this that will push something a little further down the road. That's what keeps us from folding. Thanks very much for coming.

CK: Thanks, Tom. Does anyone have any questions about the plan itself or about the process? Both Abigail and I had mentioned before, we continue to mention the "rivers registry," and I just want to make sure that everyone's aware of what that means. Currently, there are about sixteen rivers in Pennsylvania on which this process has been completed, and once this is through the planning process the stream is put on the rivers registry. Once the stream is on the registry, it is then eligible for state dollars for projects that are listed in the plan's recommendation section. That's why we have been talking for the last several meetings of the importance of this recommendation section being comprehensive, because if the recommendations are in the plan, there are state dollars available for those projects to be completed. Now that this management document has been completed, we will petition the state to place the Jordan Creek on the rivers registry. As I mentioned before, we need a plan, we need this kind of support, and we also need the documentation of the planning process we went through. All of those things get put before the state, and then the stream is put on the registry.

CK: This is the last step we need to go through in this particular process. It's probably the most important step, because there will be financial resources available for projects for improvement of the creek base of the resource. That's probably the most important factor. With that said, I open it up to questions and/or comments. The only thing I ask is that you state your name, just so we know for the record who said what.

Peter Esherick (PE): Pardon my ignorance, but what is a macro-invertebrate?

AP: They are tiny little animals in the water. They live under rocks in the streams, spend some portion of their life cycle in the stream. The reason we pay so much attention to this is that they have very short life cycles, and they tend not to be able to escape the water, so their population – the health of those macro-invertebrate populations – really tells us a lot about how healthy the water is. For example, if there is not enough oxygen in the water, or if the water is warm or there is too much sediment in the water, those macro-invertebrates won't be able to feed, they won't be able to breathe, they won't be able to reproduce. So if we see that there aren't too many macro-invertebrates here, or there are many in one location but none in another location, that really tells us a lot about water quality. That's why we pay so much attention to macro-invertebrates.

PE: Thank you. If you say the water is too warm – at what time of year? It sounds like you had the summer of 1999, but we had excessive heat that would cause the water to eliminate more oxygen.

AP: Yes. To a degree, that's true. The water temperature is somewhat dependent on the ambient temperature, but primary causes of thermal pollution or the water

temperature rising would be things like the elimination of riparian vegetation, elimination of shade along the streambank. Dams in some cases might back up the water and stop movement so that the water is sitting under the sun for a longer period of time. Sedimentation will do that, too. The slower the water is moving, the less oxygen is circulating in it. It's just kind of sitting there like a puddle instead of a stream.

Todd Davis (TD): I'm a little bit confused on the dam issue. Even though you recommend removal, you don't want to do the removal. What's the difference?

CK: There's a lot of different circumstances. We – actually, someone just brought this in. We just recently in The Morning Call had an article on the dam we removed at the Pool Wildlife Sanctuary. In that particular case, we had a low-head run-of-river dam on our property that was about three feet in elevation and about fifty feet across. The dam served no real function at all and was a liability, if anything. In those cases where the dam is not needed, not used, and doesn't really serve any purpose (aesthetic or recreational/historical value), it is quite good to remove them from an environmental standpoint because of the production of sedimentation, the ponding of water, and the blocking of migratory fish passages. So, to flatly say that we should remove all dams is not a recommendation. They need to be looked at on a case-by-case basis, depending upon the uses of that particular dam or impoundment and the other factors that are involved. Clearly, from an environmental perspective, rivers were not meant to be dammed up. Many things happen when you dam a river, whether they be those I mentioned before or sediment not cycling through the system or nutrients not cycling through the system, or the migratory fish aspect, the heating aspect, the turbulence downstream as well as the high-water conditions. All of these conditions are related to dams, and all have a negative environmental impact on the streams. The dams should all be looked at to see if anything can be done or if any other factors are involved. The Pennsylvania Fish and Boat Commission, the Department of Environmental Protection are doing a push currently for removal of unused low-head dams. There are about 4,000 permitted low-head dams in Pennsylvania, and it's estimated there may also be as many as 4,000 un-permitted dams in Pennsylvania, so we're dealing with 8,000 run-of-river low-head dams, some of which were funded and/or constructed by the Pennsylvania Fish and Boat Commission as was considered appropriate at the time. As technology is improving, we realize that that's not the best thing for the streams. As I said, some dams do provide other benefits such as recreational resources.

PE: Does the speed of the flow of water in the stream affect water temperature?

CK: To some degree, yes. The slower the water is moving without a canopy on top, the warmer that water is going to get.

PE: Do you have any idea what the speed of the water flow should be before it – say, five miles north of Allentown?

CK: The speed is going to depend upon the slope and the topography as the main things – or any obstructions that might be in the stream channel itself. I'm not sure

exactly what the mean discharge or velocity is of the flow in that particular area, but on average it's going to be a lot slower there than it would be up in headwaters area where you have a steeper grade or a steeper slope. Typically, rivers, as they come down off of headwaters at a higher elevation, have much more velocity, more drop in the upper area. The one thing that happens in the Jordan Creek – there is obviously a change in geology from the Martinsburg Shale Formation down into the Limestone Valley. Once we hit the Limestone Valley the creek tends to widen out and meander a little bit with obviously much less velocity and flow because the slope is not as great, so topography and geology play an important role in determining the speed of the creek as well as any obstructions that might be there.

PE: Will it heat a little more there?

CK: It definitely will heat a little bit more there. The one thing with the limestone section that's kind of interesting is that the limestone areas are great areas where a lot of baseflow comes in, a lot of groundwater actually comes into the stream, and the groundwater typically is 52° to 54° year round so groundwater provides a stabilization aspect into the stream as far as temperature is concerned. A lot of the trout fisheries that we have in the Lehigh Valley, and we are really blessed with a lot of reproduction, relative Lehigh Valley are due in large part to the geology underneath the Lehigh Valley and that close relationship that we have with the limestone geology and a lot of groundwater coming in. The Monocacy Creek, the Little Lehigh Creek, Cedar Creek, Saucon Creek, all have reproducing brown trout populations. Within the city limits of Allentown, Bethlehem, or Easton there are all different parts of the geology coming in, that really alkaline cold groundwater coming in during low-flow periods.

Jill Heller (JH): My name is Jill Heller, and I have a comment on the water quality analysis section. It's very well done, and I particularly liked when the result of contacts with high-quality cold-water fishery standards were optimum conditions where Jordan Creek's parameters all of a sudden just increase. It is a valuable perspective. I also encourage that there might be a section or two where the copy I got maybe didn't have it so clearly in perspective as to average or optimum or good ranges.

CK: Are there any other questions?

Male (Dave?): I was wondering if you guys had looked at any possible, like one of the land uses in the northern parts is agriculture. Have you discussed at all easements for those agricultural properties that would maintain them as agricultural and not turn them into parking lots?

CK: That's a very good point. We work very closely with Wildlands Conservancy's open land protection program in which we actually buy development rights from local farms. To date, there are 77 farms in Lehigh County alone whose development rights have been sold off and conservation easements are held on those properties. I'm not sure how many are in the watershed.

AP: I'm not sure either. I know that the copy you guys might have from last month doesn't have the agricultural easement section in it. We do have a GIS coverage of all the agricultural lands and then the ones that are currently under easement. We also have a section about what an easement is, how to go about getting one, so I'll get you a new copy.

CK: Yes. Clearly through that we cannot only protect the water quality but also protect our areas as far as the farming is concerned and the preservation of other open space. There are also recommendations in the report that are geared towards promotion of conservation easements.

PE: On a footage or mileage basis, how often do you check for runoff, bad runoff from farmland?

AP: The way we set up water quality monitoring in that area – is that what you're talking about –what we did was we took samples before each tributary and directly after each tributary had entered, so that would be a total of eight points. We have one before Mill Creek, one after Mill Creek, one before Lyon Creek, one after Lyon Creek. Then we spaced samplings out, after all the tributaries had entered, through South Whitehall and then into the more urban areas of Whitehall. We tried to space it out, make sure we could see the effects as each tributary entered.

PE: That's what I was driving at.

CK: What we try to do with the sampling is really – obviously the Jordan Creek watershed is eighty-three square miles, but we actually cut that into smaller sub-watersheds and took a look at Mill Creek and Haasen Creek and the others and took a water sample at the base of each of those to determine the water quality coming from that dead area of that sub-watershed. We then piece those together and then take a look at how everything is overall. Any other questions or comments?

TD: Todd Davis again. The watershed concerns how much area beyond the stream itself? Is it just the contour that flows down to the stream, or is it a broader area?

CK: If you could think of looking at it from the perspective of a drop of water that lands anywhere in the area. If that drop comes into the groundwater or the surface water of that particular area, then the location where it landed is part of that watershed. So the watershed would be defined by bridges and breaks in topography that would allow water to go one way or the other. So the Jordan Creek watershed is entirely in Lehigh County, it's about eighty-three square miles. Any water that would land anywhere in that eighty-three-square-mile area will eventually end up in the Jordan Creek itself. Think of the watershed as basically the bowl with one straw coming out being the Jordan Creek. Anything that comes into that bowl or into that watershed area or catchment basin would come out of that straw or go into groundwater and end up somewhere in the channel itself. When we talk about watershed, we're talking about the entire area that is drained by the Jordan Creek. In this case it is quite significant.

TD: There are smaller tributaries – other than the four you mentioned?

AP: Yes.

TD: Are they insignificant?

CK: They're not named. That is not to say that they are insignificant by any means, but there are some small tributaries that have come in. When we did our water-quality analysis and set up our sampling plan, we put the sampling points at the four major tributaries. Anything coming in on some of those smaller tributaries would have been picked up on one of the other sample locations in the main stem somewhere. We would really have a lot of sample locations if we had to sample for every single tributary that came in. We would have hundreds of sample locations, and it's not really cost-effective. We took a look at the main ones, and anything else that is coming in would be accounted for in those samples.

TK: This stream runs from rural to suburban and an urban environment. The complexity of problems that are attached to this creek are different from those of another creek somewhere else. How much more complicated is it if in fact, in this case, what is the biggest impediment to resolving the problems in the stream?

CK: That's a very good question, Tom, and there's probably a very good answer for that. What we look at is, again, the concept of a watershed. Think of it in the perspective that anything that happens within that eighty-three-square-mile area could have an impact on water quality. When I say anything, I mean from me changing my oil in my backyard in the watershed and pouring it over here or you putting chemicals onto your lawn or a farmer improperly using fertilizer or a shopping mall coming in down the road that isn't doing the proper stormwater management techniques. All these different things can have an effect on water quality. The issues that we're facing in the Jordan Creek are very similar to issues faced in eastern Pennsylvania, if not eastern United States. Everyone here knows about urban sprawl and the water-quality impacts, environmental impacts, the impacts that can relate with us really pumping up our landscape into quarter-acre and half-acre lots the expanded areas we need to deal with in order to have all those people come together with transportation and those types of things. So the problems we're facing in the Jordan are non-point-source related which means they're coming from this watershed area albeit from different locations. The point source here is pretty much gone, and when I say point source, I mean discharge coming out of a factory, or out of a sewage treatment plant.

Male: The water-quality impacts from that are fairly well regulated by the Clean Water Act and some other legislation.

CK: We're dealing now with really the quiet threat to our streams which is non-point-source pollution. It's coming from so many different areas. When you ask what the greatest impact is on the water quality of the Jordan, clearly it's non-point source, but

within that category of non-point source is a list of ten or fifteen things such as the stormwater or the lawn chemicals or the oil coming in. All those different things rank under non-point source, and clearly the biggest impact on water quality is non-point source, but in that category of non-point-source, all those different things add to the mix. One of the most important things to remember is that all these activities have an effect on water quality, but what we can to as citizens of the watershed is to minimize that impact. We can minimize that impact by using best management practices – promoting riparian buffers and a whole bunch of other things that are listed in this document and other documents like it. In other words, separate the land use from the water body. With the best management practices that we've outlined here and some of the municipal ordinances that we have proposed in here, we can minimize the impact of those developments or that lawn or all the things I mentioned before on the water resource. Hopefully, that answers your question in a round-about way. Non-point-source pollution has the biggest impact. Best management practices and education are the best ways we have to combat that problem. All those things relating to non-point source, whether it be the stream warming or the sedimentation or the increased nutrients can be minimized by education of property owners as well as best management practices. The Jordan is an amazing resource, actually a very scenic resource, very typical of streams in this part of Pennsylvania that go through different land uses. We have a fairly-forested watershed, a lot of open space, a lot of farming, and then we have the urban area. This is pretty typical of a lot of streams, at least in our area. Those impacts that I had mentioned before are fairly typical as well. With education and some of those best management practices, we can really make a difference as far as preserving, protecting, and enhancing, in this case, the Jordan Creek watershed. When we protect the Jordan Creek, we're also protecting the Lehigh River. When we protect the Lehigh River, we're also protecting the Delaware River. When we protect the Delaware River, we're also protecting Delaware Bay. The whole concept of a watershed is a very important one to understand, because we all live downstream, and we all are connected by a watershed, whether it be the Jordan or the Lehigh or the Delaware. That's why projects like this one are so important to get that message out and to actively complete projects that have been identified throughout the process.

TK: Do you feel like people have a sense of attachment to the Jordan, a sense of its existence. They see a creek and they say "oh, that's a creek." Do you feel people know what the Jordan Creek is? Is there an attachment to it?

CK: Just from my experience in working with streams in the Lehigh River watershed, we've done this particular type of project on a number of other streams. There is no local group that has put their arms around the Jordan Creek and said "this is our resource, we're going to protect it." Some of the other creeks that we've dealt with like the Little Lehigh and the Monocacy and Hokendauqua all have groups – Trout Unlimited Chapters or watershed associations – geared to protecting the resource. In this particular case, none exists. That's not to say that people don't appreciate the Jordan or aren't connected to it in other ways, but it's our role through this project to get some group organized that is dedicated and really get a sense of stewardship for the

resource. Hopefully that is going to be one of the byproducts of this particular project, to get a group that's actively involved in implementing this plan that the watershed community has supported and we have completed.

PE: I think you have to take advantage of the people that are interested in it and do the work that can be done. Others will come into the program.

CK: Thank you very much for coming. We'll be up here for a couple minutes if you have any other questions or comments. I really appreciate all the involvement that we've had throughout this public planning process. Abigail and I and Gregg and Brian who are also on the rivers department staff come to some of these meetings and, to be quite honest, we drive distances, and sometimes there is only one person at the meeting. The meeting is very important for the resource, so I'm really glad to see that there is a core group of individuals who have come to most of the meetings, and I see some new faces as well that have come to this meeting. I do appreciate that, and the Jordan Creek as a resource appreciates that.
This is our plan, collectively, and hopefully we can work to implement it over time and protect this resource that we all cherish so much. We really appreciate it, and thank you all for coming out.

APPENDIX A

JORDAN CREEK PRECIPITATION, STREAM FLOW, BASE FLOW AND RUNOFF CHARACTERISTICS

Table A1. Jordan Creek Precipitation, Streamflow and Baseflow Characteristics

YEAR	PRECIPITATION			STREAMFLOW			BASEFLOW			% BASEFLOW			STORM RUNOFF
	Schnecksville	Allentown	Average	Schnecksville	Allentown	Average	Schnecksville	Allentown	Average	Schnecksville	Allentown	Average	
1967	43.79	43.79	43.79	16.91	15.10	16.01	11.58	9.88	10.73	68.05%	65.44%	66.75%	5.28
1968	38.43	38.43	38.43	18.11	16.37	17.24	12.06	10.44	11.25	66.59%	63.73%	65.16%	5.99
1969	41.89	41.89	41.89	15.69	12.66	14.18	9.48	8.47	8.975	60.43%	66.89%	63.66%	5.20
1970	41.59	41.59	41.59	18.21	17.36	17.79	10.03	11.19	10.61	55.08%	64.46%	59.77%	7.18
1971	48.50	48.50	48.50	29.43	26.12	27.78	18.61	15.37	16.99	63.24%	58.83%	61.04%	10.79
1972	55.85	55.85	55.85	30.64	28.49	29.57	19.48	15.54	17.51	63.59%	54.54%	59.07%	12.06
1973	48.17	48.17	48.17	31.80	28.49	30.15	19.55	17.67	18.61	61.48%	62.03%	61.76%	11.54
1974	48.19	48.00	48.10	22.97	21.88	22.43	15.55	14.31	14.93	67.71%	65.40%	66.56%	7.50
1975	55.54	55.54	55.54	29.55	28.51	29.03	17.23	15.92	16.575	58.29%	55.83%	57.06%	12.46
1976	39.90	39.90	39.90	21.86	21.88	21.87	11.79	11.84	11.815	53.95%	55.63%	54.79%	10.06
1977	49.60	49.60	49.60	20.60	21.28	20.94	11.56	11.26	11.41	56.13%	52.91%	54.52%	9.53
1978	45.99	45.99	45.99	38.00	34.03	36.02	21.08	18.78	19.93	55.47%	55.19%	55.33%	16.09
1979	49.71	49.71	49.71	30.51	26.66	28.59	15.6	14	14.8	51.12%	52.50%	51.81%	13.79
1980	29.82	29.82	29.82	20.57	18.00	19.29	14.04	12.12	13.08	68.28%	67.32%	67.80%	6.21
1981	35.08	35.08	35.08	11.61	9.83	10.72	7.41	5.49	6.45	63.84%	55.89%	59.87%	4.27
1982	43.40	43.40	43.40	22.25	20.11	21.18	12.71	11.51	12.11	57.12%	57.21%	57.17%	9.07
1983	52.70	52.70	52.70	25.15	22.89	24.02	15.38	12.61	13.995	61.14%	55.07%	58.11%	10.03
1984	52.41	52.41	52.41	36.77	36.46	36.62	18.09	18.74	18.415	49.20%	51.41%	50.31%	18.20
1985	47.03	47.03	47.03	11.25	10.51	10.88	6.86	6.09	6.475	60.96%	57.97%	59.47%	4.41
1986	43.20	43.20	43.20	22.96	20.14	21.55	13.21	12.26	12.735	57.53%	60.89%	59.21%	8.82
1987	46.70	46.70	46.70	23.89	21.22	22.56	13.65	11.9	12.775	56.95%	56.08%	56.52%	9.78
1988	39.42	39.42	39.42	24.72	18.97	21.85	13.61	11.62	12.615	55.05%	61.22%	58.14%	9.23
1989	45.01	45.01	45.01	25.43	21.98	23.71	14.28	13.49	13.885	56.16%	61.37%	58.77%	9.82
1990	44.27	44.27	44.27	25.55	22.44	24.00	15.42	13.57	14.495	60.37%	60.48%	60.43%	9.50
1991	34.38	34.38	34.38	20.35	17.38	18.87	12.9	11.53	12.215	63.42%	66.35%	64.89%	6.65
1992	N/A	N/A	N/A	15.70	14.00	14.85	10.29	8.73	9.51	65.52%	62.35%	63.94%	5.34
1993	52.96	52.98	52.97	27.26	26.66	26.96	16.81	15.05	15.93	61.68%	56.43%	59.06%	11.03
1994	48.82	48.82	48.82	33.54	35.89	34.72	19.83	20.47	20.15	59.13%	57.03%	58.08%	14.57
1995	38.46	38.49	38.48	16.83	15.71	16.27	10.18	10.11	10.145	60.51%	64.34%	62.43%	6.13
1996	56.87	56.87	56.87	29.42	28.72	29.07	16.44	15.3	15.87	55.89%	53.25%	54.57%	13.20
1997	38.49	38.49	38.49	29.91	27.42	28.67	14.89	14.04	14.465	49.78%	51.22%	50.50%	14.20
1998	39.62	39.62	39.62	24.17	20.80	22.49	15.14	13.15	14.145	62.62%	63.25%	62.94%	8.34

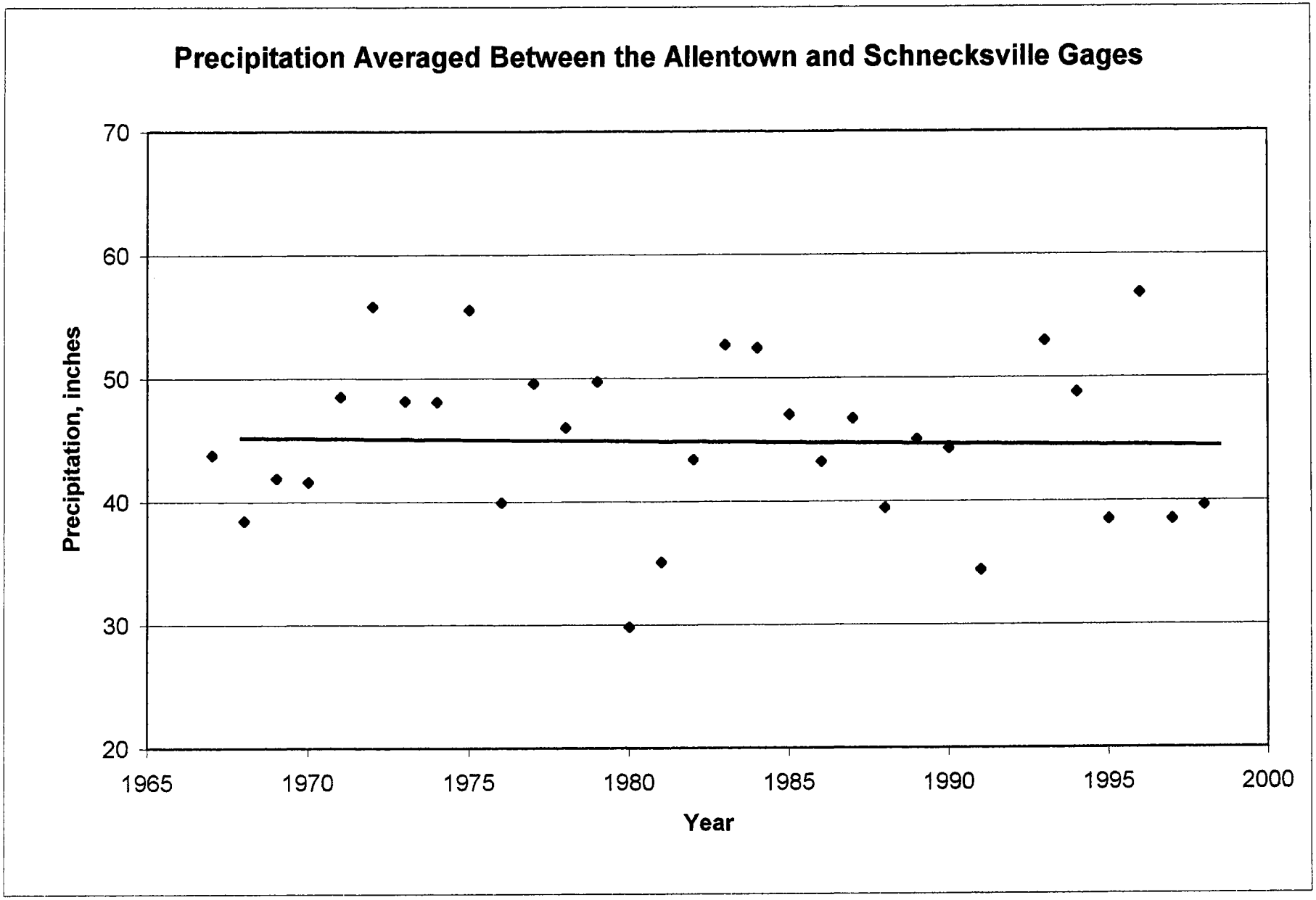

Precipitation Averaged Between the Allentown and Schnecksville Gages
Precipitation, inches
70
60
50
40
30
20
1965
1970
1975
1980
1985
1990
1995
2000
Year

Figure A1

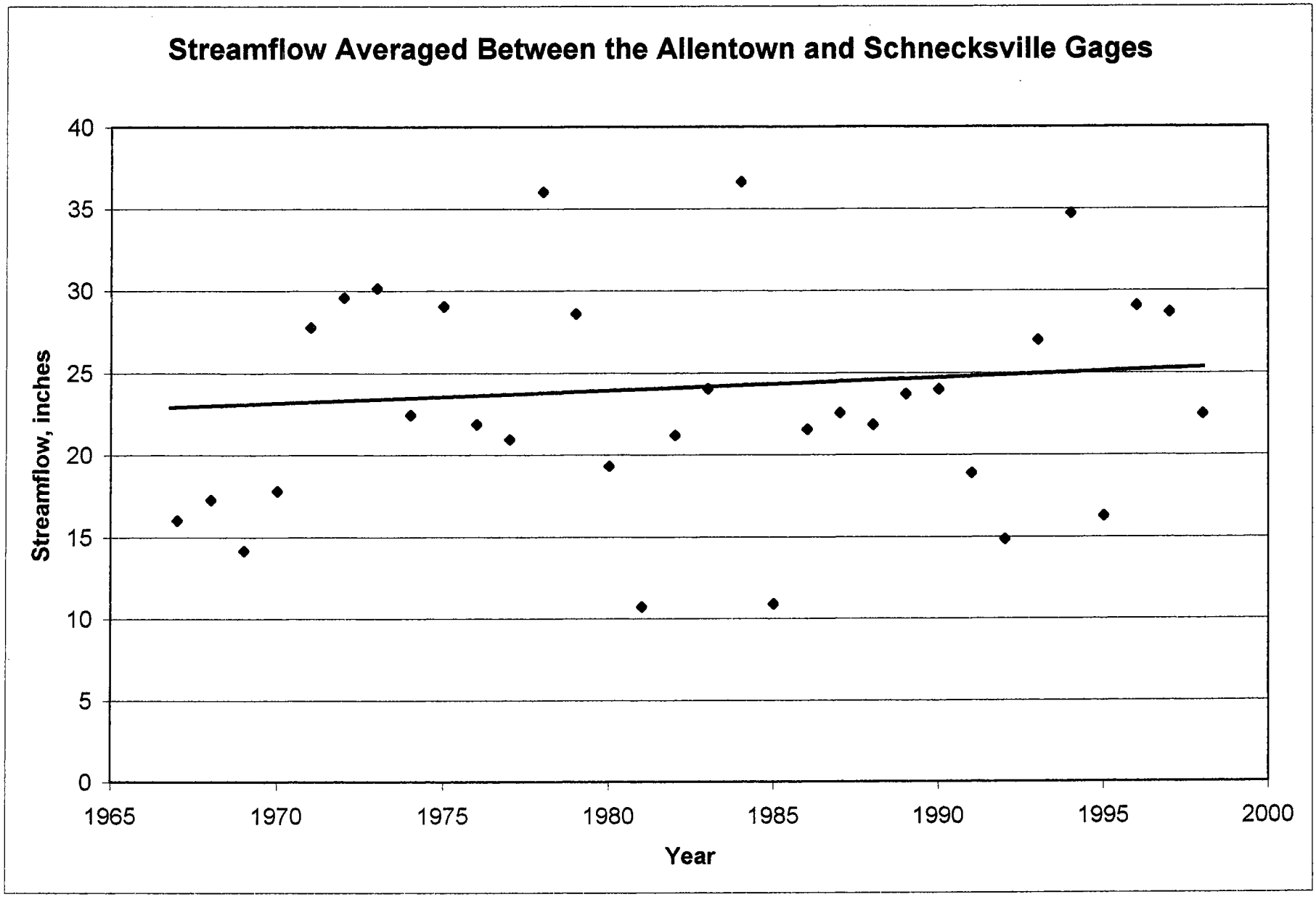

Streamflow Averaged Between the Allentown and Schnecksville Gages
Streamflow, inches
40
35
30
25
20
15
10
5
0
1965
1970
1975
1980
1985
1990
1995
2000
Year

Figure A2

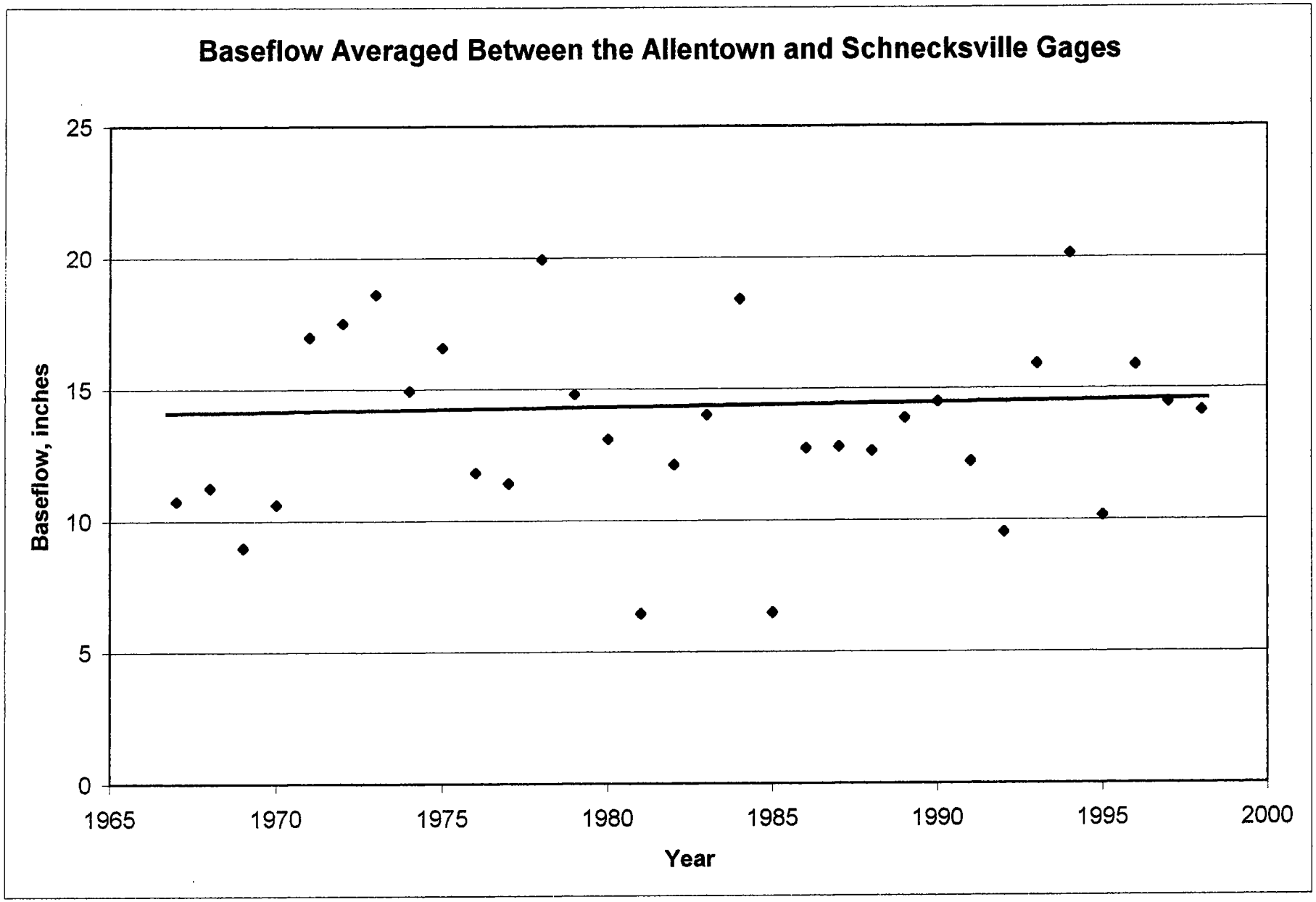

Baseflow Averaged Between the Allentown and Schnecksville Gages
Baseflow, inches
25
20
15
10
5
0
1965
1970
1975
1980
1985
1990
1995
2000
Year

Figure A3

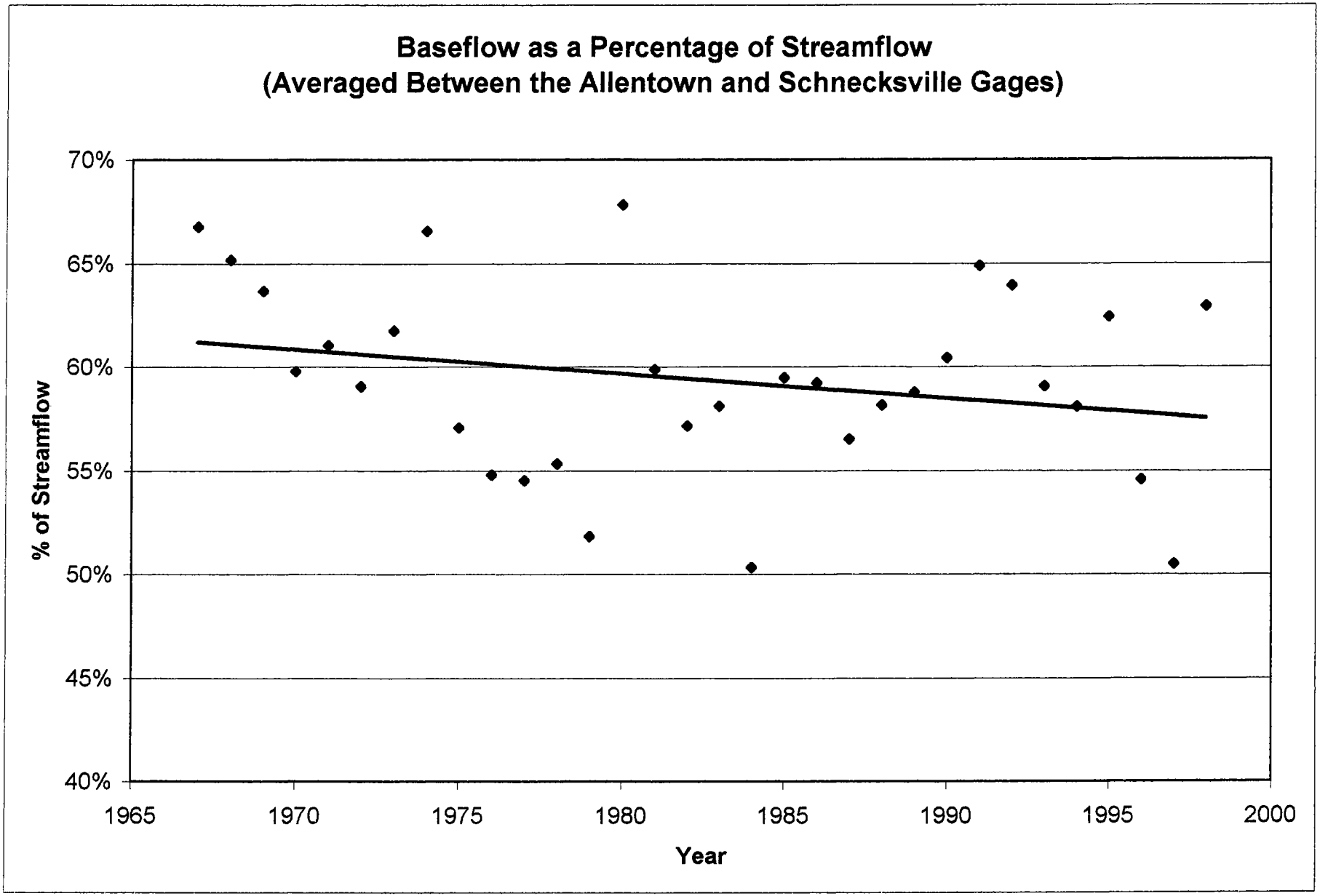

Baseflow as a Percentage of Streamflow
(Averaged Between the Allentown and Schnecksville Gages)
70%
65%
60%
55%
50%
45%
40%
% of Streamflow
1965
1970
1975
1980
1985
1990
1995
2000
Year

Figure A4

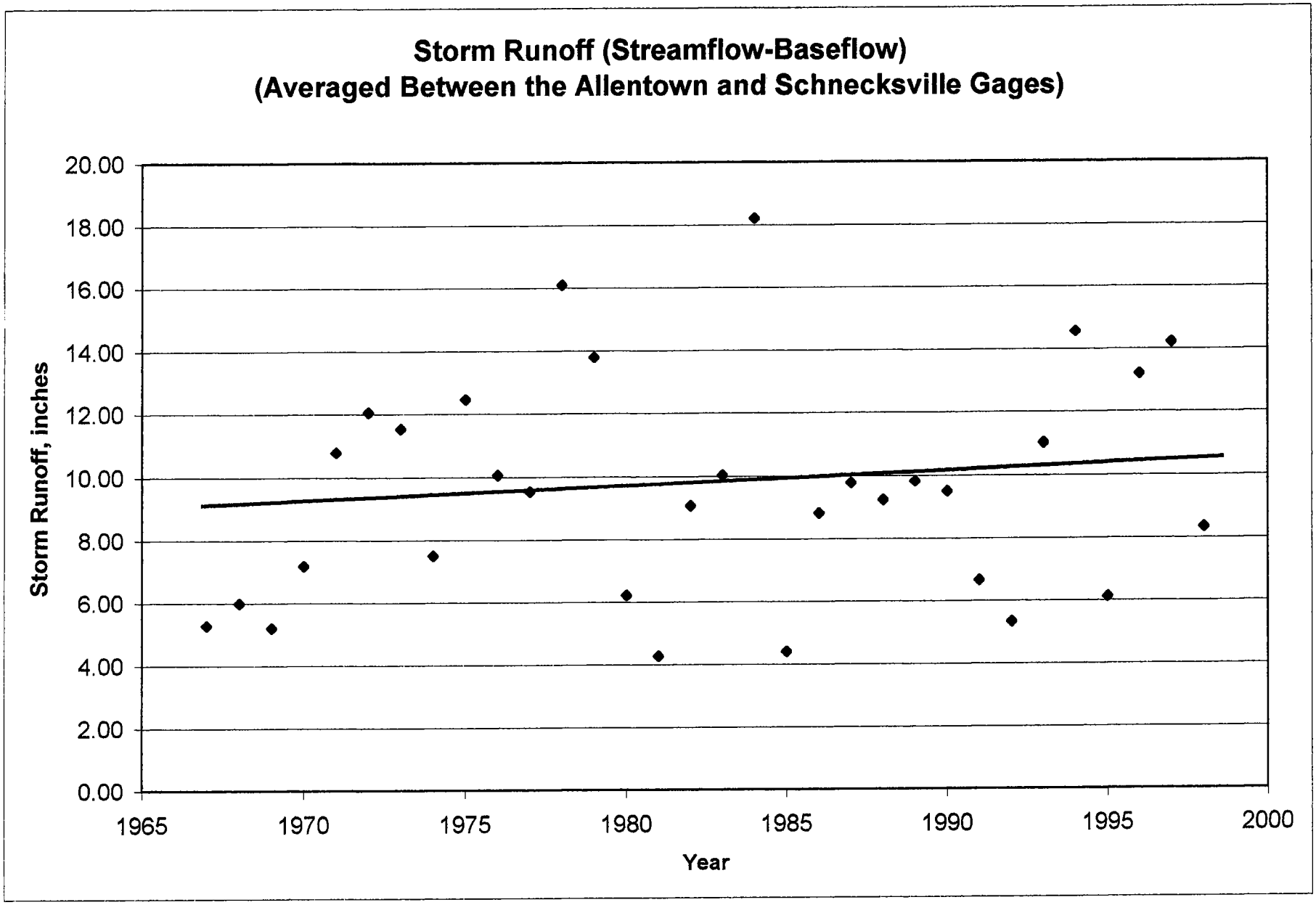

Storm Runoff (Streamflow-Baseflow)
(Averaged Between the Allentown and Schnecksville Gages)
Storm Runoff, inches
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1965
1970
1975
1980
1985
1990
1995
2000
Year

Figure A5

APPENDIX B

WATER QUALITY MONITORING DATA AND ANALYSIS

Table B1. 1999 Water Quality Parameter Averages

Site #	Air Temp. (°C)	Water Temp. (°C)	pH	Dissolved Oxygen (mg/L)	Specific Conductance (μmhos)	(NH4 +) Ammonia (mg/L)	(PO4) Phospate (mg/L)	(NO3) Nitrate (mg/L)	Dissolved Solids (mg/L)	Total Hardness (mg/L)	Calcium Hardness (mg/L)	Alkalinity (mg/L)
1	27.10	22.80	8.10	11.10	774.30	0.11	0.11	9.20	495.50	263.00	142.80	168.60
2	27.30	23.00	8.30	11.50	792.30	0.02	0.19	7.00	506.50	248.00	164.80	162.00
4	26.00	24.70	8.10	8.80	1281.30	0.07	0.72	7.20	821.30	326.00	173.60	223.20
5	27.00	23.70	8.40	8.70	252.10	0.01	0.13	9.50	161.00	95.00	71.00	47.50
7	26.00	21.30	7.80	8.60	318.70	0.04	0.03	5.50	204.00	119.00	81.80	69.80
8	27.00	24.30	7.30	6.70	232.30	0.05	0.03	3.80	148.80	80.00	55.20	57.60
10	27.00	23.20	8.60	9.60	218.30	0.03	0.01	5.30	139.50	83.00	51.30	49.50
11	26.00	23.00	8.20	10.10	235.00	0.05	0.11	16.30	150.60	86.00	52.00	40.30
11.5	28.00	26.20	8.70	10.10	207.40	0.03	0.02	4.60	132.80	81.00	44.40	50.60
12	28.50	24.90	8.10	9.30	232.60	0.14	0.02	6.30	148.80	88.00	48.80	52.70
13	31.00	24.90	8.70	9.90	196.00	0.02	0.01	3.70	125.60	78.00	42.80	49.60
14	25.00	24.10	8.80	10.00	193.00	0.02	0.04	5.20	123.40	73.00	53.60	52.80
15	25.50	22.80	8.00	8.80	203.60	0.13	0.05	4.40	130.60	83.00	53.20	58.30
17	28.10	20.20	7.20	8.30	89.90	0.02	0.02	6.80	57.60	30.00	17.60	22.00

site #	date	water temperature °C	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
15	7/27/98	21.1	7.95	185.5	7.43	92.1	47	75	55	4.93	0.04	0.2		15
15	8/3/98	18.0	7.8	185.3	7.73	92.9	51	78	55	5.37	0.008	0.23	0.81	3
15	8/12/98	21.7	9.1	210	7.06	104	80	82	78	4.58	0.07	0.23	0.84	0
15	8/17/98	22.2	8.2	180.2		90.8	69	75	52	3.7	0.035	0.23	3.73	27
15	1999 average	22.8	9.32	203.6	7.98	130.6	58.3	83	53				1.96	11
15	1998 average	21.1	8.51	188.9	7.58	94.7	47.8	78	51	8.12	0.032	0.2	2.52	9
15	98-99 average	21.7	8.82	194.5	7.74	109.6	51.8	80	52	8.12	0.032	0.2	2.33	10
17	6/1/99	17.2	8.24	86.5	7.25	55.4	23	30	19				1.45	
17	6/15/99	23.0	8.47	99.4	7.17	63.6	28	35	19				1.48	
17	6/28/99	21.5	7.37	90.2	7.05	57.9	20	30	17				0.65	0
17	7/13/99	17.4	8.05	89.4	7.07	57.2	23	30	14				0.55	3
17	7/27/99	21.9	8.95	84	7.28	54	16	26	19					6
17	6/25/98	18.9	8.7	109	6.1		11	50	13	18.48	0.003	0.02		0
17	7/6/98	16.8	9.1	97.1	7.79	48.5	2	40	16	14.3	0.008	0.05	2.73	6
17	7/13/98	17.4	8.8	94.6	7.94	47.5	2	35		14.3	0.008	0.05	1.58	6
17	7/20/98	13.8	7.8	90.5	7.3	45.3	13	35	18	9.68	0.003	0.27	2.16	0
17	7/27/98	17.6	8.2	89.4	7.65	44.7	19	40	14	7.48	0.055	0.18		15
17	8/3/98	17.2	7.8	85	7.46	42.7	20.5	30	16	5.94	0.04	0.2	1.86	0
17	8/12/98	19.5	8.2	98	7.57	49	44	30	22	18.92	0.035	0.33	1.66	0
17	8/17/98	19.9	8.2	87.6		43.7	39	25	16	5.72	0.003	0.13	1.22	21
17	1999 average	20.2	8.22	89.9	7.16	57.6	22	30	18				1.03	3
17	1998 average	17.6	8.35	93.9	7.4	45.9	18.8	36	16	11.85	0.019	0.15	1.87	6
17	98-99 average	18.6	8.3	92.4	7.3	50.8	20	34	17	11.85	0.019	0.15	1.53	5

Table B2. Weekly 1998 and 1999 water quality data

site #	date	water temperature °c	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
13	1999 average	24.9	10.18	196	8.65	125.6	49.6	78	43				4.09	9
13	1998 average	22.8	9.8	368.1	8.63	87.1	40.9	72	39	7.43	0.016	0.19	7.7	9
13	98-99 average	23.6	9.94	301.9	8.64	103.1	44.3	74	41	7.43	0.016	0.19	6.06	9
14	6/1/99	23.7	9.81	181	8.64	116	47	65	39				4.71	
14	6/15/99	23.0	9.84	193	8.51	123	57	70	55				6.03	
14	6/28/99	26.6	11.45	191	9.09	122	49	69	50				1.9	12
14	7/13/99	21.2	10.97	203	8.69	130	56	82	65				1.08	6
14	7/27/99	25.8	14.53	197	8.86	126	55	80	59				0.61	6
14	6/25/98	22.6	9.4	1.7	8.34		16.5	70	11	13.86	0	0.09		3
14	7/6/98	20.6	10.2	169.3	8.24	84.7	27	70	28	13.64	0.028	0.07	11.88	12
14	7/13/98	20.4	9.2	171.9	8.5	85.9	34	70		9.24	0	0.27	10.04	12
14	7/20/98	23.1	9.8	166.8	7.96	83.2	32	65	55	5.5	0.008	0.27	7.66	6
14	7/27/98	21.1	7.9	169.5	7.8	84.6	44	78	50	8.36	0.003	0.3		12
14	8/3/98	18.1	8.4	177	7.62	88.5	50	76	50	3.6	0	0.25	3.8	0
14	8/12/98	21.5	9.8	195.2	7.87	97.6	66	80	61	5.37	0.02	0.36	5.22	0
14	8/17/98	21.7	8.4	175.3		87.6	70	70	50	4.93	0	0.3	8.22	12
14	1999 average	24.1	11.32	193	8.76	123.4	52.8	73	54				2.87	8
14	1998 average	21.1	9.14	153.3	8.05	87.4	42.4	72	44	8.06	0.007	0.24	7.8	7
14	98-99 average	22.3	9.98	168.6	8.34	102.4	46.4	73	48	8.06	0.007	0.24	5.56	7
15	6/1/99	22.6	8.61	194	7.88	125	47	80	52				3.11	
15	6/15/99	21.6	8.87	205	7.89	131	57	81	50				1.86	
15	6/28/99	25.0	8.16	209	7.75	134	63	82	55				0.9	21
15	7/13/99	19.4	8.98	208	7.82	133	77	90	50				----	10
15	7/27/99	25.3	11.96	202	8.55	130	47.5	83	59					3
15	6/25/98	22.5	8.8	184	7.68		13	72	13	14.3	0.028	0.02		0
15	7/6/98	19.5	9.2	188.1	7.6	94.1	31	75	34	13.64	0.048	0	3.81	10
15	7/13/98	19.9	8.9	191	7.95	95.7	39.5	80		10.34	0.003	0.33	3.33	19
15	7/20/98	23.7	8.1	187	7.59	93.1	52	85	69	8.14	0.02	0.33	2.61	0

Table B2. Weekly 1998 and 1999 water quality data

site #	date	water temperature °c	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
12	6/1/99	24.4	8.02	213	7.77	136	42.5	81	47				5.56	
12	6/15/99	24.5	8.87	228	8.06	146	52	84	42				3.06	
12	6/28/99	27.9	9.37	236	8.45	151	52	83	44				1.7	15
12	7/13/99	24.0	11	239	8.66	153	59	90	50				0.97	12
12	7/28/99	23.8	9.5	247	7.68	158	58	100	61					3
12	6/25/98	24.9	9.8	187	8.24		20	72	8	12.1	0	0		0
12	7/6/98	22.2	9.4	196.5	8.38	98.8	20	80	18	11.22	0.035	0.15	4.66	19
12	7/13/98	22.7	9.5	203	7.26	102.4	35	75		10.56	0.015	0.27	4.02	15
12	7/20/98	24.4	9.1	203	8.37	101	35	80	52	8.58	0	0.3	2.5	3
12	7/27/98	22.6	8.5	208	8.34	103	45	85	69	6.28	0	0.27		19
12	8/4/98	20.7	9.8	200	7.85	100.7	73	90	65	5.37	0	0.11	1.8	0
12	8/12/98	22.6	9.7	222	7.69	112.1	73	87	82	4.58	0.028	0.27	2.04	0
12	8/17/98	22.6	8.4	200		100.8	72.5	80	55	3.7	0.015	0.11	5.6	21
12	1999 average	24.9	9.35	232.6	8.12	148.8	52.7	88	49				2.82	10
12	1998 average	22.8	9.28	202.4	8.02	102.7	46.7	81	50	7.8	0.012	0.19	3.44	10
12	98-99 average	23.6	9.3	214	8.06	121.9	49	84	49	7.8	0.012	0.19	3.19	10
13	6/1/99	25.6	9.34	180	8.66	115	36	67	32				8.84	
13	6/15/99	25.4	10.19	193	8.8	124	48	76	39				6.32	
13	6/28/99	28.8	11.78	190	9	122	50	68	36				2.92	10
13	7/13/99	23.7	11.17	204	8.9	131	59	82	52				1.2	10
13	7/28/99	20.9	8.4	213	7.91	136	55	95	55				1.17	6
13	6/25/98	24.5	10	163	8.43		15.5	65	7	9.24	0	0.02		10
13	7/6/98	21.4	10.6	169	9.09	84.5	22	70	19	13.2	0.048	0.07	10.95	15
13	7/13/98	21.9	9.7	172.9	9.15	86.4	32	70		11.22	0.003	0.25	9.74	21
13	7/20/98	24.4	9.5	168.5	8.99	84.4	30	70	50	8.58	0.003	0.42	6.04	6
13	7/27/98	22.6	10	1723	8.91	86.1	51	75	47	5.15	0.048	0.18		10
13	8/3/98	21.4	9.4	185.5	7.88	86.7	39	74	55	4.4	0.015	0.13	4.12	0
13	8/12/98	22.9	10	190.2	7.98	95.1	66	80	52	4.4	0.003	0.25	6.9	0
13	8/17/98	23.2	9.2	172.5		86.2	72	70	42	3.26	0.008	0.18	8.42	12

Table B2. Weekly 1998 and 1999 water quality data

site #	date	water temperature °c	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
11	7/1/98	20.1	9.7	192.4		96.2	43	82	36	11.44	0	0.2		21
11	7/6/98	20.5	9.2	201	8.34	100	13	80	11	15.4	0.02	0.27	5.32	12
11	7/13/98	21.6	8.9	206	8.41	103.7	43	75		15.4	0	0.39	4.13	6
11	7/21/98	20.7	7.8	210	7.33	105.8	42	85	78	17.38	0.035	0.45	2.91	0
11	7/27/98	22.1	9.3	217	7.55	108	34	85	69	16.28	0.055	0.36		0
11	8/4/98	20.9	9.6	223	8.32	112.4	80	92	61	16.28	0.008	0.3	1.33	0
11	8/12/98	22.6	10	226	7.84	113.9	67	95	73	10.78	0	0.39	1.54	0
11	8/17/98	22.1		199		100.2	58	75	52	12.32	0.035	0.25	7.13	19
11	1999 average	23.0	9.59	235	8.23	150.6	40.3	86	52				3.57	8
11	1998 average	21.3	9.21	209.3	7.97	105	47.5	84	54	14.41	0.019	0.33	3.73	7
11	98-99 average	22.0	9.37	219.2	8.09	122.6	44.7	84	53	14.41	0.019	0.33	3.65	7
11.5	6/1/99	24.8	9.18	195	8.41	125	41	76	32				12.57	
11.5	6/15/99	25.1	10	206	8.64	132	53	78	47				9.98	
11.5	6/28/99	28.7	9.49	209	8.77	133	50	78	44				4.8	10
11.5	7/13/99	23.9	10.66	218	8.71	140	55	87	47				2.07	12
11.5	7/27/99	28.7	14.12	209	9.15	134	54	85	52				0.34	6
11.5	6/25/98	25.3	9.4	169	8.8		15.5	70	4	11.66	0	0.02		0
11.5	7/6/98	23.6	9.2	178.1	8.81	89	14.5	70	9	10.78	0.035	0.11	16.78	15
11.5	7/13/98	24.0	9	183.9	8.99	92	34	70		9.68	0.008	0.25	14.96	10
11.5	7/20/98	25.5	9.8	181.7	8.78	90.8	46	70	59	8.58	0.35	0.3	11.83	0
11.5	7/27/98	24.6	10.6	181.4	9.1	90.7	45	75	50	3.39	0.028	0.2		3
11.5	8/4/98	22.5	10.2	186.9	8.51	93.5	56	79	55	4.75	0.008	0.2	5.96	0
11.5	8/12/98	24.7	10.6	199	7.94	100	77	79	69	3.7	0.003	0.25	7.22	0
11.5	8/17/98	23.0	9.2	178.7		89.4	67	72	47	2.95	0	0.13	13.72	19
11.5	1999 average	26.2	10.69	207.4	8.74	132.8	50.6	81	44				5.95	9
11.5	1998 average	24.2	9.75	182.3	8.7	92.2	44.4	73	42	6.94	0.054	0.18	11.75	6
11.5	98-99 average	25.0	10.11	192	8.72	109.1	46.8	76	43	6.94	0.054	0.18	9.11	7

Table B2. Weekly 1998 and 1999 water quality data

site #	date	water temperature °c	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
8	7/21/98	24.5	5.4	199	7.15	100.1	62	80	73	5.28	0.015	0.3	11.4	0
8	7/28/98	23.6	5.6	199.9	7.33	100.6	58	80	55	3.3	0.076	0.3	7.38	6
8	8/4/98	23.6	7	195.8	7.78	97.9	62	89	65	14.3	0.028	0.25	6.16	0
8	8/13/98	22.9	5.2	204		102.5	43	81	59	3.48	0.04	0.3	9.27	12
8	8/18/98	22.2	7.2	199		100.5	72	78	61	4.75	0.015	0.25	34.97	19
8	1999 average	24.3	6.53	232.3	7.34	148.8	57.6	88	55				15.21	8
8	1998 average	23.1	6.82	196.6	7.38	98.7	53.6	80	47	7.45	0.028	0.27	15.3	10
8	98-99 average	23.5	6.72	208.5	7.36	115.4	55.1	83	50	7.45	0.028	0.27	15.26	10
10	6/17/99						42.5	82	55				12.81	
10	7/14/99	21.3	11.91	231	8.92	147	62	90	59	13.86			3.19	19
10	7/27/99	23.2	10.38	223	8.9	143	54	90	50					3
10	7/1/98	23.0	10	178.1		89	72	75	28		0	0.09		15
10	7/6/98	24.5	10	185.9	9.08	94.9	18	75	8	14.3	0.055	0.15	20.16	6
10	7/13/98	26.6	7.6	189.2	9.17	94.7	42.5	80		11.22	0.035	0.27	21.69	12
10	7/21/98	22.7	8.1	195	8.25	97.5	39	70	61	6.82	0	0.25	13.6	0
10	7/28/98	21.4	9.2	196.2	8.25	98	63	85	52	6.38	0.07	0.2	8.63	0
10	8/4/98	26.5	10	199	8.81	100.1	59	95	65	5.06	0.008	0.18	9.36	0
10	8/13/98	21.9	10.42	200	8.21	100.9	44	85	69	4.4	0.04	0.18	11.76	19
10	8/18/98	21.6	9.3	188.8		94.4	70	72	44	4.4	0.008	0.27	22.57	21
10	1999 average	23.2	10.23	218.3	8.61	139.5	49.5	83	51	11.79	0.455	0.3	14.23	11
10	1998 average	23.5	9.33	191.5	8.63	96.2	50.9	80	47	7.51	0.027	0.2	15.4	9
10	98-99 average	23.4	9.63	200.4	8.62	110.6	50.4	81	49	8.54	0.113	0.22	14.97	10
11	6/1/99	21.3	8.96	209	8.02	134	34	79	44				7.93	
11	6/15/99	21.3	8.81	234	7.86	150	43	82	59				3.58	
11	6/28/99	25.1	9.27	242	8.29	155	39.5	85	52				1.78	10
11	7/13/99	21.2	10.39	251	8.54	161	43	92	50				2.94	10
11	7/27/99	26.0	10.51	239	8.46	153	42	90	55				1.6	3

Table B2. Weekly 1998 and 1999 water quality data

site #	date	water temperature °c	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
5	8/18/98	24.1	9.6	271		135	74	85	73	5.94	0.015	0.27	18.11	27
5	1999 average	23.7	9.6	252	8.41	161	47.5	95	71				21.86	
5	1998 average	22.5	8.56	286.4	8.07	143.3	67.6	112	82	9.58	0.653	0.35	8.71	8
5	98-99 average	22.7	8.68	282.6	8.11	145.3	63.6	108	79	9.58	0.653	0.35	12.47	8
7	6/3/99	20.4	8.63	265	7.85	170	53	105	69				8.85	
7	6/17/99						67	120	86				3.32	
7	6/29/99	24.2	8.04	341	7.72	218	67	122	86				1	6
7	7/14/99	19.5	7.75	350	7.68	224	92	130	86				0.15	6
7	7/1/98	21.7	10	269		135.2	71	110	8	9.46	0	0.09		3
7	7/7/98	20.5	9	275	7.79	139	57	110	8	6.38	0.02	0.27	2.09	3
7	7/14/98	21.3	8.8	278	7.84	139	87	110		5.72	0.008	0.27	1.52	12
7	7/21/98	23.3	7.3	288	7.19	145.5	65	120	119	4.18	0	0.33	1.22	0
7	7/28/98	21.6	8.9	292	7.35	145	74	119	96	3.3	0.085	0.23	0.53	3
7	8/4/98	21.8	8	287	7.68	144.6	95	125	91	2.46	0	0.27	0.18	0
7	8/13/98	21.4	8.8	304		152.6	73	125	114	1.98	0.003	0.27	0.35	3
7	8/18/98	21.9	9	312		157.1	115	120	107	3.26	0	0.2	2.24	19
7	1999 average	21.3	8.14	318.7	7.75	204	69.8	119	82				3.33	6
7	1998 average	21.7	8.73	288.1	7.57	144.8	79.6	117	78	4.59	0.015	0.24	1.16	5
7	98-99 average	21.6	8.53	298.3	7.65	164.5	75.8	118	79	4.59	0.015	0.24	2.06	6
8	6/3/99	22.1	7.18	195	7.36	125	36	81	50				46.94	
8	6/17/99						60	83	55				13.4	
8	6/29/99	26.3	5.57	237	7.19	152	54	86	50				9.41	15
8	7/14/99	22.0	6.49	250	7.31	160	72	95	52				3.81	10
8	7/28/99	26.9	6.88	247	7.51	158	66	97	69				2.5	0
8	7/1/98	22.6	9.95	184		92	42.5	72	7	15.18	0	0.09		6
8	7/7/98	22.1	7.3	194.6	7.46	97.4	45	80	7	9.24	0.028	0.3	18.44	21
8	7/14/98	22.9	6.9	196.8	7.19	98.6	44	80		4.07	0.02	0.36	19.46	19

Table B2. Weekly 1998 and 1999 water quality data

site #	date	water temperature °c	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
2	1999 average	23.0	12.94	792.3	8.31	506.5	162	248	165	5.15	0.008	0.3	16.61	7
2	1998 average	21.6	10.99	603.9	8.41	301.9	128	206	143	8.79	0.336	0.23	15.06	9
2	98-99 average	22.1	11.69	666.7	8.37	370.1	141.1	222	152	8.39	0.3	0.24	15.71	9
4	6/3/99	23.8	8.36	497	8.05	319	97	150	91				44.27	
4	6/17/99						191	270	205				6.9	
4	6/29/99	26.8	8.19	1576	8.15	1010	299	410	134				4.38	10
4	7/14/99	22.6	8.68	1459	8.06	936	271	400	196				6.57	10
4	7/2/98	21.2	8	431	7.73	216	82	125	17	9.68	4	0.2		6
4	7/7/98	23.3	11	427	8.48	215	87	135	19	10.78	0.28	0.5	18.34	19
4	7/14/98	24.7	10.6	515	8.45	257	142	180		7.48	0.02	0.36	12.76	19
4	7/21/98	25.2	6.9	934	8.05	466	164	270	242	5.5	0	0.27	5.23	0
4	7/28/98	24.1	8	1313	7.87	657	195	300	218	5.28	0.085	0.2	2.54	10
4	8/6/98	24.9	9.9	1230	7.95	613	221	310	218	9.24	0.02	0.15	0.88	0
4	8/13/98	23.5	8.4	1205		603	168	250	185	9.68	0.04	0.5	2.76	12
4	8/18/98	23.4	8.5	1226		613	288	300	255	5.37	0.055	0.27	19.64	19
4	1999 average	24.7	8.77	1281.3	8.14	821.3	223.2	326	174				15.53	8
4	1998 average	23.8	8.91	910.1	8.09	455	168.4	234	165	7.88	0.563	0.31	8.88	11
4	98-99 average	24.1	8.87	1033.8	8.11	577.1	189.5	269	169	7.88	0.563	0.31	11.3	10
5	6/3/99	23.7	9.6	252	8.41	161	41	87	69				39.66	
5	6/17/99						54	102	73				4.06	
5	7/2/98	20.7	8.1	207	7.47	104.4	37	82	16	13.64	5	0.13		6
5	7/7/98	23.6	9.4	228	8.38	115.1	49	85	8	10.56	0.028	0.61	17.96	10
5	7/14/98	24.9	9.5	246	8.75	123.7	47	90		9.24	0.028	0.42	7.49	21
5	7/21/98	24.8	8.6	256	8.55	129.2	58	100	96	6.38	0	0.48	0	0
5	7/28/98	21.3	7.5	349	7.62	175	84	140	126	5.5	0.076	0.33		0
5	8/6/98	18.1	9	472	7.62	234	142	220	166	20.24	0.008	0.2		0
5	8/13/98	22.7	6.8	262		130	50	90	86	5.15	0.07	0.33	0	3

Table B2. Weekly 1998 and 1999 water quality data

Table B2. Weekly Water Quality Data, Summer 1998 and Summer 1999

site #	date	water temperature °c	dissolved oxygen mg/L O_2	specific conductance µmhos	pH	dissolved solids mg/L TDS	alkalinity mg/L $CaCo_3$	total hardness mg/L $CaCo_3$	calcium hardness mg/L Ca	nitrate mg/L NO_3	ammonia nitrogen mg/L NH_4	phosphate mg/L PO_4	discharge ft^3/s	turbidity NTU
1	6/3/99	21.9	8.4	522	7.92	334	127	170	114				53.44	
1	6/29/99	24.4	8.7	863	7.85	552	186.5	265	150				18.07	6
1	7/14/99	20.7	12.52	872	8.19	558	197.5	300	134				11.58	10
1	7/28/99	24.4	14.99	840	8.42	538	171	325	166				14.99	3
1	7/2/98	21.0	9.8	410	8.22	206	91	155	42	13.2	1	0.11		3
1	7/7/98	21.2	11.7	435	8.6	218	121	175	50	12.32	0.048	0.09	44.28	27
1	7/14/98	22.2	10.5	200	8.62	250	145	210		9.68	0.028	0.18	36.38	3
1	7/21/98	23.5	11.8	607	8.35	304	159	250	196	8.36	0	0.23	28.61	0
1	7/28/98	22.5	14.2	638	8.44	319	159	290	150	8.58	0.04	0.2	22.48	0
1	8/6/98	22.5		765	8.2	382	171	290	196	10.34	0.028	0.23	27.9	0
1	8/13/98	21.0	10.6	850		424	178	260	205	8.14	0.004	0.36	27.26	3
1	8/18/98	21.9	9.4	660		329	182	250	175	7.92	0.035	0.3	27.96	10
1	1999 average	22.9	11.15	774.3	8.1	495.5	168.6	263	143	24.64	0.65	0.45	26.29	6
1	1998 average	22.0	11.14	570.6	8.41	304	150.8	235	145	9.82	0.148	0.21	30.7	6
1	98-99 average	22.3	11.15	638.5	8.28	367.8	157.6	246	144	11.46	0.204	0.24	28.86	6
2	6/3/99	22.8	9.74	571	8.27	365	119	170	150				43.08	
2	6/17/99						164	235	166				13.61	
2	6/29/99	25.3	10.99	835	8.22	534	161	260	185				8.37	6
2	7/28/99	23.8	15.72	847	8.48	542	171	300	166				9.12	6
2	7/2/98	21.1	9.5	433	8.08	216	107	135	61	12.76	2	0.23		10
2	7/7/98	21.2	9.6	397	8.44	199	106	150	69	13.2	0.48	0.2	26.16	24
2	7/14/98	22.4	12.1	434	8.85	218	119	180		8.8	0.028	0.27	20.1	10
2	7/21/98	22.2	11.3	578	8.61	289	119	220	175	6.38	0.035	0.27	15.86	0
2	7/28/98	22.0	13.6	621	8.46	310	117	215	134	7.4	0.06	0.25	10.58	3
2	8/6/98	22.2	10.8	778	8	388	139	250	185	8.36	0.035	0.2	11.45	0
2	8/13/98	20.9		830		415	139	250	175	6.82	0.035	0.25	10.99	10
2	8/18/98	21.0	10	760		380	178	250	205	6.6	0.015	0.18	10.28	15

Table B2. Weekly 1998 and 1999 water quality data

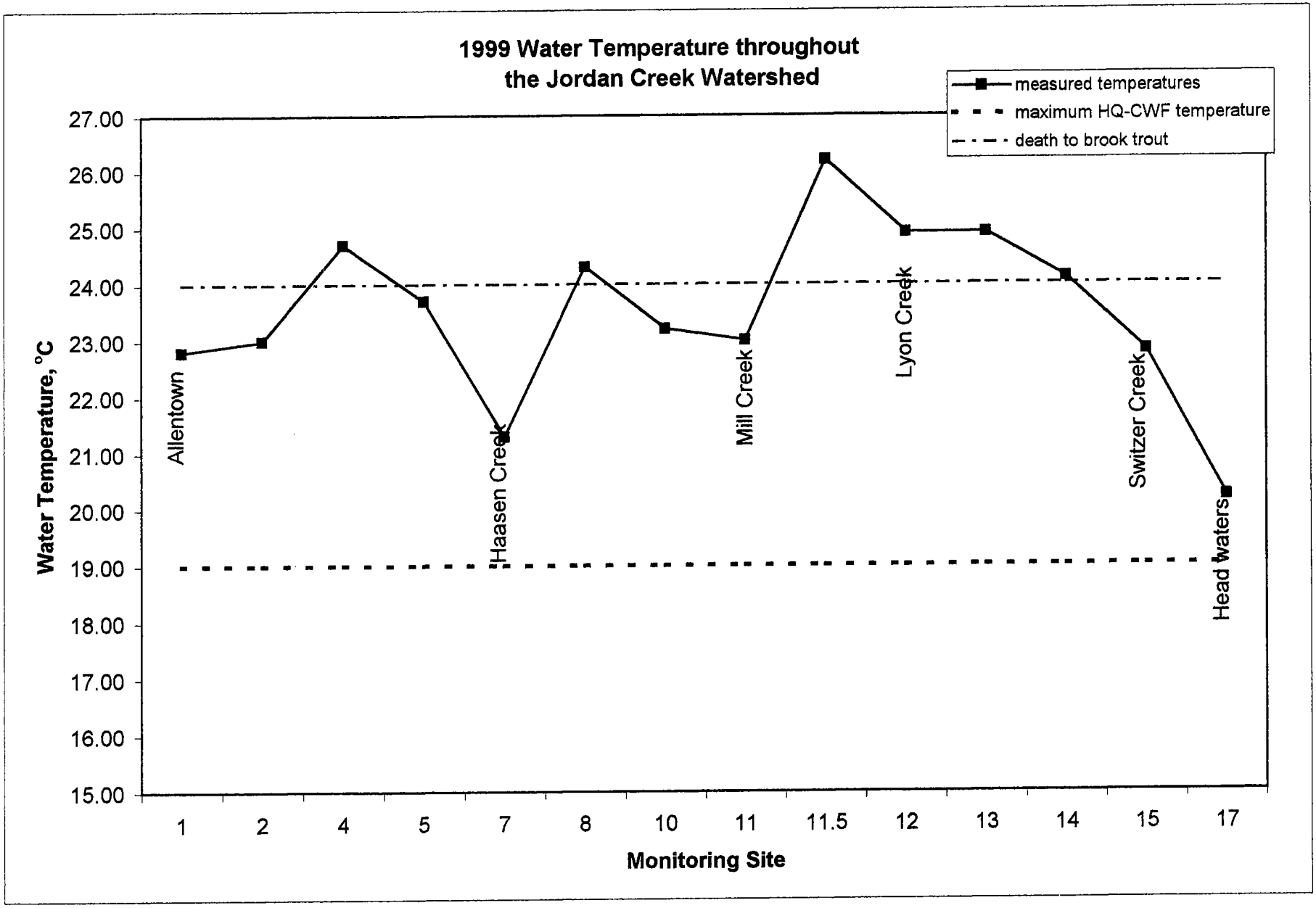


Figure B1. Water Teperature

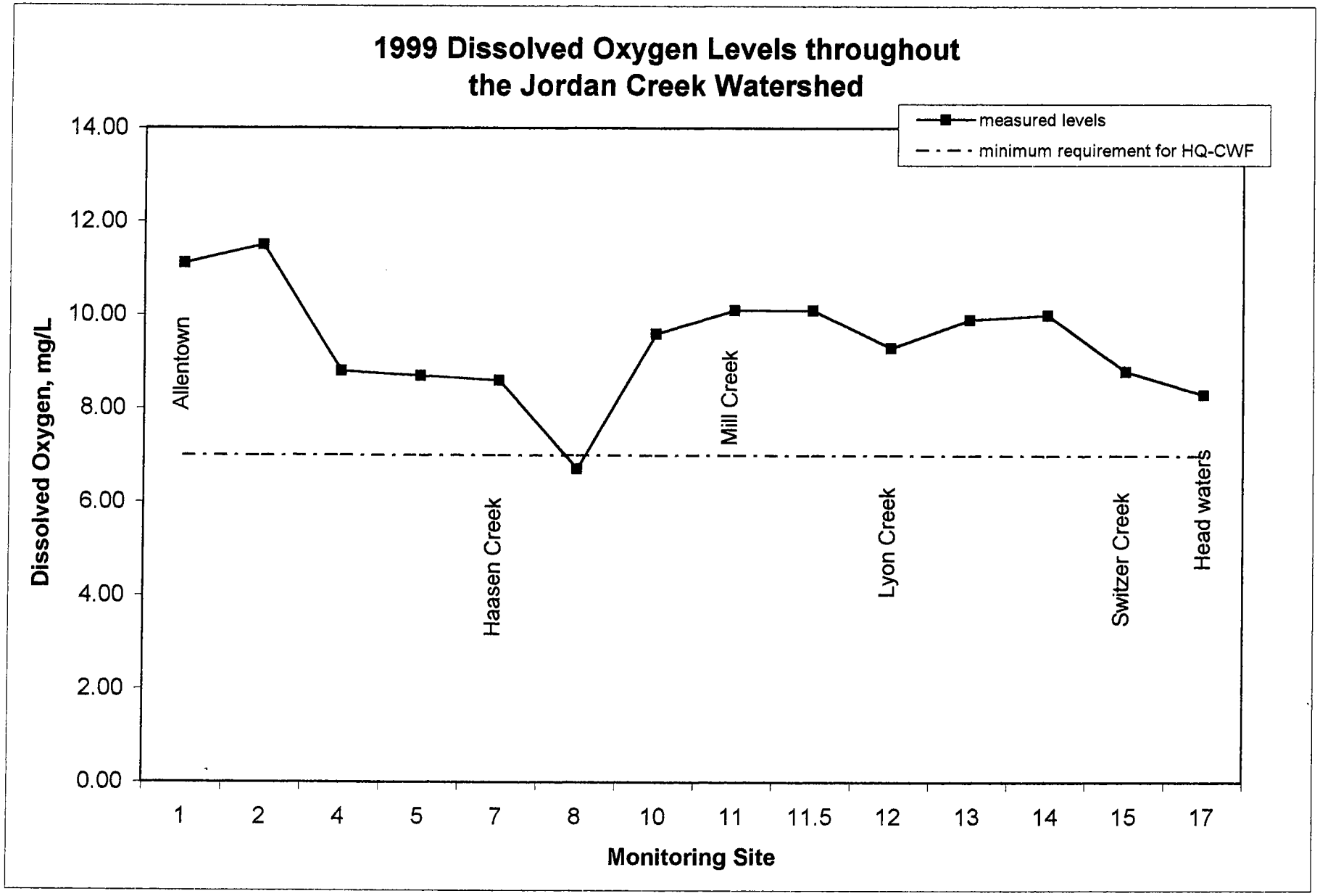


Figure B2. Dissolved Oxygen

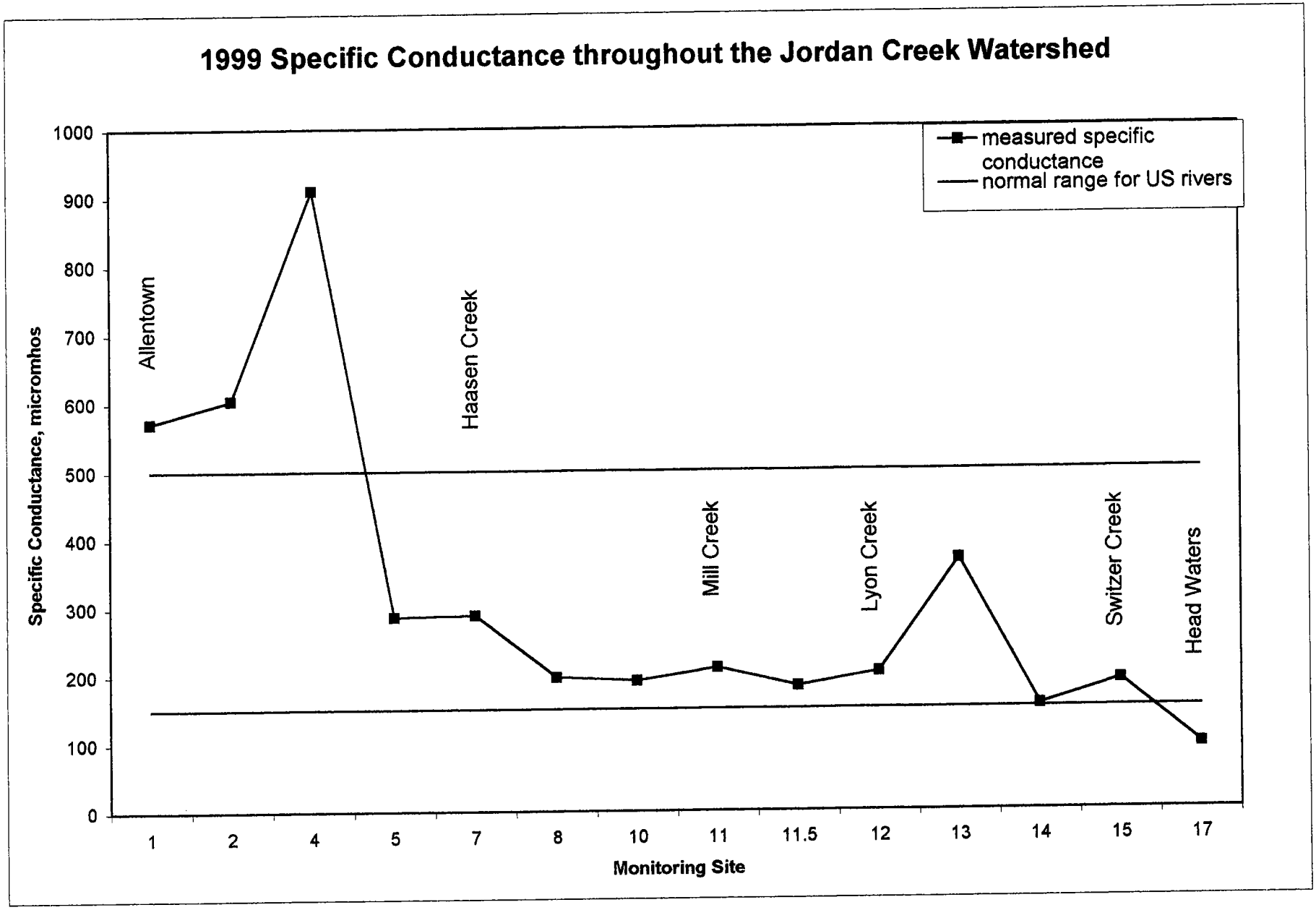


Figure B3. Specific Conductance

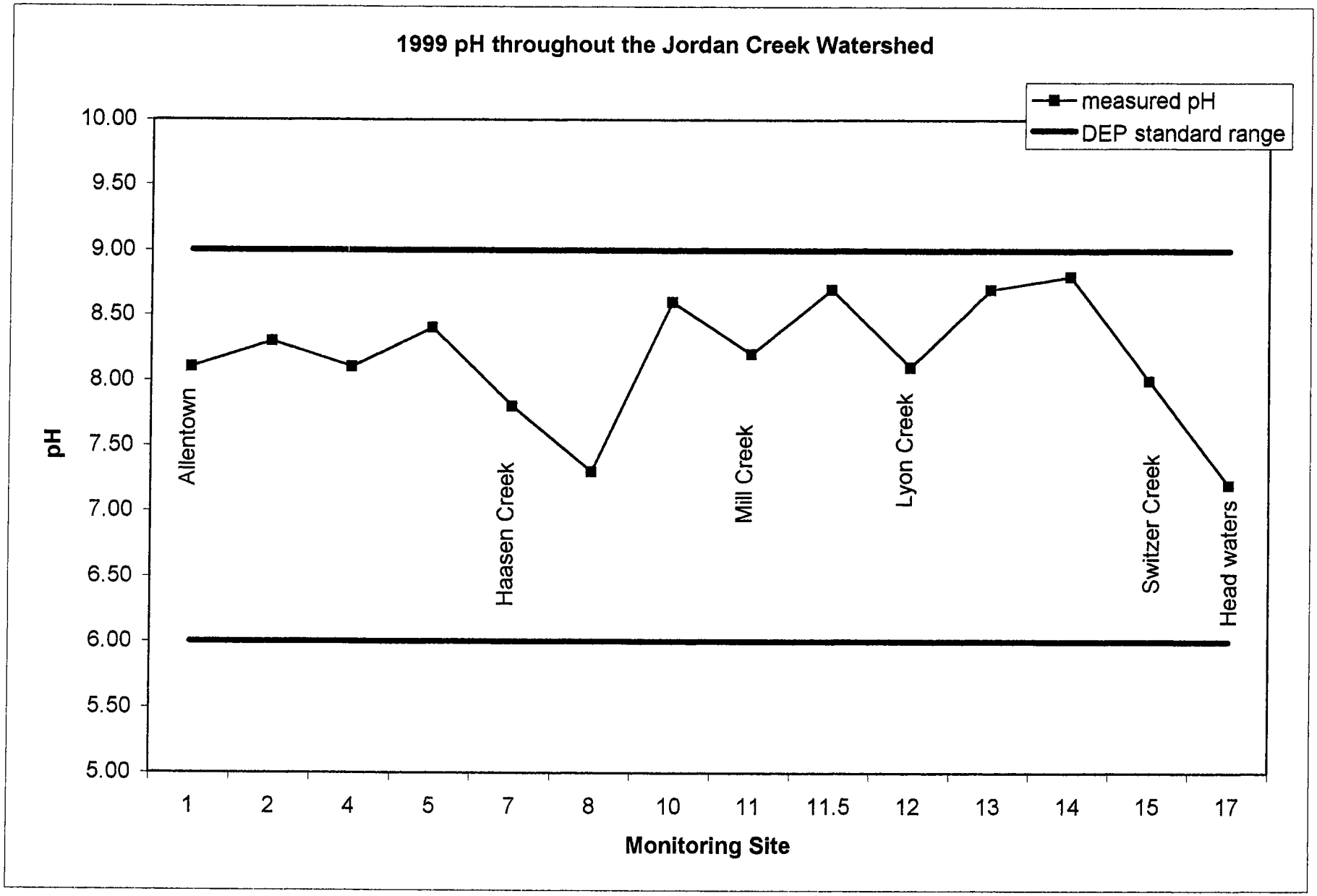

1999 pH throughout the Jordan Creek Watershed
measured pH
DEP standard range
pH
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
Allentown
Haasen Creek
Mill Creek
Lyon Creek
Switzer Creek
Head waters
1
2
4
5
7
8
10
11
11.5
12
13
14
15
17
Monitoring Site

Figure B4. pH

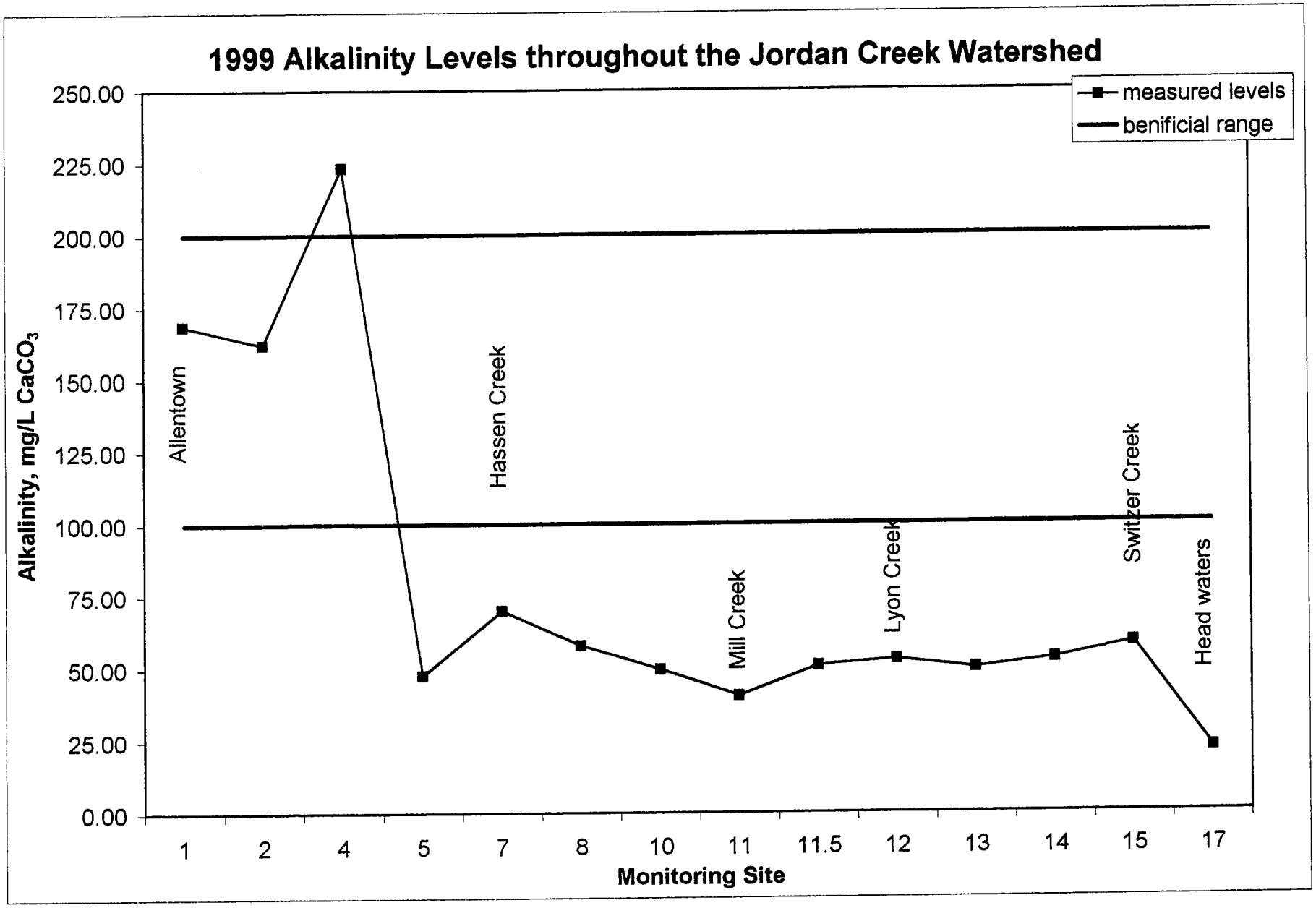


Figure B5. Alkalinity

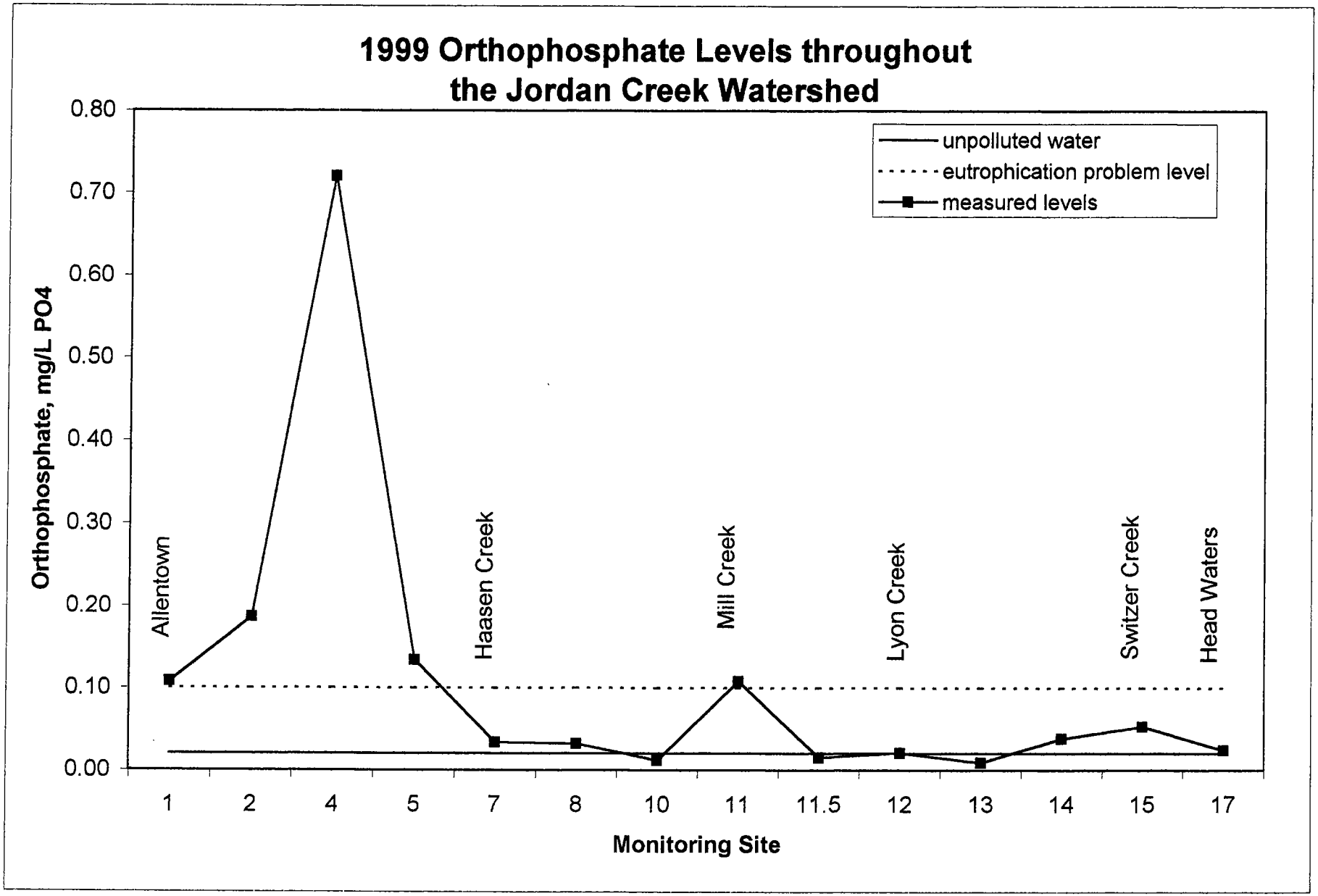


Figure B6. Orthophosphate

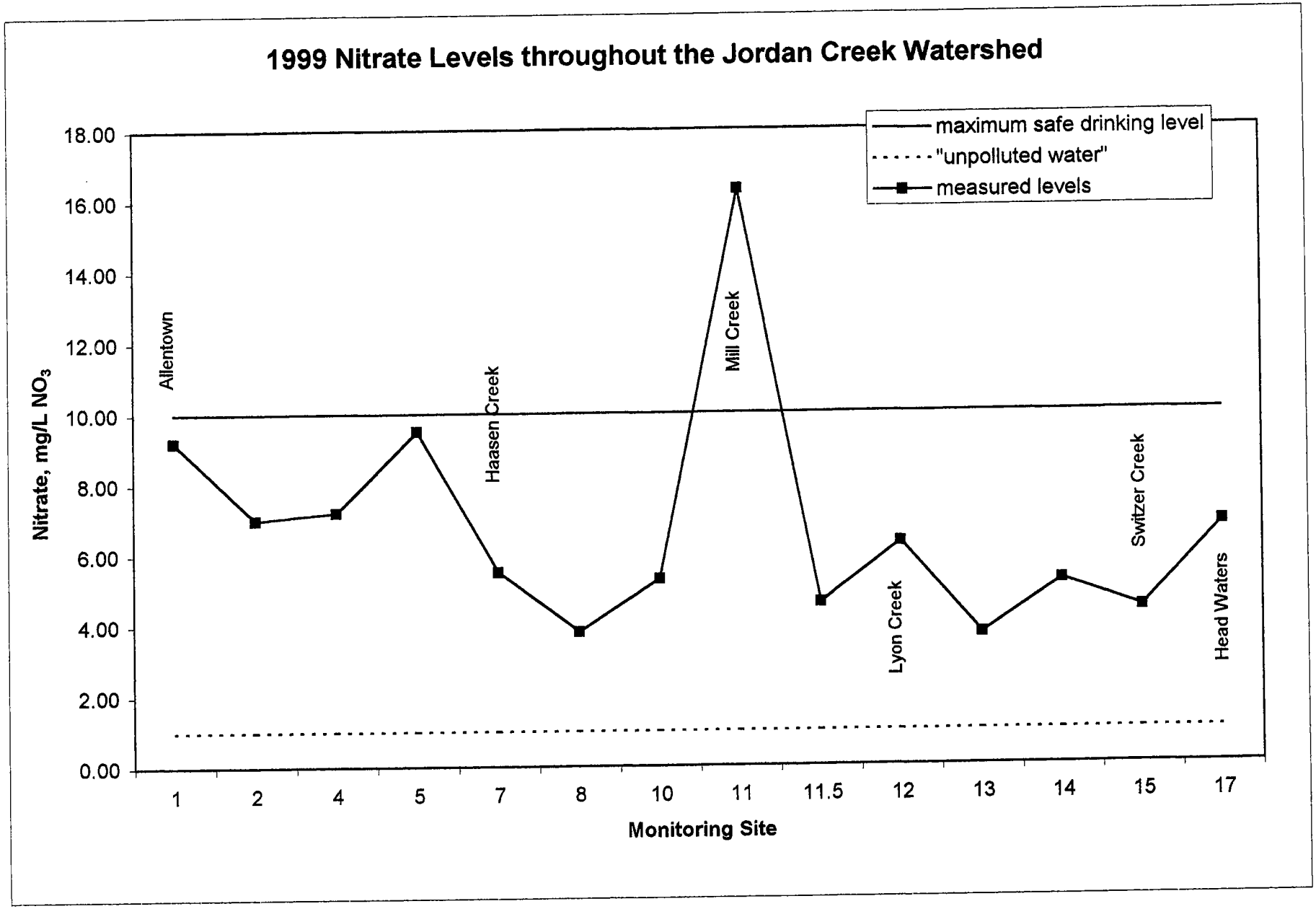


Figure B7. Nitrate

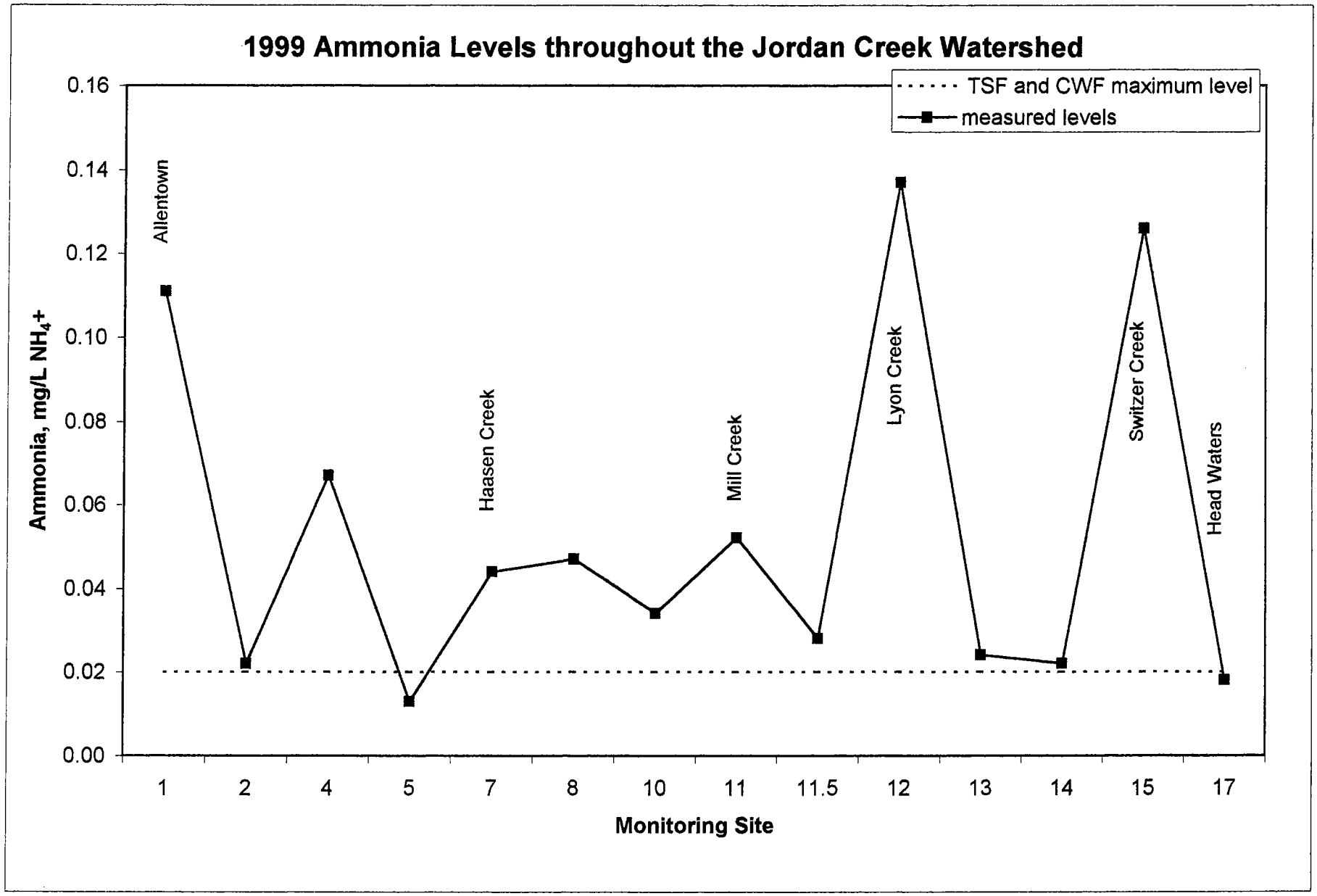


Figure B8. Ammonia

Table B3. Explanation of Water Quality Parameters

pH

Background: pH is based on a scale from 1 to 14. On this scale, 0 is the most acidic value, and 14 is the most alkaline value. Seven would be neutral. A change of one pH unit represents a 10-fold change in acidity or alkalinity. Type of bedrock and other natural conditions may affect pH readings. For instance, streams underlain by limestone may reach a pH as high as 9. In addition, abundance of algae may cause pH to become more acidic after sundown, and then increase after dawn due to changes in carbon dioxide concentrations. However, abnormal pH values may be indicative of pollution.

Sources of Abnormal Readings: Sources of abnormal readings include abandoned mine drainage, industrial effluent, acid rain, sewage lagoons, and livestock containment areas. Sources of alkaline conditions include concrete plants, water treatment plants, and raw sewage.

Standards: pH levels between 6.5 and 8.2 are optimal for most aquatic organisms. The Department of Environmental Protection Water Quality Standard for pH is between 6 and 9.

SPECIFIC CONDUCTANCE/TOTAL DISSOLVED SOLIDS

Background: The specific conductance of a stream measures the quantity of ions in the water, or the ability of the water to conduct an electrical current. Conductivity is typically measured in microhoms. Geologic formations have significant impact on the specific conductance of a stream. Streams flowing through carbonate bedrocks often yield high conductivity. Specific conductance values typically have a direct relationship to total dissolved solids (TDS), which is the concentration of dissolved materials, such as salts, found in the water.

Sources of Abnormal Readings: A specific conductance or TDS value falling outside the normal range for a site may be caused by almost any pollutant. Point source discharges as well as storm water runoff may be contributors to excessive readings. Basically these testing parameters serve as a check to make sure pollutants are not being overlooked that are not part of the regular sampling routine.

ALKALINITY

Background: Alkalinity measures the ability of a stream to resist changes in pH. This property is often referred to as the buffering capacity of a stream. Buffering capacity is important because it allows a stream to assimilate acidic pollution or contamination. Like specific conductance, alkalinity is greatly determined by the type of underlying bedrock and also the soil type through which the water flows.

Source of Abnormal Readings: Alkalinity values in excess of what bedrock types indicate as normal may be a result of sewage, livestock wastes, and/or the production of concrete. Very low readings may be due to heavy rains or other acidic contamination. Abrupt changes in alkalinity may signify pollution.

Standards: Alkalinity levels between 100 and 200 mg/L provide ideal buffering within a stream. Endurable pH levels may be maintained at this level of alkalinity, and aquatic life may be protected from acidic shock. This occurs when there is a sudden increase or decrease in pH that aquatic life can not rapidly adapt to for survival.

TOTAL HARDNESS

Background: Total hardness tests usually measure the calcium and magnesium carbonate concentration in a water sample. These are the major components of hardness, which is the amount of dissolved minerals in water. Minerals are dissolved from bedrock and soil as water passes through them. The calcium component of hardness is very important to aquatic life as it is used for the cell walls of plants and the shells and bones of aquatic organisms. However, high levels of hardness can cause precipitation and deposition of calcium carbonate on the stream bottom, which disrupts normal stream activity. Water with high hardness may also cause indoor plumbing problems. Hard water also aids buffering capacity as heavy metals and other toxic compounds may be more detrimental in soft water than in hard water.

Sources of Abnormal Readings: High hardness values are often associated with limestone formations.

Standards: Optimal values of hardness for aquatic life range from 100 to 200 mg/L. At levels above 250 mg/L, calcium carbonate will begin to precipitate. Hardness values should be slightly higher than alkalinity values. If there is a major difference between the two values, chloride and sulfate ions may be present.

CALCIUM

Background: Calcium is the most abundant of the alkaline-earth metals and is a major constituent of many common rock minerals. It is an essential element for plant and animal life and is a major component of the solutes in most natural water.

Sources of Abnormal Readings: Calcium is generally a predominant cation in river waters. Measured pH in river water is generally not well correlated with calcium concentration.

Standards: The average concentration of calcium in river water is between 13.4 to 15 mg/L.

TEMPERATURE

Background: Temperature is a key determinant of what species can survive in a particular environment. Although temperature preferences vary widely among species, they do have one commonality. All species are negatively impacted by rapid fluctuations in temperature.

Sources of Abnormal Readings: Discharges of coolant and waste waters from industrial or utility plants, runoff from heated surfaces such as pavement and roofs, and lack of stream cover to provide shading are among the top sources of thermal pollution.

Standards: Life and the reproductive necessities for trout are the target standards for water temperature. Growth is impaired in an adult brook trout at temperatures above 66°F or about 19°C. Death of brook trout will occur at temperatures above 75°F or about 24°C. DEP Water Quality Standards dictate a temperature no greater than 66°F for a high quality, cold water fishery (HQ-CWF). There should also be no fluctuation greater than 2°F in a one-hour period.

DISOLVED OXYGEN

Background: Dissolved oxygen is absorbed from the atmosphere and its concentration is related to the temperature and density of the water. Cold water can hold more oxygen than warm water. Therefore low values can sometimes be attributed to shallow, poorly shaded water, which can cause warming and decrease the amount of oxygen the water can hold. The decomposition of organic material can also lower levels of dissolved oxygen. Plant life also influences dissolved oxygen content. Plant life may cause a diurnal fluctuation in DO levels. During the day, while plants are undergoing photosynthesis, they emit oxygen to the stream. However, the DO level will drop at night while the plants are not producing oxygen but fish and other aquatic life are still consuming it. The result is a drop in DO at night, reaching a minimum just before dawn, then rising to a peak by late afternoon. Thus, plant life may have a dramatic impact on DO levels.

Sources of Abnormal Readings: In areas of dense algae growth, DO levels are likely to drop significantly at night or increase excessively during the day. Low readings may also be indicative of pollutants, such as inadequately treated sewage, introduced to the water supply that consume the available oxygen so that it is not available to aquatic life. Bacteria are capable of consuming large quantities of oxygen during the decomposition of organic material. High DO levels may occur where turbulent conditions increase the natural aeration of the stream.

Standards: Trout require a dissolved oxygen (DO) level of at least 7 mg/L for unimpaired production, which is the minimum Water Quality Standard set by the DEP for a high quality, cold-water fishery (HQCWF) such as the Jordan Creek.

NITROGEN

Background: Nitrogen exists in several forms in the aquatic environment. Nitrate is the most completely oxidized state of nitrogen commonly found in water, and is the most readily available state utilized for plant growth. Since nitrate plays a key role in stimulating plant growth, it is heavily used as a nutrient component of fertilizer. High nitrate levels in streams cause excessive plant and algae growth and promote a deteriorating process called eutrophication.

Sources of Abnormal Readings: Fertilizer runoff resulting from improper application, human and animal wastes from failing septic systems and sewage treatment plants and livestock confinement areas, and decomposing organic matter are all causes for elevated nitrate readings.

Standards: Unpolluted waters will normally have a nitrate level less than 1 mg/L. The DEP Water Quality Standard for nitrate is 10 mg/L. At higher concentrations water is unsafe to drink due to the possible presence of altered forms of nitrite, which may cause serious illness to both man and wildlife.

ORTHO-PHOSPHATE

Background: Ortho-phosphate is just one form of phosphorus found in natural waters. This is the tested form of phosphate because it is the form of phosphate used in fertilizer and applied to agricultural fields and residential lawns. Other forms of phosphorus found in natural waters that have not been tested include polyphosphates, and organically bound phosphates. Phosphates naturally found in water are derived from decomposing organic material and leaching of phosphorus rich bedrock. Like nitrates, phosphates negatively impact water by causing accelerated rates of eutrophication.

Sources of Abnormal Readings: Fertilizer runoff; human and animal waste from failing septic systems, sewage treatment plants, and livestock confinement areas; mass quantities of decomposing organic matter; industrial effluent; and detergent wastewater are all possible sources of elevated phosphate levels.

Standards: Phosphate levels below 0.03 mg/l are generally considered to be unpolluted. Levels between 0.03 and 0.1 mg/l are sufficient to stimulate plant growth. The critical level for avoiding accelerated eutrophication is 0.1 mg/L. Levels above 0.1 mg/l are considered problem areas. There has not been a standard set for safe drinking water because humans can tolerate extremely high levels before it even takes affect on the digestive system.

APPENDIX C

JORDAN CREEK MACRO-INVERTEBRATE AND FISH DATA AND ANALYSIS

Table C1. 1999 Jordan Creek Macro-Invertebrate Sampling Data

(Source: Lehigh University and Wildlands Conservancy)

Class	Family	EPA PTR*	Feeding Group**	Sampling Site 1	2	3	4	5	6	Total Individuals
Coleoptera	Psephenidae	4	SC	2	6	1	1	9	1	**20**
	Gyrinidae	N/A	PR	0	1	0	0	0	0	**0**
	Elmidae	4	SC	18	24	36	41	121	58	**298**
Ephemeroptera	Ephemerellidae	1	CG	4	0	6	3	32	2	**47**
	Heptagenidae	4	CG	8	13	13	1	6	2	**43**
	Baetidae	4	CG	2	9	14	7	6	0	**38**
	Leptophlebidae	2	CG	0	1	0	0	0	0	**1**
	Caenidae	7	CG / CF	1	15	71	19	15	12	**133**
	Tricorythidae	4	CG	0	2	0	1	0	0	**3**
Plecoptera	Perlidae	1	PR	1	8	3	0	0	0	**12**
	Perlodidae	2	PR / SC / CG	7	2	1	0	0	1	**11**
Trichoptera	Hydropyschidae	4	CF	9	33	5	9	6	85	**147**
	Hydroptilidae	4	SC / CG	3	3	9	0	6	13	**34**
	Philopotamidae	3	CF	0	9	3	20	9	2	**43**
	Limnephilidae	4	SH / CG / SC	1	0	1	0	1	0	**3**
	Glossosomatidae	0	SC	0	1	0	0	0	0	**1**
	Uenoidae	N/A	SC / CG	0	1	0	0	0	0	**1**
	Helicopsychidae	3	SC	0	0	0	2	3	1	**6**
Diptera	Chironomidae	6	CG / 10% PR	84	163	86	22	67	224	**646**
	Ceratopogonidae	6	PR / CG	2	0	2	3	1	0	**8**
	Tipuliidae	3	CG	7	9	3	0	2	2	**23**
Odonata	Gomphidae	1	PR	0	0	0	0	2	0	**2**
	Coenagriondae	9	PR	0	0	1	0	0	0	**1**
Hemiptera	Veliidae	N/A	PR	3	11	9	0	1	0	**24**
	Gerridae	N/A	PR	0	0	0	0	0	0	**0**
Megaloptera	Corydalidae	0	PR	1	1	0	0	0	0	**2**
	Sialidae	4	PR	0	0	1	0	0	0	**1**
Mollusca	Bivalvia	N/A	CF	0	1	1	2	1	0	**5**
Gastropoda	Gastropoda	N/A	N/A	0	0	0	6	7	0	**13**
Annelida	Oligachaeta	6 to 10	N/A	8	7	0	4	0	1	**20**
	Hirudinea	10	N/A	0	0	5	0	17	11	**33**
			TOTALS	**161**	**320**	**271**	**141**	**312**	**415**	**1621**

*EPA Pollution Tolerance Rating
(0-3.75 excellent) (3.76-4.25 very good) (4.26-5 good) (5.01-5.75 fair) (5.76-6.5 fairly poor) (6.51-7.25 poor) (>7.26 very poor)

** Macro-invertebrate Functional Feeding Group
CG=Collector Gatherers SH=Shredders
SC=Scrapers CF=Collector Filterers PR=Predators

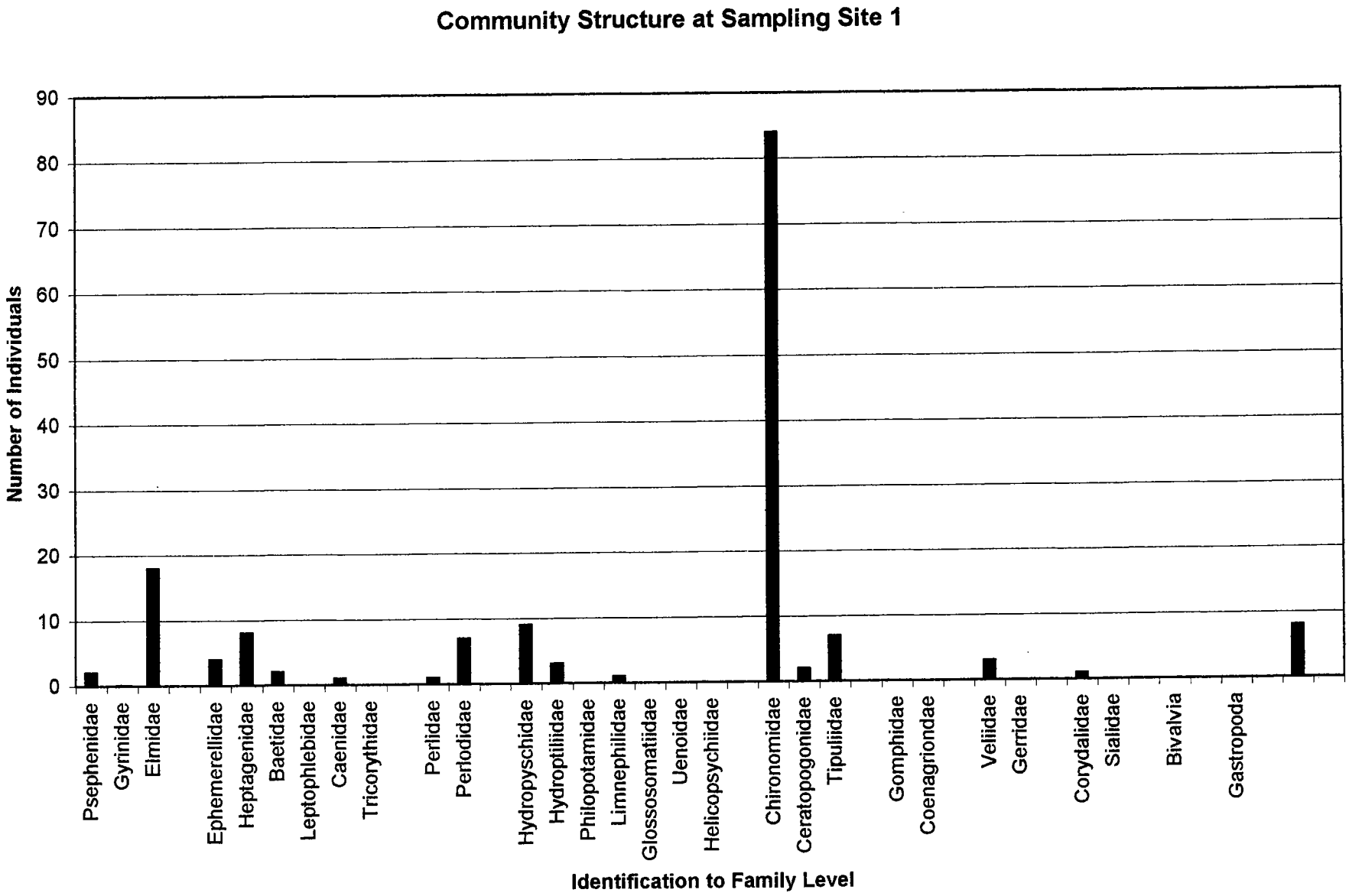

Community Structure at Sampling Site 1
Number of Individuals
90
80
70
60
50
40
30
20
10
0
Psephenidae
Gyrinidae
Elmidae
Ephemerellidae
Heptagenidae
Baetidae
Leptophlebidae
Caenidae
Tricorythidae
Perlidae
Perlodidae
Hydropyschidae
Hydroptiliidae
Philopotamidae
Limnephilidae
Glossosomatiidae
Uenoidae
Helicopsychiidae
Chironomidae
Ceratopogonidae
Tipuliidae
Gomphidae
Coenagriondae
Veliidae
Gerridae
Corydalidae
Sialidae
Bivalvia
Gastropoda
Identification to Family Level

Figure C1a.

Percent Composition of Macro-Invertebrate Community at Sampling Site1

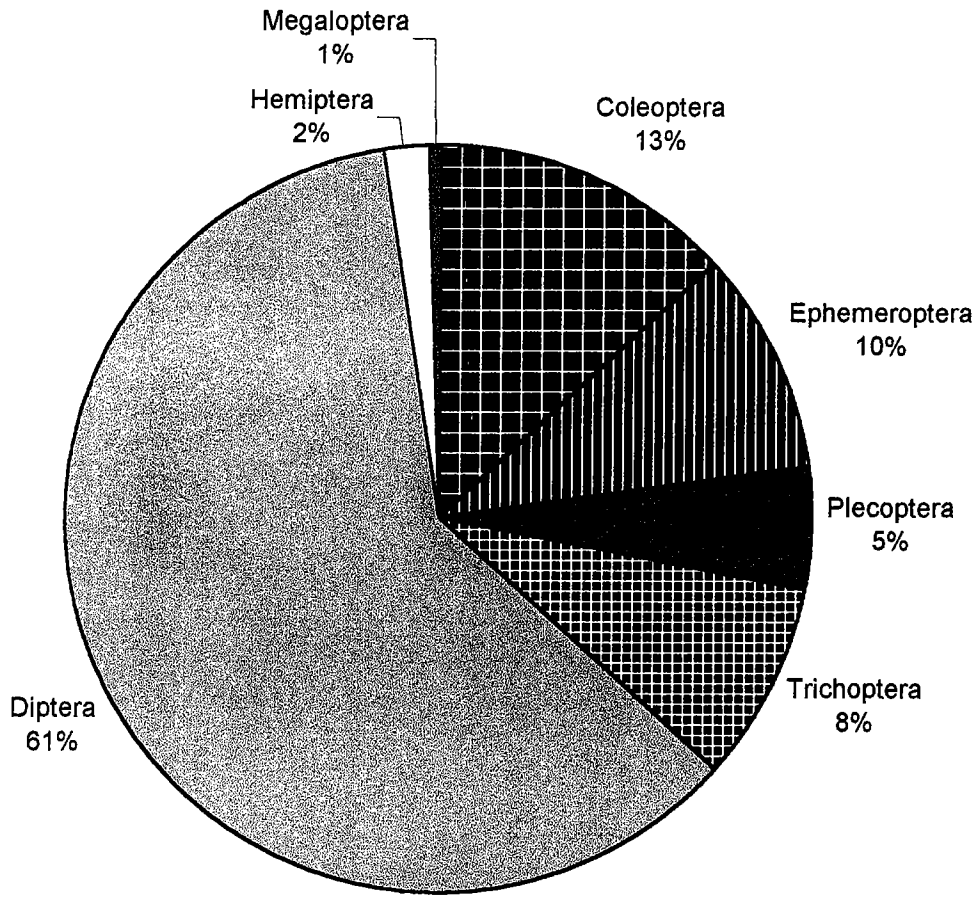


Figure C1b

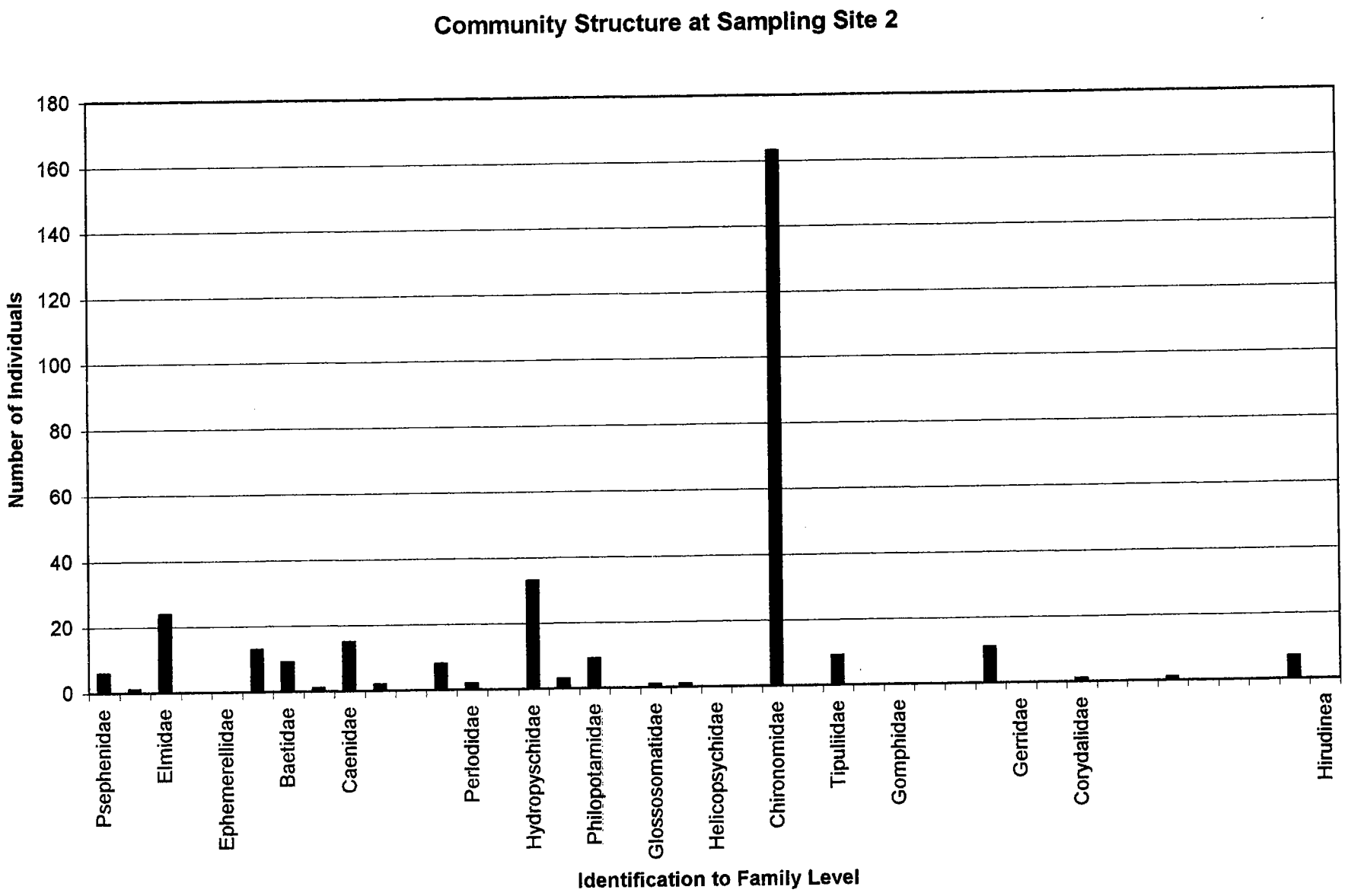

Community Structure at Sampling Site 2
Number of Individuals
180
160
140
120
100
80
60
40
20
0
Psephenidae
Elmidae
Ephemerellidae
Baetidae
Caenidae
Perlodidae
Hydropyschidae
Philopotamidae
Glossosomatidae
Helicopsychidae
Chironomidae
Tipuliidae
Gomphidae
Gerridae
Corydalidae
Hirudinea
Identification to Family Level

Figure C2a.

Percent Composition of Macro-Invertebrate Community at Sampling Site 2

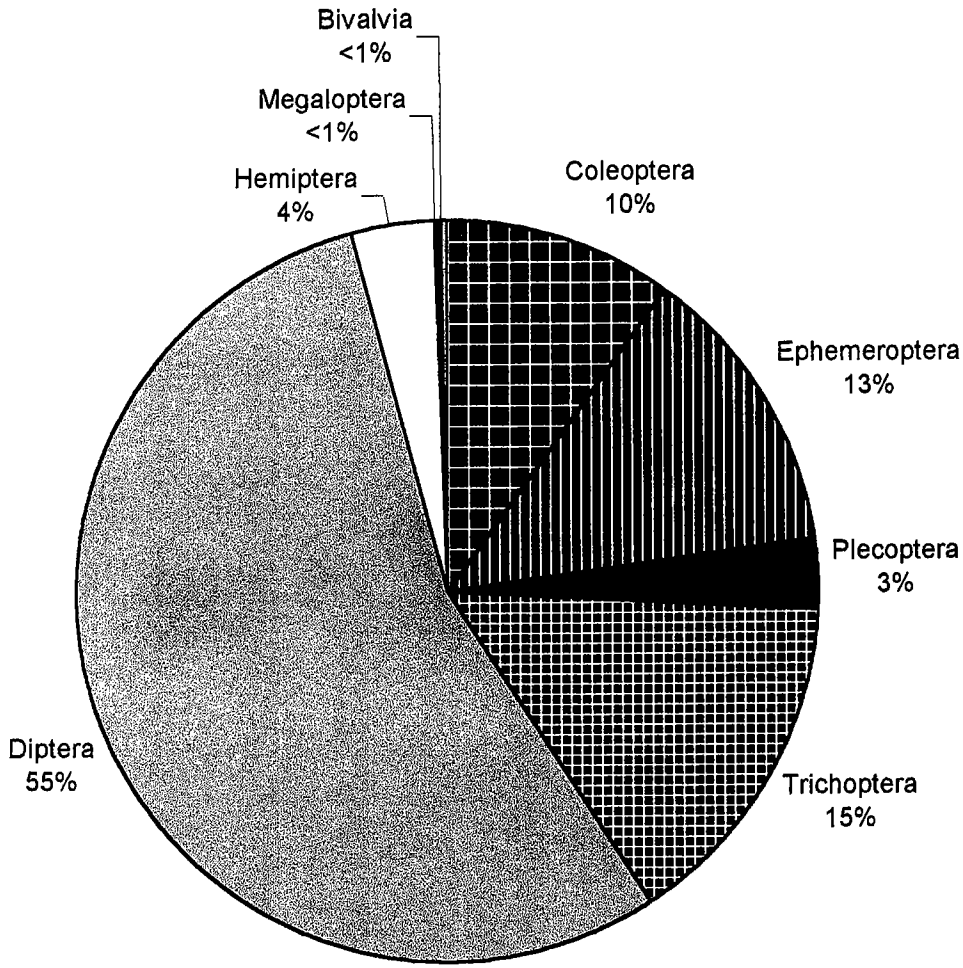


Figure C2b

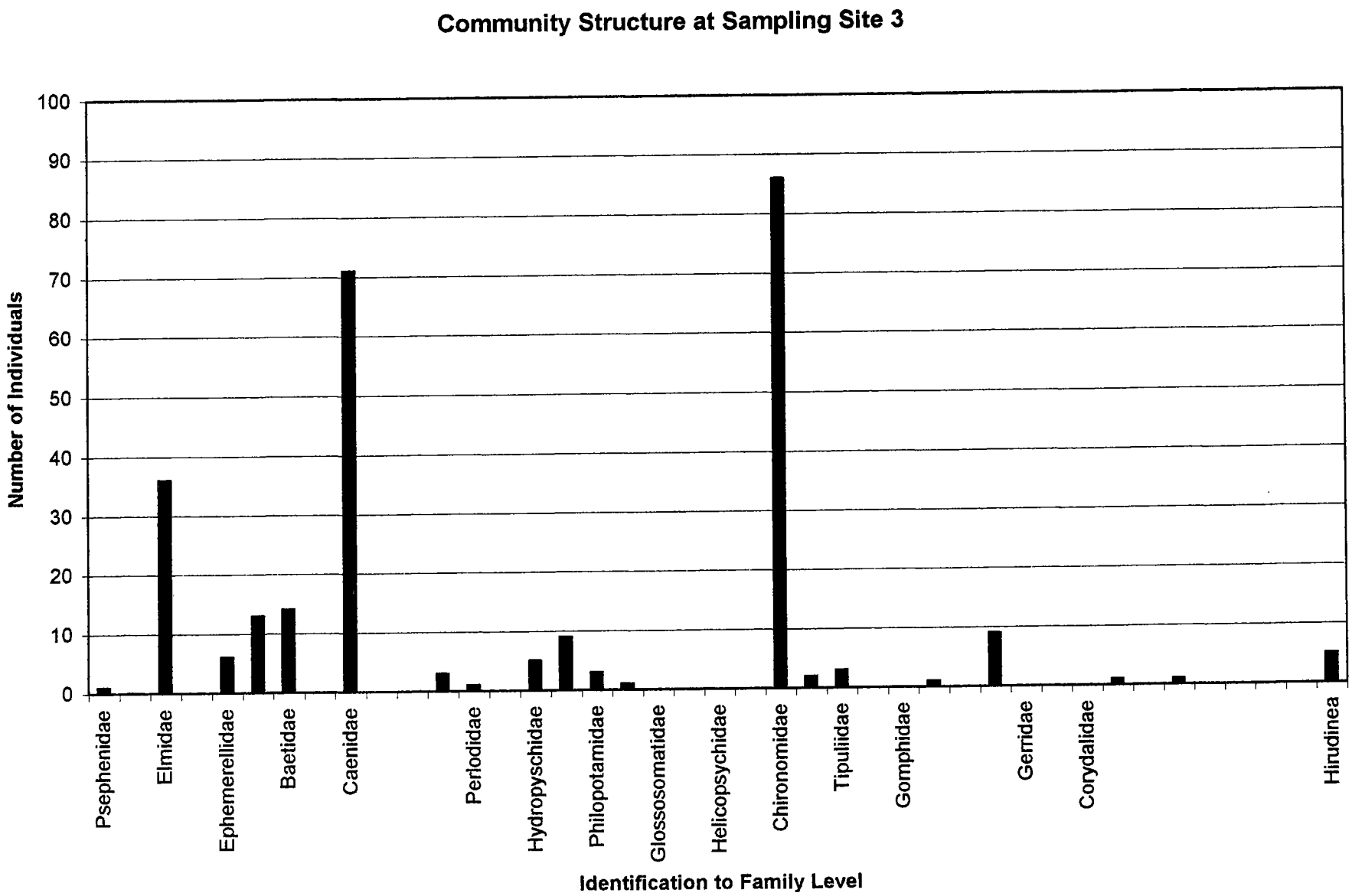

Community Structure at Sampling Site 3
Number of Individuals
100
90
80
70
60
50
40
30
20
10
0
Psephenidae
Elmidae
Ephemerellidae
Baetidae
Caenidae
Perlodidae
Hydropyschidae
Philopotamidae
Glossosomatidae
Helicopsychidae
Chironomidae
Tipuliidae
Gomphidae
Gerridae
Corydalidae
Hirudinea
Identification to Family Level

Figure C3a.

Percent Composition of Macro-Invertebrate Community at Sampling Site 3

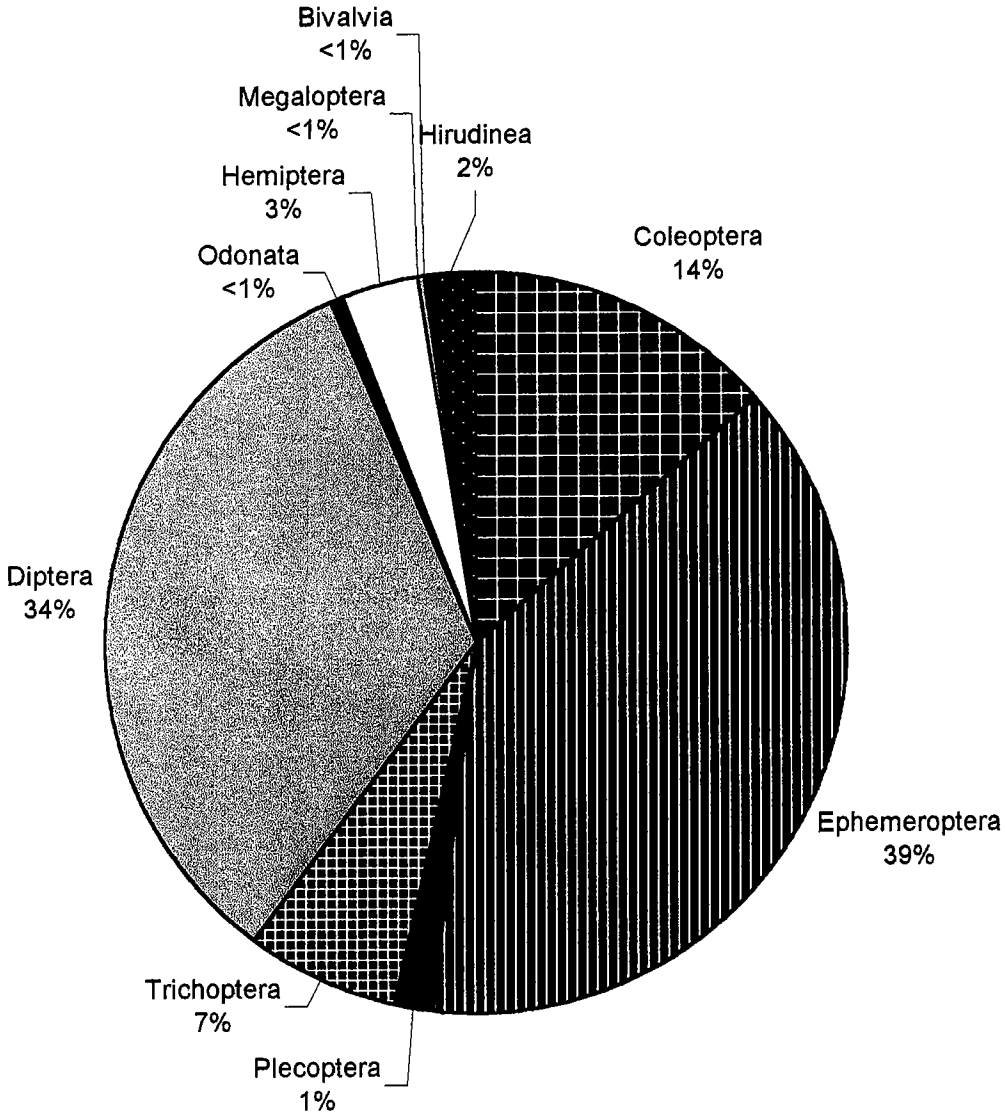


Figure C3b

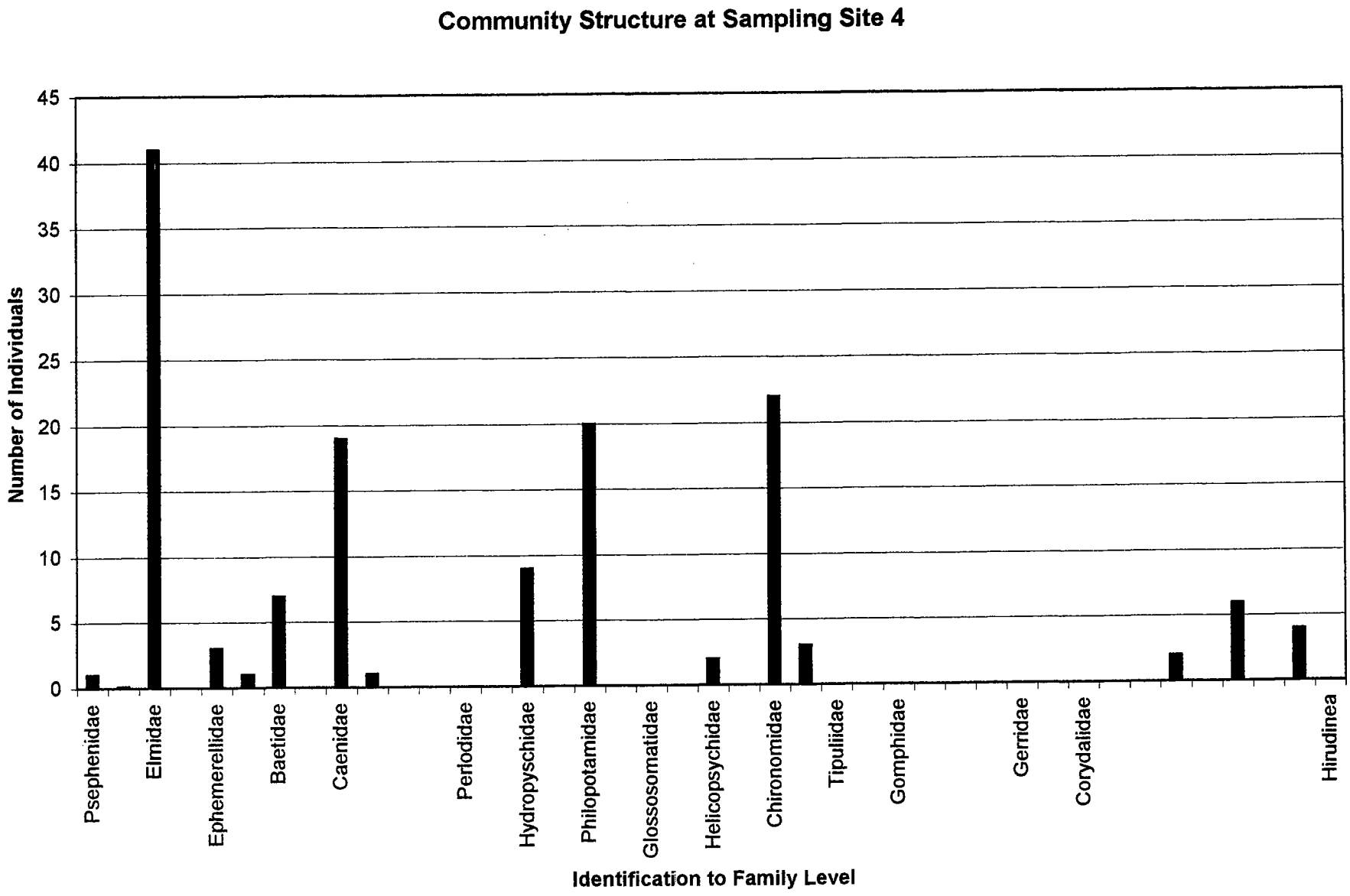

Community Structure at Sampling Site 4
Number of Individuals
45
40
35
30
25
20
15
10
5
0
Psephenidae
Elmidae
Ephemerellidae
Baetidae
Caenidae
Perlodidae
Hydropyschidae
Philopotamidae
Glossosomatidae
Helicopsychidae
Chironomidae
Tipuliidae
Gomphidae
Gerridae
Corydalidae
Hirudinea
Identification to Family Level

Figure C4a.

Percent Composition of Macro-Invertebrate Community at Sampling Site 4

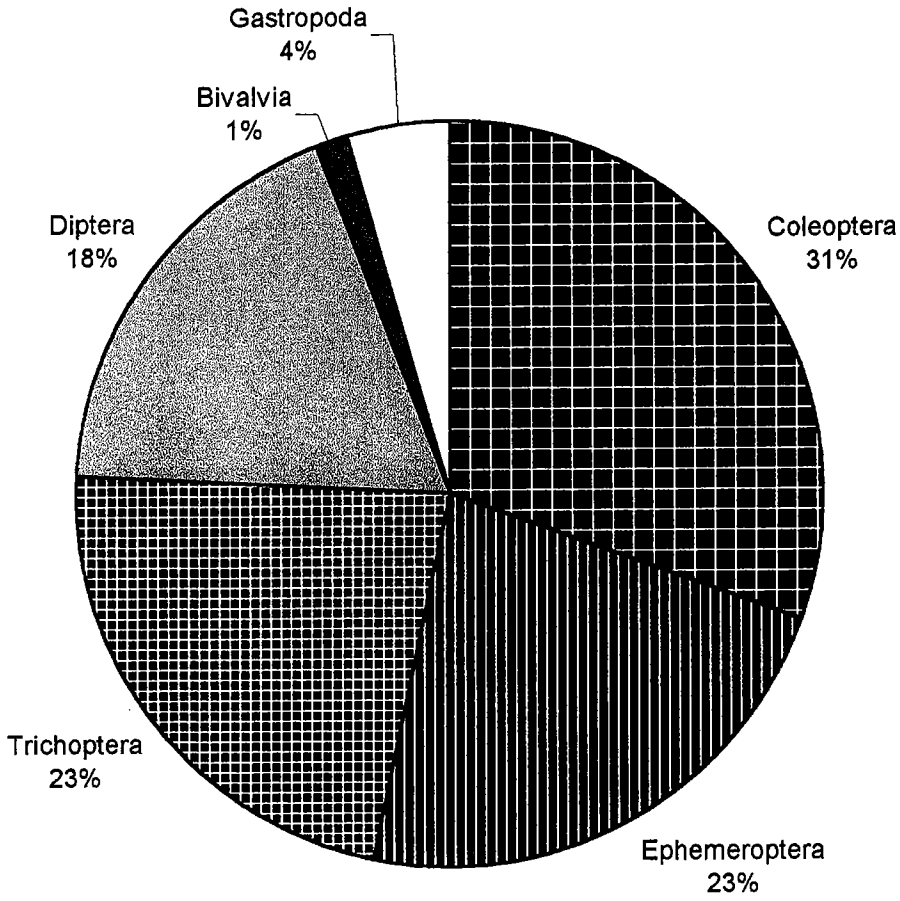


Figure C4b

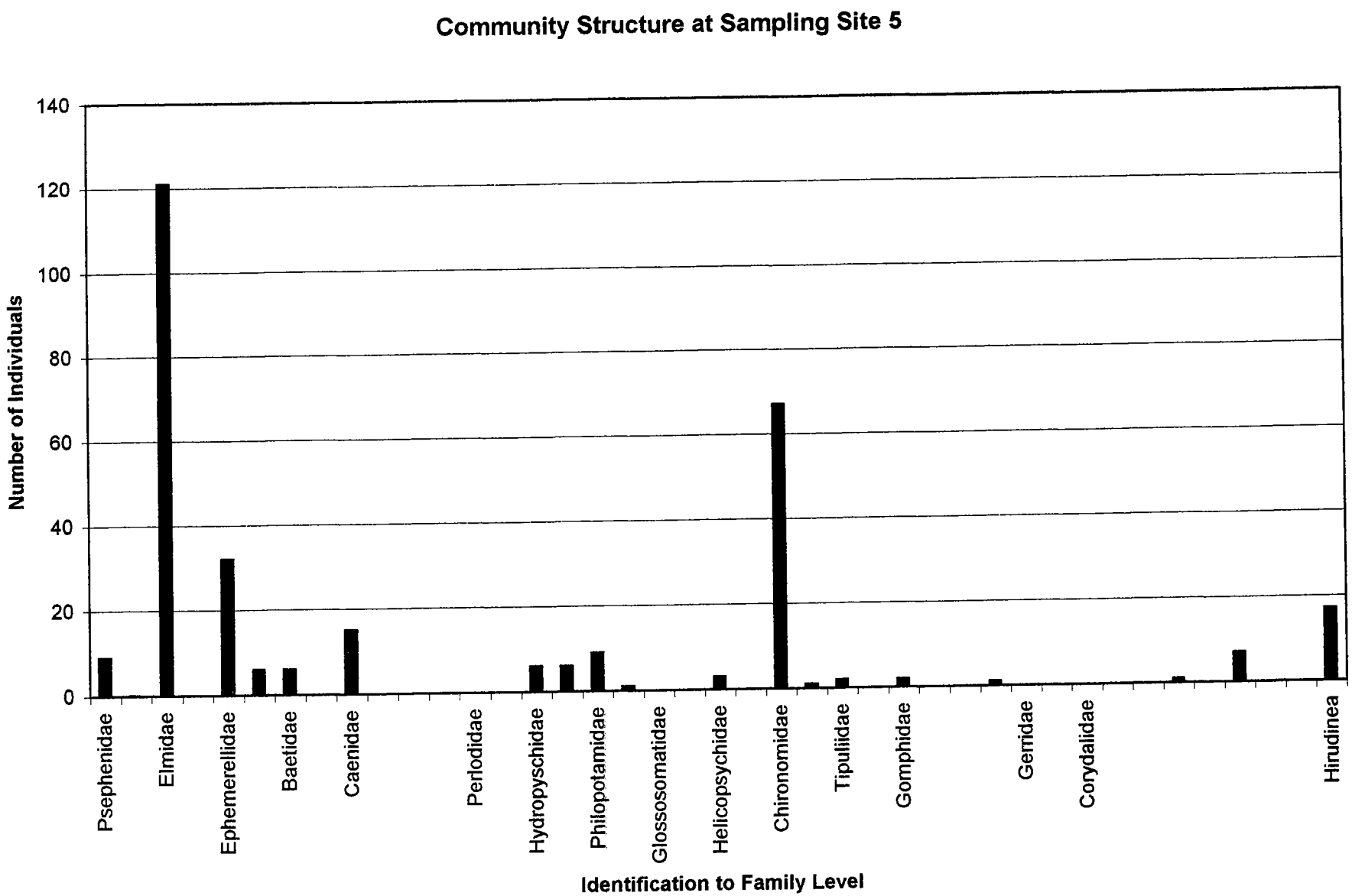

Community Structure at Sampling Site 5
Number of Individuals
140
120
100
80
60
40
20
0
Psephenidae
Elmidae
Ephemerellidae
Baetidae
Caenidae
Perlodidae
Hydropyschidae
Philopotamidae
Glossosomatidae
Helicopsychidae
Chironomidae
Tipulidae
Gomphidae
Gerridae
Corydalidae
Hirudinea
Identification to Family Level

Figure C5a.

Percent Composition of Macro-Invertebrate Community at Sampling Site 5

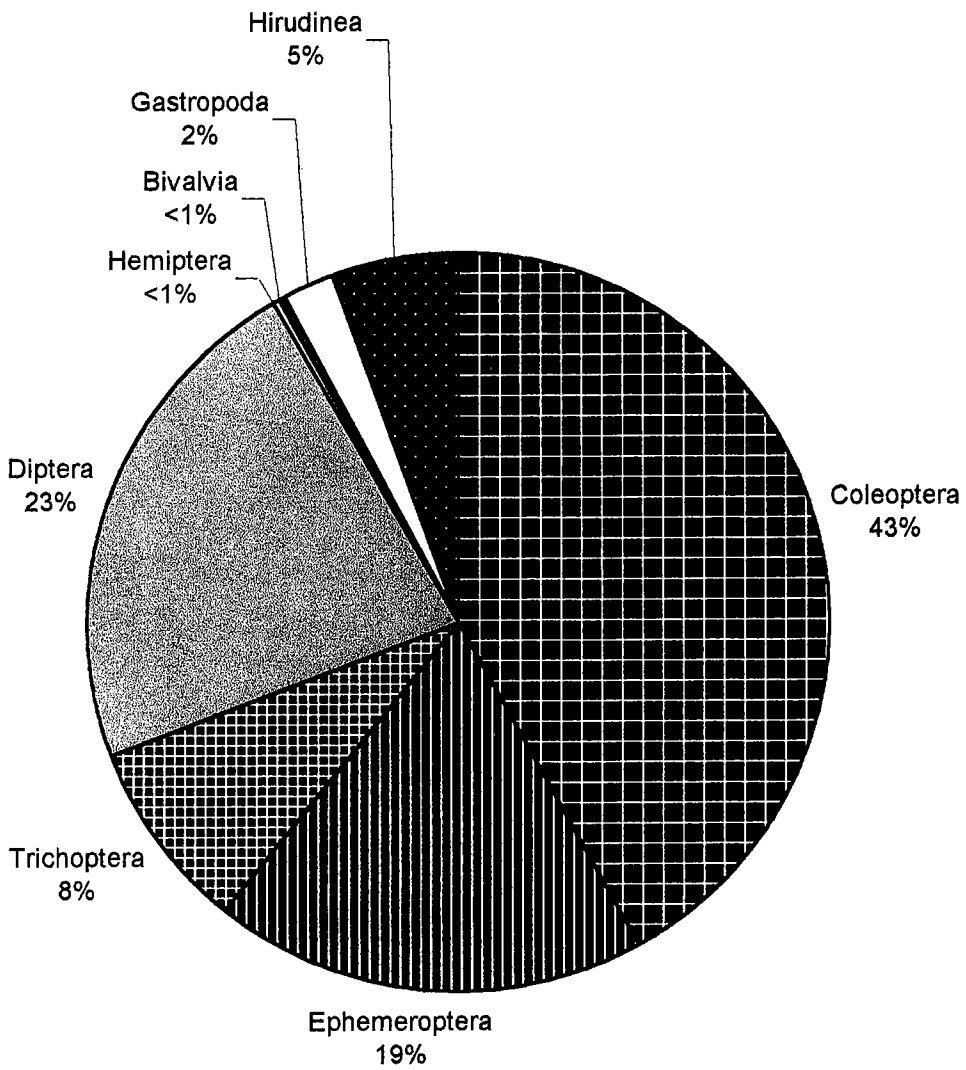


Figure C5b

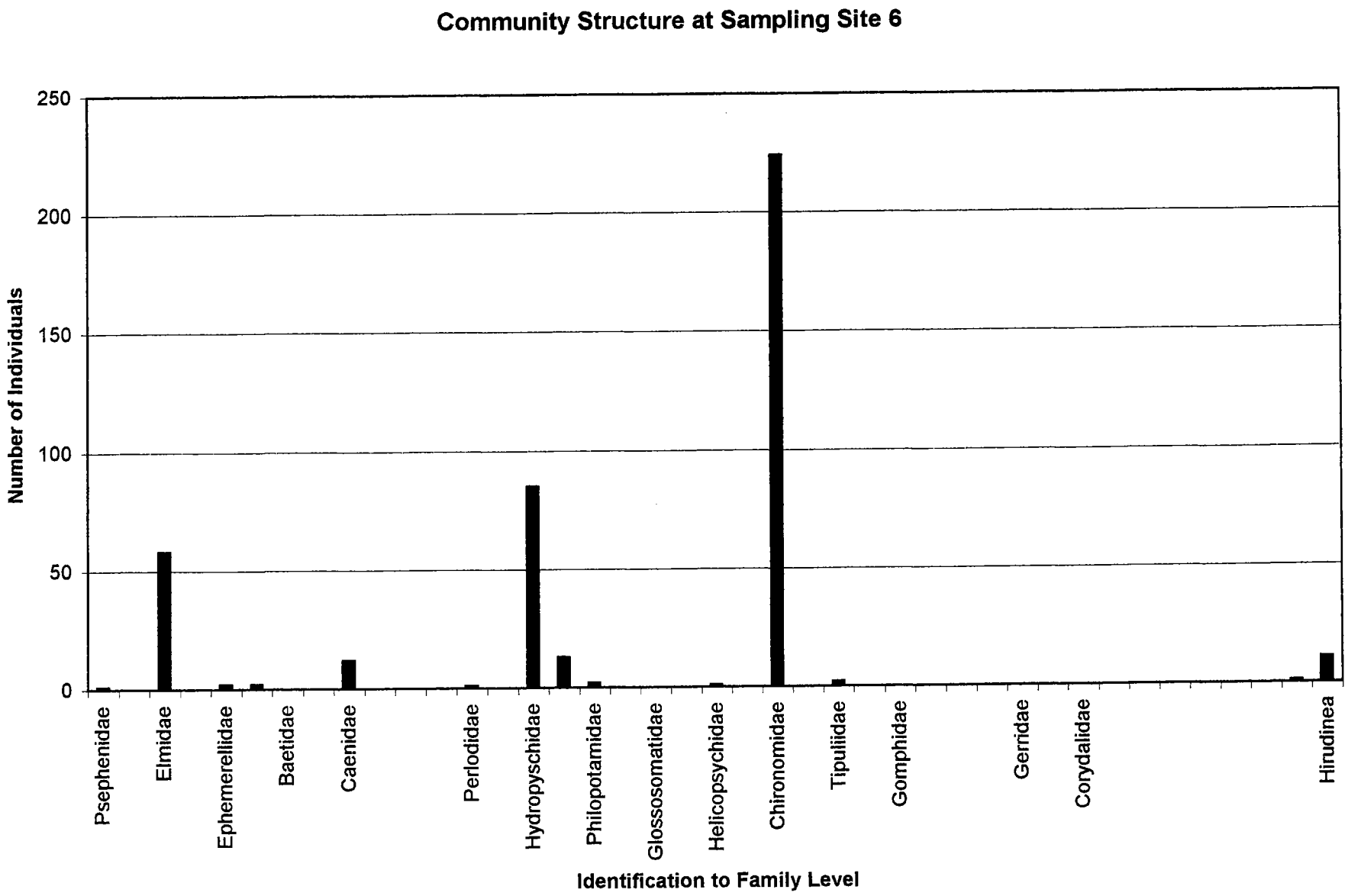

Community Structure at Sampling Site 6
Number of Individuals
250
200
150
100
50
0
Psephenidae
Elmidae
Ephemerellidae
Baetidae
Caenidae
Perlodidae
Hydropyschidae
Philopotamidae
Glossosomatidae
Helicopsychidae
Chironomidae
Tipuliidae
Gomphidae
Gerridae
Corydalidae
Hirudinea
Identification to Family Level

Figure C6a.

Percent Composition of Macro-Invertebrate Community at Sampling Site 6

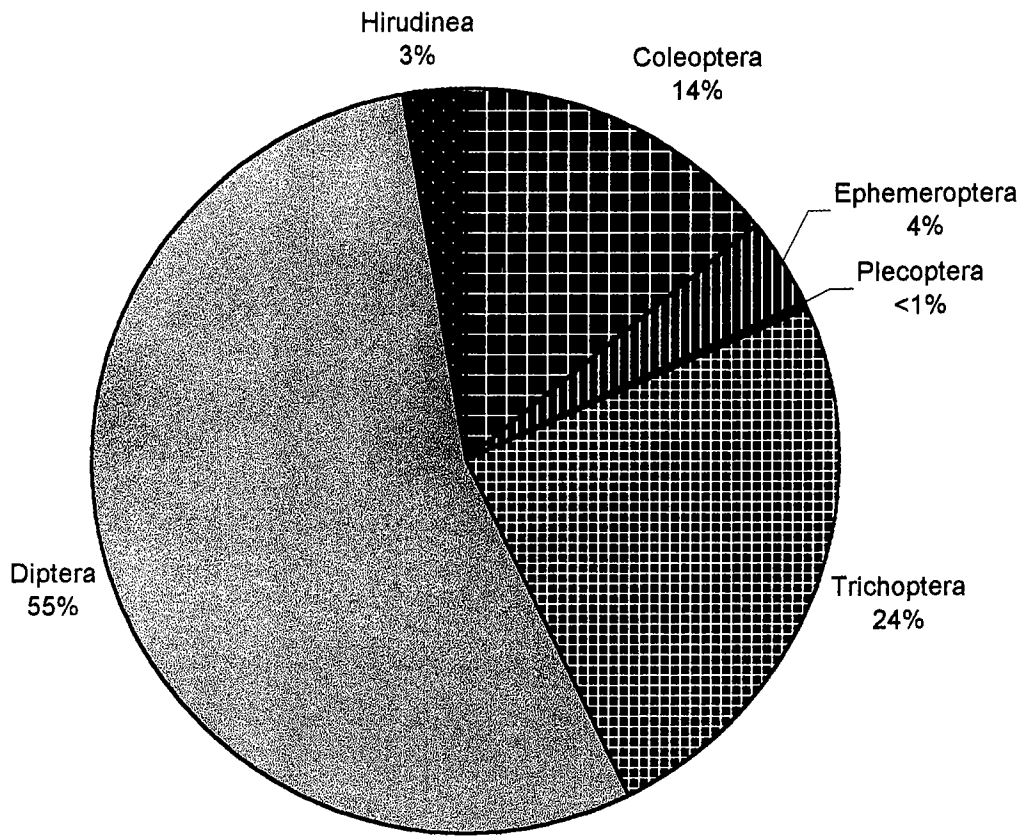


Figure C6b

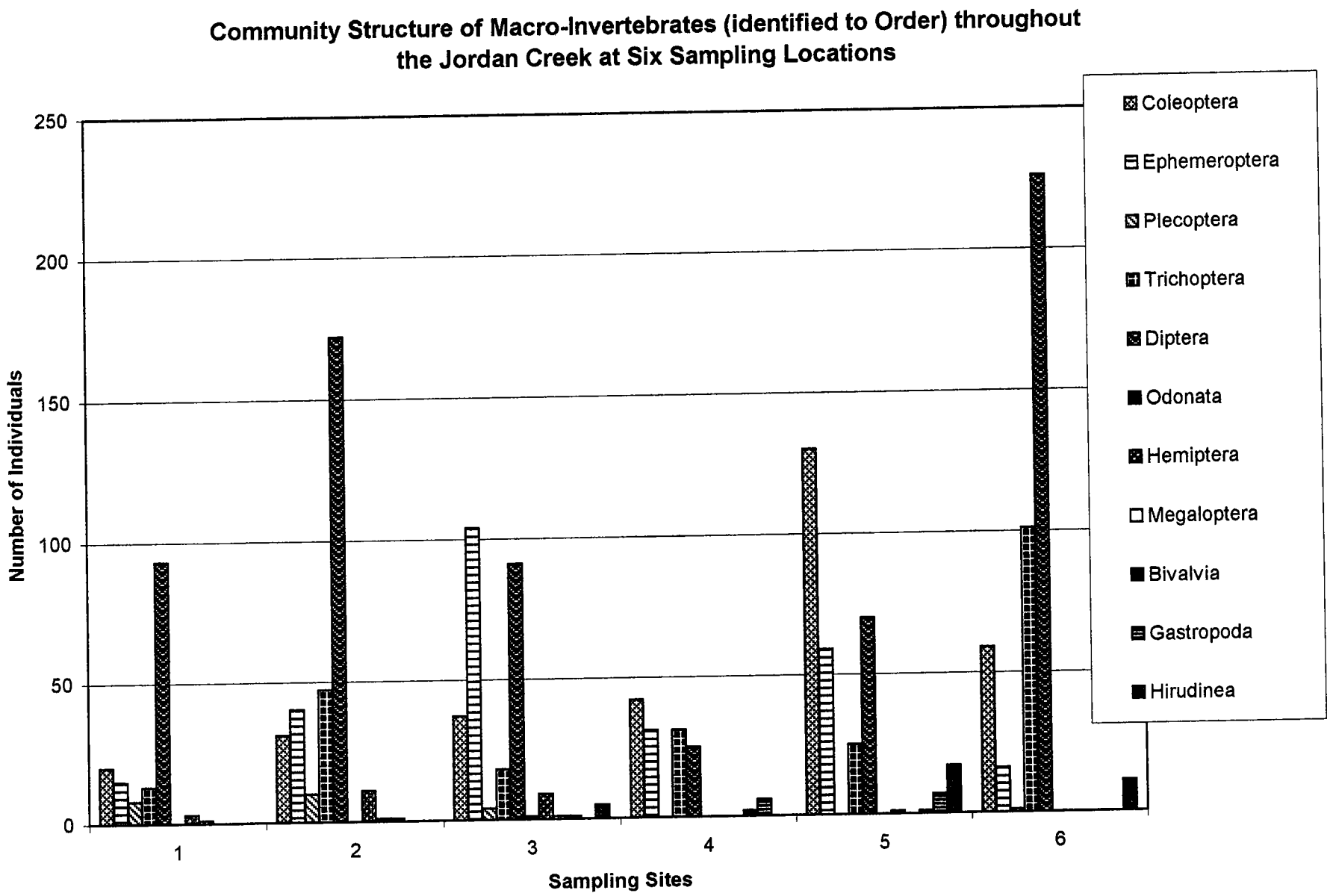

Community Structure of Macro-Invertebrates (identified to Order) throughout the Jordan Creek at Six Sampling Locations
Number of Individuals
250
200
150
100
50
0
1
2
3
4
5
6
Sampling Sites
Coleoptera
Ephemeroptera
Plecoptera
Trichoptera
Diptera
Odonata
Hemiptera
Megaloptera
Bivalvia
Gastropoda
Hirudinea

Figure C7

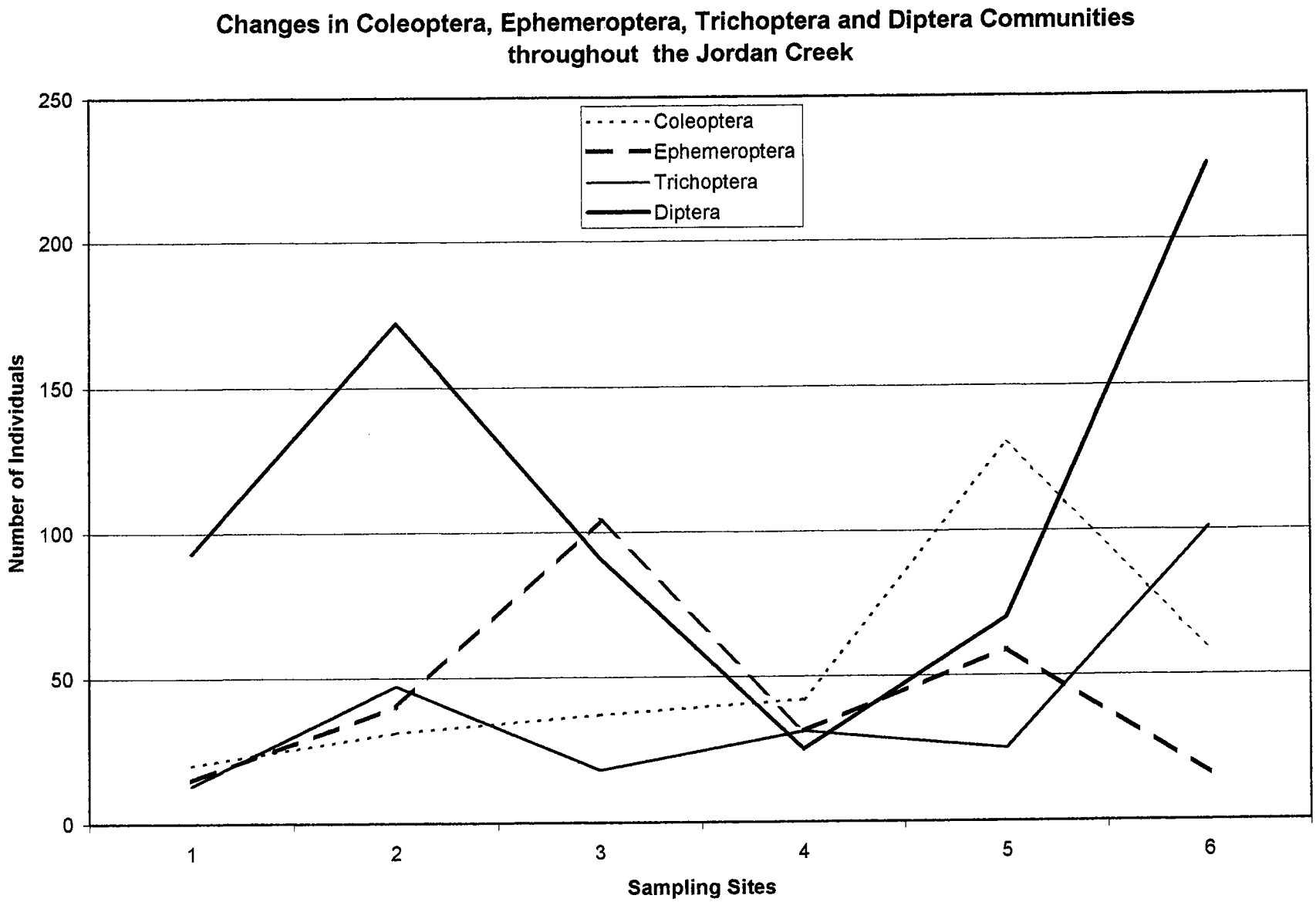

Changes in Coleoptera, Ephemeroptera, Trichoptera and Diptera Communities throughout the Jordan Creek
Coleoptera
Ephemeroptera
Trichoptera
Diptera
Number of Individuals
250
200
150
100
50
0
1
2
3
4
5
6
Sampling Sites

Figure C8

Table C2. Educational Fish Survey 1988, Jordan Creek, 6-29-88

Species	Scientific Name		Station 1	2	3	4	Tolerance Rating
American Eel	*Anguilla rostrata*		2	0	0	0	Tolerant
Banded Killifish	*Fundulus diaphanus*		17	11	5	0	Tolerant
Blacknose Dace	*Rhinichthys atratulus*		1	4	0	0	Tolerant
Bluntnose Minnow	*Pimephales notatus*		0	0	2	0	Tolerant
Brown Bullhead	*Ictalurus nebulosus*		0	1	2	84	Tolerant
Brown Trout	*Salmo trutta*		1	0	0	0	Intolerant
Carp	*Cyprinus carpio*		0	0	0	2	Tolerant
Comely Shiner	*Notropis ameonus*		13	1	0	1	Tolerant
Common Goldfish	*Carassius auratus*		1	0	2	0	Tolerant
Common Shiner	*Notropis cornutus*		7	5	1	0	Intermediate
Cutlips Minnow	*Exoglossum maxillingua*		1	1	0	0	Intolerant
Fallfish	*Semotulus corporalis*		10	1	0	0	Intermediate
Golden Shiner	*Notemigonas crysoleucas*		1	0	1	0	Tolerant
Largemouth Bass	*Micropterus salmoides*		0	0	0	2	Intermediate
Marginated Madtom	*Noturus insignis*		2	0	0	0	Intermediate
Pumpkinseed	*Lepomis gibbosus*		23	1	8	3	Intermediate
Redbreast Sunfish	*Lepomis auritus*		2	0	4	0	Intermediate
Rockbass	*Ambloplites repositories*		17	4	0	0	Intermediate
Satinfin Shiner	*Notropis analostanus*		6	2	0	0	Tolerant
Smallmouth Bass	*Micropterus dolomieui*		1	0	0	0	Intermediate
Spottail Shiner	*Notropis hudsonius*		9	0	0	0	Intermediate
Tessalated Darter	*Etheostoma olmstedi*		2	0	0	0	Intermediate
White Sucker	*Catostomas commersoni*		16	23	0	0	Tolerant
	Total Species		**19**	**11**	**8**	**5**	

Table C3. Educational Fish Survey 1988, Jordan Creek, 10-19-88

			Station		
Species	**Scientific Name**		**1**	**2**	**Tolerance Rating**
Banded Killifish	*Fundulus diaphanus*		2	1	Tolerant
Blacknose Dace	*Rhinichthys atratulus*		7	3	Tolerant
Comely Shiner	*Notropis ameonus*		0	12	Tolerant
Common Shiner	*Notropis cornutus*		2	1	Intermediate
Cutlips Minnow	*Exoglossum maxillingua*		2	2	Intolerant
Fallfish	*Semotulus corporalis*		7	21	Intermediate
Golden Shiner	*Notemigonas crysoleucas*		2	0	Tolerant
Longnose Dace	*Rhinicthys cataractae*		3	1	Intermediate
Marginated Madtom	*Noturus insignis*		1	0	Intermediate
Pumpkinseed	*Lepomis gibbosus*		4	1	Intermediate
Redbreast Sunfish	*Lepomis auritus*		2	3	Intermediate
Rockbass	*Ambloplites repositories*		4	6	Intermediate
Satinfin Shiner	*Notropis analostanus*		5	0	Tolerant
Smallmouth Bass	*Micropterus dolomieui*		1	0	Intermediate
Spottail Shiner	*Notropis hudsonius*		61	13	Intermediate
Tessalated Darter	*Etheostoma olmstedi*		1	0	Intermediate
White Sucker	*Catostomas commersoni*		4	12	Tolerant
	Total Species		**16**	**12**	

Table C4. International Minerals and Chemical Corporation Fish Survey 1990, Jordan Creek 6-12-90

Species	Scientific Name		Station 2	Tolerance Rating
American Eel	*Anguilla rostrata*		R	Tolerant
Common Carp	*Cyprinus carpio*		R	Tolerant
Common Shiner	*Notropis cornutus*		A	Intermediate
Fallfish	*Semotilus corporalis*		P	Intermediate
Green Sunfish	*Lepomis cyanellus*		P	Tolerant
Pumpkinseed Sunfish	*Lepomis gibbosus*		C	Intermediate
Rock Bass	*Ambloplites rupestris*		R	Intermediate
White Sucker	*Catostomus commersoni*		R	Tolerant
	Total Species		**8**	

R - Rare (1-2 Individuals)
P - Present (3-24 Individuals)
C - Common (25-99 Individuals)
A - Abundant (>100 Individuals)

Table C5. Catchable Trout Program Survey 1990, Jordan Creek, 7-23-90

Species	Scientific Name	Site 2	Site 3	Tolerance Rating
American Eel	Anguilla rostrata	X	X	Tolerant
Blacknose Dace	Rhinicthys atratulus	X	X	Tolerant
Brown Bullhead	Ameirus nebulosus		X	Tolerant
Brown Trout	Salmo trutta	X		Intolerant
Common Shiner	Luxulus cornutus	X	X	Intermediate
Creek Chub	Semotilus atromaculatus	X	X	Tolerant
Cutlips Minnow	Exoglossum maxillingua		X	Intolerant
Fallfish	Semotilus corporalis	X		Intermediate
Green Sunfish	Lepomis cyanellus		X	Tolerant
Largemouth Bass	Micropterus salmoides	X	X	Intermediate
Longnose Dace	Rhinichthys cataractae	X	X	Intermediate
Margined Madtom	Notorus insignis	X	X	Intermediate
Pumpkinseed Sunfish	Lepomis gibbosus		X	Intermediate
Redbreast Sunfish	Lepomis auritus		X	Intermediate
Rock Bass	Ambloplites rupestris	X	X	Intermediate
Satinfin Shiner	Cyprinella analostana		X	Tolerant
Smallmouth Bass	Micropterus dolomieu		X	Intermediate
Tessellated Darter	Etheostoma olmstedi	X	X	Intermediate
White Sucker	Catastomus commersoni	X	X	Tolerant
	Total Species	**12**	**17**	

Table C6. Pittman-Moore,Inc. 1991, Jordan Creek Fish Survey, 7-2-91

Species	Scientific Name		Site 1	Site 2	Site 3	Tolerance Rating
American Eel	*Anguilla rostrata*		X		X	Tolerant
Banded Killifish	*Fundulus diaphanous*			X	X	Tolerant
Blacknose Dace	*Rhinichthys artratulus*		X		X	Tolerant
Brook Trout	*Salvelinus fontinalis*				X	Intolerant
Brown Bullhead	*Ictalurus nebulosus*		X	X	X	Tolerant
Brown Trout	*Salmo trutta*				X	Intolerant
Carp	*Cyprinus carpio*		X	X		Tolerant
Common Shiner	*Notropis ameonus*		X		X	Intermediate
Creek Chub	*Semotilus atromaculatus*			X		Tolerant
Cutlips Minnow	*Exoglossum maxillingua*		X	X	X	Intolerant
Golden Shiner	*Notemigonas crysoleucas*			X		Tolerant
Goldfish	*Carassius aurafus*			X		Tolerant
Green Sunfish	*Lepomis cyanellus*		X	X	X	Tolerant
Largemouth Bass	*Mirropterus salmoides*		X			Intermediate
Longnose Dace	*Rhinichthys cataractae*				X	Intermediate
Margined Madtom	*Noturus insignis*				X	Intermediate
Pumpkinseed	*Lepomis macrochirus*		X	X		Intermediate
Rainbow Trout	*Salmo gairdneri*				X	Intolerant
Redbreast Sunfish	*Lepomis macrochirus*			X	X	Intermediate
Rock Bass	*Ambloplites rupellus*		X		X	Intermediate
Smallmouth Bass	*Micropterus dolomieui*		X		X	Intermediate
Spotfin Shiner	*Notropis spilopferus*		X	X	X	Tolerant
Spottail Shiner	*Notropis hudsonius*		X		X	Intermediate
Tesselated Darter	*Etheostoma olmstedi*				X	Intermediate
White Sucker	*Catostomus commersoni*		X	X	X	Tolerant
		Total Species	**14**	**12**	**19**	

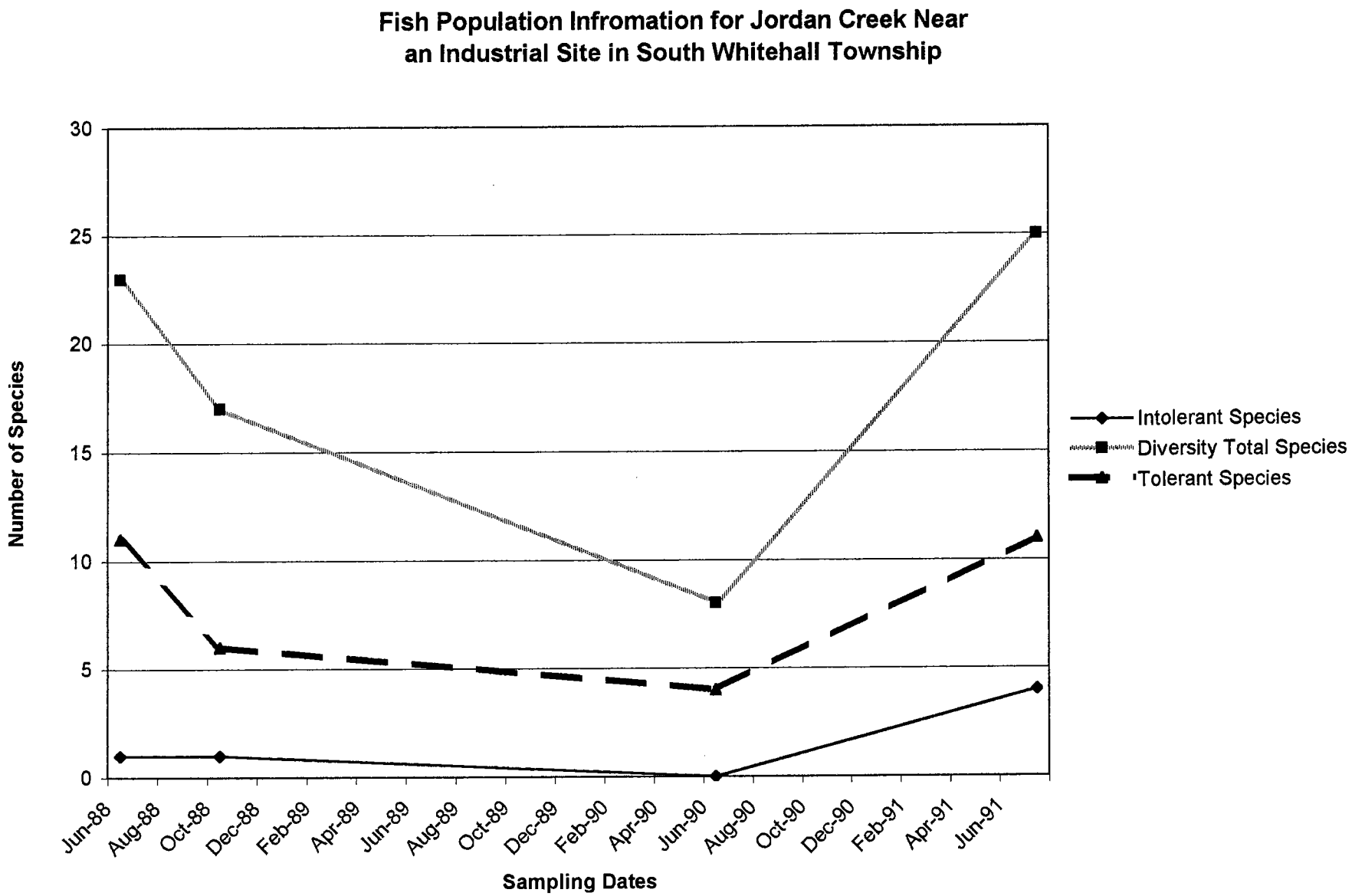

Fish Population Infromation for Jordan Creek Near
an Industrial Site in South Whitehall Township
Number of Species
30
25
20
15
10
5
0
Jun-88
Aug-88
Oct-88
Dec-88
Feb-89
Apr-89
Jun-89
Aug-89
Oct-89
Dec-89
Feb-90
Apr-90
Jun-90
Aug-90
Oct-90
Dec-90
Feb-91
Apr-91
Jun-91
Sampling Dates
Intolerant Species
Diversity Total Species
Tolerant Species

Figure C9

APPENDIX D

CORRELATIONS BETWEEN LAND USE IN THE JORDAN CREEK AND GEOLOGY AND WATER QUALITY

Table D1. Jordan Creek Water Quality vs. Limestone %

Site	% Limestone	H2O Temperature	Nitrate	pH	Ammonia	Alkalinity	Phosphate	Total Hardness
		°C	mg/L		mg/L	mg/L	mg/L	mg/L
1	18.62	22.27	11.46	8.28	0.20	157.60	0.24	246
2	13.75	22.09	8.39	8.37	0.30	141.10	0.24	222
4	9.21	24.08	7.88	8.11	0.56	189.50	0.31	269
5	6.92	22.65	9.58	8.11	0.65	63.60	0.35	108
7	9.44	21.57	4.59	7.65	0.02	75.80	0.24	118
8	0.15	23.47	7.45	7.36	0.03	55.10	0.27	83
10	0.00	23.41	8.54	8.62	0.11	50.40	0.22	81
11	0.00	21.96	14.41	8.09	0.02	44.70	0.33	84
11.5	0.00	24.95	6.94	8.72	0.05	46.80	0.18	76
12	0.00	23.64	7.80	8.06	0.01	49.00	0.19	84
13	0.00	23.58	7.43	8.64	0.02	44.30	0.19	74
14	0.00	22.27	8.06	8.34	0.01	46.40	0.24	73
15	0.00	21.74	8.12	7.74	0.03	51.80	0.20	80
17	0.00	18.62	11.85	7.30	0.02	20.00	0.15	34

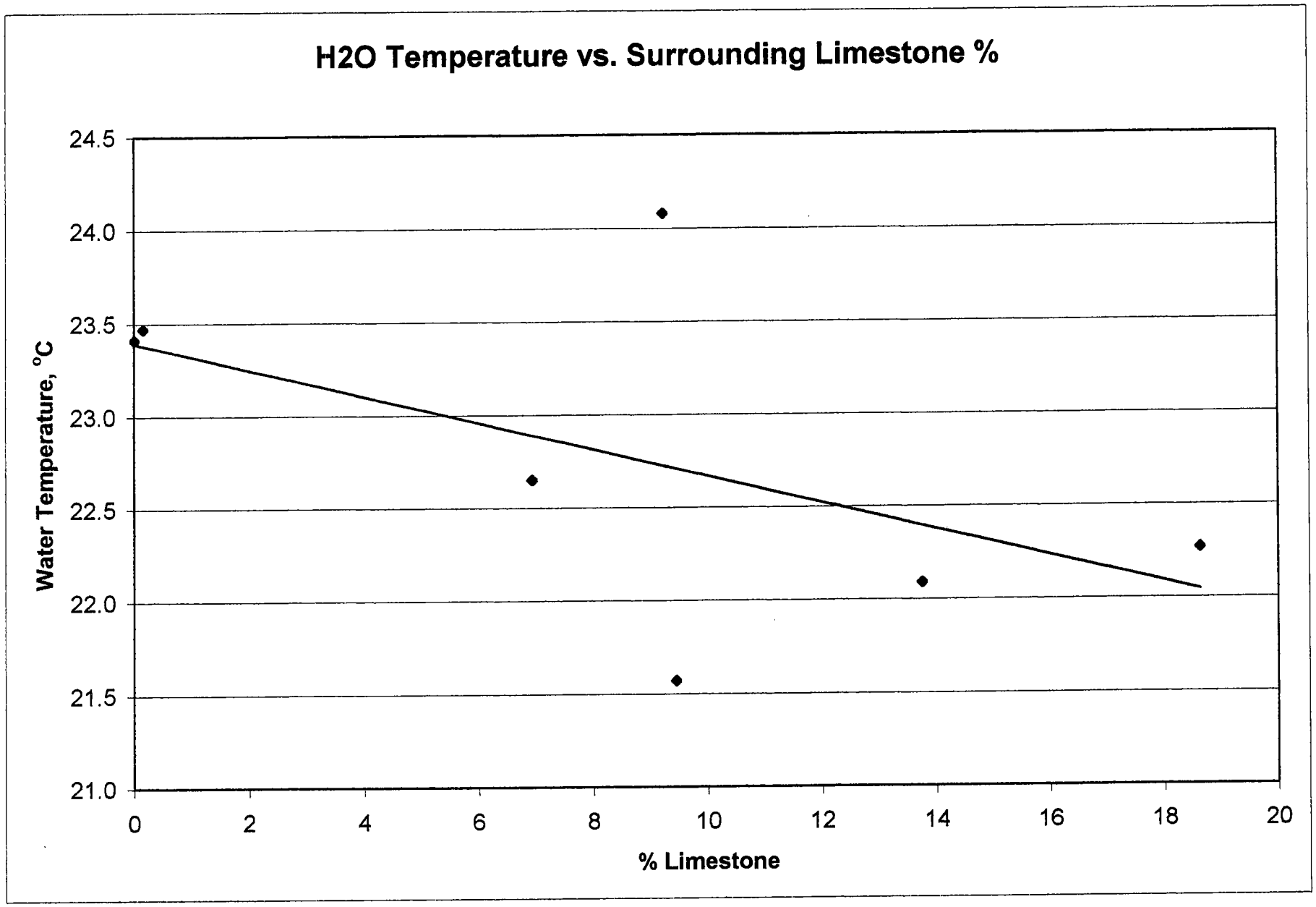


Figure D1. Water Temperature

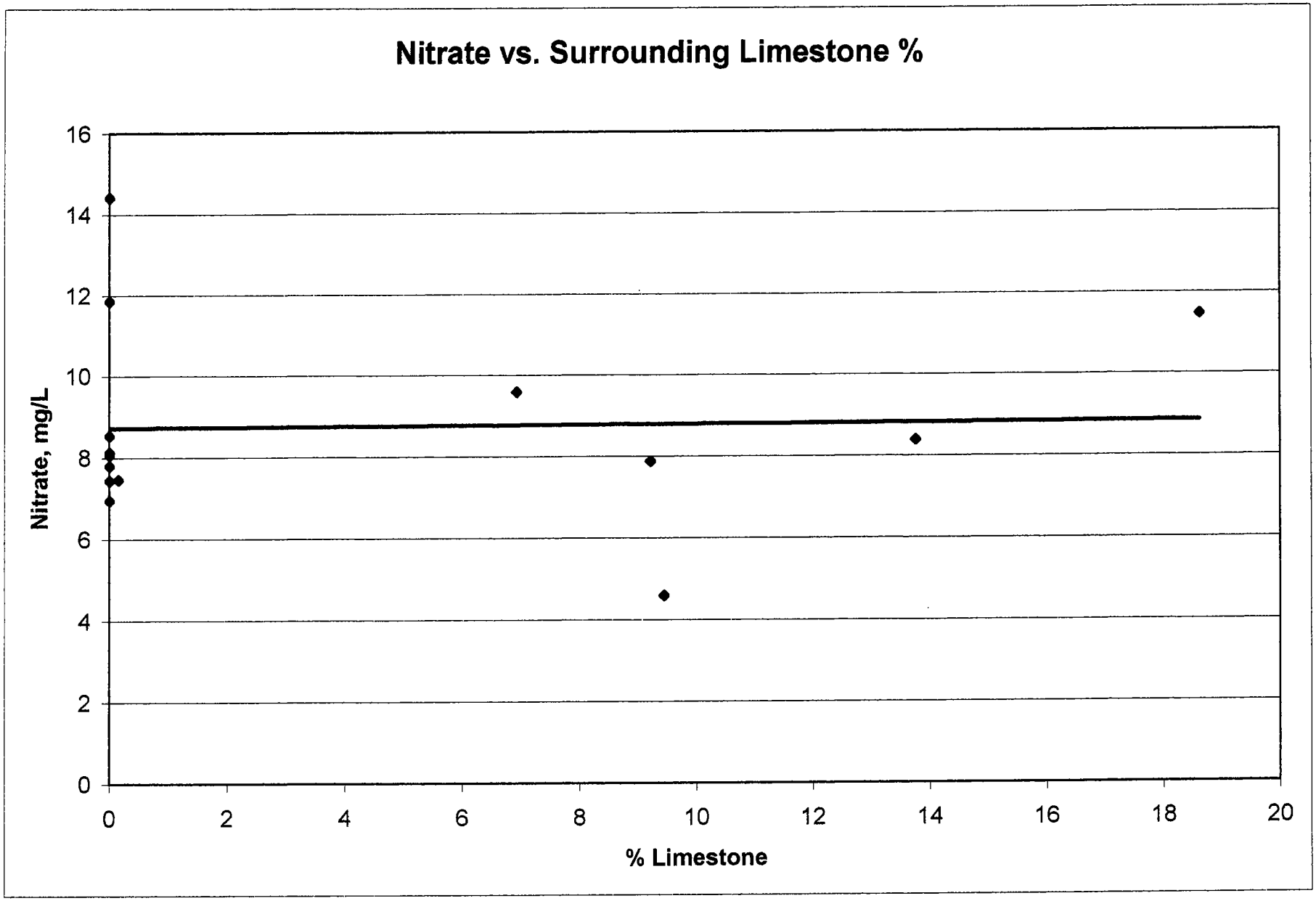


Figure D2. Nitrate

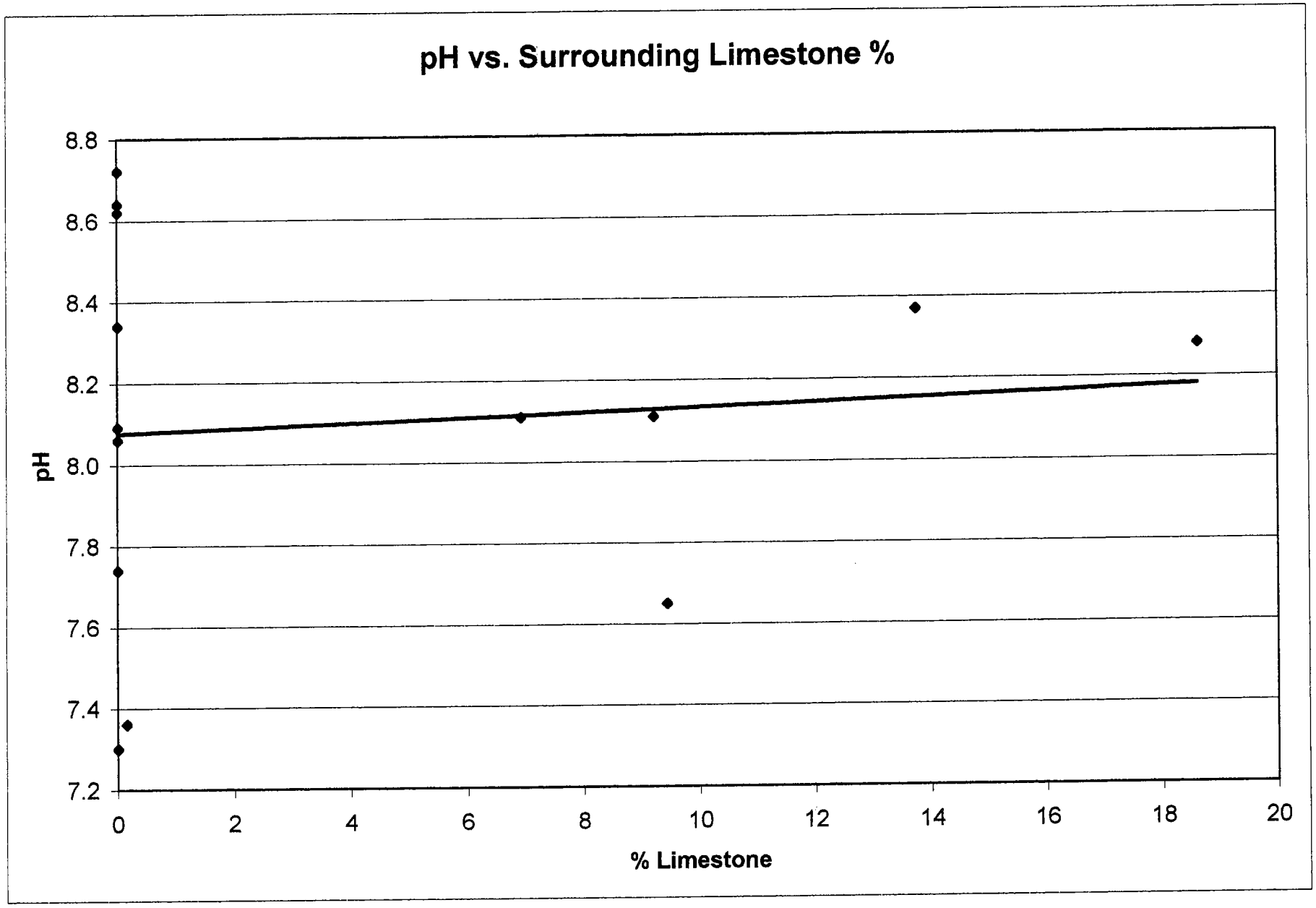

pH vs. Surrounding Limestone %
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
pH
0
2
4
6
8
10
12
14
16
18
20
% Limestone

Figure D3. pH

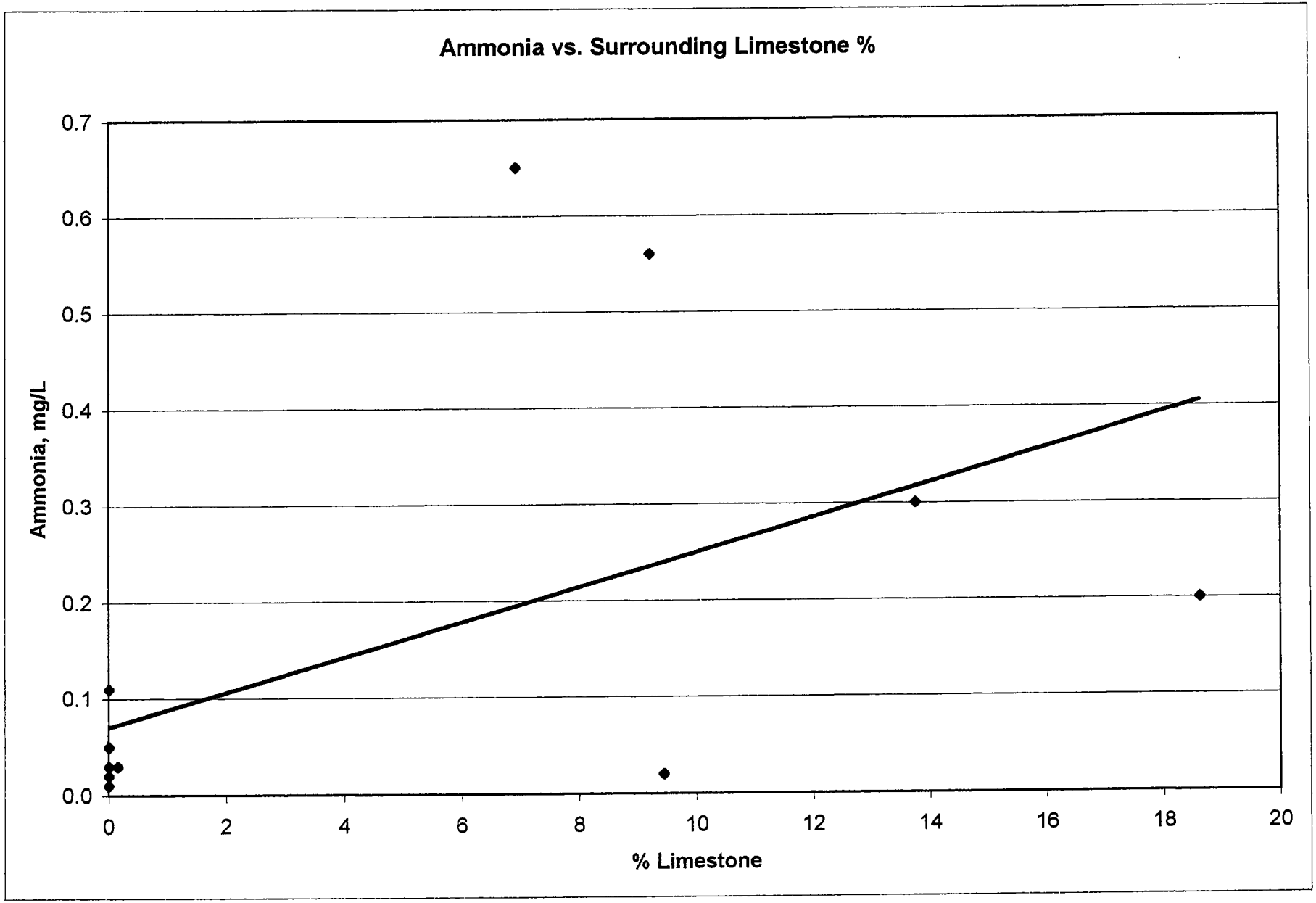


Figure D4. Ammonia

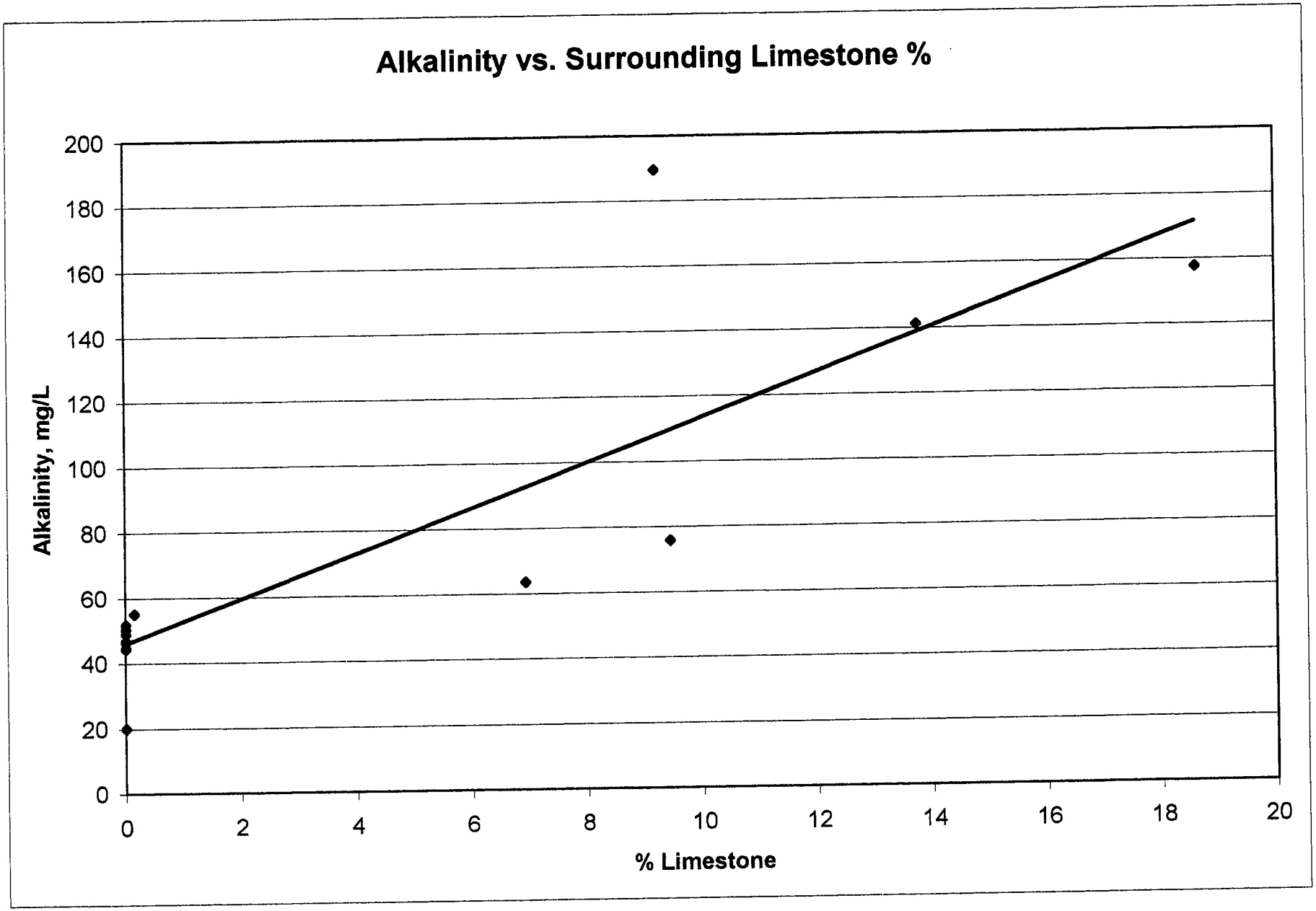


Figure D5. Alkalinity

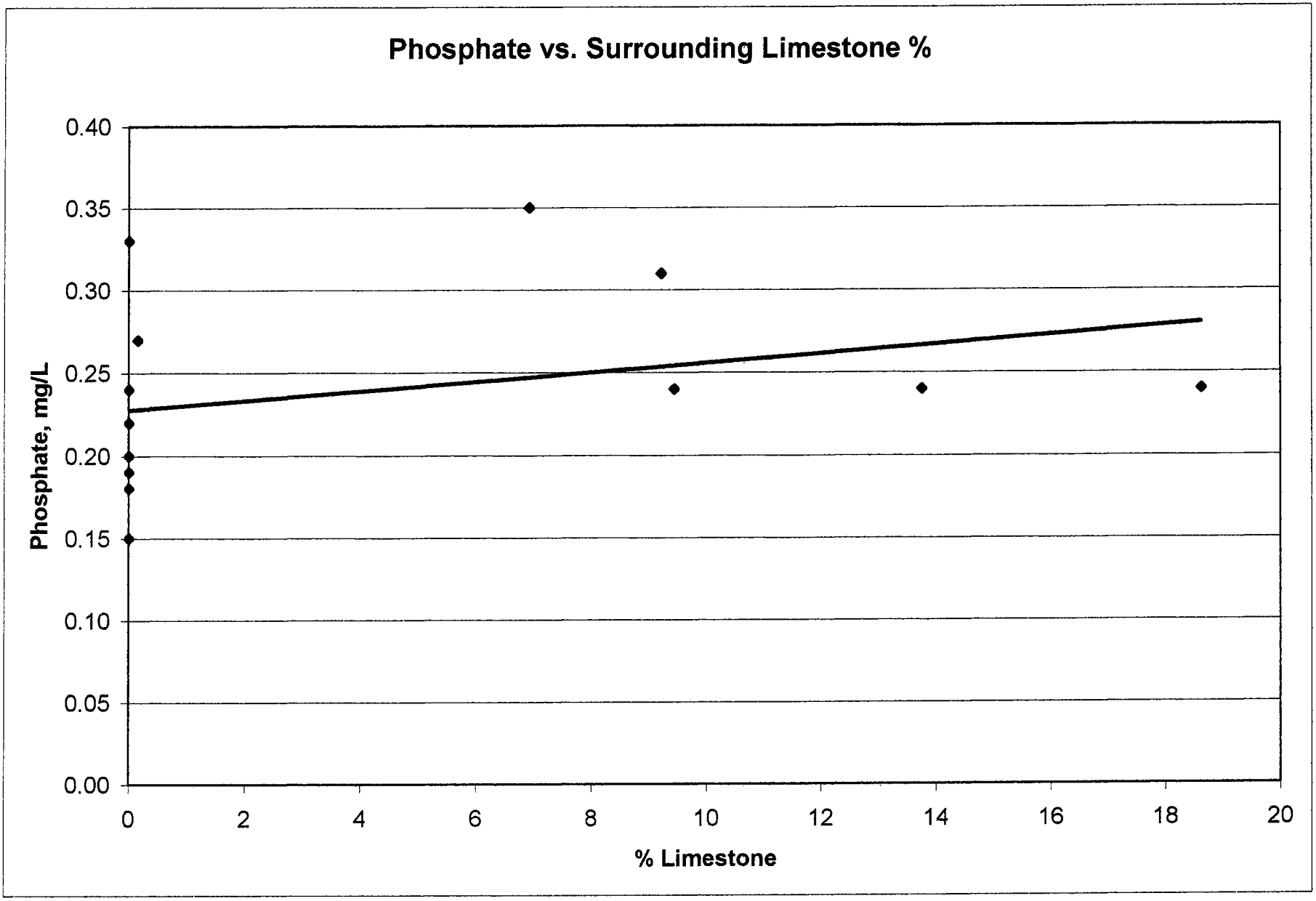


Figure D6. Phosphate

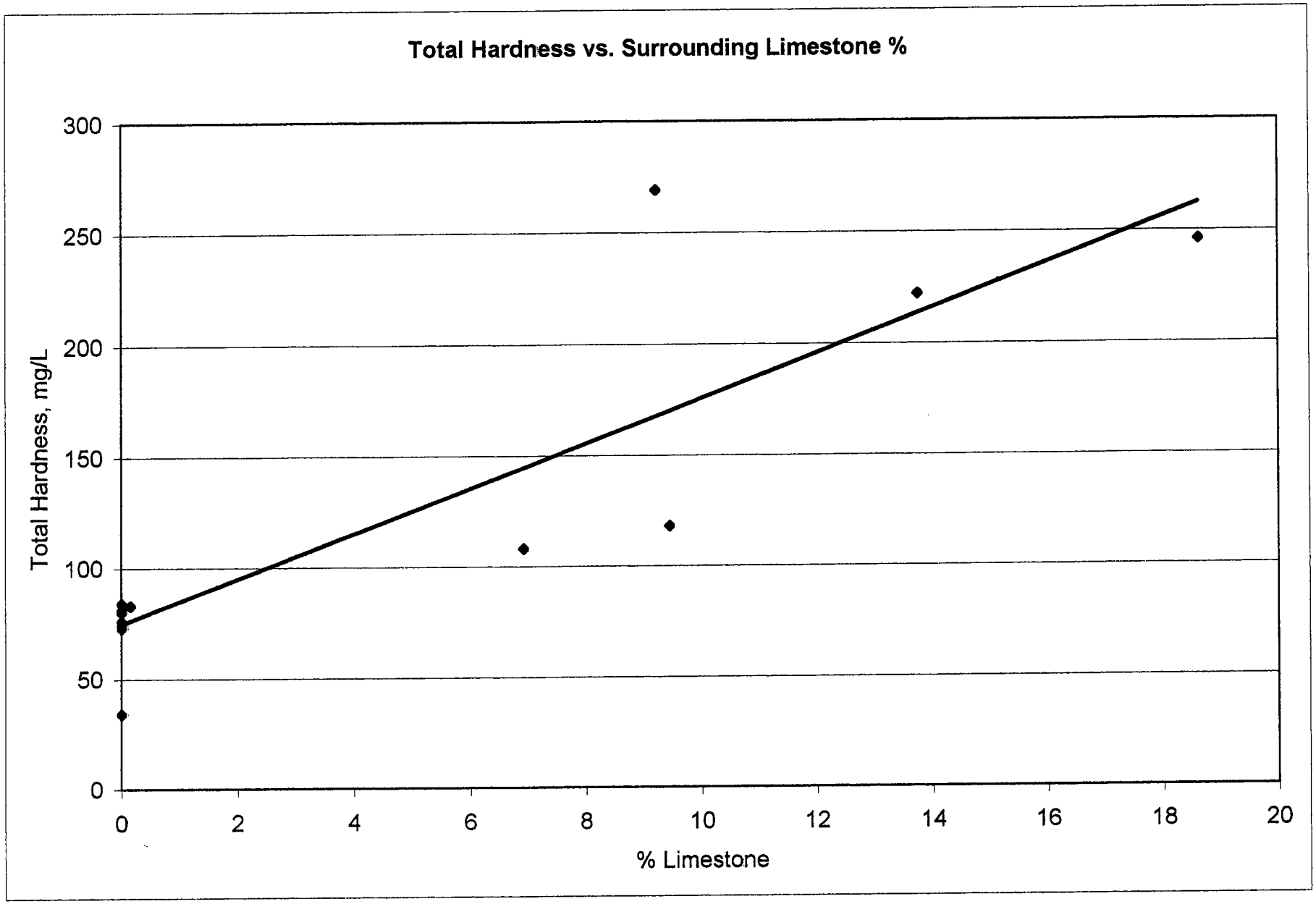


Figure D7. Total Hardness

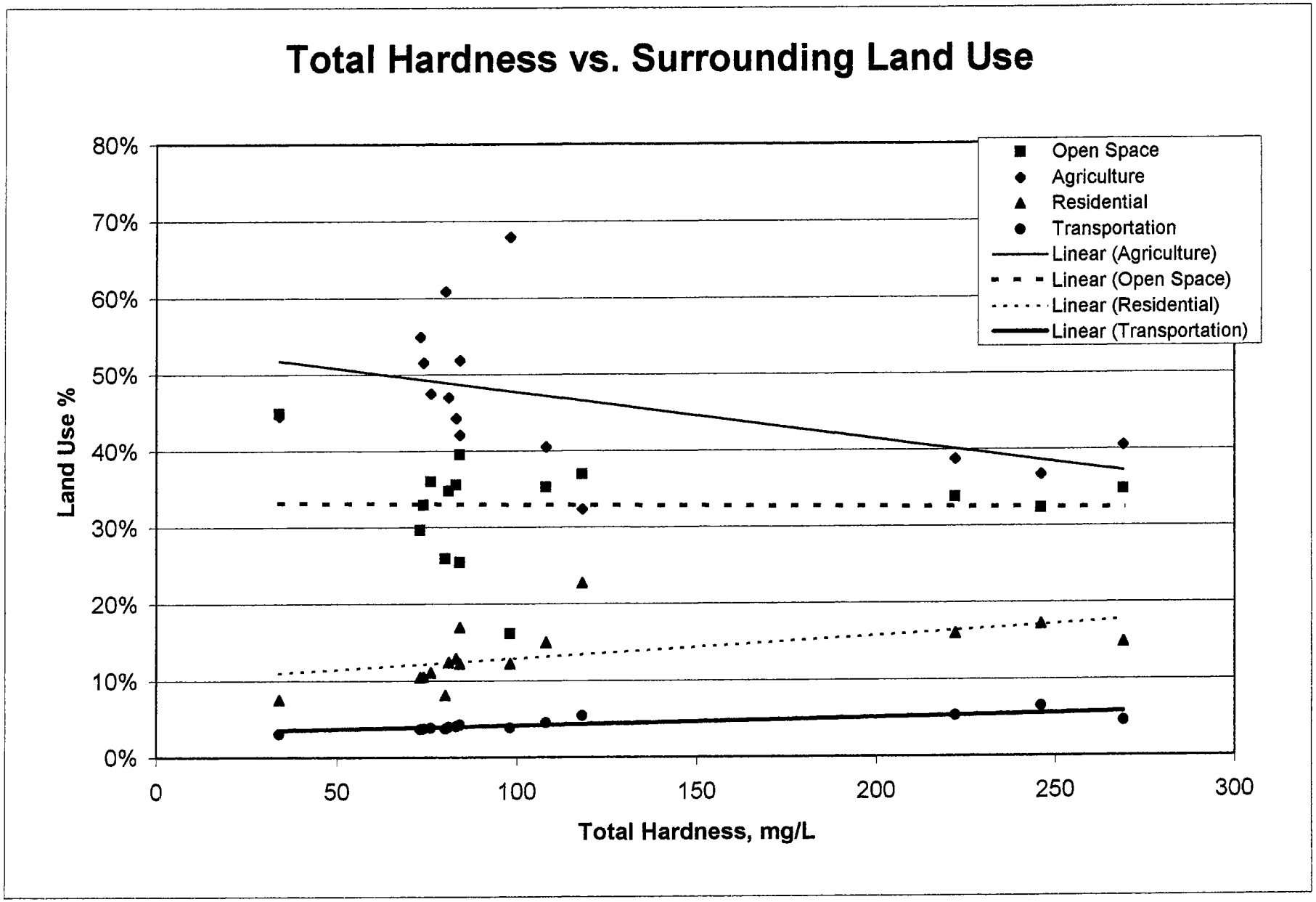


Figure D8. Total Hardness

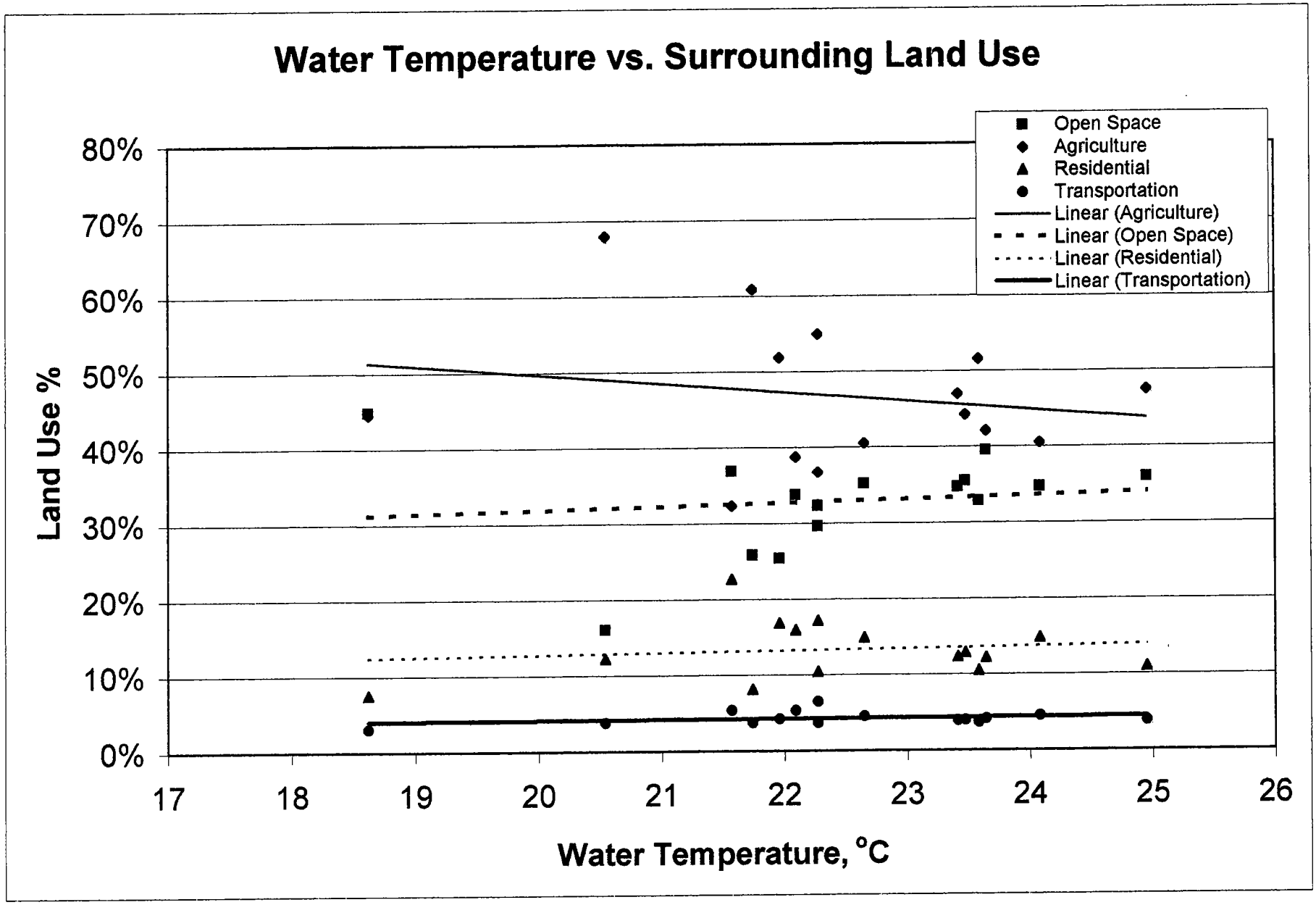


Figure D9. Water Temperature

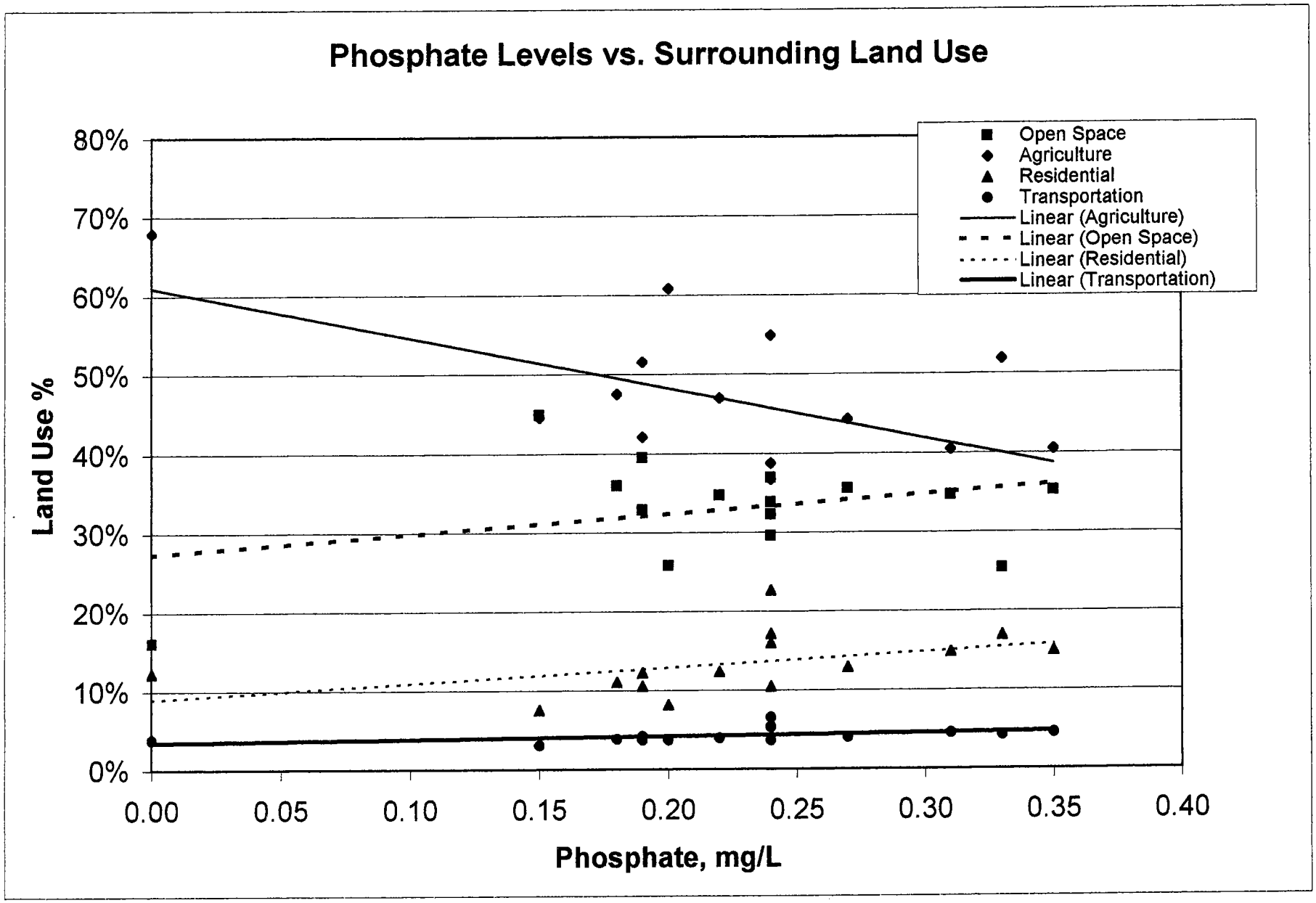


Figure D10. Phosphate

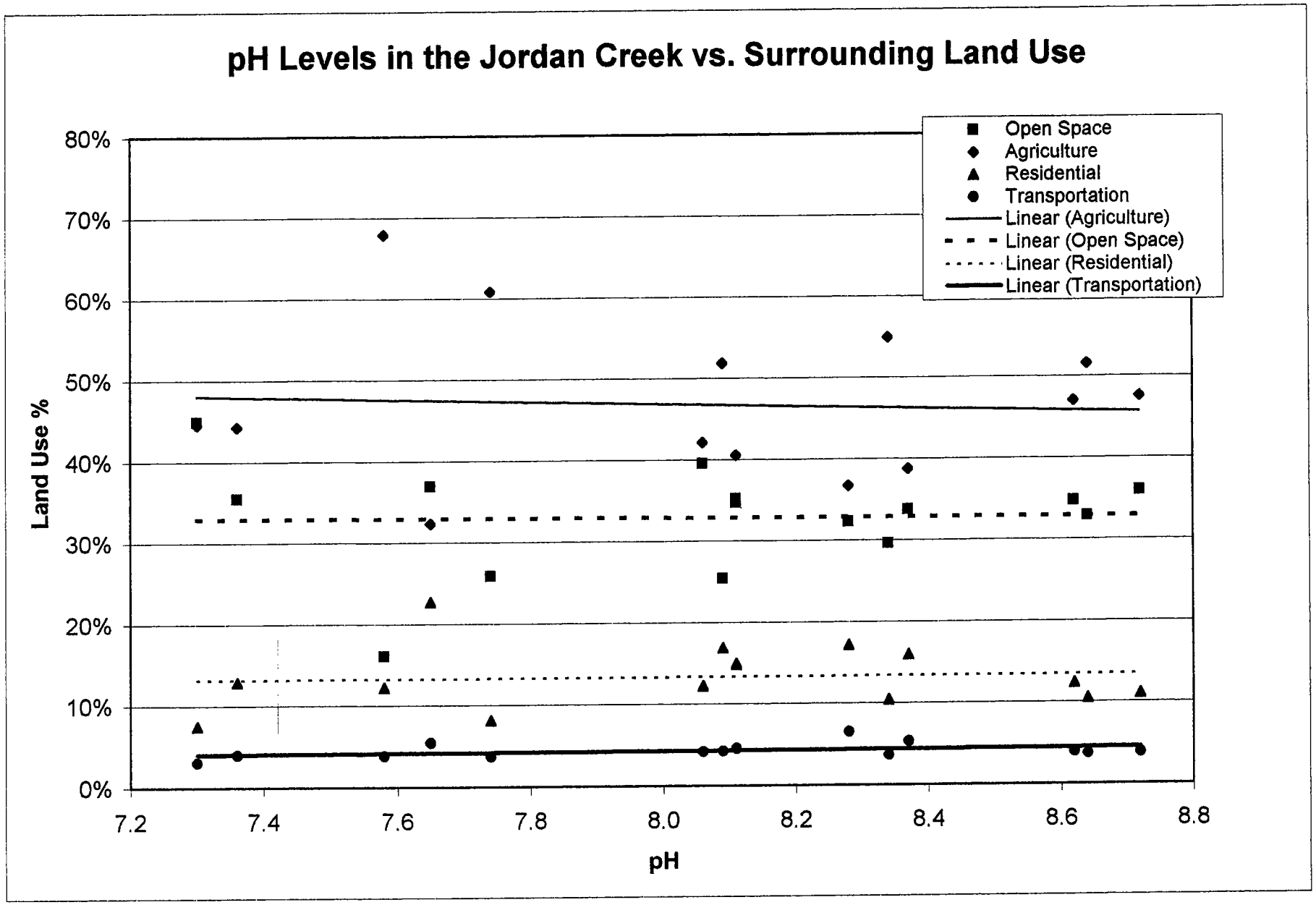


Figure D11. pH

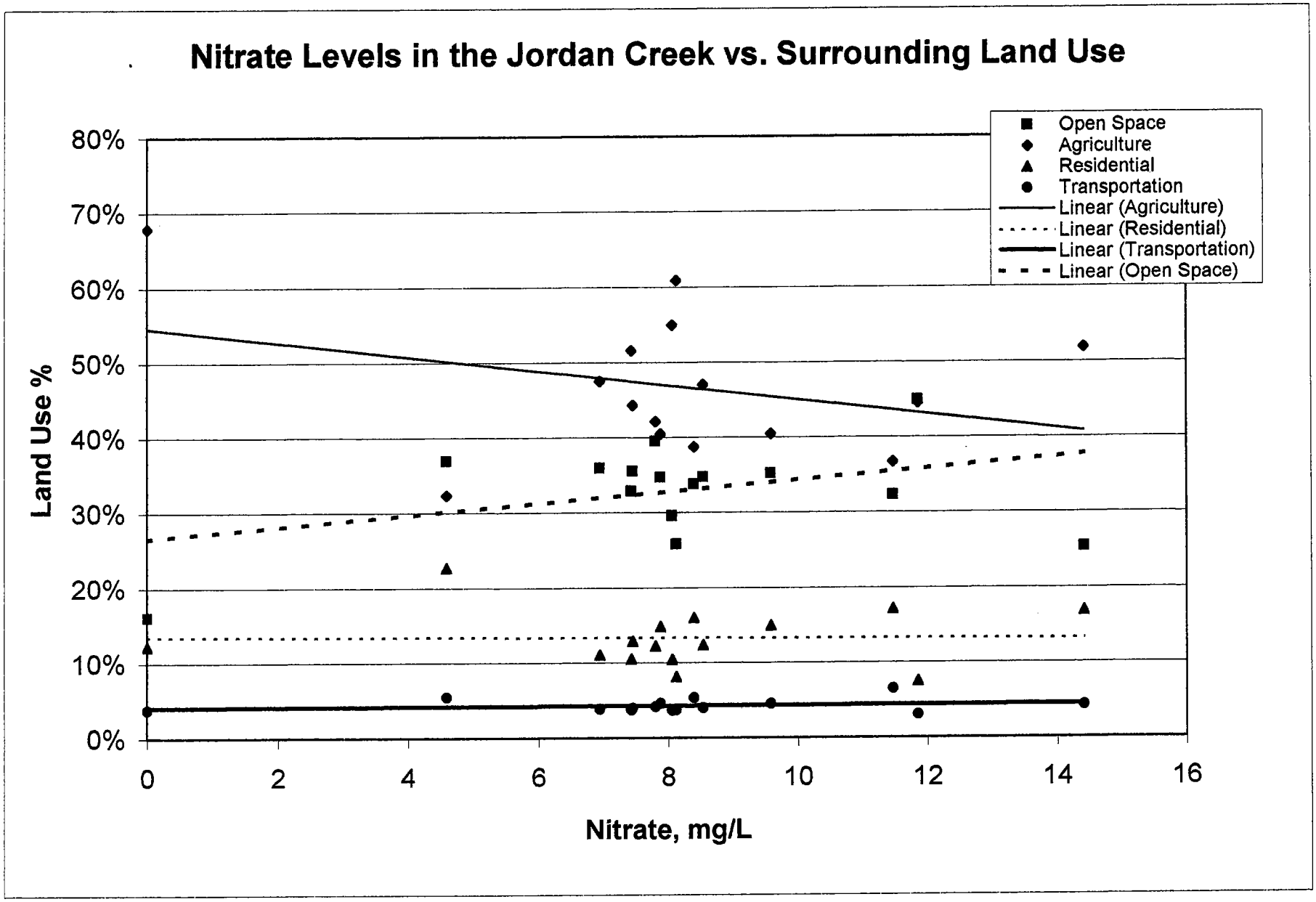


Figure D12. Nitrate

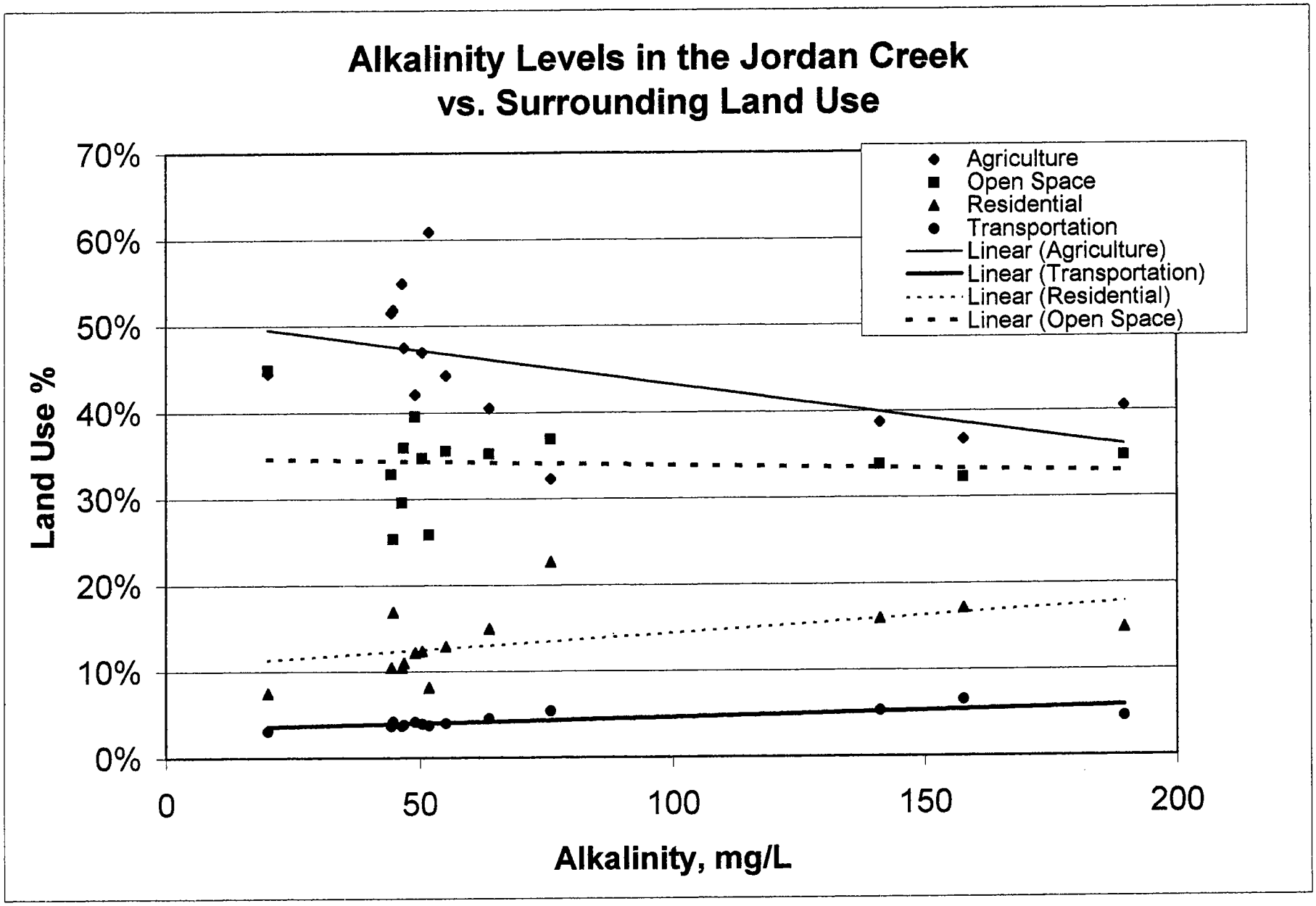


Figure D13. Alkalinty

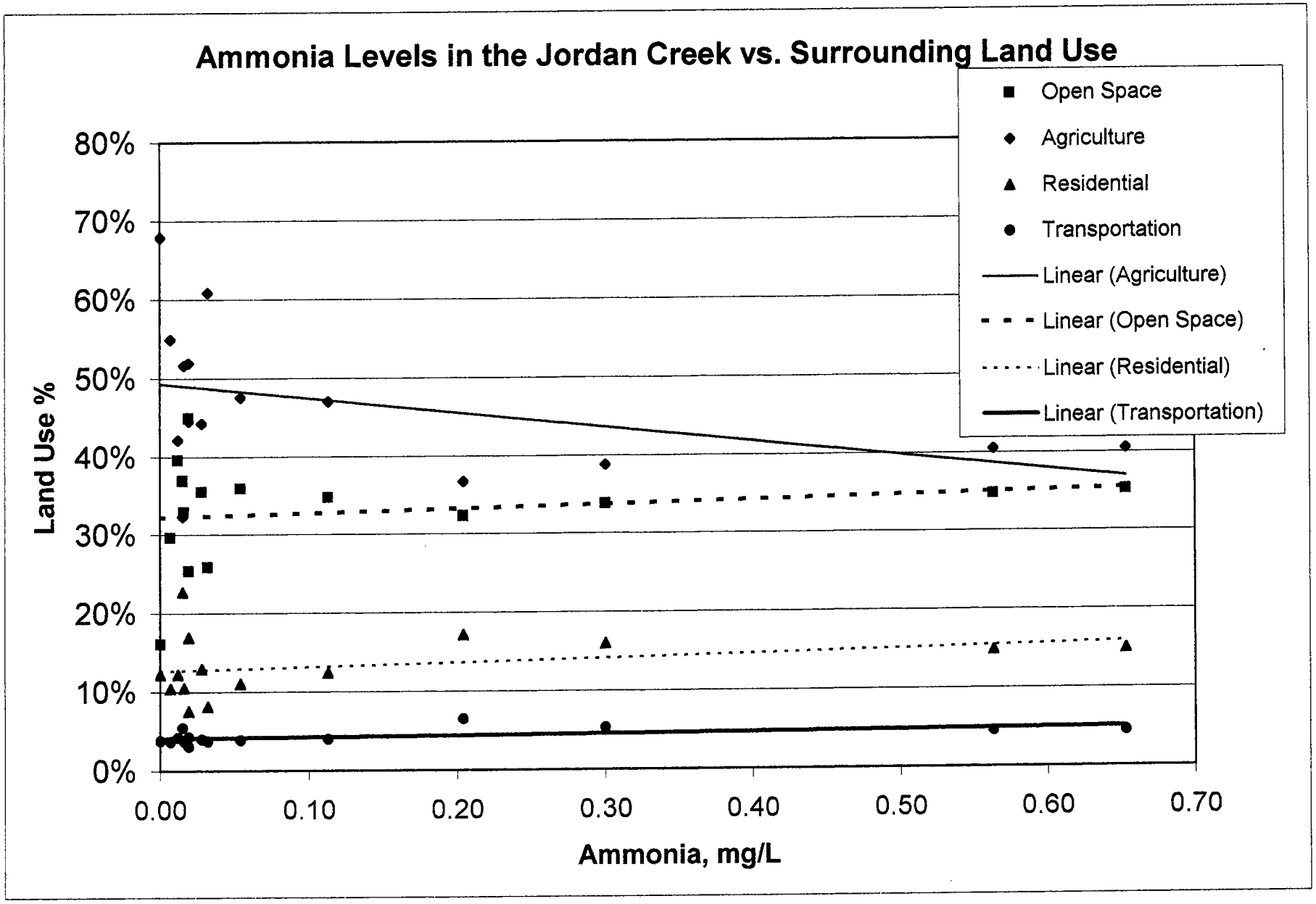


Figure D14. Ammonia

APPENDIX E

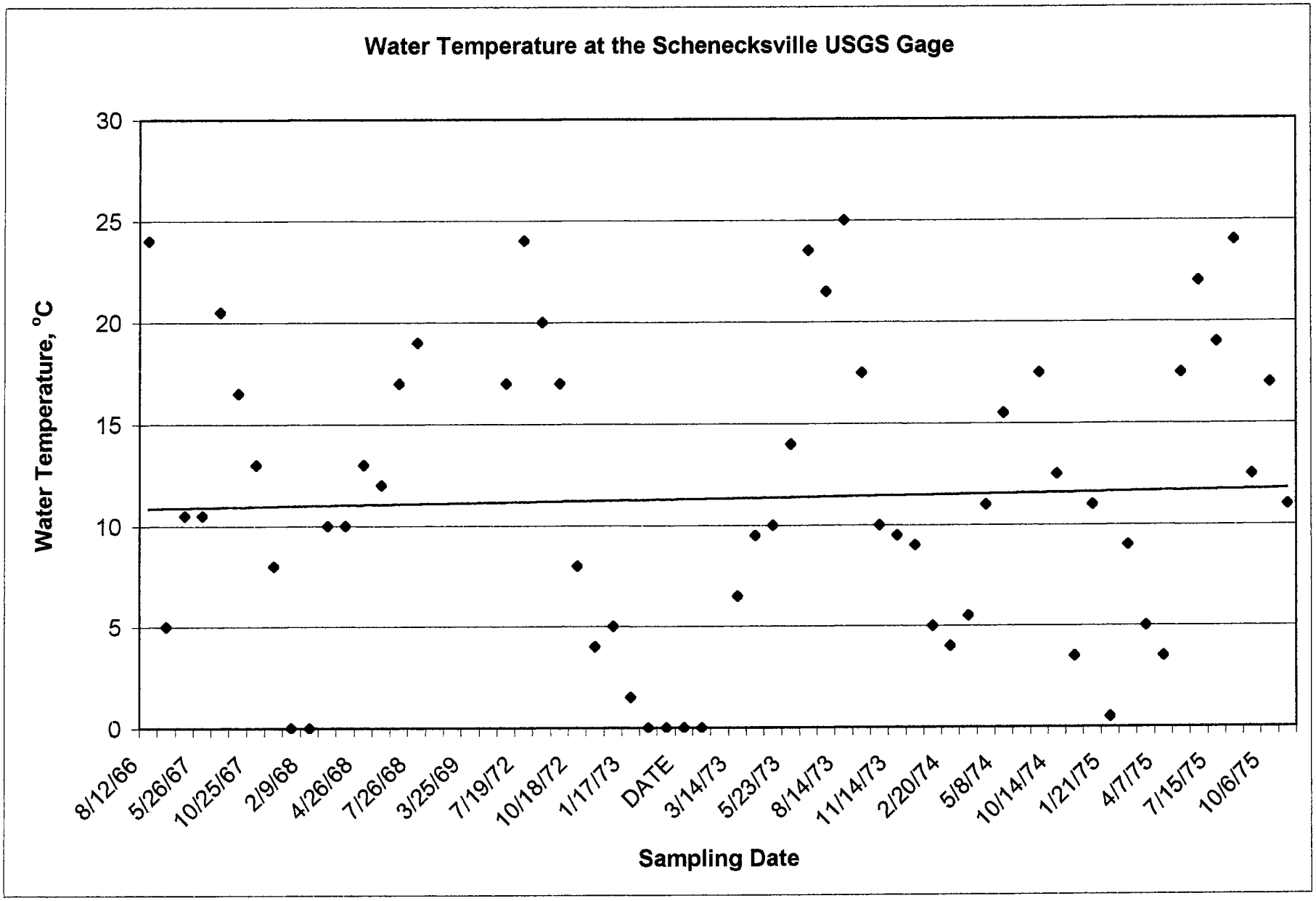
PREVIOUS WATER QUALITY DATA

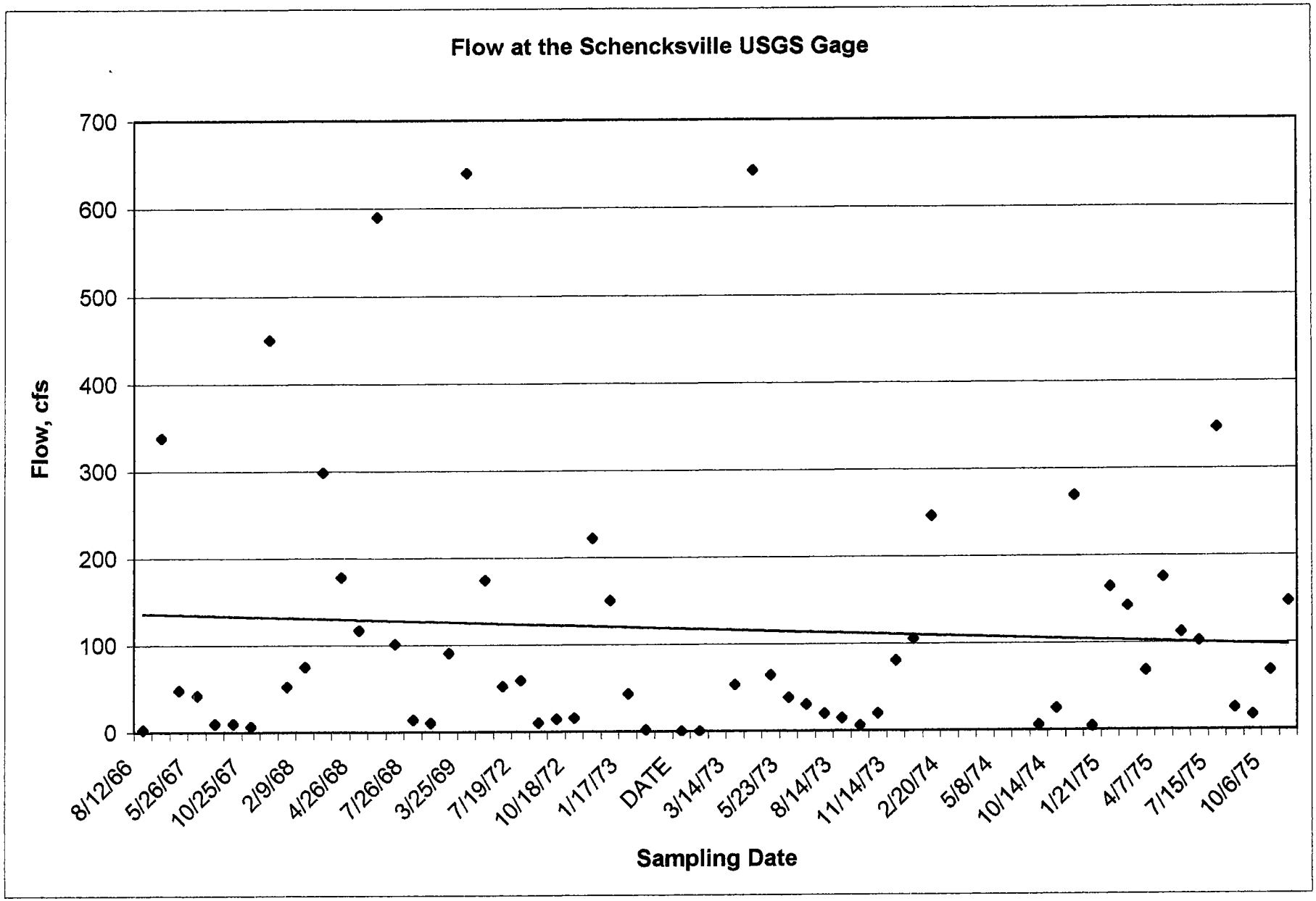
JORDAN CREEK AT SCHNECKSVILLE

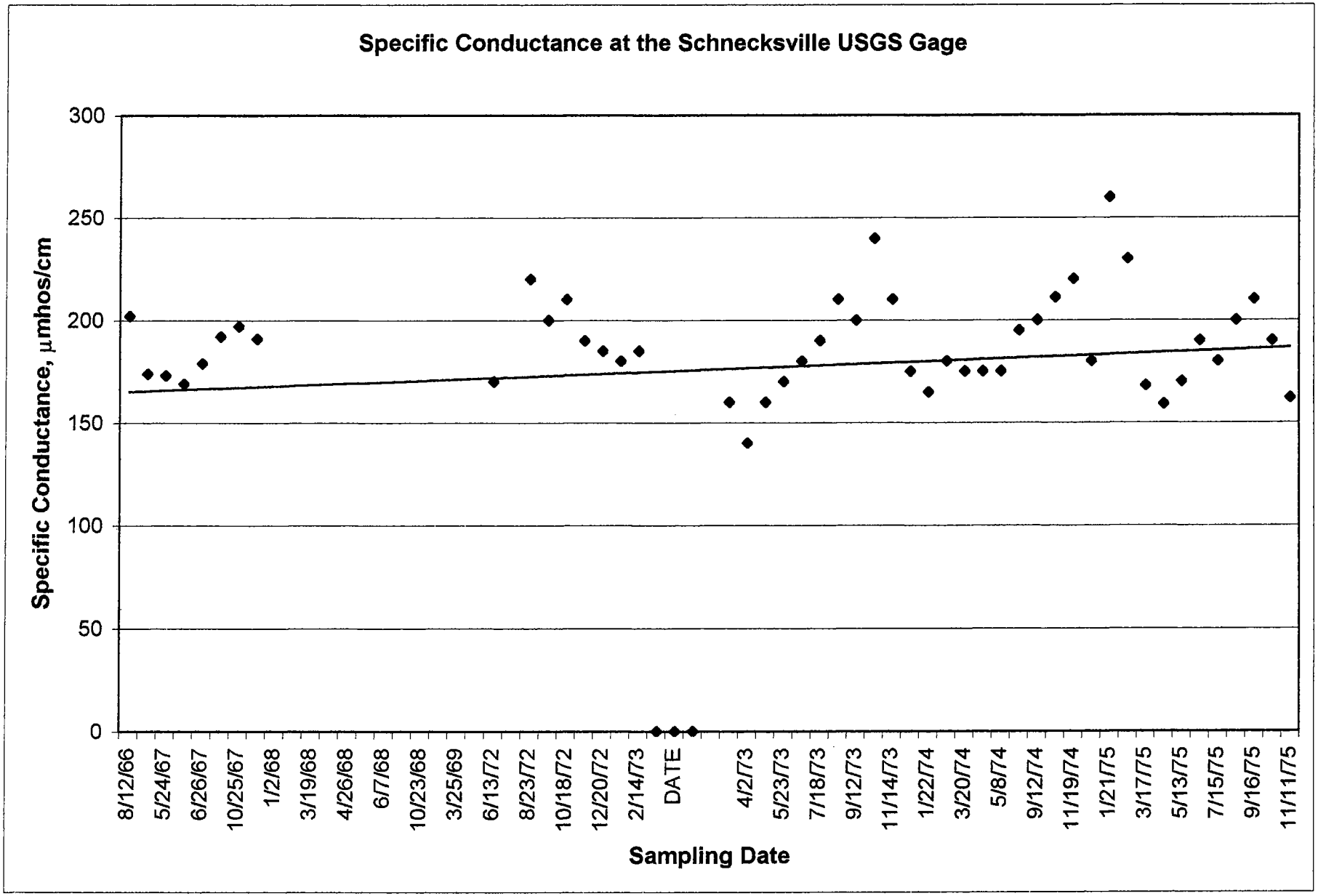
STATION ID: 01451800

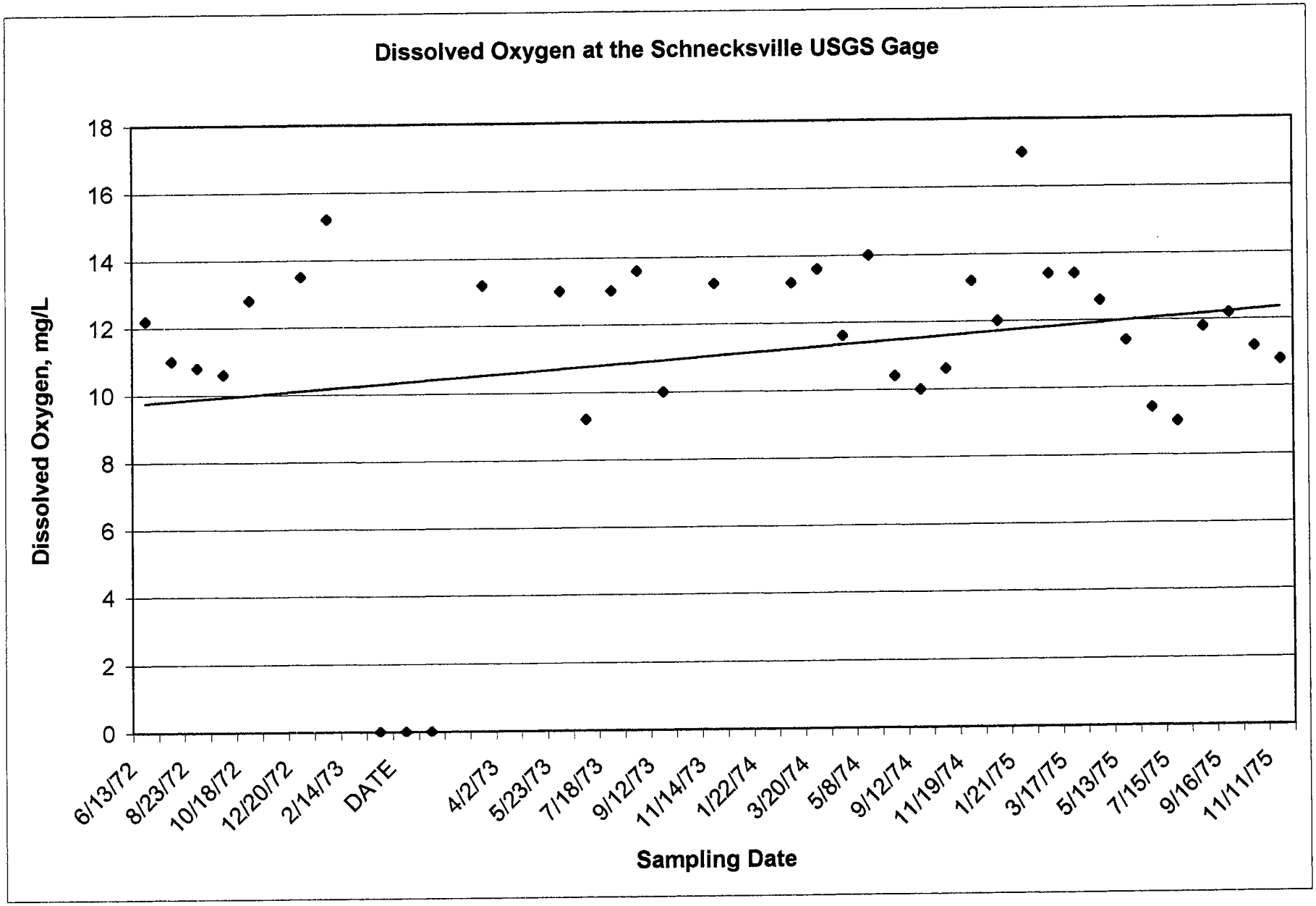
DATE	WATER TEMPERATURE	FLOW	SPECIFIC CONDUCTANCE	DISSOLVED OXYGEN	pH	ALKALINITY	NITROGEN AMMONIA	NITROGEN NITRATE	PHOSPHOROUS ORTHOPHOSPHATE
	°C	cfs	µmhos/cm	mg/L		mg/L $CaCO_3$	mg/L NH_4	mg/L NO_3	mg/L PO_4
8/12/66	24	2.6	202		7.4	67		1.3	
3/13/67	5	338	174		7.1	15		24	
5/24/67	10.5	48	173		6.9	31		12	
5/26/67	10.5	42	169		7.5	31		12	
6/26/67	20.5	9.4	179		7.6	43		5.9	
9/20/67	16.5	9.4	192		7.9	50		12	
10/25/67	13	6.5	197		7.9	45		6.8	
12/13/67	8	450	191		6.9	16		21	
1/2/68	0	52							
2/9/68	0	75							
3/19/68	10	298							
3/22/68	10	178							
4/26/68	13	117							
5/29/68	12	590							
6/7/68	17	101							
7/26/68	19	14							
10/23/68		10							
12/9/68		90							
3/25/69		640							
3/27/69		174							
6/13/72	17	52	170	12.2	8.8		0.03	3.4	0.03
7/19/72	24	59		11	6.9		0.01	2.7	0.02
8/23/72	20	10.2	220	10.8	8.3	44	0.06	2.7	0.03
9/20/72	17	14.3	200	10.6	7.7	51	0.02	1.5	0.03
10/18/72	8	15.5	210	12.8	7	51	0.01	1.5	0.04
11/22/72	4	222	190		6.6	18	0.06	6.1	0.03
12/20/72	5	150	185	13.5	6.8	14	0.03	5.9	0.03
1/17/73	1.5	43	180	15.2	7.7	17	0.02	5	0.02
2/14/73	0	1.4	185		7.2	22	0.08	5.6	0.02

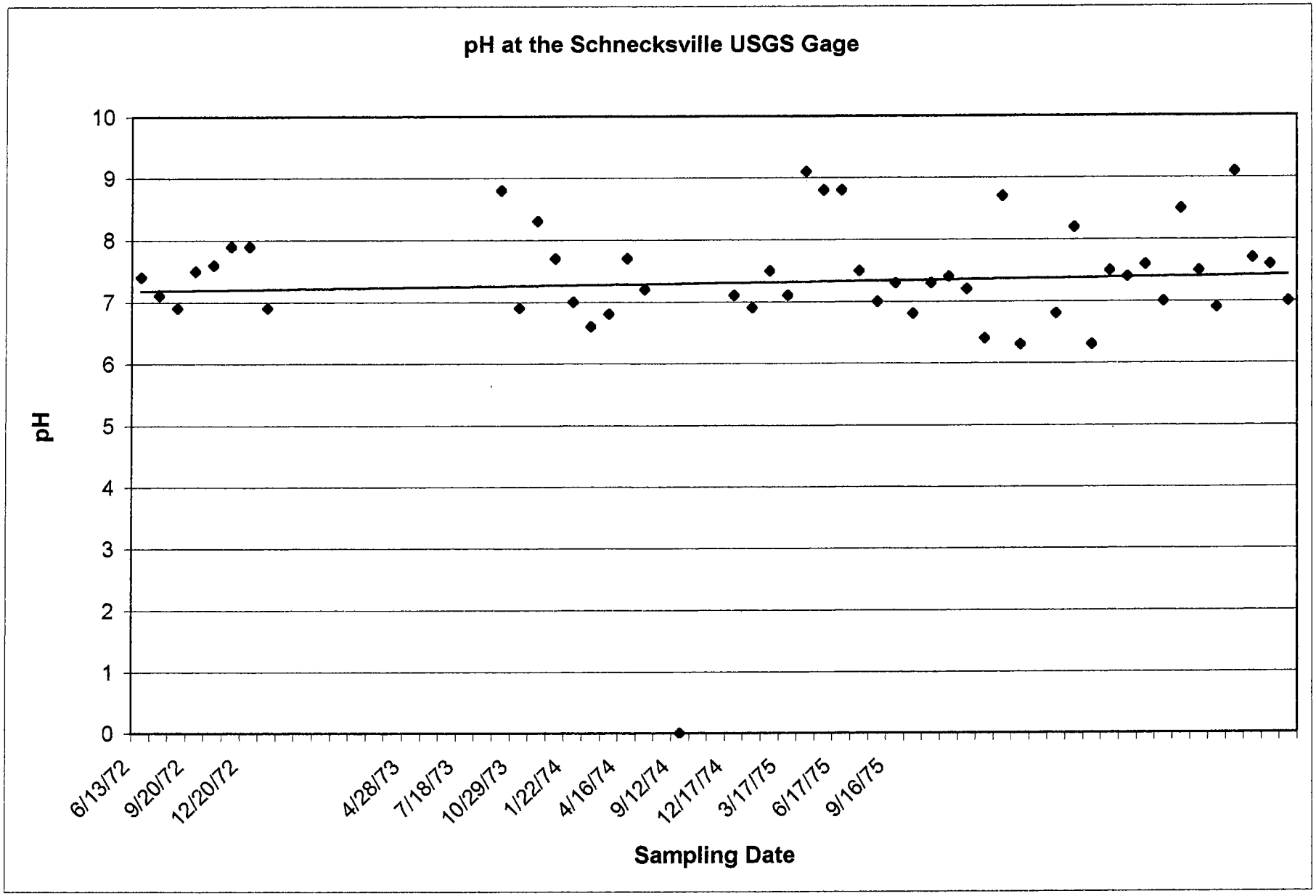
DATE	WATER TEMPERATURE	FLOW	SPECIFIC CONDUCTANCE	DISSOLVED OXYGEN	pH	ALKALINITY	NITROGEN AMMONIA	NITROGEN NITRATE	PHOSPHOROUS ORTHOPHOSPHATE
	°C	cfs	µmhos/cm	mg/L		mg/L $CaCO_3$	mg/L NH_4	mg/L NO_3	mg/L PO_4
3/14/73	6.5	53	160	13.2	7.1	20	0.09	4.1	0.01
4/2/73	9.5	642	140		6.9				0.09
4/28/73	10	64	160		7.5		0.02	2.5	0.014
5/23/73	14	38	170	13	7.1		0.22	2.7	0.04
6/12/73	23.5	30.5	180	9.2	9.1		0.05		0.03
7/18/73	21.5	19.5	190	13	8.8		0.06		0.03
8/14/73	25	14.5	210	13.6	8.8		0.13		0.09
9/12/73	17.5	5.6	200	10	7.5	66	0.04		0.09
10/29/73	10	19.5	240		7		0.06	2.3	0.02
11/14/73	9.5	80	210	13.2	7.3		0.08	3.8	0.01
12/5/73	9	105	175		6.8		0.11	2.7	0.024
1/22/74	5	246	165		7.3		0.12	1.1	0.033
2/20/74	4		180	13.2	7.4		0.17	4.5	0.04
3/20/74	5.5		175	13.6	7.2		0.05	1.8	0.01
4/16/74	11		175	11.6	6.4	80	0.17	4.2	0.01
5/8/74	15.5		175	14	8.7		0.15	2.3	0.01
6/19/74			195	10.4	6.3	58	0.22	2.7	
9/12/74	17.5	5.6	200	10		66	0.03	1.3	
10/14/74	12.5	25	211	10.6	6.8	40	0.04	3.4	0.03
11/19/74	3.5	269	220	13.2	8.2		0.04	2.7	0.01
12/17/74	11	4.4	180	12	6.3	22	0.06	4.3	
1/21/75	0.5	164	260	17	7.5	20	0.06	4.7	0.02
2/18/75	9	142	230	13.4	7.4	30	0.14	3.4	0.03
3/17/75	5	68	168	13.4	7.6	27	0.01	3.6	0.01
4/7/75	3.5	175	159	12.6	7	16	0.01	5.3	
5/13/75	17.5	112	170	11.4	8.5	31	0.01	2.3	0.01
6/17/75	22	102	190	9.4	7.5	31	0.05	3.2	
7/15/75	19	347	180	9	6.9	30	0.06	3.6	0.01
8/19/75	24	25	200	11.8	9.1	44	0.01	0.02	0.01
9/16/75	12.5	17	210	12.2	7.7	41		2	0.02
10/6/75	17	68	190	11.2	7.6	33	0.04	3.8	0.01
11/11/75	11	147	162	10.8	7	20	0.03	2.4	0.01

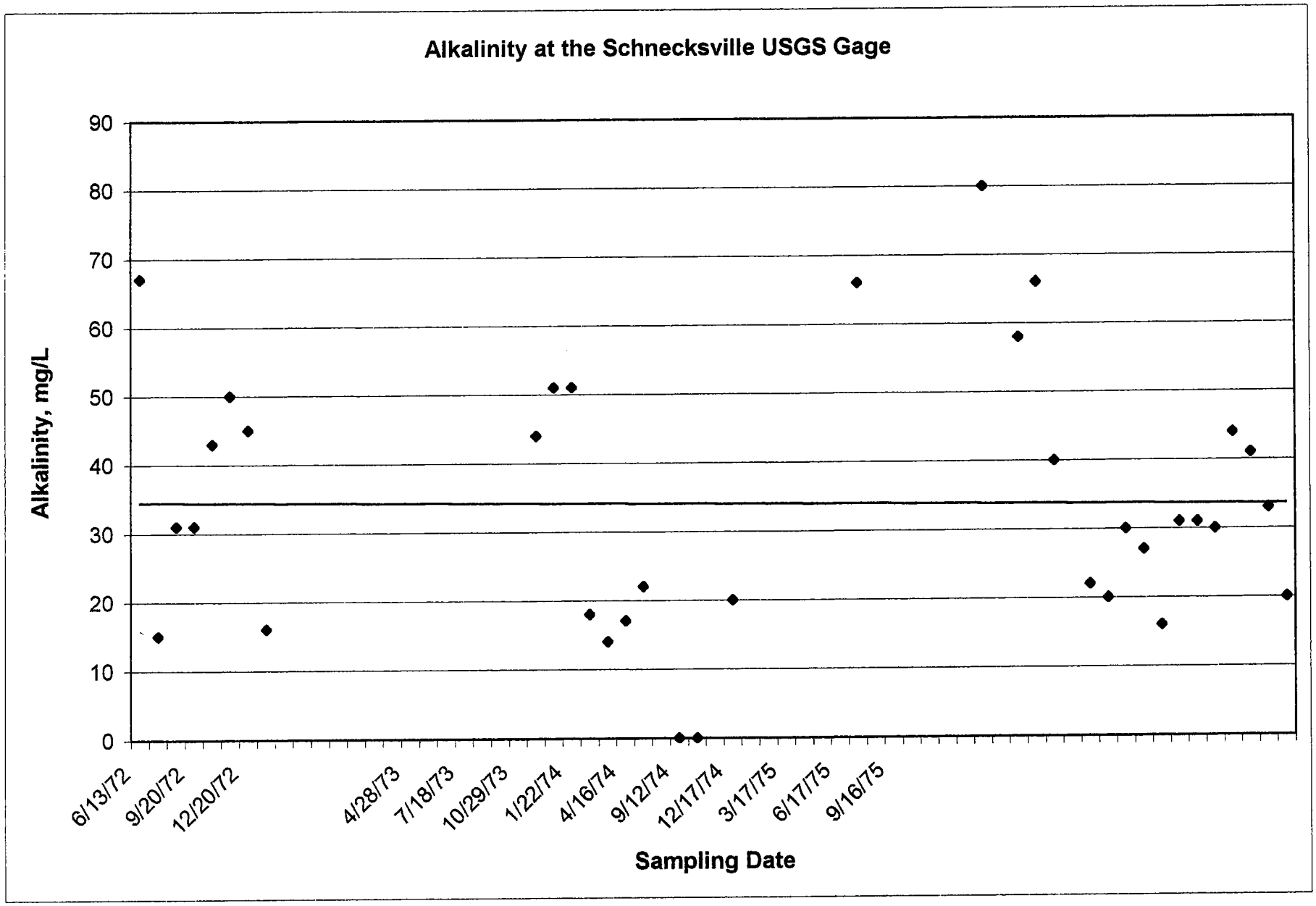

Water Temperature at the Schenecksville USGS Gage
Water Temperature, °C
30
25
20
15
10
5
0
8/12/66
5/26/67
10/25/67
2/9/68
4/26/68
7/26/68
3/25/69
7/19/72
10/18/72
1/17/73
DATE
3/14/73
5/23/73
8/14/73
11/14/73
2/20/74
5/8/74
10/14/74
1/21/75
4/7/75
7/15/75
10/6/75
Sampling Date

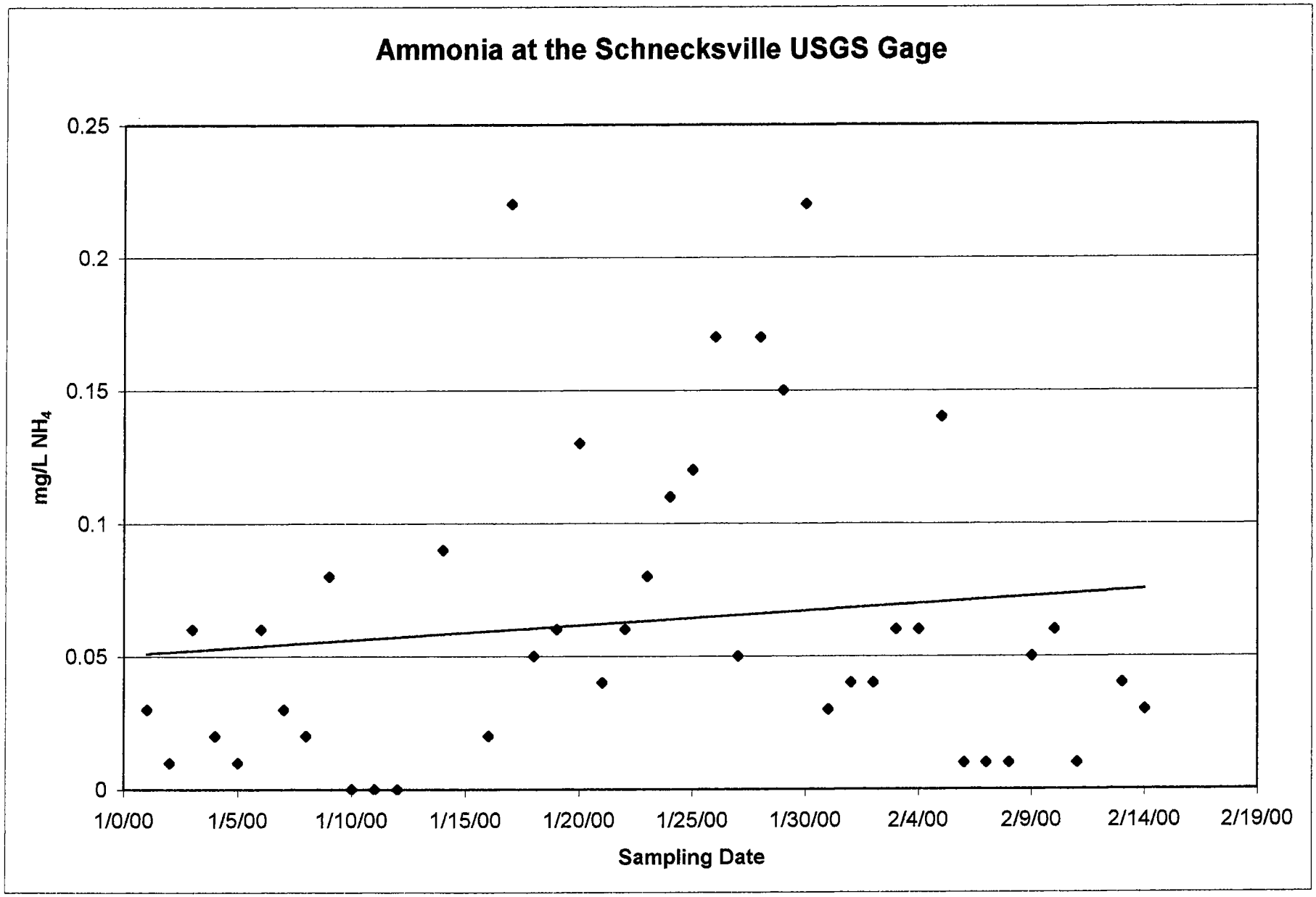

Flow at the Schencksville USGS Gage
Flow, cfs
700
600
500
400
300
200
100
0
8/12/66
5/26/67
10/25/67
2/9/68
4/26/68
7/26/68
3/25/69
7/19/72
10/18/72
1/17/73
DATE
3/14/73
5/23/73
8/14/73
11/14/73
2/20/74
5/8/74
10/14/74
1/21/75
4/7/75
7/15/75
10/6/75
Sampling Date

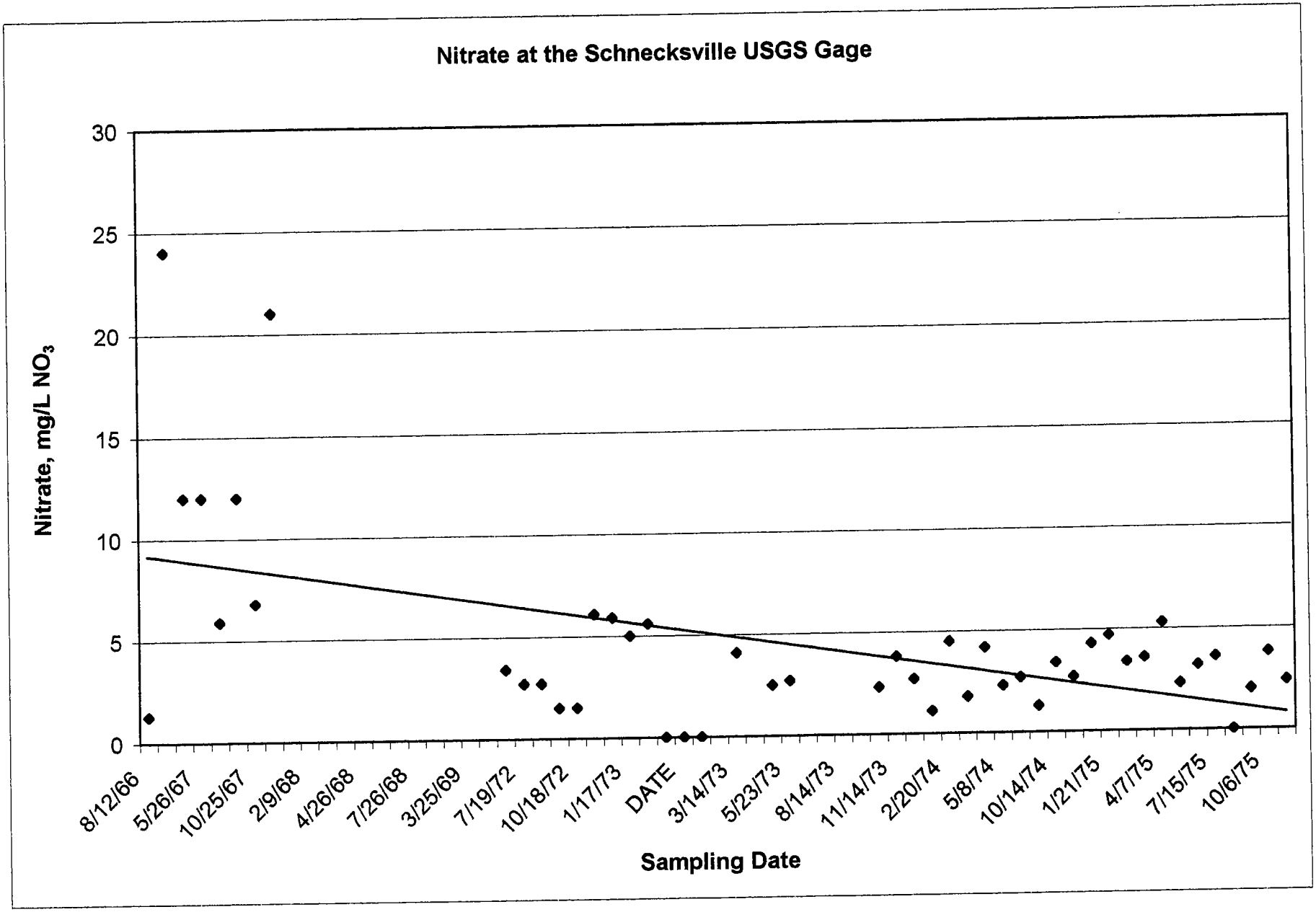

Specific Conductance at the Schnecksville USGS Gage
Specific Conductance, µmhos/cm
300
250
200
150
100
50
0
8/12/66
5/24/67
6/26/67
10/25/67
1/2/68
3/19/68
4/26/68
6/7/68
10/23/68
3/25/69
6/13/72
8/23/72
10/18/72
12/20/72
2/14/73
DATE
4/2/73
5/23/73
7/18/73
9/12/73
11/14/73
1/22/74
3/20/74
5/8/74
9/12/74
11/19/74
1/21/75
3/17/75
5/13/75
7/15/75
9/16/75
11/11/75
Sampling Date

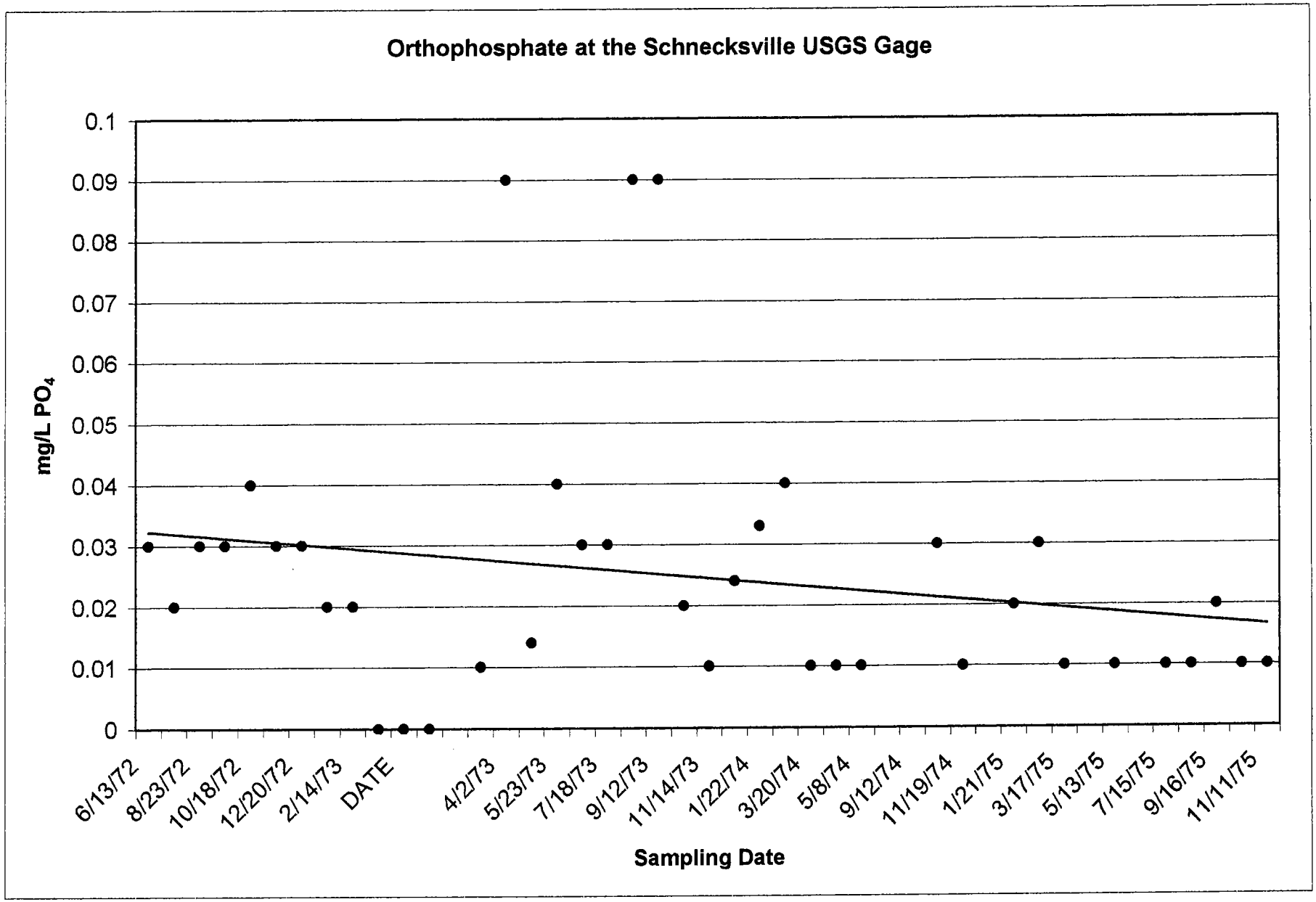

Dissolved Oxygen at the Schnecksville USGS Gage
Dissolved Oxygen, mg/L
18
16
14
12
10
8
6
4
2
0
6/13/72
8/23/72
10/18/72
12/20/72
2/14/73
DATE
4/2/73
5/23/73
7/18/73
9/12/73
11/14/73
1/22/74
3/20/74
5/8/74
9/12/74
11/19/74
1/21/75
3/17/75
5/13/75
7/15/75
9/16/75
11/11/75
Sampling Date


pH at the Schnecksville USGS Gage
pH
10
9
8
7
6
5
4
3
2
1
0
6/13/72
9/20/72
12/20/72
4/28/73
7/18/73
10/29/73
1/22/74
4/16/74
9/12/74
12/17/74
3/17/75
6/17/75
9/16/75
Sampling Date


Alkalinity at the Schnecksville USGS Gage
Alkalinity, mg/L
90
80
70
60
50
40
30
20
10
0
6/13/72
9/20/72
12/20/72
4/28/73
7/18/73
10/29/73
1/22/74
4/16/74
9/12/74
12/17/74
3/17/75
6/17/75
9/16/75
Sampling Date


Ammonia at the Schnecksville USGS Gage
0.25
0.2
0.15
0.1
0.05
0
mg/L NH4
1/0/00
1/5/00
1/10/00
1/15/00
1/20/00
1/25/00
1/30/00
2/4/00
2/9/00
2/14/00
2/19/00
Sampling Date


Nitrate at the Schnecksville USGS Gage
Nitrate, mg/L NO3
30
25
20
15
10
5
0
8/12/66
5/26/67
10/25/67
2/9/68
4/26/68
7/26/68
3/25/69
7/19/72
10/18/72
1/17/73
DATE
3/14/73
5/23/73
8/14/73
11/14/73
2/20/74
5/8/74
10/14/74
1/21/75
4/7/75
7/15/75
10/6/75
Sampling Date


Orthophosphate at the Schnecksville USGS Gage
mg/L PO4
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
6/13/72
8/23/72
10/18/72
12/20/72
2/14/73
DATE
4/2/73
5/23/73
7/18/73
9/12/73
11/14/73
1/22/74
3/20/74
5/8/74
9/12/74
11/19/74
1/21/75
3/17/75
5/13/75
7/15/75
9/16/75
11/11/75
Sampling Date

TRIBUTARY WATER QUALITY DATA, 1967

Date	H_2O Temp °C	Flow cfs	Conductance µmhos	pH	Alkalinity mg/L $CaCO_3$	Total Hardness mg/L $CaCo_3$	Phosphate mg/L PO_4	Nitrate mg/L NO_3
LYON CREEK								
(near weidasville, station 01451740)								
3/13/67	5.5	80.4	177	6.9	16	69	1.70	25.0
9/20/67	20.5	3.5	203	7.6	46	85	0.12	13.0
10/25/67	14.0	3.0	213	6.8	45	87	0.40	8.1
MILL CREEK								
(near weidasville, station 1451780)								
3/13/67	4.0	61.5	190	6.9	17	77	0.06	24.0
9/20/67	17.0	2.4	198	7.5	46	86	0.00	12.0
10/25/67	13.0	1.8	203	7.6	46	86	0.01	9.0
HAASEN CREEK								
(at mouth near kernsville, station 01451860)								
7/11/67	19.5	18.3	354	8.1	97	174	0.18	8.2
10/25/67	14.0		397	7.2	89	151	0.00	9.1
9/4/68			386	8.0	126	180		9.4
JORDAN CREEK								
(at schearersville, station 01451950)								
10/25/67			606	7.4	118	185	0.05	1.7
4/30/68	13.0		660	3.2		98		11.0
9/5/68			478	8.3	125	187		3.2
JORDAN CREEK								
(at kernsville, station 01451840)								
7/11/67	24.0	27.0	166	6.9	37	64	0.05	6.3
9/4/68			207	7.9	57	87		3.2
1/22/69	0.0		189	7.6	23	66		32.0
JORDAN CREEK								
(near stetlersville, station 01451900)								
10/25/67			289	8.2	84	131	0.06	6.1
9/4/68			314	8.2	94	139		7.6

JORDAN CREEK (At Pleasant Corners, Station ID: 01451695)

Date	Parameter	Value	Unit
13-Jun-72	ALKALINITY, TOTAL	23.00	$CaCO_3$
19-Jul-72	ALKALINITY, TOTAL	33.00	$CaCO_3$
23-Aug-72	ALKALINITY, TOTAL	33.00	$CaCO_3$
20-Sep-72	ALKALINITY, TOTAL	40.00	$CaCO_3$
18-Oct-72	ALKALINITY, TOTAL	45.00	$CaCO_3$
13-Jun-72	FLOW, STREAM, MEAN DAILY	16.50	cfs
19-Jul-72	FLOW, STREAM, MEAN DAILY	16.00	cfs
23-Aug-72	FLOW, STREAM, MEAN DAILY	2.00	cfs
23-Aug-72	FLOW, STREAM, MEAN DAILY	2.00	cfs
20-Sep-72	FLOW, STREAM, MEAN DAILY	7.00	cfs
18-Oct-72	FLOW, STREAM, MEAN DAILY	1.70	cfs
13-Jun-72	NITRATE NITROGEN, DISSOLVED	15.00	mg/L NO_3
19-Jul-72	NITRATE NITROGEN, DISSOLVED	10.00	mg/L NO_3
23-Aug-72	NITRATE NITROGEN, DISSOLVED	9.30	mg/L NO_3
20-Sep-72	NITRATE NITROGEN, DISSOLVED	6.20	mg/L NO_3
18-Oct-72	NITRATE NITROGEN, DISSOLVED	5.80	mg/L NO_3
13-Jun-72	NITROGEN, AMMONIA, DISSOLVED	0.08	mg/L NH_4
19-Jul-72	NITROGEN, AMMONIA, DISSOLVED	0.03	mg/L NH_4
23-Aug-72	NITROGEN, AMMONIA, DISSOLVED	0.04	mg/L NH_4
20-Sep-72	NITROGEN, AMMONIA, DISSOLVED	0.17	mg/L NH_4
18-Oct-72	NITROGEN, AMMONIA, DISSOLVED	0.00	mg/L NH_4
13-Jun-72	OXYGEN, DISSOLVED	10.00	mg/L
19-Jul-72	OXYGEN, DISSOLVED	9.20	mg/L
23-Aug-72	OXYGEN, DISSOLVED	9.60	mg/L
20-Sep-72	OXYGEN, DISSOLVED	10.40	mg/L
18-Oct-72	OXYGEN, DISSOLVED	12.20	mg/L
13-Jun-72	pH	7.80	
19-Jul-72	pH	7.90	
23-Aug-72	pH	7.90	
20-Sep-72	pH	7.40	
18-Oct-72	pH	6.80	
13-Jun-72	PHOSPHATE, ORTHO	0.04	mg/L PO_4
19-Jul-72	PHOSPHATE, ORTHO	0.03	mg/L PO_4
23-Aug-72	PHOSPHATE, ORTHO	0.04	mg/L PO_4
20-Sep-72	PHOSPHATE, ORTHO	0.00	mg/L PO_4
18-Oct-72	PHOSPHATE, ORTHO	0.04	mg/L PO_4

Date	Parameter	Value	Unit
13-Jun-72	SPECIFIC CONDUCTANCE	135.00	µmhos/cm
23-Aug-72	SPECIFIC CONDUCTANCE	150.00	µmhos/cm
20-Sep-72	SPECIFIC CONDUCTANCE	142.00	µmhos/cm
18-Oct-72	SPECIFIC CONDUCTANCE	160.00	µmhos/cm

13-Jun-72	TEMPERATURE, WATER	16.00	°C
19-Jul-72	TEMPERATURE, WATER	21.00	°C
23-Aug-72	TEMPERATURE, WATER	18.00	°C
20-Sep-72	TEMPERATURE, WATER	15.00	°C
18-Oct-72	TEMPERATURE, WATER	6.00	°C

SWITZER CREEK (Near Pleasant Corners, Station ID: 1451700)

Date	Parameter	Value	Unit
3/13/67	TEMPERATURE, WATER	4.00	°C
	FLOW, STREAM, MEAN DAILY	53.30	cfs
	COLOR (PLATINUM-COBALT UNITS)	10.00	
	SPECIFIC CONDUCTANCE	170.00	µmhos/cm
	pH	7.00	
	ALKALINITY, TOTAL	13.00	mg/L $CaCO_3$
	BICARBONATE ION	16.00	mg/L HCO_3
	CARBONATE ION	0.00	mg/L $CaCO_3$
	PHOSPHATE, TOTAL	0.82	mg/L PO_4
	HARDNESS, TOTAL	67.00	mg/L $CaCO_3$
	HARDNESS, NON-CARBONATE	54.00	mg/L $CaCO_3$
	CALCIUM, DISSOLVED	19.00	mg/L Ca
	MAGNESIUM, DISSOLVED	4.70	mg/L Mg
	SODIUM, DISSOLVED	3.60	mg/L Na
	SODIUM ADSORPTION RATIO	0.20	
	SODIUM, PERCENT	10.00	% Na^+
	POTASSIUM, DISSOLVED	1.90	mg/L K
	CHLORIDE,TOTAL IN WATER	8.50	mg/L Cl^-
	SULFATE, TOTAL	28.00	mg/L SO_4
	FLUORIDE, DISSOLVED	0.00	mg/L F^-
	SILICA, DISSOLVED	6.60	mg/L SiO_2
	COPPER, DISSOLVED	0.00	µg/L Cu
	IRON, DISSOLVED	0.00	µg/L Fe
	MANGANESE, DISSOLVED	10.00	µg/L Mn
	ZINC, DISSOLVED	20.00	µg/L Zn
	ALUMINUM, TOTAL	100.00	µg/L Al^-
	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C)	135.00	mg/L
	SOLIDS, DISSOLVED	19.40	tons/day
	SOLIDS, DISSOLVED	0.18	tons/acre-foot
	NITRATE NITROGEN, DISSOLVED	25.00	mg/L NO_3
9/12/67	TEMPERATURE, WATER	20.50	°C
	FLOW, STREAM, MEAN DAILY	2.70	cfs
	COLOR (PLATINUM-COBALT UNITS)	2.00	
	SPECIFIC CONDUCTANCE	179.00	µmhos/cm
	pH	7.90	
	ALKALINITY, TOTAL	46.00	mg/L $CaCO_3$
	BICARBONATE ION	56.00	mg/L HCO_3
	CARBONATE ION	0.00	mg/L $CaCO_3$
	PHOSPHATE, TOTAL	0.04	mg/L PO_4
	HARDNESS, TOTAL	74.00	mg/L $CaCO_3$
	HARDNESS, NON-CARBONATE	28.00	mg/L $CaCO_3$
	CALCIUM, DISSOLVED	21.00	mg/L Ca

	MAGNESIUM, DISSOLVED	5.20	mg/L Mg
	SODIUM, DISSOLVED	3.80	mg/L Na
	SODIUM ADSORPTION RATIO	0.20	
	SODIUM, PERCENT	10.00	% Na^+
	POTASSIUM, DISSOLVED	2.30	mg/L K
	CHLORIDE,TOTAL IN WATER	7.50	mg/L Cl^-
	SULFATE, TOTAL	20.00	mg/L SO_4
	FLUORIDE, DISSOLVED	0.00	mg/L F^-
	SILICA, DISSOLVED	3.60	mg/L SiO_2
	COPPER, DISSOLVED	0.00	µg/L Fe
	IRON, DISSOLVED	10.00	µg/L Fe
	MANGANESE, DISSOLVED	0.00	µg/L Mn
	ZINC, DISSOLVED	890.00	µg/L Zn
	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C)	112.00	mg/L
	SOLIDS, DISSOLVED	0.82	tons/day
	SOLIDS, DISSOLVED	0.15	tons/acre-foot
	NITRATE NITROGEN, DISSOLVED	13.00	mg/L NO_3

10/25/67	TEMPERATURE, WATER	13.00	°C
	FLOW, STREAM, MEAN DAILY	2.60	cfs
	COLOR (PLATINUM-COBALT UNITS)	2.00	
	SPECIFIC CONDUCTANCE	186.00	µmhos/cm
	pH	6.90	
	ALKALINITY, TOTAL	40.00	mg/L $CaCO_3$
	BICARBONATE ION	49.00	mg/L HCO_3
	CARBONATE ION	0.00	mg/L $CaCO_3$
	PHOSPHATE, TOTAL	0.00	mg/L PO_4
	HARDNESS, TOTAL	77.00	mg/L $CaCO_3$
	HARDNESS, NON-CARBONATE	37.00	mg/L $CaCO_3$
	CALCIUM, DISSOLVED	22.00	mg/L Ca
	MAGNESIUM, DISSOLVED	5.20	mg/L Mg
	SODIUM, DISSOLVED	4.10	mg/L Na
	SODIUM ADSORPTION RATIO	0.20	
	SODIUM, PERCENT	10.00	% Na^+
	POTASSIUM, DISSOLVED	2.40	mg/L K
	CHLORIDE,TOTAL IN WATER	7.30	mg/L Cl^-
	SULFATE, TOTAL	24.00	mg/L SO_4
	FLUORIDE, DISSOLVED	0.00	mg/L F^-
	SILICA, DISSOLVED	5.50	mg/L SiO_2
	MANGANESE, TOTAL	0.00	µg/L Mn
	RESIDUE,TOTAL FILTRABLE (DRIED AT 180C)	107.00	mg/L
	SOLIDS, DISSOLVED-SUM OF CONSTITUENTS	106.00	mg/L
	SOLIDS, DISSOLVED	0.75	tons/day
	SOLIDS, DISSOLVED	0.15	tons/acre-foot
	NITRATE NITROGEN, DISSOLVED	11.00	mg/L NO_3
	IRON	0.00	µg/L Fe

6/13/72	TEMPERATURE, WATER	17.00	°C
	TEMPERATURE, AIR	22.00	°C
	FLOW, STREAM, MEAN DAILY	6.50	cfs
	STAGE, STREAM	5.09	feet
	SPECIFIC CONDUCTANCE	165.00	µmhos/cm
	OXYGEN, DISSOLVED	10.00	mg/L
	pH	7.50	
	NITROGEN, ORGANIC, TOTAL	1.30	mg/L N
	NITROGEN, ORGANIC, DISSOLVED	1.30	mg/L N
	NITROGEN, AMMONIA, DISSOLVED	0.02	mg/L N
	NITROGEN, AMMONIA, TOTAL	0.07	mg/L N
	NITRATE NITROGEN, DISSOLVED	0.00	mg/L N
	NITRATE NITROGEN, TOTAL	0.68	mg/L N
	NITROGEN, KJELDAHL, DISSOLVED	1.30	mg/L N
	NITROGEN, KJELDAHL, TOTAL	1.30	mg/L N
	PHOSPHATE, ORTHO	0.03	mg/L PO_4
	PHOSPHORUS, TOTAL	0.08	mg/L P
	PHOSPHORUS, DISSOLVED	0.03	mg/L P
	PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE	0.01	mg/L P
	TURBIDITY (SEVERITY)	0.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	770.00	
	FECAL STREPTOCOCCI,MF M-ENTEROCOCCUS AGAR,35C,48H	840.00	
	PHOSPHORUS,IN TOTAL ORTHOPHOSPHATE	0.05	mg/L P
	NITROGEN, AMMONIA, DISSOLVED	0.03	mg/L NH_4
	NITRATE NITROGEN, DISSOLVED	0.00	mg/L NO_3
	TEMPERATURE, WATER	21.00	°C
	TEMPERATURE, AIR	23.00	°C
	FLOW, STREAM, MEAN DAILY	13.00	cfs
	STAGE, STREAM	4.77	feet
	OXYGEN, DISSOLVED	9.00	mg/L
	ALKALINITY	42.00	mg/L $CaCO_3$
	NITROGEN, ORGANIC, TOTAL	0.78	mg/L N
	NITROGEN, ORGANIC, DISSOLVED	0.84	mg/L N
	NITROGEN, AMMONIA, DISSOLVED	0.01	mg/L N
	NITROGEN, AMMONIA	0.07	mg/L N
	NITRATE NITROGEN, DISSOLVED	2.70	mg/L N
	NITRATE NITROGEN	3.60	mg/L N

MILL CREEK (At Schnecksville, Station ID: 01451700)

Date	Parameter	Value	Unit
06/13/72	ALKALINITY, TOTAL	33.00	mg/L $CaCo_3$
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	480.00	
	NITRATE NITROGEN, DISSOLVED	18.00	mg/L NO_3
	OXYGEN, DISSOLVED	10.40	mg/L
	PH	7.50	
	PHOSPHATE, ORTHO	0.13	mg/L PO_4
	SPECIFIC CONDUCTANCE	185.00	µmhos/cm
	TEMPERATURE, WATER	16.00	°C
07/19/72	ALKALINITY, TOTAL	43.00	mg/L $CaCo_3$
	NITRATE NITROGEN, DISSOLVED	11.00	mg/L NO_3
	OXYGEN, DISSOLVED	9.20	mg/L
	PH	7.40	
	PHOSPHATE, ORTHO	0.15	mg/L PO_4
	TEMPERATURE, WATER	21.00	°C
08/23/72	ALKALINITY, TOTAL	49.00	mg/L $CaCo_3$
	NITRATE NITROGEN, DISSOLVED	18.00	mg/L NO_3
	OXYGEN, DISSOLVED	8.50	mg/L
	PH	7.40	
	PHOSPHATE, ORTHO	0.46	mg/L PO_4
	SPECIFIC CONDUCTANCE	250.00	µmhos/cm
	TEMPERATURE, WATER	20.00	°C
09/20/72	ALKALINITY, TOTAL	56.00	mg/L $CaCo_3$
	NITRATE NITROGEN, DISSOLVED	12.00	mg/L NO_3
	OXYGEN, DISSOLVED	9.00	mg/L
	PH	7.40	
	PHOSPHATE, ORTHO	0.55	mg/L PO_4
	SPECIFIC CONDUCTANCE	250.00	µmhos/cm
	TEMPERATURE, WATER	16.50	°C
10/18/72	ALKALINITY, TOTAL	54.00	mg/L $CaCo_3$
	OXYGEN, DISSOLVED	9.40	mg/L
	PH	6.90	
	PHOSPHATE, ORTHO	1.10	mg/L PO_4
	SPECIFIC CONDUCTANCE	275.00	µmhos/cm
	TEMPERATURE, WATER	8.00	°C
11/22/72	ALKALINITY, TOTAL	16.00	mg/L $CaCo_3$
	NITRATE NITROGEN, DISSOLVED	30.00	mg/L NO_3
	OXYGEN, DISSOLVED	13.20	mg/L

Date	Parameter	Value	Unit
	PH	6.60	
	PHOSPHATE, ORTHO	0.09	mg/L PO_4
	SPECIFIC CONDUCTANCE	200.00	µmhos/cm
	TEMPERATURE, WATER	3.00	°C
12/20/72	ALKALINITY, TOTAL	18.00	mg/L $CaCo_3$
	NITRATE NITROGEN, DISSOLVED	22.00	mg/L NO_3
	OXYGEN, DISSOLVED	13.40	mg/L
	PH	7.60	
	PHOSPHATE, ORTHO	0.09	mg/L PO_4
	SPECIFIC CONDUCTANCE	215.00	µmhos/cm
	TEMPERATURE, WATER	5.00	°C
01/17/73	ALKALINITY, TOTAL	24.00	mg/L $CaCo_3$
	NITRATE NITROGEN, DISSOLVED	8.00	mg/L NO_3
	OXYGEN, DISSOLVED	16.00	mg/L
	PH	7.00	
	PHOSPHATE, ORTHO	0.13	mg/L PO_4
	SPECIFIC CONDUCTANCE	210.00	µmhos/cm
	TEMPERATURE, WATER	3.50	°C
02/14/73	ALKALINITY, TOTAL	40.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	240.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	11.00	
	NITRATE NITROGEN, DISSOLVED	23.00	mg/L NO_3
	OXYGEN, DISSOLVED	15.00	mg/L
	PH	7.30	
	PHOSPHATE, ORTHO	0.16	mg/L PO_4
	SPECIFIC CONDUCTANCE	195.00	µmhos/cm
	TEMPERATURE, WATER	1.50	°C
03/13/73	ALKALINITY, TOTAL	20.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	1400.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	160.00	
	NITRATE NITROGEN, DISSOLVED	24.00	mg/L NO_3
	OXYGEN, DISSOLVED	11.90	mg/L
	PH	7.40	
	PHOSPHATE, ORTHO	0.16	mg/L PO_4
	SPECIFIC CONDUCTANCE	200.00	µmhos/cm
	TEMPERATURE, WATER	12.00	°C
04/02/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	13000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	1200.00	
	PH	6.90	
	SPECIFIC CONDUCTANCE	150.00	µmhos/cm

Date	Parameter	Value	Unit
	SPECIFIC CONDUCTANCE	170.00	µmhos/cm
	TEMPERATURE, WATER	9.50	°C
	TEMPERATURE, WATER	10.00	°C
04/28/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	1800.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	1000.00	
	PH	7.60	
	SPECIFIC CONDUCTANCE	200.00	µmhos/cm
	TEMPERATURE, WATER	10.00	°C
05/23/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	4800.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	730.00	
	NITRATE NITROGEN, DISSOLVED	14.00	mg/L NO_3
	OXYGEN, DISSOLVED	11.60	mg/L
	PH	7.20	
	PHOSPHATE, ORTHO	0.25	mg/L PO_4
	SPECIFIC CONDUCTANCE	190.00	µmhos/cm
	TEMPERATURE, WATER	13.00	°C
06/12/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	4800.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	170.00	
	NITRATE NITROGEN, DISSOLVED	16.00	mg/L NO_3
	OXYGEN, DISSOLVED	11.40	mg/L
	PH	7.40	
	PHOSPHATE, ORTHO	0.43	mg/L PO_4
	SPECIFIC CONDUCTANCE	215.00	µmhos/cm
	TEMPERATURE, WATER	21.00	°C
07/18/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	7200.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	670.00	
	NITRATE NITROGEN, DISSOLVED	16.00	mg/L NO_3
	OXYGEN, DISSOLVED	10.60	mg/L
	PH	7.50	
	PHOSPHATE, ORTHO	0.58	mg/L PO_4
	SPECIFIC CONDUCTANCE	220.00	µmhos/cm
	TEMPERATURE, WATER	18.50	°C
08/14/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	4400.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	550.00	
	NITRATE NITROGEN, DISSOLVED	12.00	mg/L NO_3
	OXYGEN, DISSOLVED	12.00	mg/L
	PH	7.40	
	PHOSPHATE, ORTHO	0.67	mg/L PO_4
	SPECIFIC CONDUCTANCE	240.00	µmhos/cm
	TEMPERATURE, WATER	22.00	°C

Date	Parameter	Value	Unit
09/12/73	ALKALINITY, TOTAL	64.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	120000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	6000.00	
	NITRATE NITROGEN, DISSOLVED	14.00	mg/L NO_3
	OXYGEN, DISSOLVED	10.80	mg/L
	PH	7.30	
	PHOSPHATE, ORTHO	1.50	mg/L PO_4
	SPECIFIC CONDUCTANCE	270.00	µmhos/cm
	TEMPERATURE, WATER	18.00	°C
10/29/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	3400.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	530.00	
	OXYGEN, DISSOLVED	10.00	mg/L
	PH	6.60	
	SPECIFIC CONDUCTANCE	245.00	µmhos/cm
	TEMPERATURE, WATER	9.50	°C
11/14/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	250.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	50.00	
	OXYGEN, DISSOLVED	11.40	mg/L
	PH	7.20	
	SPECIFIC CONDUCTANCE	240.00	µmhos/cm
	TEMPERATURE, WATER	8.50	°C
12/05/73	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	300000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	1600.00	
	OXYGEN, DISSOLVED	10.00	mg/L
	PH	6.70	
	SPECIFIC CONDUCTANCE	190.00	µmhos/cm
	TEMPERATURE, WATER	11.00	°C
01/22/74	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	15000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	470.00	
	OXYGEN, DISSOLVED	13.00	mg/L
	PH	7.20	
	SPECIFIC CONDUCTANCE	210.00	µmhos/cm
	TEMPERATURE, WATER	5.00	°C
02/20/74	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	3800.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	390.00	
	OXYGEN, DISSOLVED	13.60	mg/L
	PH	7.40	
	SPECIFIC CONDUCTANCE	230.00	µmhos/cm
	TEMPERATURE, WATER	4.00	°C

Date	Parameter	Value	Unit
03/20/74	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	500.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	73.00	
	OXYGEN, DISSOLVED	13.20	mg/L
	PH	7.30	
	SPECIFIC CONDUCTANCE	200.00	µmhos/cm
	TEMPERATURE, WATER	5.50	°C
04/16/74	ALKALINITY, TOTAL	80.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	680.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	40.00	
	OXYGEN, DISSOLVED	10.80	mg/L
	PH	6.20	
	SPECIFIC CONDUCTANCE	190.00	µmhos/cm
	TEMPERATURE, WATER	13.00	°C
05/08/74	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	140.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	20.00	
	OXYGEN, DISSOLVED	12.40	mg/L
	PH	8.30	
	SPECIFIC CONDUCTANCE	210.00	µmhos/cm
	TEMPERATURE, WATER	13.00	°C
06/19/74	ALKALINITY, TOTAL	74.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	11000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	1800.00	
	OXYGEN, DISSOLVED	9.70	mg/L
	PH	6.70	
	SPECIFIC CONDUCTANCE	240.00	µmhos/cm
	TEMPERATURE, WATER	16.00	°C
10/14/74	ALKALINITY, TOTAL	50.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	7400.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	1300.00	
	OXYGEN, DISSOLVED	10.10	mg/L
	PH	6.90	
	SPECIFIC CONDUCTANCE	239.00	µmhos/cm
	TEMPERATURE, WATER	12.50	°C
11/19/74	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	550.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	120.00	
	OXYGEN, DISSOLVED	12.70	mg/L
	PH	7.80	
	SPECIFIC CONDUCTANCE	265.00	µmhos/cm
	TEMPERATURE, WATER	3.00	°C
12/17/74	ALKALINITY, TOTAL	26.00	mg/L $CaCo_3$

Date	Parameter	Value	Unit
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	2400.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	150.00	
	OXYGEN, DISSOLVED	11.80	mg/L
	PH	6.40	
	SPECIFIC CONDUCTANCE	210.00	µmhos/cm
	TEMPERATURE, WATER	5.00	°C
01/21/75	ALKALINITY, TOTAL	20.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	590.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	150.00	
	OXYGEN, DISSOLVED	17.00	mg/L
	PH	6.20	
	SPECIFIC CONDUCTANCE	240.00	µmhos/cm
	TEMPERATURE, WATER	0.50	°C
02/18/75	ALKALINITY, TOTAL	34.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	25000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	2200.00	
	OXYGEN, DISSOLVED	12.20	mg/L
	PH	6.60	
	SPECIFIC CONDUCTANCE	260.00	µmhos/cm
	TEMPERATURE, WATER	5.00	°C
03/17/75	ALKALINITY, TOTAL	29.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	580.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	170.00	
	OXYGEN, DISSOLVED	13.60	mg/L
	PH	7.50	
	SPECIFIC CONDUCTANCE	187.00	µmhos/cm
	TEMPERATURE, WATER	4.50	°C
04/07/75	ALKALINITY, TOTAL	18.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	6100.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	530.00	
	OXYGEN, DISSOLVED	12.20	mg/L
	PH	7.00	
	SPECIFIC CONDUCTANCE	172.00	µmhos/cm
	TEMPERATURE, WATER	3.50	°C
05/13/75	ALKALINITY, TOTAL	31.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	1700.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	240.00	
	OXYGEN, DISSOLVED	10.00	mg/L
	PH	7.60	
	SPECIFIC CONDUCTANCE	195.00	µmhos/cm
	TEMPERATURE, WATER	16.50	°C

Date	Parameter	Value	Unit
06/17/75	ALKALINITY, TOTAL	33.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	40000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	2500.00	
	OXYGEN, DISSOLVED	9.00	mg/L
	PH	7.30	
	SPECIFIC CONDUCTANCE	205.00	µmhos/cm
	TEMPERATURE, WATER	18.00	°C
07/15/75	ALKALINITY, TOTAL	33.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	11000.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	800.00	
	OXYGEN, DISSOLVED	9.20	mg/L
	PH	6.80	
	SPECIFIC CONDUCTANCE	205.00	µmhos/cm
	TEMPERATURE, WATER	19.00	°C
08/19/75	ALKALINITY, TOTAL	44.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	5800.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	1600.00	
	OXYGEN, DISSOLVED	9.60	mg/L
	PH	7.10	
	SPECIFIC CONDUCTANCE	210.00	µmhos/cm
	TEMPERATURE, WATER	18.00	°C
09/16/75	ALKALINITY, TOTAL	48.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	1100.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	90.00	
	OXYGEN, DISSOLVED	10.60	mg/L
	PH	7.10	
	SPECIFIC CONDUCTANCE	240.00	µmhos/cm
	TEMPERATURE, WATER	12.50	°C
10/06/75	ALKALINITY, TOTAL	31.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	480.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	67.00	
	OXYGEN, DISSOLVED	10.20	mg/L
	PH	6.70	
	SPECIFIC CONDUCTANCE	210.00	µmhos/cm
	TEMPERATURE, WATER	16.50	°C
11/11/75	ALKALINITY, TOTAL	34.00	mg/L $CaCo_3$
	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	1400.00	
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	180.00	
	OXYGEN, DISSOLVED	10.90	mg/L
	PH	7.10	

LYON CREEK, (At Lyon Valley, Station ID: 01451738)

Date	Parameter	Value	Unit
06/13/72	ALKALINITY, TOTAL	30.00	mg/L $CaCo_3$
	NITRATE NITROGEN, DISSOLVED	18.00	mg/L NO_3
	NITROGEN, AMMONIA, DISSOLVED	0.08	mg/L NH_4
	OXYGEN, DISSOLVED	10.40	mg/L
	pH	7.50	
	PHOSPHATE, ORTHO	0.01	mg/L PO_4
	SPECIFIC CONDUCTANCE	190.00	µmhos/cm
	TEMPERATURE, WATER	18.00	°C
07/19/72	ALKALINITY, TOTAL	33.00	mg/L $CaCo_3$
	FLOW, STREAM, MEAN DAILY	13.00	cfs
	NITRATE NITROGEN, DISSOLVED	13.00	mg/L NO_3
	NITROGEN, AMMONIA, DISSOLVED	0.05	mg/L NH_4
	OXYGEN, DISSOLVED	9.40	mg/L
	pH	7.60	
	PHOSPHATE, ORTHO	0.05	mg/L PO_4
	TEMPERATURE, WATER	25.00	°C
08/23/72	ALKALINITY, TOTAL	42.00	mg/L $CaCo_3$
	FLOW, STREAM, MEAN DAILY	7.60	cfs
	NITRATE NITROGEN, DISSOLVED	14.00	mg/L NO_3
	NITROGEN, AMMONIA, DISSOLVED	0.05	mg/L NH_4
	OXYGEN, DISSOLVED	8.80	mg/L
	pH	7.70	
	PHOSPHATE, ORTHO	0.08	mg/L PO_4
	SPECIFIC CONDUCTANCE	295.00	µmhos/cm
	TEMPERATURE, WATER	23.00	°C
09/20/72	ALKALINITY, TOTAL	51.00	mg/L $CaCo_3$
	FLOW, STREAM, MEAN DAILY	4.00	cfs
	NITRATE NITROGEN, DISSOLVED	7.10	mg/L NO_3
	NITROGEN, AMMONIA, DISSOLVED	0.10	mg/L NH_4
	OXYGEN, DISSOLVED	10.00	mg/L
	pH	7.40	
	PHOSPHATE, ORTHO	0.05	mg/L PO_4
	SPECIFIC CONDUCTANCE	225.00	µmhos/cm
	TEMPERATURE, WATER	18.00	°C
10/18/72	FLOW, STREAM, MEAN DAILY	4.00	cfs
	OXYGEN, DISSOLVED	12.40	mg/L
	pH	6.90	
	PHOSPHATE, ORTHO	0.04	mg/L PO_4
	SPECIFIC CONDUCTANCE	215.00	µmhos/cm

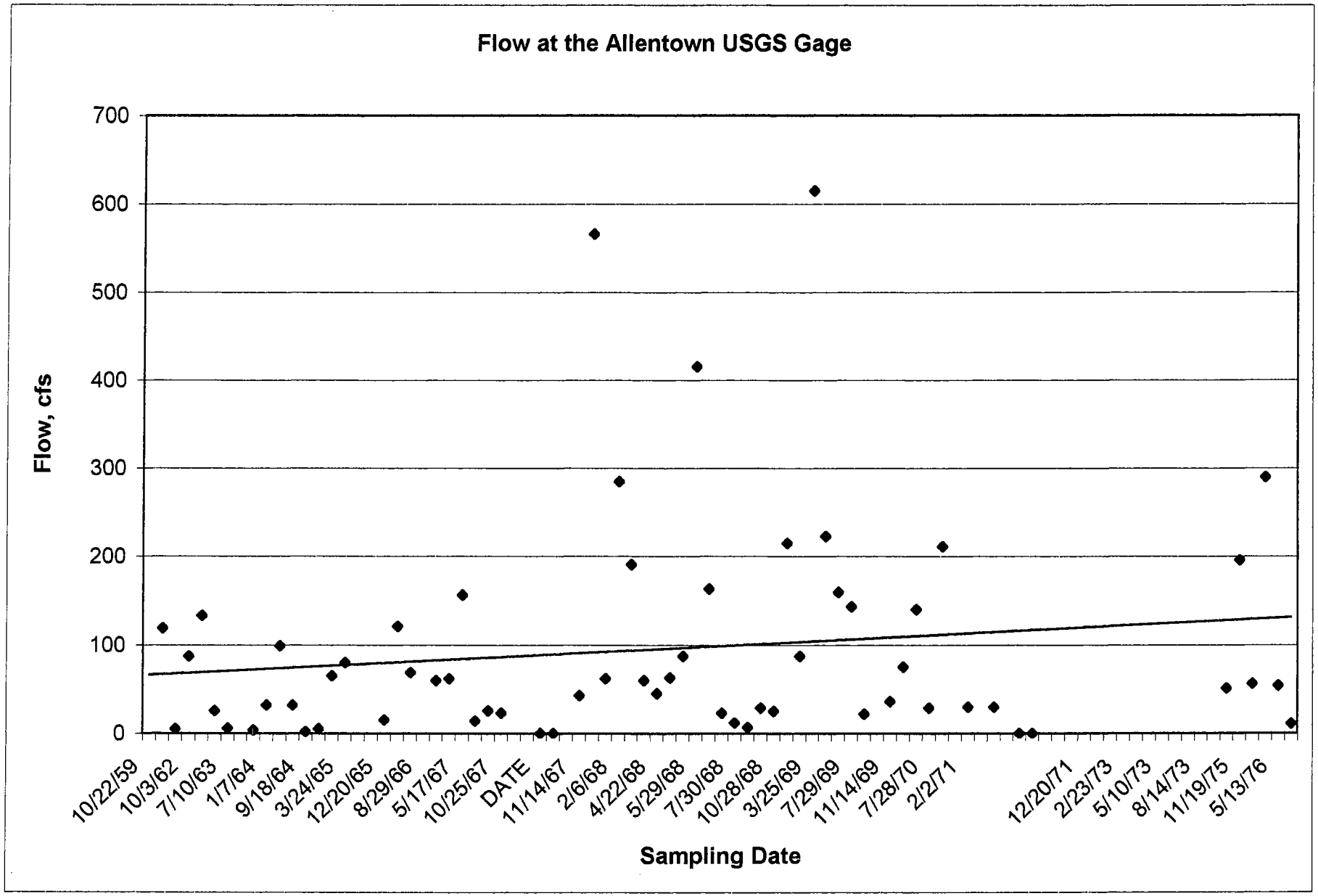
JORDAN CREEK AT ALLENTOWN

STATION ID: 01452000

DATE	WATER TEMP. °C	FLOW cfs	SPECIFIC CONDUCTANCE µmhos/cm	DISSOLVED OXYGEN mg/L	pH	ALKALINITY mg/L $CaCO_3$	NITROGEN AMMONIA mg/L NH_4	NITROGEN NITRATE mg/L NO_3	PHOSPHOROUS ORTHO. mg/L PO_4
10/22/59	16		327		6.8			6.10	
4/26/60		119	212		7.1			9.40	
7/16/62		5		9.20	8.4	135			
10/3/62	13	87		9.20	7.5	65			
1/15/63	1	133		12.79	7.5	42			
4/15/63	11	26		10.00	7.2	75			
7/10/63	17	6		7.80	8.0	135			
10/14/63	10			7.20	8.0	135			
10/23/63		3.7	411		7.2	151			
1/7/64	1	32		9.80	7.4	83			
4/1/64	3	99		12.19	7.5	48			
6/24/64	18	32		5.40	7.3	91			
9/18/64		1.9	473		7.4	153			
9/21/64	16	5		4.60	7.5	153			
12/15/64	1	65		11.59	7.3	62			
3/24/65	6	80		17.00	7.4	69			
6/15/65	16			7.00	7.6	144			
9/21/65	15			5.80	7.5	155			
12/20/65	2	15		9.90	7.3	100			
3/14/66	7	121	215	8.80	7.4	51			
6/6/66	19	69	350	6.80	7.4	140			
8/29/66	21		380	9.00	8.0	139			
12/5/66	1	60	350	13.00	7.5	99			
2/20/67	2	62	250	13.59	7.2	53			0.00
5/17/67	11	156	215	11.00	7.3	45			0.00
6/26/67	19.5	14	451		8.2	125			
8/21/67	19	26	311	6.40	7.1	58			
10/25/67	14	23	507		8.1	111			
11/8/67			300						

DATE	WATER TEMP. °C	FLOW cfs	SPECIFIC CONDUCTANCE µmhos/cm	DISSOLVED OXYGEN mg/L	pH	ALKALINITY mg/L $CaCO_3$	NITROGEN AMMONIA mg/L NH_4	NITROGEN NITRATE mg/L NO_3	PHOSPHOROUS ORTHO. mg/L PO_4
11/14/67	19	43							
12/13/67	8	566	225		7.6	28			
12/29/67	0	62							
2/6/68	2	285							
2/13/68	1	191	130	13.39	6.9	88			0.02
3/12/68	5	60							
4/22/68	15	45							
5/6/68	13	63	300	10.39	7.5	72			0.02
5/28/68	13	87							
5/29/68	12	415							
6/6/68	19	163							
7/23/68	19	23							
7/30/68	17	12	440	6.20	7.3	130			0.01
9/5/68	19	7							
10/8/68		29							
10/28/68	10	25		8.00	7.1	119			0.02
12/4/68		215							
2/3/69	7.399	87		4.00	12.4	50			0.06
3/25/69		615							
3/27/69		223							
5/6/69	16	159	330	8.40	7.6	77			0.02
7/29/69	21.5	143	260	7.00	7.0	61			0.07
11/6/69	10	22		9.60	7.4	112			0.02
11/13/69	8.5			6.20	7.5	196			
11/14/69	7	36		9.60	6.6	106			0.01
2/3/70	5.399	75		12.00	7.0	57			0.03
5/5/70	15	140		9.00	7.2	65			0.05
7/28/70	20	29	380	6.40	7.5	116			0.05
10/27/70	14	211		13.00	8.0	47			0.25
2/1/71	0			12.39	7.0	85			
2/2/71	0	30		12.39	7.0	85			0.04
4/28/71	11			9.00	7.2	92			
4/29/71	11	30		9.00	7.2	92			0.00

DATE	WATER TEMP. °C	FLOW cfs	SPECIFIC CONDUCTANCE µmhos/cm	DISSOLVED OXYGEN mg/L	pH	ALKALINITY mg/L $CaCO_3$	NITROGEN AMMONIA mg/L NH_4	NITROGEN NITRATE mg/L NO_3	PHOSPHOROUS ORTHO. mg/L PO_4
5/21/71	14			7.40	7.3	87	1.00	2.20	
7/27/71	20			8.00	7.4	105			
12/20/71			236		7.9	66			0.01
2/1/72	0.5			11.50	7.2	58			
2/13/73			280		7.7	154	0.10	6.24	
2/23/73	0.5999		210	11.00	7.4	35		1.60	
3/5/73			250		7.7	41	0.20	3.60	
4/2/73					6.6	24	0.50	3.36	
5/10/73			180		7.6	47	0.12	4.92	
7/10/73			350		8.1	136	0.11	4.20	
8/9/73					8.4	45	0.30	2.30	
8/14/73			330		7.6	107	0.34	1.20	
9/20/73			250		7.7	73		2.16	
10/16/75	16	51	200	10.39		78	0.12		
11/19/75	10	196	160	10.59	7.6	52	0.10	4.08	
12/16/75	7	56	230	10.39		242	0.45	3.60	
2/19/76	7	290	180	11.79	7.3	40	0.20	2.40	
5/13/76	16	54	350	9.60	7.7	68	0.45	2.04	
8/19/76	18	11	500	8.10	8.5	136	0.91	0.90	


Flow at the Allentown USGS Gage
Flow, cfs
700
600
500
400
300
200
100
0
10/22/59
10/3/62
7/10/63
1/7/64
9/18/64
3/24/65
12/20/65
8/29/66
5/17/67
10/25/67
DATE
11/14/67
2/6/68
4/22/68
5/29/68
7/30/68
10/28/68
3/25/69
7/29/69
11/14/69
7/28/70
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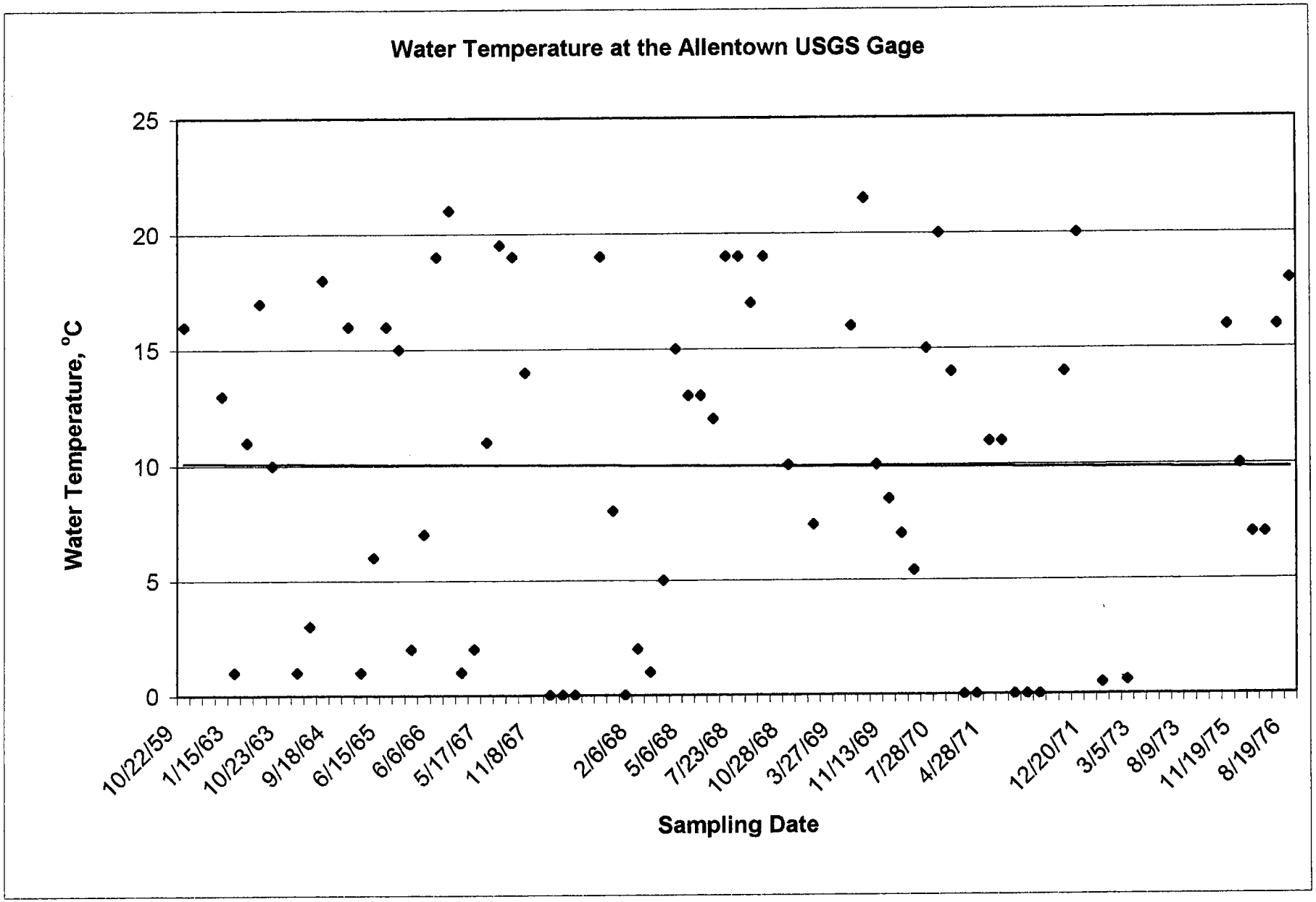
11/19/75
5/13/76
Sampling Date


Water Temperature at the Allentown USGS Gage
Water Temperature, °C
25
20
15
10
5
0
10/22/59
1/15/63
10/23/63
9/18/64
6/15/65
6/6/66
5/17/67
11/8/67
2/6/68
5/6/68
7/23/68
10/28/68
3/27/69
11/13/69
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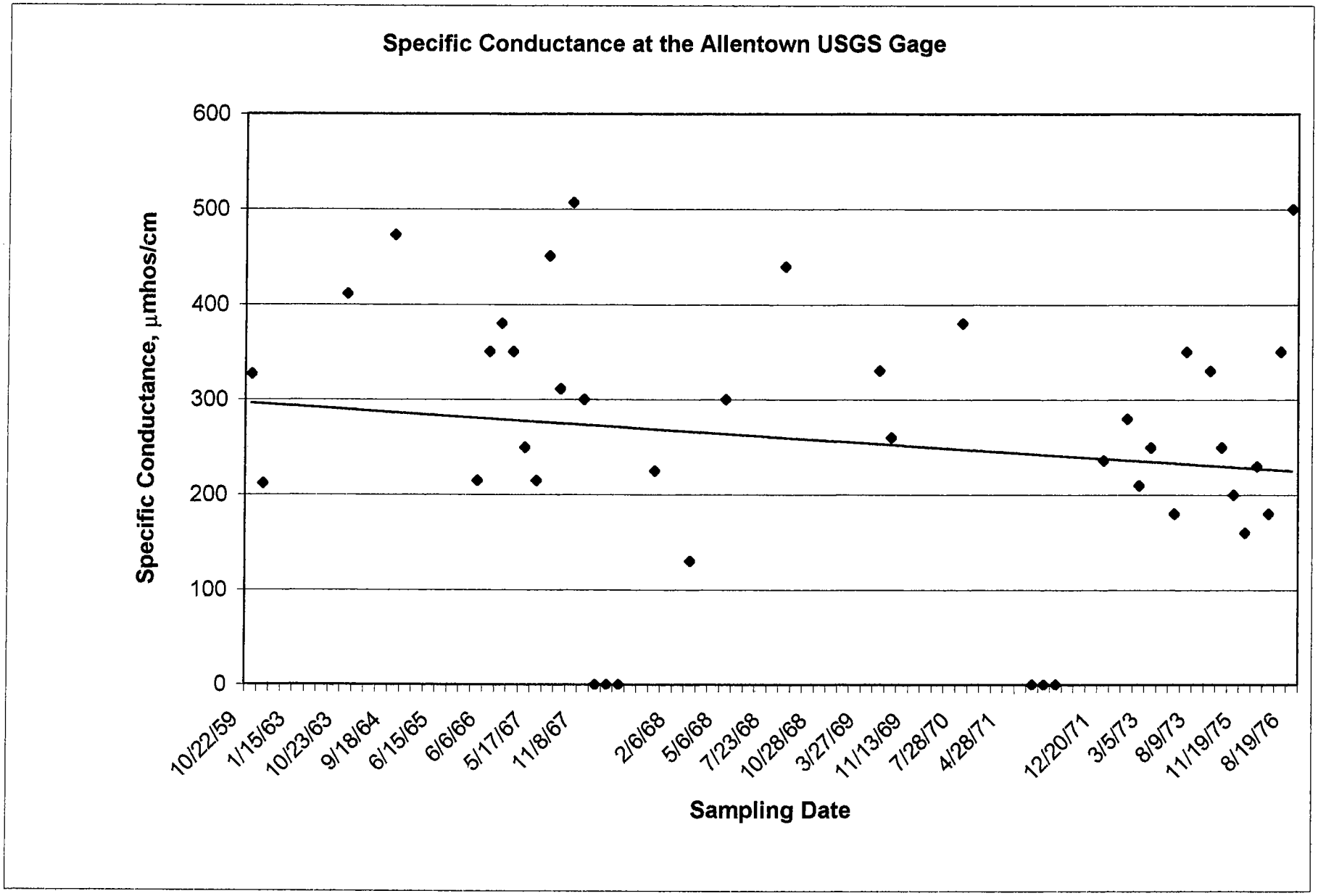
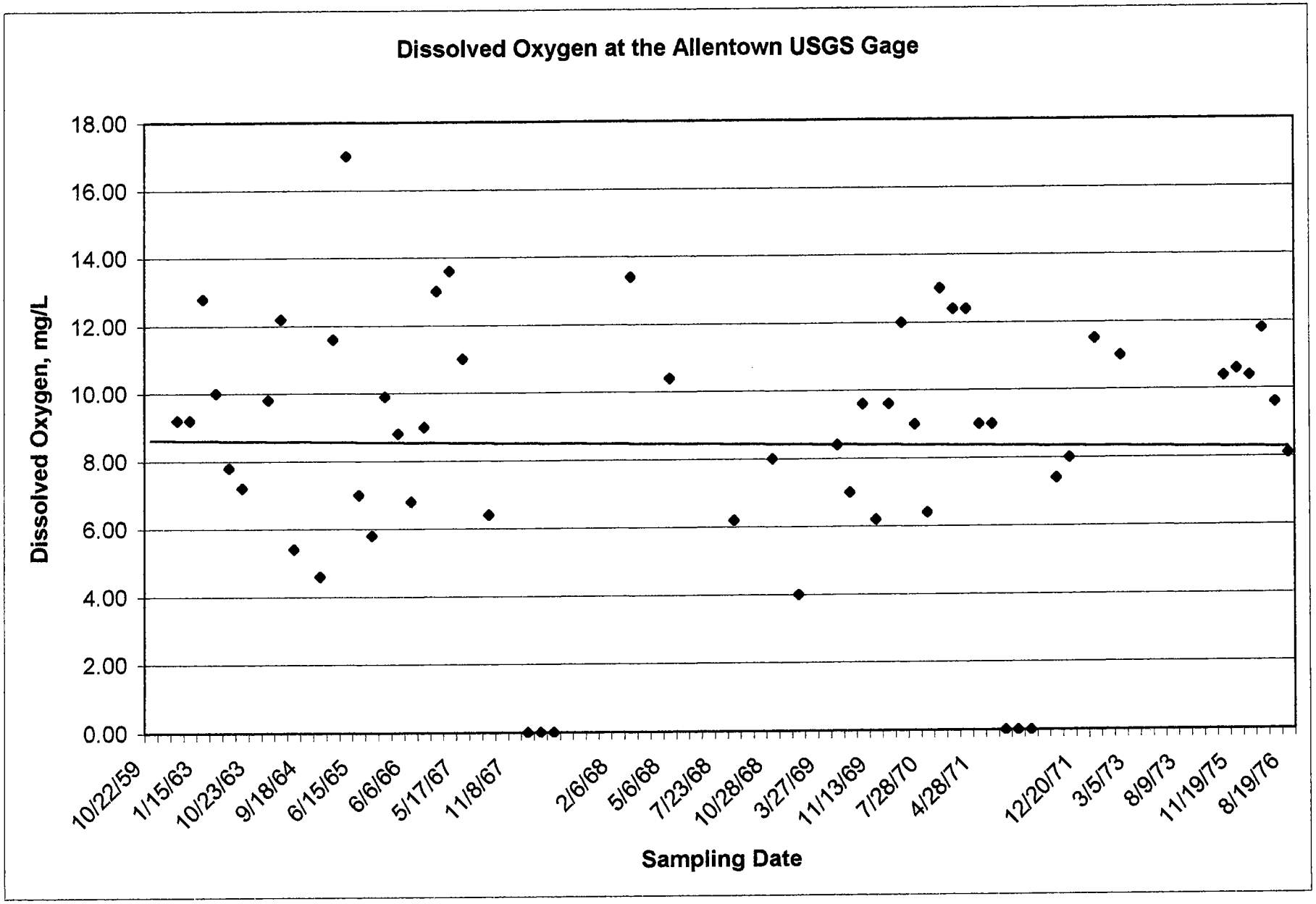
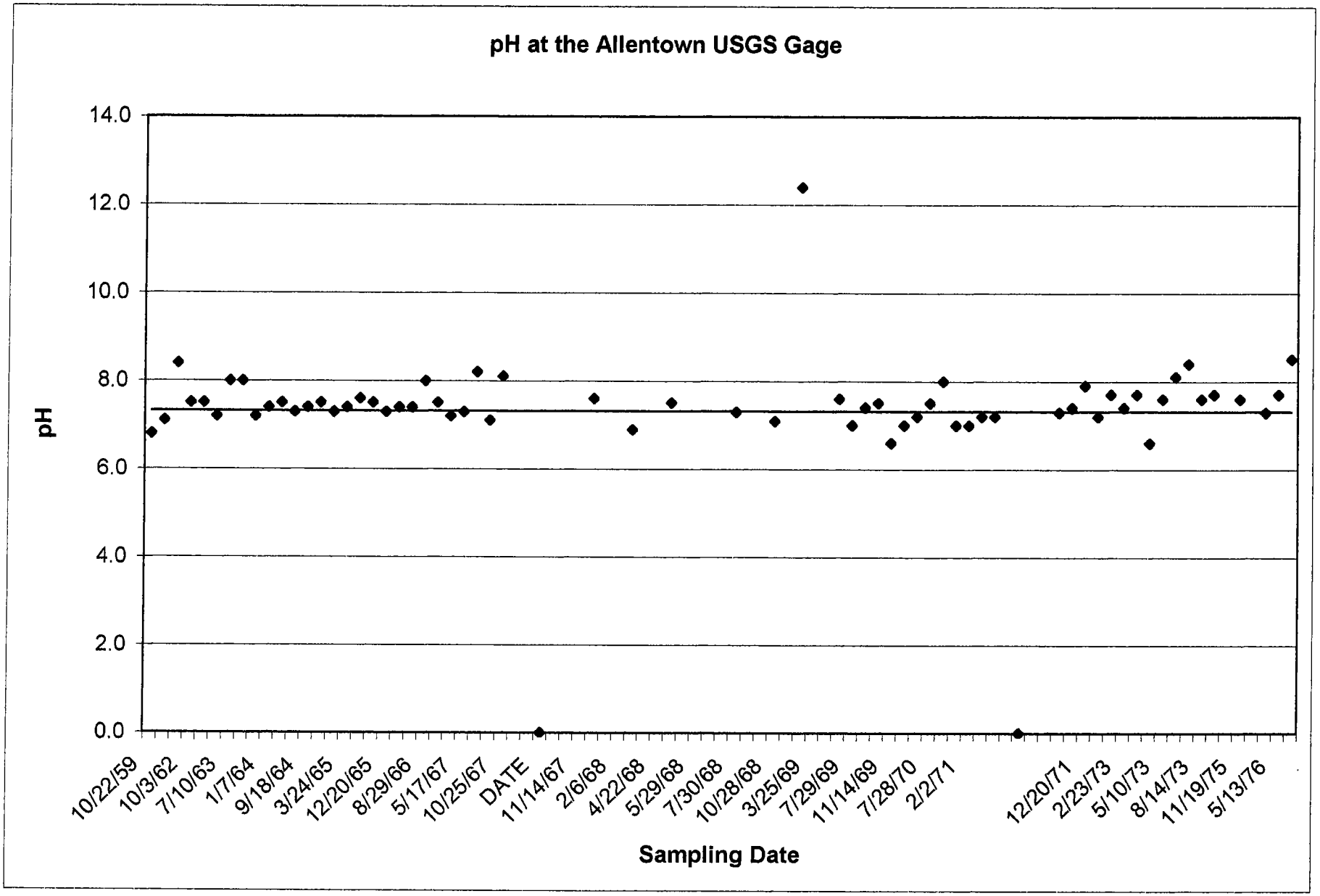
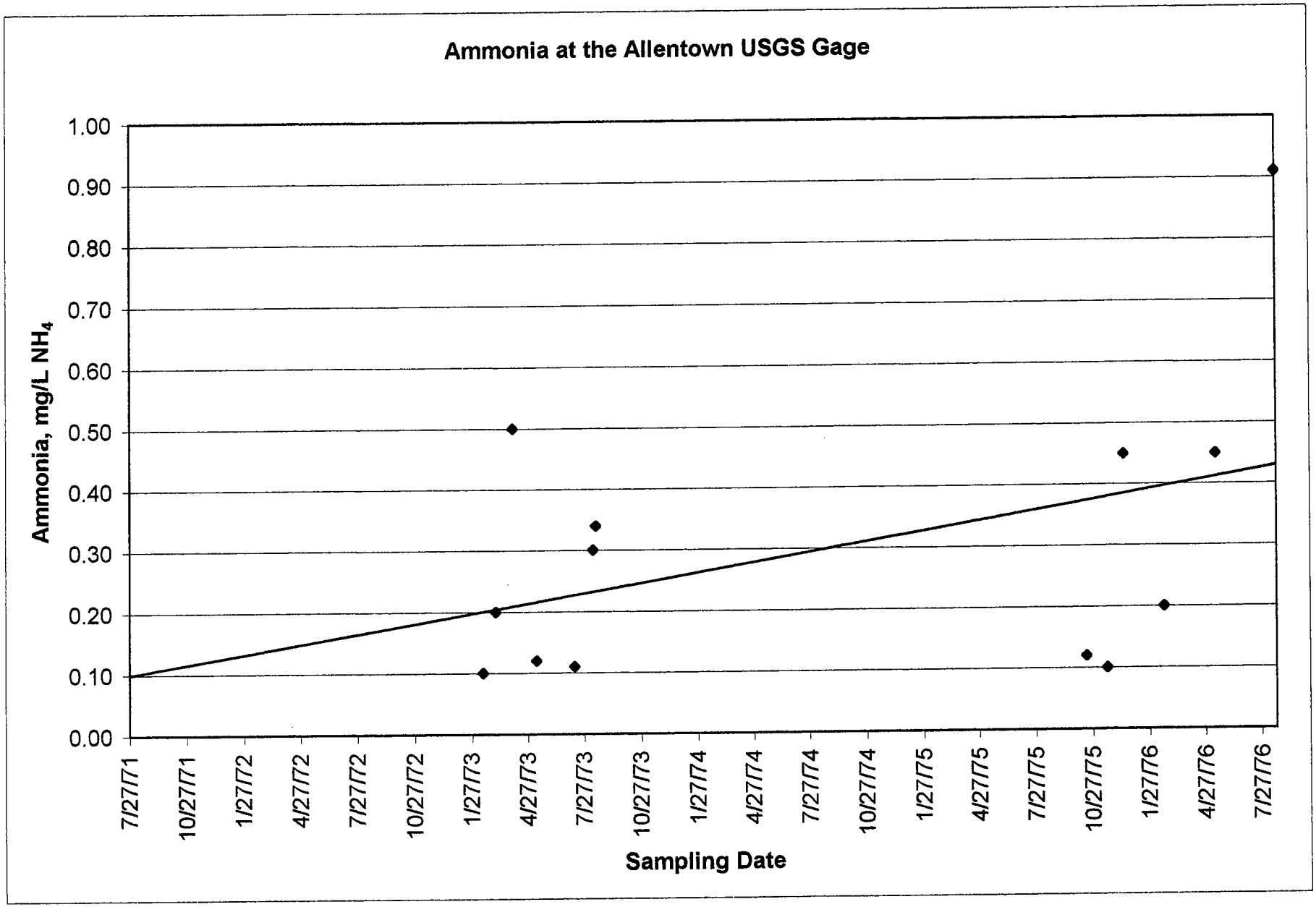
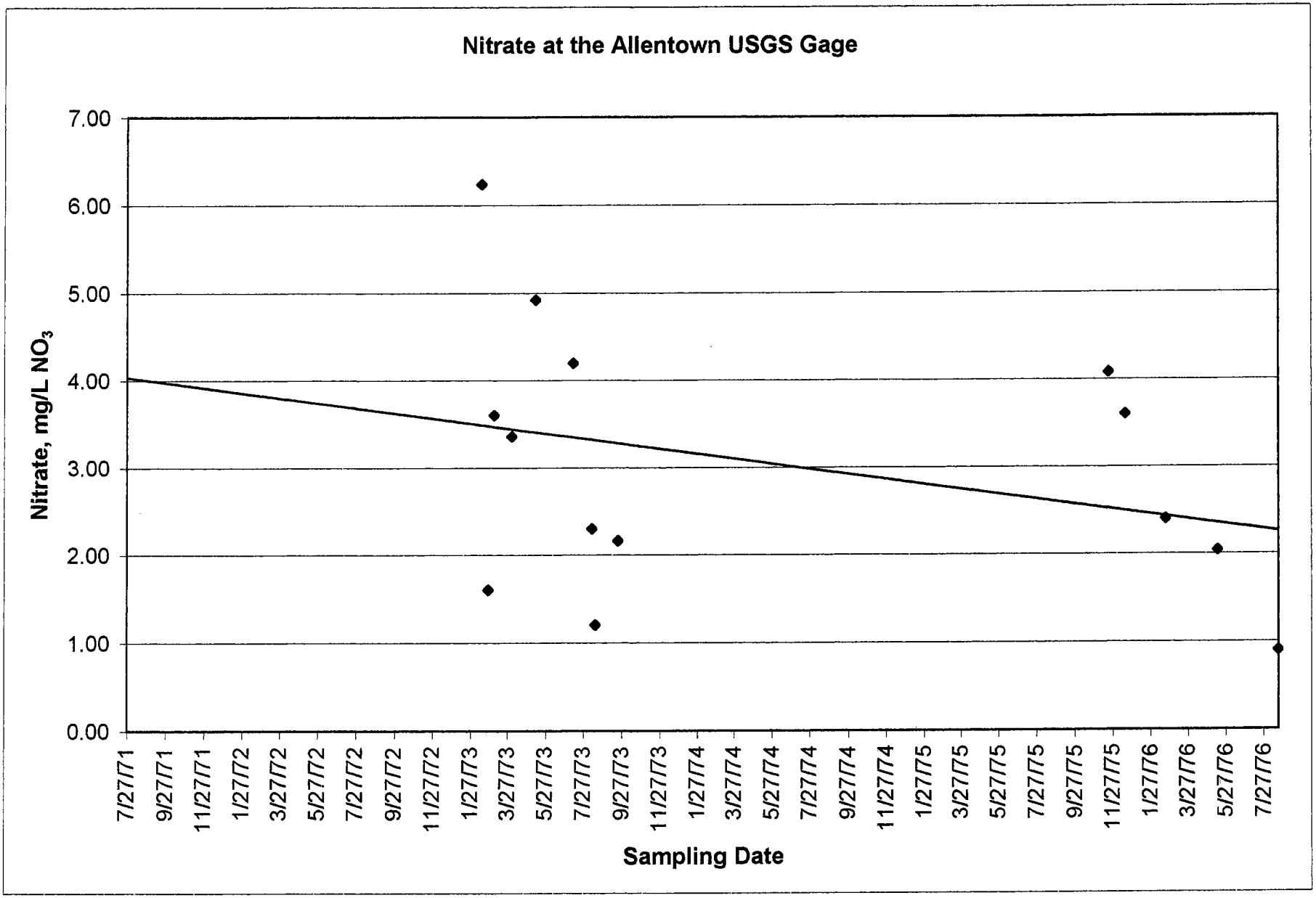
11/19/75
8/19/76
Sampling Date


Specific Conductance at the Allentown USGS Gage
Specific Conductance, µmhos/cm
600
500
400
300
200
100
0
10/22/59
1/15/63
10/23/63
9/18/64
6/15/65
6/6/66
5/17/67
11/8/67
2/6/68
5/6/68
7/23/68
10/28/68
3/27/69
11/13/69
7/28/70
4/28/71
12/20/71
3/5/73
8/9/73
11/19/75
8/19/76
Sampling Date


Dissolved Oxygen at the Allentown USGS Gage
Dissolved Oxygen, mg/L
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
10/22/59
1/15/63
10/23/63
9/18/64
6/15/65
6/6/66
5/17/67
11/8/67
2/6/68
5/6/68
7/23/68
10/28/68
3/27/69
11/13/69
7/28/70
4/28/71
12/20/71
3/5/73
8/9/73
11/19/75
8/19/76
Sampling Date


pH at the Allentown USGS Gage
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
pH
10/22/59
10/3/62
7/10/63
1/7/64
9/18/64
3/24/65
12/20/65
8/29/66
5/17/67
10/25/67
DATE
11/14/67
2/6/68
4/22/68
5/29/68
7/30/68
10/28/68
3/25/69
7/29/69
11/14/69
7/28/70
2/2/71
12/20/71
2/23/73
5/10/73
8/14/73
11/19/75
5/13/76
Sampling Date


Ammonia at the Allentown USGS Gage
Ammonia, mg/L NH_4
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
7/27/71
10/27/71
1/27/72
4/27/72
7/27/72
10/27/72
1/27/73
4/27/73
7/27/73
10/27/73
1/27/74
4/27/74
7/27/74
10/27/74
1/27/75
4/27/75
7/27/75
10/27/75
1/27/76
4/27/76
7/27/76
Sampling Date


Nitrate at the Allentown USGS Gage
Nitrate, mg/L NO_3
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
7/27/71
9/27/71
11/27/71
1/27/72
3/27/72
5/27/72
7/27/72
9/27/72
11/27/72
1/27/73
3/27/73
5/27/73
7/27/73
9/27/73
11/27/73
1/27/74
3/27/74
5/27/74
7/27/74
9/27/74
11/27/74
1/27/75
3/27/75
5/27/75
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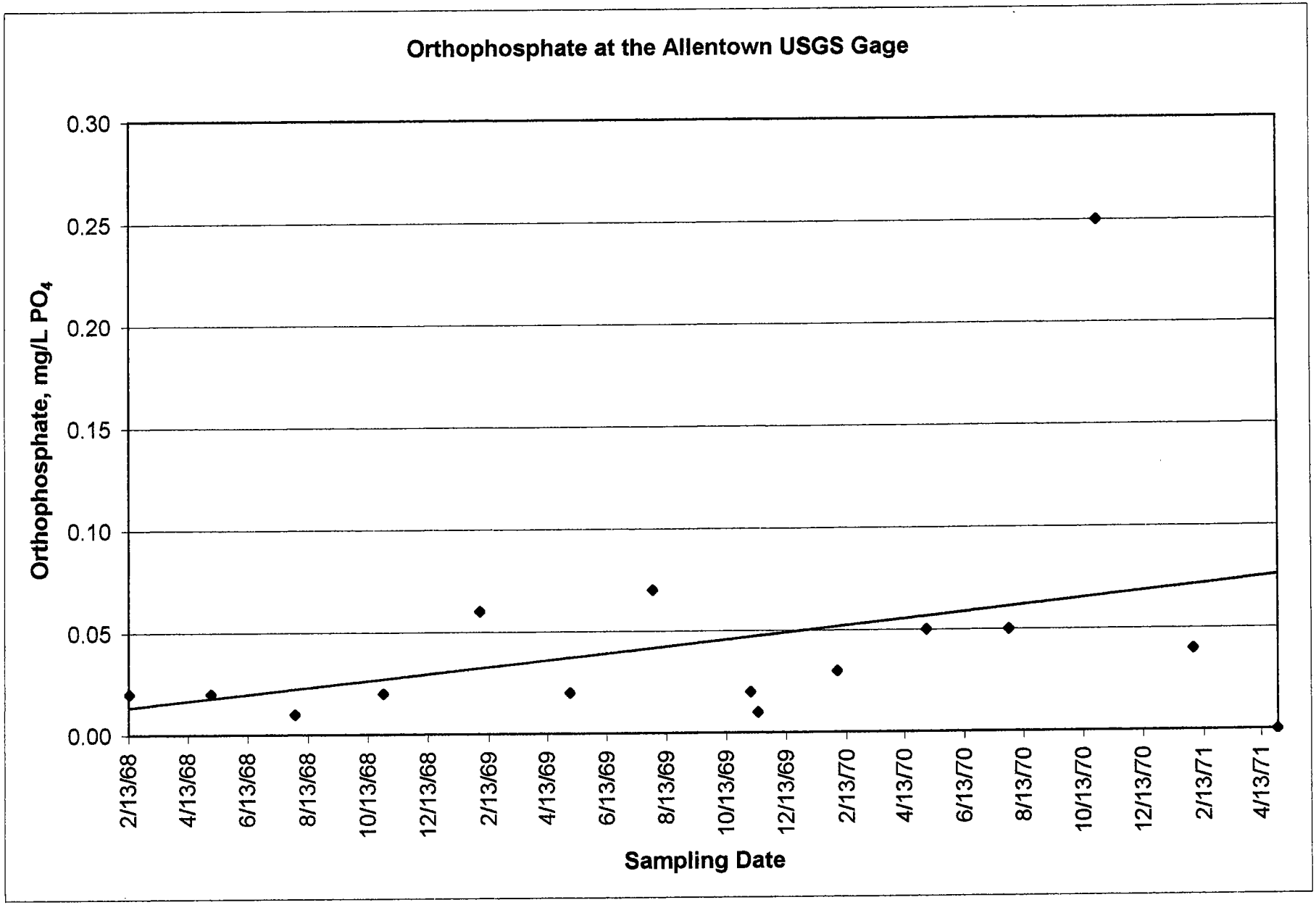
5/27/76
7/27/76
Sampling Date


Orthophosphate at the Allentown USGS Gage
Orthophosphate, mg/L PO_4
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2/13/68
4/13/68
6/13/68
8/13/68
10/13/68
12/13/68
2/13/69
4/13/69
6/13/69
8/13/69
10/13/69
12/13/69
2/13/70
4/13/70
6/13/70
8/13/70
10/13/70
12/13/70
2/13/71
4/13/71
Sampling Date

APPENDIX F

CONSERVATION FUNDING PROGRAMS

UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) CONSERVATION PROGRAMS

While there are a variety of USDA programs available to assist people with their conservation needs, the following primary financial assistance programs are the principal programs available. Citizens and groups are encouraged to contact the State Offices of the appropriate agency for more specific information about each program.

Lehigh County USDA Service Center
2211 Mack Boulevard
Allentown, PA 18104
Phone (610) 791-9810,
Extension 2: Farm Service Agency
Extension 3: Natural Resource Conservation Service

Lehigh-Northampton County Conservation District
1068 Bushkill Center Road
Nazareth, Pa. 18064
Phone (610) 759-9570, extension 104

Conservation Technical Assistance (CTA)

Contact: USDA, Natural Resources Conservation Service

The purpose of the program is to assist land-users, communities, units of state and local government, and other federal agencies in planning and implementing conservation systems. The purpose of the conservation systems are to reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding, and improve woodlands.

Objectives of the program are to:

- Assist individual land users, communities, conservation districts, and other units of State and local government and Federal agencies to meet their goals for resource stewardship and assist individuals to comply with State and local requirements. NRCS assistance to individuals is provided through conservation districts in accordance with the memorandum of understanding signed by the Secretary of Agriculture, the governor of the state, and the conservation district. Assistance is provided to land users voluntarily applying conservation and to those who must comply with local or State laws and regulations.
- Assist agricultural producers to comply with the highly erodible land (HEL) and wetland (Swampbuster) provisions of the 1985 Food Security Act as

amended by the Food, Agriculture, Conservation and Trade Act of 1990 (16 U.S.C. 3801 et. seq.) and the Federal Agriculture Improvement and Reform Act of 1996 and wetlands requirements of Section 404 of the Clean Water Act. NRCS makes HEL and wetland determinations and helps land users develop and implement conservation plans to comply with the law.

- Provide technical assistance to participants in USDA cost-share and conservation incentive programs. (Assistance is funded on a reimbursable basis from the CCC.)
- Collect, analyze, interpret, display, and disseminate information about the condition and trends of the Nation's soil and other natural resources so that people can make good decisions about resource use and about public policies for resource conservation.
- Develop effective science-based technologies for natural resource assessment, management, and conservation.

Conservation Farm Option (CFO)

Contact: USDA, Farm Service Agency or Natural Resources Conservation Service

The Conservation Farm Option is a pilot program for producers of wheat, feed grains, cotton, and rice. The program's purposes include conservation of soil, water, and related resources, water quality protection and improvement, wetland restoration, protection and creation, wildlife habitat development and protection, or other similar conservation purposes. Eligibility is limited to owners and producers who have contract acreage enrolled in the Agricultural Market Transition Act program, i.e. production flexibility contracts. The CFO is a voluntary program. Participants are required to develop and implement a conservation farm plan. The plan becomes part of the CFO contract which covers a ten year period. CFO is not restricted as to what measures may be included in the conservation plan, so long as they provide environmental benefits. During the contract period the owner or producer (1.) receives annual payments for implementing the CFO contract and (2.) agrees to forgo payments under the Conservation Reserve Program, the Wetlands Reserve Program, and the Environmental Quality Incentives Program in exchange for one consolidated payment.

Conservation of Private Grazing Land Initiative (CPGL)

Contact: USDA, Natural Resources Conservation Service

The Conservation of Private Grazing Land initiative will ensure that technical, educational, and related assistance is provided to those who own private grazing lands. It is not a cost share program. This technical assistance will offer opportunities for: better grazing land management; protecting soil from erosive

wind and water; using more energy-efficient ways to produce food and fiber; conserving water; providing habitat for wildlife; sustaining forage and grazing plants; using plants to sequester greenhouse gases and increase soil organic matter; and using grazing lands as a source of biomass energy and raw materials for industrial products.

Conservation Plant Material Centers

Contact: USDA, Natural Resources Conservation Service

The purpose of the program is to provide native plants that can help solve natural resource problems. Beneficial uses for which plant material may be developed include biomass production, carbon sequestration, erosion reduction, wetland restoration, water quality improvement, streambank and riparian area protection, coastal dune stabilization, and other special conservation treatment needs. Scientists at the Plant Materials Centers seek out plants that show promise for meeting an identified conservation need and test their performance. After species are proven, they are released to the private sector for commercial production. The work at the 26 centers is carried out cooperatively with state and Federal agencies, commercial businesses, and seed and nursery associations.

Conservation Reserve Program (CRP)

Contact: USDA, Farm Service Agency

The Conservation Reserve Program reduces soil erosion, protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filterstrips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices.

Environmental Quality Incentives Program (EQIP)

Contact: USDA, Natural Resources Conservation Service

The Environmental Quality Incentives Program provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation. The purposes of the program are achieved through the implementation of a conservation plan that includes

structural, vegetative, and land management practices on eligible land. Five- to ten-year contracts are made with eligible producers. Cost-share payments may be made to implement one or more eligible structural or vegetative practices, such as animal waste management facilities, terraces, filter strips, tree planting, and permanent wildlife habitat. Incentive payments can be made to implement one or more land management practices, such as nutrient management, pest management, and grazing land management.

Fifty percent of the funding available for the program will be targeted at natural resource concerns relating to livestock production. The program is carried-out primarily in priority areas that may be watersheds, regions, or multi-state areas, and for significant statewide natural resource concerns that are outside of geographic priority areas.

Soil Survey Programs

Contact: USDA, Natural Resources Conservation Service

The National Cooperative Soil Survey Program (NCSS) is a partnership led by NRCS of Federal land management agencies, state agricultural experiment stations and state and local units of government that provide soil survey information necessary for understanding, managing, conserving and sustaining the nation's limited soil resources.

Soil surveys provide an orderly, on-the-ground, scientific inventory of soil resources that includes maps showing the locations and extent of soils, data about the physical and chemical properties of those soils, and information derived from that data about potentialities and problems of use on each kind of soil in sufficient detail to meet all reasonable needs for farmers, agricultural technicians, community planners, engineers, and scientists in planning and transferring the findings of research and experience to specific land areas. Soil surveys provide the basic information needed to manage soil sustainably. They also provide information needed to protect water quality, wetlands, and wildlife habitat. Soil surveys are the basis for predicting the behavior of a soil under alternative uses, its potential erosion hazard, potential for ground water contamination, suitability and productivity for cultivated crops, trees, and grasses. Soil surveys are important to planners, engineers, zoning commissions, tax commissioners, homeowners, developers, as well as agricultural producers. Soil surveys also provide a basis to help predict the effect of global climate change on worldwide agricultural production and other land-dependent processes. The NRCS Soil Survey Division through its World Soil Resources Staff helps gather and interpret soil information for global use.

NRCS provides the soil surveys for the privately owned lands of the nation and, through its National Soil Survey Center, provides scientific expertise to enable the NCSS to develop and maintain a uniform system for mapping and assessing

soil resources so that soil information from different locations can be shared, regardless of which agency collects it. NRCS provides most of the training in soil survey to Federal agencies and assists other Federal agencies with their soil inventories on a reimbursable basis. NRCS is also responsible for developing the standards and mechanisms for providing digital soil information for the national spatial data infrastructure required by Executive Order 12906.

Farmland Protection Program (FPP)

Contact: USDA, Natural Resources Conservation Service

The Farmland Protection Program provides funds to help purchase development rights to keep productive farmland in agricultural uses. Working through existing programs, USDA joins with State, tribal, or local governments to acquire conservation easements or other interests from landowners. USDA provides up to 50 percent of the fair market easement value. To qualify, farmland must: be part of a pending offer from a State, tribe, or local farmland protection program; be privately owned; have a conservation plan; be large enough to sustain agricultural production; be accessible to markets for what the land produces; have adequate infrastructure and agricultural support services; and have surrounding parcels of land that can support long-term agricultural production. Depending on funding availability, proposals must be submitted by the government entities to the appropriate NRCS State Office during the application window.

Emergency Watershed Protection (EWP)

Contact: USDA, Natural Resources Conservation Service

The purpose of the Emergency Watershed Protection program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed.

It is not necessary for a national emergency to be declared for an area to be eligible for assistance. Program objective is to assist sponsors and individuals in implementing emergency measures to relieve imminent hazards to life and property created by a natural disaster. Activities include providing financial and technical assistance to remove debris from streams, protect destabilized streambanks, establish cover on critically eroding lands, repairing conservation practices, and the purchase of flood plain easements. The program is designed for installation of recovery measures.

Flood Risk Reduction Program (FRR)

Contact: USDA, Farm Service Agency

The Flood Risk Reduction Program was established to allow farmers who voluntarily enter into contracts to receive payments on lands with high flood potential. In return, participants agree to forego certain USDA program benefits. These contract payments provide incentives to move farming operations from frequently flooded land.

Forestry Incentives Program (FIP)

Contact: USDA, Natural Resources Conservation Service

The Forestry Incentives Program (FIP) supports good forest management practices on privately owned, non-industrial forestlands nationwide. FIP is designed to benefit the environment while meeting future demands for wood products. Eligible practices are tree planting, timber stand improvement, site preparation for natural regeneration, and other related activities. FIP is available in counties designated by a Forest Service survey of eligible private timber acreage.

Watershed Surveys and Planning

Contact: USDA, Natural Resources Conservation Service

The Watershed and Flood Prevention Act, P.L. 83-566, August 4, 1954, (16 U.S.C. 1001-1008) authorized this program. Prior to fiscal year 1996, small watershed planning activities and the cooperative river basin surveys and investigations authorized by Section 6 of the Act were operated as separate programs. The 1996 appropriations act combined the activities into a single program entitled the Watershed Surveys and Planning program. Activities under both programs are continuing under this authority.

The purpose of the program is to assist Federal, State, and local agencies and tribal governments to protect watersheds from damage caused by erosion, floodwater, and sediment and to conserve and develop water and land resources. Resource concerns addressed by the program include water quality, opportunities for water conservation, wetland and water storage capacity, agricultural drought problems, rural development, municipal and industrial water needs, upstream flood damages, and water needs for fish, wildlife, and forest-based industries.

Types of surveys and plans include watershed plans, river basin surveys and studies, flood hazard analyses, and flood plain management assistance. The

focus of these plans is to identify solutions that use land treatment and nonstructural measures to solve resource problems.

Resource Conservation & Development Program (RC&D)

Contact: USDA, Natural Resources Conservation Service

The purpose of the Resource Conservation and Development (RC&D) program is to accelerate the conservation, development and utilization of natural resources, improve the general level of economic activity, and to enhance the environment and standard of living in authorized RC&D areas. It improves the capability of State, tribal and local units of government and local nonprofit organizations in rural areas to plan, develop and carry out programs for resource conservation and development. The program also establishes or improves coordination systems in rural areas. Current program objectives focus on improvement of quality of life achieved through natural resources conservation and community development which leads to sustainable communities, prudent use (development), and the management and conservation of natural resources. Authorized RC&D areas are locally sponsored areas designated by the Secretary of Agriculture for RC&D technical and financial assistance program funds. NRCS can provide grants for land conservation, water management, community development, and environmental needs in authorized RC&D areas.

Stewardship Incentives Program (SIP)

Contact: USDA, Forest Service

The Stewardship Incentive Program provides technical and financial assistance to encourage non-industrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity. Eligible landowners must have an approved Forest Stewardship Plan and own 1,000 or fewer acres of qualifying land. Authorizations may be obtained for exceptions of up to 5,000 acres.

Watersheds Operations --Small Watershed Program and Flood Prevention Program (WF 08 or FP 03)

Contact: USDA, Natural Resources Conservation Service

The Small Watershed Program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in

watersheds of 250,000 or fewer acres. Both technical and financial assistance are available.

Wetlands Reserve Program (WRP)

Contact: USDA, Natural Resources Conservation Service

The Wetlands Reserve Program is a voluntary program to restore wetlands. Participating landowners can establish conservation easements of either permanent or 30-year duration, or can enter into restoration cost-share agreements where no easement is involved. In exchange for establishing a permanent easement, the landowner receives payment up to the agricultural value of the land and 100 percent of the restoration costs for restoring the wetlands The 30-year easement payment is 75 percent of what would be provided for a permanent easement on the same site and 75 percent of the restoration cost. The voluntary agreements are for a minimum 10-year duration and provide for 75 percent of the cost of restoring the involved wetlands. Easements and restoration cost-share agreements establish wetland protection and restoration as the primary land use for the duration of the easement or agreement. In all instances, landowners continue to control access to their land.

Wildlife Habitat Incentives Program (WHIP)

Contact: USDA, Natural Resources Conservation Service

The Wildlife Habitat Incentives Program provides financial incentives to develop habitat for fish and wildlife on private lands. Participants agree to implement a wildlife habitat development plan and USDA agrees to provide cost-share assistance for the initial implementation of wildlife habitat development practices. USDA and program participants enter into a cost-share agreement for wildlife habitat development. This agreement generally lasts a minimum of 10 years from the date that the contract is signed.

Note: More information about these programs is available from staff at the State Office of NRCS and FSA as appropriate.

STREAMBANK FENCING

3 PROGRAMS MAKE FENCING EASIER AND MORE AFFORDABLE

U.S. Fish and Wildlife Streambank Fencing Project

- U. S. Fish and Wildlife will provide wooden fence posts and two strands of wire
- Farmer must install fencing
- Streambank corridor must include a 15-foot buffer on each side of the stream

Ducks Unlimited

- Ducks Unlimited will hire a fencing company to install fencing
- Farmer does not need to do any work with the installation
- Fencing includes wooden fence posts and up to two strands of wire
- Streambank corridor must include a 15-foot buffer on each side of the stream
- Farmer can earn credits toward other BMPs for giving more than a 30-foot buffer
- Ducks Unlimited will provide trees and shrubs for the buffer, if so desired
- Completely private funding

Conservation Reserve Program

- CRP will provide 50% cost-share and 40% incentive payment for the installation of streambank fencing
- Fencing must be double-strand electric
- Streambank corridor must include a 35-foot buffer on each side of the stream
- Farmer will receive annual payment for loss of pasture and an annual mainatenance payment
- Cost-share can include crossings and/or alternative water source for animals
- Cost-share for installation of trees and shrubs

⇒ *These programs can partner with each other to provide optimum incentive for streambank fencing.*

⇒ *For more information, contact the Natural Resources Conservation Service at (610) 759-9570.*

PA NUTRIENT MANAGEMENT PROGRAM

FUNDING AVAILABLE TO PRODUCERS FOR NUTRIENT MANAGEMENT

Plan Development Incentive Program
Provides 75% cost-share for the development of a Nutrient Management Plan
Cost-share available for plans written by farmers or commercial specialists

Nutrient Management Plan Implementation Grant Program
Provides grants that will cost-share up to 80% or $75,000 towards the installation of any Best Management Practices (BMPs) listed in an approved Nutrient Management Plan
Some BMPs include rain spouting, barnyard heavy-use protection, diversions, waterways, barnyard curbing and manure storage (contact the NRCS for a more detailed list)
Applicant must show a financial distress in order to be eligible for a grant
Applicant must be an agricultural operation in existence on or before October 1, 1997
Can be partnered with other programs

AgiLink
Provides low-interest loans to implement BMPs that are part of an approved Nutrient Management Plan
Can be partnered with other programs

⇒ *These programs can partner with each other to provide maximum financial assistance.*

⇒ *For more information, contact Natural Resources Conservation Service at (610) 759-9570, ext. 104.*

SOURCES OF INFORMATION PERTAINING TO FARMLAND AND OPEN SPACE PRESERVATION

Wildlands Conservancy
Land Preservation Program
3701 Orchid Place
Emmaus, Pa. 18049-1637
610-965-4397

Bureau of Farmland Protection
Room 404
Agriculture Building
2301 North Cameron Street
Harrisburg, Pa. 17110-9408
717-783-3167

Land Trust Alliance
1319 F Street NW, Suite 501
Washington, DC 20004-1106
202-638-4725