Watershed Assessment

Allentown, Pennsylvania

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Contents

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EXECUTIVE SUMMARY

As part of its commitment to the source water assessment program, the Pennsylvania Department of Environmental Protection (DEP) began a pilot project through an agreement with Region 3 of the Environmental Protection Agency. Under the project The Cadmus Group, Inc. studied three watersheds including the Little Lehigh. Cadmus delineated the watershed, reviewed potential and actual pollutant sources, analyzed the susceptibility of the watershed to the sources, and prepared a management plan consisting of a series of recommendations. This report is the summary of the project for the Allentown Bureau of Water Resources.

Several methods were employed to identify potential contaminants in the watershed: 1) review of point source pollution databases; 2) interview of key watershed stakeholder/informants and mapping; 3) stressed stream analysis sampling and windshield surveys of the watershed; and 4) GIS land use modeling and nonpoint source pollution estimation using loading functions. The data collected from these methods were then used to determine key problems for the reservoir.

Key Concerns

Review of previous studies and several rounds of water quality sampling identified one key concern for the watershed, and a variety of lesser but important issues.

Erosion of watershed soils and their ultimate transport to the water treatment plant is a key concern in the watershed because sediments can increase the difficulty of treating and filtering raw water. Another sediment-related water quality problem is adsorbed pollutants. A portion of the pollutants attached to sediments can become dissolved again if conditions such as pH change. Adsorbed pollutants of potential long-term concern are metals. This study cataloged commercial and industrial sites. Little direct contribution of pollutants from these sites was observed, however, stormwater from these sites can deliver chronic loadings of pollutants to the Little Lehigh.

Other findings include little impact from point sources except for the potential for Giardia and Cryptosporidium contribution. There are several samples with curiously high levels of fecal coliform bacteria that warrant further investigation. Pesticides don't appear to be a major concern, although it is possible that there are localized spikes of concentration during peak application periods in the spring that have not been detected by previous sampling. There is little evidence to date that pesticides are a threat to intake however.

Recommendations

Management recommendations discussed in the report include the following:

- Develop an Active Watershed Coalition (section 9.1)
- Draw Up a Set of Short and Long-Term Goals (section 9.1)
- Focus on Key Issues (section 9.1)
- Develop Long-Term Sources of Funding and In-Kind Services (section 9.2)
- Develop a Long-Term Monitoring Program (section 9.3)
- Consider Hiring a Part-Time Watershed Inspector (section 9.4)

Specific recommendations include:

- Conduct a detailed sediment study to focus sediment reduction efforts.
- Actively promote protection of streamside buffer zones. These zones are vital for reducing sediment and nutrient loads. The land now held by the City is a vital resource that should be held and managed. The City should consider expanding its streamside holdings through lease or purchase of buffer zones in the lower reaches of the watershed. Agricultural programs such as the conservation reserve program can help in this regard for selected subwatersheds such as Toad Creek.
- Work with appropriate agencies to develop BMP demonstration projects. In an example of a successful project, the Chester Water Authority worked with several groups including the Pennsylvania Fish and Boat Commission to develop stream bank protection projects.
- Reach out to users of toxic materials to encourage responsible behavior. Approach automobile parts suppliers to encourage oil recycling. Discuss commercial and industrial floor drains with EPA Region 3's Class V well program.

1.0 INTRODUCTION: A WATERSHED APPROACH

The passage of the 1996 Amendments to the Safe Drinking Water Act (SDWA) has created a new focus on preventing drinking water contamination through source water protection. The Amendments redirect the regulatory focus from identifying and treating contamination at the water supply's intake towards maintaining the quality of the source water and preventing new contamination. Reducing or preventing chemical and microbiological contamination of source waters could allow water suppliers to avoid costly treatment or minimize monitoring requirements. Regulators could also save resources that would otherwise have to be devoted to compliance assistance, oversight, and enforcement.

Protection of drinking water sources requires the combined efforts of federal, state, and local government programs and citizen efforts devoted to environmental and public health management. The partnerships are necessary because prevention is often about land use and water management, which are addressed at the State and local levels. But, regulation of the activities conducted in the watershed is generally a Federal and/or State function. These partners also can share data, technical assistance, training and other tools to assist the water supply's efforts.

As part of its commitment to the source water assessment program, the Pennsylvania Department of Environmental Protection (DEP) began a pilot project. Through an agreement between DEP and the Environmental Protection Agency, Region 3, The Cadmus Group, Inc. is delineating the watershed, assessing susceptibility, and preparing a management plan for three surface water supplies. This report is the summary of that project for the City of Allentown.

1.1 New Requirements under the Safe Drinking Water Act

The Safe Drinking Water Act[1] requires States to establish programs for delineating source water areas of public water systems, and for assessing the susceptibility of these source waters to contamination. Delineation of the watershed involves evaluating hydrogeologic information about the source of supply, as well as water flow, recharge, and discharge information affecting the source waters.[2]

The contaminants of concern are those raw water contaminants regulated under the SDWA (contaminants with a maximum contaminant level (MCL), contaminants regulated under the Surface Water Treatment Rule, and the microorganism *Cryptosporidium*.)[3] In addition, States may include contaminants that are not regulated under the SDWA, but which the State has determined may present a threat to public health.

Potential sources of these contaminants include areas of established contamination such as Superfund sites and toxic release or spill sites. Other potential sources include those that generate, store, or use contaminants that may pose a threat if not properly controlled. Examples include: National Pollutant Discharge Elimination System (NPDES) permittees, underground storage tanks (USTs), underground injection

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[1]ß1453(a)(1-3) of the SDWA stipulates the State requirements for developing source water assessment programs.

[2]The SDWA permits States to draw the boundaries of watersheds along state political boundaries, but encourages States and systems to coordinate with their cross-border partners to ensure that the source waters are protected upstream of the border.

wells, hazardous and non-hazardous waste management facilities, nonpoint sources (such as runoff of pesticides and nutrients from farmlands), and stormwater.

The risk of contamination by these sources is evaluated through examination of several factors including examination of the type of contaminant, the distance of the source from a stream channel, the distance or time of travel from an intake, and the likelihood of a spill or mishap. In the case of aquifers, studies of soils and hydrology, and an examination of the fate and transport of the contaminants is also useful

Once potential contaminant sources to which a PWS may be susceptible are identified and inventoried, options for managing these sources need to be determined. The source water management plan identifies ways to reduce or eliminate the potential threat to drinking water supplies within source water protection areas. This can be accomplished either through federal, state, or local regulatory or statutory controls, or by using non-regulatory (voluntary) measures centered on an involved public. EPA's State Source Water Assessment and Protection Programs Guidance notes that while land-use controls, regulatory and pollutant source management measures, and other methods have traditionally been used for a variety of purposes in controlling impacts of land use and municipal growth. It further notes that only recently have these tools been employed to protect drinking water supplies on a large scale.

Critical to the implementation of the plan is the participation by the public and local stakeholders. Involving residents of the watershed, watershed associations, non-profit organizations like local conservancy groups, as well as the regulatory partners from

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[3]The list includes *Cryptosporidium* because EPA is in the process of regulating this microorganism.

the beginning of the project pays off in interest and investment in achieving the goals outlined in the management plan.

1.2 Pilot Projects in Pennsylvania

Three public water supplies using surface water sources were selected for the pilot projects: the City of Allentown, Chester Water Authority, and the City of Reading. An initial meeting in June 1998 between Daniel Koplish, (Manager of Water Resources), and Joe McMahon of the City of Allentown Bureau of Water Resources, local stakeholders such as Chris Kocher of the Wildlands Conservancy, EPA, DEP, and Cadmus kicked off the project. Historical information about the system and watershed were presented, and areas of concern or problems noted in the watershed by the meeting participants were highlighted.

Using Geographic Information System (GIS) data obtained from DEP, Cadmus delineated the watershed boundaries, which defined the source water protection area. Other GIS data collected that helped spatially review the watershed's status included land use data, roads, water bodies, location of NPDES permittees (limited data), and soils data. The GIS data were used to help identify areas of concern for the assessment phase of the project.

An assessment of the source water protection area was conducted during summer of 1998. The assessment combined field sampling and observations with searches of databases maintained by regulatory agencies to identify existing or potential sources of contamination. Additional interviews with state, county, and township staff and local citizen groups flagged other issues in the watershed. Finally, data obtained from fieldwork or databases were analyzed and, in some cases, modeled, to measure impact on the source water. Chapters 4 through 8 describe the information collected during the assessment.

The observations serve as the foundation for developing a management plan, which summarizes the next steps needed to ensure continued protection of the source waters. The data collected helped the team establish priorities for the watershed and the City. The next steps range from a recommendation to further study specific issues identified to suggestions for best management practices. The management options are provided in Chapter 9.

2.0 THE WATERSHED AND DRINKING WATER SYSTEM

2.1 Description

The city of Allentown withdraws water from the Little Lehigh Creek to supply areas in and around the city of Allentown with drinking water. The Little Lehigh Creek, a tributary to the Lehigh River, is located in Eastern Pennsylvania. The Little Lehigh Creek originates in Longswamp Township in Berks County, flows through Lower Macungie and Salisbury Townships, and the City of Allentown before its confluence with the Jordan Creek. Major tributaries to the Little Lehigh include Toad Creek, Spring Creek (fed by Schaefer Run, Breinig Run, and Iron Run), Swabia Creek, Leibert Creek, Jordan Creek, and Trout Creek. However, Jordan Creek and Trout Creek are not included in this assessment, because they join the Little Lehigh Creek downstream of the city of Allentown's Water Treatment Plant; and are not used as a drinking water source for the city of Allentown. The Little Lehigh is approximately 24 miles long and has a 107.5 square mile drainage area,[4] not including Jorden Creek. Approximately 88.8 square miles of the drainage basin are located in Lehigh County, while 18.7 square miles is located in Berks County. Based on GIS analysis under this project, roughly 95 square miles of the drainage are upstream of the water treatment plant.

2.2 Geology and Lithology

In Berks County, the headwaters of the Little Lehigh Creek are underlain by noncarbonated rocks such as the Reading Prong. In Lehigh County, the Little Lehigh is underlain by the Beekmantown and Allentown limestone formations that are usually found in the Great Valley section of the Valley and Ridge Physiographic Province. South Mountain in Lehigh County forms the border of the Little Lehigh Creek Basin to the south and the east.[5]

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[4]Wildlands Conservancy. Little Lehigh Creek Stream Corridor Conservation Project Stream Status Report, January, 1994.

[5]Joint Planning Commission Lehigh-Northampton Counties. Little Lehigh Creek Watershed, Stormwater

2.3 Topography

Generally, the topography of the watershed is gently rolling with a high degree of closed depressions. One third of the depressions are karst depressions that are associated with the solution of carbonate rock, and two thirds of the depressions are glacial and quarrying features.[6] The Little Lehigh starts at an altitude of approximately 830 feet above sea level in Berks County near Topton Mountain. Most of the Little Lehigh flows at an altitude of 400 feet until it travels almost to its confluence with the Lehigh River, where it flows at an altitude of 225 feet above sea level.

2.4 Soils

Soils found along the Little Lehigh in Berks County are generally of the Chester-Glenville-Brandywine association. These soils tend to be deep or moderately deep, well-drained to moderately well-drained, and have rolling to hilly soils. These soils are formed from weathered material from granitic gneiss and other igneous or metamorphosed rocks. Soils in this association tend to be medium to strongly acidic. Runoff from this soil association may be medium to slow, where permeability is slow or moderately slow.[7]

Soils in Lehigh County consist of the Duffield-Washington association. These soils are characterized by deep, well-drained soils that are generally neutral to strongly acidic, depending on the soil horizon they are found in. Duffield-Washington soils are

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Management Plan, March, 1987.

[6]Joint Planning Commission Lehigh-Northampton Counties. Little Lehigh Creek Watershed, Stormwater Management Plan, March, 1987.

[7] Natural Resources Conservation Service, National Cooperative Soil Survey. Official Soil Series Description. Revised February, 1983 and November, 1990.

generally weathered from limestone in limestone valley. Permeability is generally moderate, and runoff tends to be medium to rapid.[8]

2.5 Land Use

Land use in the Little Lehigh watershed varies significantly. Allentown, Whitehall, Salisbury, and Emmaus are predominantly urban areas, while Maxatawny and Longswamp Townships in Berks County, and Weisenberg and Upper Milford Townships in Lehigh County are predominantly rural. Macungie and Alburtis are small, urbanized areas, and Upper Macungie Township and the Eastern portion of Lower Macungie Township are predominantly urban and suburban areas that have been under intense developmental pressure in the past few years. Western portions of Lower Macungie Township are still zoned mostly for agricultural use.

Large amounts of land adjacent to the main stem, as well as some portions of the major tributaries (Trout Creek and Cedar Creek) to the Little Lehigh are maintained as open space. Both the city of Allentown and Lower Macungie Township maintain a number of parks and recreation areas along the Little Lehigh. While these open space lands are not likely to be used for developmental purposes, they are not necessarily managed to preserve or improve water quality. With improved management techniques, these open space lands can be used to improve water quality in the Little Lehigh Creek watershed.[9] Previous studies have categorized 35 percent of the watershed as urban and suburban, and approximately 65 percent as rural or agricultural.[10] Using GIS data for the Lehigh County portion of the watershed generously provided by the Lehigh Planning

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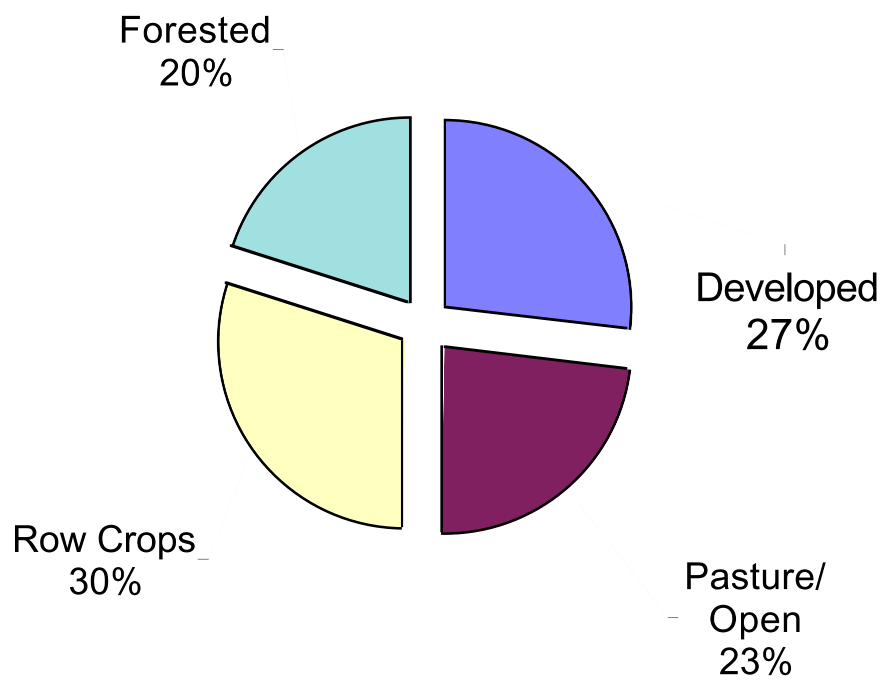
[8] Natural Resources Conservation Service, National Cooperative Soil Survey. Official Soil Series Description. Revised January, 1981 and February, 1992.

[9] Wildlands Conservancy. Little Lehigh Creek Stream Corridor Conservation Project Stream Status Report, January, 1994.

[10] Natural Resources Conservation Service, National Cooperative Soil Survey. Official Soil Series Description. Revised January, 1981 and February, 1992.

Commission and integrating it with data for the remainder of the watershed provided by DEP's GIS staff, Cadmus developed slightly different values as illustrated in the Figure 2-1, with the developed area at 27 percent.

Figure 2-1
Land Use in the Little Lehigh Watershed Upstream of the Water Intake



2.6 Population

In 1990, the population of Lehigh and Berks Counties was 291,130 and 336,523, respectively. By 1997, the population of Lehigh County increased to 297,703, an increase of 2.3 percent, while the population of Berks County increased to 354,057, or 5.2 percent. Overall, the population in both counties increased by 3.8 percent (an absolute change of 24,104 persons). Table 2-1 below shows the population changes in each county from 1990 to 1997. Table 2-2 shows population changes from 1990 to 1996 (the most recent data for which population figures are available for municipalities) for each municipality within the Little Lehigh watershed. Table 2-3 shows population changes from 1990 to 1996 for municipalities partially in the watershed.

Table 2-1
Population 1990-1997

	1990[11]	1997	Absolute Change	Percentage Change
Lehigh County, PA	291,130	297,703	6,573	2.3
Berks County, PA	336,523	354,057	17,534	5.2
Total (Both Counties)	627,653	651,760	24,107	3.8

Table 2-2 shows that the population throughout municipalities completely in the Little Lehigh watershed has grown by 8.7 percent, and the population of municipalities partially in the watershed have decreased by 1.9 percent. However, some municipalities have experienced more significant population changes from 1990 to 1996. For example, the population of Alburtis in Lehigh County grew by 45.9 percent, an increase of 650 persons. Upper Macungie and Macungie grew by 16.7, and 13.6 percent, respectively.

[11] Bureau of the Census. Estimates of the Population of Counties for July 1, 1997, and Population Change: April 1, 1990 to July 1, 1997, March, 17, 1998.

Table 2-2
Population of Municipalities Within the Watershed, 1990-1996[12]

	County	1990	1996	Absolute Change	Percentage Change
Alburtis	Lehigh	1,415	2,065	650	45.9
Emmaus	Lehigh	11,157	11,544	387	3.5
Longswamp Township	Berks	5,387	5,730	343	6.4
Lower Macungie	Lehigh	16,871	17,806	935	5.5
Macungie	Lehigh	2,597	2,951	354	13.6
Topton Township	Berks	1,987	2,032	45	2.3
Upper Macungie	Lehigh	8,757	10,216	1,459	16.7
TOTAL		48,171	52,344	4,173	8.7

* The total represents population only for the municipalities completely within the watershed.

The city of Allentown, with a 2.9 percent decrease, was the only municipality in the watershed to show a decreasing population from 1990 to 1996. Future population growth in the region may necessitate the development of more housing units, which may further affect water quality in the Little Lehigh Creek watershed. To offset increasing demands on water in the watershed, sound land use management practices will need to be implemented.

2.7 General Hydrology

Mean areal precipitation in the Little Lehigh watershed was measured by the National Weather Service as approximately 38.9 inches, or approximately 6.3 inches below normal in Lehigh County in 1997, the last complete year before this study.[13] In

[12] Bureau of the Census. Estimates of the Population of Counties for July 1, 1997, and Population Change: April 1, 1990 to July 1, 1997, March, 17, 1998.

[13] National Weather Service Website. "Mean Areal Precipitation and Departure from Normal." Http://marfcws1.met.psu.edu/Archive/1997/pa_dep_12.gif.

Berks County, mean areal precipitation was measured at 37.1 inches, 8.8 inches below normal.

Table 2-3
Population of Municipalities Partially in the Watershed, 1990-1996[14]

	County	1990	1996	Absolute Change	Percentage Change
Allentown	Lehigh	105,301	102,211	-3,090	-2.9
Maxatawny Township	Berks	5,724	6,119	395	6.9
Upper Milford	Lehigh	6,304	6,734	430	6.8
TOTAL		117,329	115,064	-2,265	-1.9

* The total represents only those municipalities that are partially within the watershed. Since parts of these municipalities lie within another watershed, the figures above are not reflective of the population within the watershed.

Baseflow runoff was calculated by the Unites States Geographical Survey (USGS) as 200 cfs. The Little Lehigh Creek is classified as high quality, cold water fishes (HQ-CWF). The high quality designation suggests that the Little Lehigh Creek has excellent quality water, and/or other environmental features requiring special water quality protection.[15] The Little Cedar Creek, a tributary to the Little Lehigh Creek is spring fed, and also classified as HQ-CWF.[16]

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[14] Bureau of the Census. Estimates of the Population of Counties for July 1, 1997, and Population Change: April 1, 1990 to July 1, 1997, March, 17, 1998.

[15] Wildlands Conservancy. Little Lehigh Creek Stream Corridor Conservation Project Stream Status Report, January, 1994.

[16] Wildlands Conservancy with Department of Biology, Cedar Crest College. June, 1991, Cedar Creek Stream Greenway Preservation Project.

2.8 The Drinking Water System

The Allentown Water system supplies water to the City of Allentown, and portions of Salisbury and Hanover Townships. The system also sells bulk water to Salisbury, South Whitehall, Whitehall, and Hanover Townships. The average use in 1993 was 20.87 MGD. The permitted total withdrawal by the system is 39 MGD, but the City has some flexibility in the sources it uses because the sum of allocations from individual sources is far larger:[17]

Water Source	Allocation (MGD)
Little Lehigh Creek	28.0
Schantz Spring	9.0
Crystal Spring	4.0
Lehigh River	30.0

The water system serves roughly 120,000 and is projected to serve a stable or declining population through 2010. Accounting for population needs and water use by the commercial and industrial sector, water demand is projected to remain stable through 2010.[18]

The Allentown water treatment plant consists of two stages of rapid mix basins, two four stage flocculation basins, lamella plate sedimentation basins and dual media filters. The plant has just completed a major $23.5M upgrade that included increasing the

[17] Joint Planning Commission. Water Supply and Sewage Facilities Plan, December 1995.
[18] Ibid.

plants capacity to 30 MGD in part through installation of lamella settling plates in the clarifier unit.[19]

2.9 Creek Water Quality and Previous Studies

The Little Lehigh Creek and it s tributaries in general have moderate to high water quality. There are few direct discharges of wastewater into the watershed's streams. The close linking of ground and surface waters in the watershed produces cold water temperatures that are conducive to support of a cold water fishery. Nitrate levels measured during this study are moderate to high indicative of loading from agriculture, but are not as high as watersheds supporting intensive agriculture in other parts of the state. Nitrate levels are generally below 50 percent of the drinking water standard of 10 mg/l. There is, however, evidence of sedimentation in many stream reaches from deposition of the Creeks' suspended solid load. Previous studies have noted fish habitat degradation from this factor.

The main threats to the water quality of the watershed are increasing background levels of metals, nutrients, and organics from developed land uses, and to a lesser extent the threat of more acute releases from commercial and industrial sites if accidents occur.

[19] City of Allentown, Water Filtration Plant. 1998.

2.9.1 Wildlands Study

In 1994, the Wildlands Conservancy performed a study of the Little Lehigh that included research of past work, stream walks, and stream chemistry sampling using field test kits. The primary finding of the study was that erosion and sedimentation were the primary water quality problems in the basin. Sedimentation problems were noted in several reaches of the Little Lehigh, Toad, Spring, Swabia, and Leibert Creeks. A series of water quality indicators were also analyzed. While most of these indicators do not correlate with drinking water MCLs, they are indicative of stream health and the level of disturbance/ contamination. Selected results are summarized below:

> The dissolved oxygen[20] level of the Creeks was high in general with only two sites near the headwaters having less than optimal levels. These reduced levels may be more indicative of groundwater oxygen levels, than of a pollution source.
>
> Nitrate levels measured in Toad Creek (6 to 10 mg/l), and in the Little Lehigh (5 to 8 mg/l) from the Little Lehigh's confluence with Toad Creek downstream to its confluence with Swabia Creek.
>
> Phosphorus levels were elevated in Toad Creek. While the study attributes the high levels to nonpoint sources, the Topton POTW releases high levels of phosphorus, as found in this project.

Based on stream sampling the report concluded that in addition to sediment, temperature and nitrate were problems. While these parameters may be an issue for aquatic life, neither in the levels measured is a problem for drinking water. While a

[20] Dissolved oxygen is necessary for most forms of aquatic life including fish and macroinvertebrates. More oxygen can dissolve in cold water than warm water. Oxygen is removed by wastes such as sewage that are biodegraded. Oxygen is added by plants and by riffle areas where water and air mix.

nitrate level of 10 was measured in Toad Creek (and also measured in this study) a combination of dilution and instream nutrient transformation[21] reduce the level at the intake to 5 to 6 mg/l, well below the MCL.

2.9.2 Pennsylvania 303(d) List of Impaired Waters

Pennsylvania's Department of Environmental Protection (DEP) assesses water quality in the state, and identifies water bodies that are impaired through various programs. Section 305 (b) of the federal Clean Water Act (CWA) requires the Commonwealth of Pennsylvania to issue a report on all impaired waters. Section 303 (d) of the CWA requires the State to determine the impaired waters that will not support designated uses even after appropriate pollution control technology has been used. A list of such waters in the Little Lehigh Watershed is presented in Table 2-4. Sources and causes of impairment are included in the list. The State, or the EPA, must then develop Total Maximum Daily Load values (TMDLs) for each water body on the list. TMDLs identify the maximum allowable pollutant loads to a water body that will prevent water quality violations. The difficulty that all states including Pennsylvania face is how to address water body impairment caused by nonpoint sources.

Data used to assess water quality in Pennsylvania include the Surface Water Monitoring Program including data collected through the PA Water Quality Network (WQN). The WQN is run by the Bureau of Watershed Conservation and consists of

[21] Nitrate is readily taken up by plant life and converted to organic matter. For example, Cadmus has observed removal processes in reservoirs that convert stream concentrations of greater than 10 mg/l to 5 mg/l and less at the dam side water intake.

Table 2-4

Stream Segments n the Little Lehigh Watershed Identified on the Pennsylvania List of Waters, Section 303(d) List 1998.*

Watershed	State Water Plan ID	Stream Code	Segment ID/Miles	Data Source	Source of Impairment	Cause of Impairment	Priority
Little Cedar Creek Watershed	02-C	03570	583/1.06	Surface Water Monitoring Program	Urban Runoff/Storm Sewers	Suspended Solids	High**
Little Lehigh Creek Watershed	02-C	03420	970722-0830-TTS/ 0.81	Unassessed Project	Agriculture	Siltation	High**†
Little Lehigh Creek Watershed	02-C	03420	970722-0830-TTS/ 0.81	Unassessed Project	Construction	Siltation	High**†
Schaefer Run Watershed	02-C	03605	970820-0800-TTS/ 0.87	Unassessed Project	Agriculture	Siltation	High†
Schaefer Run Watershed	02-C	03605	970820-0800-TTS/ 0.87	Unassessed Project	Agriculture	Other Habitat Alterations	High†
Swabia Creek Watershed	02-C	03579	970618-1400-TTS/ 4.75	Unassessed Project	Agriculture	Siltation	High†
Swabia Creek Watershed	02-C	03579	970919-1530-TTS/ 0.45	Unassessed Project	Agriculture	Siltation	High**†
Toad Creek Watershed	02-C	03624	970613-1430-TTS/ 3.74	Unassessed Project	Agriculture	Siltation	High†
Toad Creek Watershed	02-C	03624	970613-1430-TTS/ 3.74	Unassessed Project	Agriculture	Organic Enrichment /Low D.O.	High†

* Pennsylvania Department of Environmental Protection, Commonwealth of Pennsylvania, Section 303(d) List 1998. August 7, 1998. The table above is reproduced from the Section 303(d) List.
** Stream segment is targeted for development of total maximum daily load (TMDL) by 2000.
† New listing for 1998.

fixed stations and reference stations to assess water quality and the effectiveness of water pollution management strategies. Chemical and physical analyses are performed monthly, and biological analyses are performed annually. All chemical data from the WQN is stored in the U.S. EPA STORET database.

Data from government agencies, universities, advisory groups, citizen monitoring groups, watershed associations, public interest groups, and sportsmen's groups were also solicited as data sources by Pennsylvania for the 303(d) list. After several validity and quality assurance checks, relevant data are included on the 303 (d) list.

Sources of impairment are assigned priority rankings based on the severity of pollution and uses of specific water bodies. The priority rankings correspond to TMDL development over the next 2 years. Sources that are considered a high priority for TMDL development include industrial and municipal point sources, package plants, combined sewer overflow, agriculture, silviculture, urban runoff/storm sewers, surface and subsurface mining, abandoned mine drainage, land disposal, and onsite waste water. Prioritizing stream segments allows the DEP to address the most severe pollution problems first. Cadmus recommends that the City contact the DEP to learn what actions may flow from the high priority ranking.

2.9.3 Sampling by Bureau of Water Resources--1998

The Allentown Bureau of Water Resources initiated a program of watershed sampling in summer 1998. The program sampled 17 sites weekly for a variety of water quality parameters. Constituents analyzed included nitrogen (nitrate), phosphorus (total, ortho), suspended solids, turbidity, alkalinity, and pH.

At the writing of this report data from four sampling runs collected in July through September were available. Summaries of the sampling follow: The first three sampling dates occurred after dry weather. One inch of rain fell in the two days prior to sampling on August 19, 1998. Nearly an inch of rain fell three days before the September 10, 1998 sampling. The results of the August 19 sampling indicate increased stream flow while the data for September 10 do not, probably because flow subsided in the three days before sampling took place.

<u>Nitrate:</u> Nitrate values ranged from 1 to 2 mg/l at the headwaters of the Little Lehigh, but increase to 4 to 5 mg/l downstream to the water intake. The nitrate concentrations of the tributaries vary greatly with several sites in Toad Creek having widely varying concentrations from 2.6 to 18.5 mg/l. This variation is probably the result of variation in the discharge of the Topton wastewater plant and variation in the dilution ratio of the discharge and the Creek. We recommend that this be investigated further. The nitrate values for the Hilltop site are curiously low compared with this project's samples (concentrations of 7 to 10 mg/l). (see Chapter 8) Other tributaries have nitrate values varying from 0.8 (Schaeffer Run) to 6.1 (Spring Creek).

<u>Phosphorus:</u> Ortho-phosphate levels varied greatly between sampling stations and between sampling dates. For example Cedar Creek had a value of 8.675 on August 6, but a concentration of 0.038 on September 9. In general, with the exception of Toad Creek and Cedar Creek concentrations are at or below 0.2 mg/l (equivalent to 0.066 as phosphorus). Cedar Creek may receive phosphorus from resident geese populations on the in Creek ponds and Toad Creek receives phosphorus from the Topton WWTP. Concentrations below the Topton WWTP varied from 6 to 22 mg/l (equivalent to 2 to

7.33 mg/l as phosphorus)probably depending on the concentration of the discharge and the level of dilution in the Creek. This is a high level considering that total phosphorus in undiluted, untreated wastewater varies from 6 to 20 mg/l.

Phosphorus levels were elevated at most of the stations except Toad Creek and Cedar Creek probably because of higher flows transporting additional phosphorus. Toad and Cedar Creeks showed lower concentrations, probably because the sources of phosphorus were diluted.

Suspended Solids: Suspended solids (TSS) are greatly dependent on flow. One continuous source of suspended solids is the Topton WWTP. A typical secondary treatment limit for TSS is 30 mg/l. Downstream of the WWTP the TSS concentration in the Creek varied from 8 to 10 for three samples. On August 19 the value was 37 mg/l probably because of higher flows. Overall TSS values ranged from 0.4 to 14.6 on the three low-flow days with the exception of the site below the Topton WWTP. On August 19 many of the sites had elevated TSS with values ranging from 2 to 29 mg/l. Turbidity samples showed similar variation with the highest values on August 19 with values ranging from 2.2 to 35.5 NTU.

3.0 METHODOLOGY

There are five major components of a source water assessment program as defined by the EPA: 1) delineation of the source water protection area; 2) contaminant inventory; 3) susceptibility analysis; 4) public access; and 5) public participation. (USEPA, 1997). While these components are required by the EPA for all source water assessments, each water supply protection program needs to be tailored to the local issues and needs. The EPA and the State will provide general guidance and assistance to local protection programs, however, the active protection of the water supply and the key to long-term control are ultimately the responsibility of the local water purveyors in partnership with watershed residents, communities, businesses and other stakeholders (EPA, 1997).

3.1 Delineation of the Source Water Protection Area

For surface water systems, the delineation of the watershed is defined by all the land area, or watershed, that drains towards the water supply intake. For the three PA watersheds under this study, the watershed boundary was delineated on USGS topographical quads (1:24,000 scale) and were digitized and mapped using GIS software.

3.2 Contaminant Inventory

For each watershed, a comprehensive inventory of potential sources of pollution was identified. These sources can be divided into point and nonpoint sources and are summarized in the text and tables and illustrated in a series of GIS maps. Point sources of pollution can be traced to a definable source or pipe. Nonpoint sources of pollution emanate from the land or air without a discernible discharge point and include agriculture, residential development, deicing salts (both storage and usage), forestry, dumps, mined lands, septic systems, streambank erosion, and roadbank erosion. Another potential concern is recreational boating. Likely source areas are first identified using land use maps obtained from state and county agencies. This basic inventory will provide the following information for potential nonpoint sources of pollution: location (map), area (size in acres if applicable), relative distance to the water supply intake (if applicable), pollutant types by pollutant source (toxics, sediments, nutrients, salts, pesticides, pathogens, etc.), and the implication of each pollutant type for the water supply (i.e., pathogens cause disease and health consequences).

Several methods were employed to identify potential contaminants in the three watersheds: 1) review of point source pollution databases; 2) interview of key watershed stakeholder/informants and mapping; 3) stressed stream analysis sampling and windshield surveys of the watershed; and 4) GIS land use modeling and nonpoint source pollution estimation using loading functions. The data collected from these methods were then used as the basis for the susceptibility analysis.

- <u>Point Sources</u>-Available data from the pollutant sources, including: direct surface or groundwater discharges, NPDES permittees, hazardous waste sites and spills, petroleum and chemical bulk storage facilities, salt storage facilities, and landfill/dump sites were collected from appropriate state and federal agencies. They are presented in maps and tables in following sections. These data provide important baseline information on location and extent of activity in each watershed/subwatershed contribution area.

- <u>Stakeholder Interviews and Pollution Source Mapping</u>-Key stakeholders/informants who live and work in the watershed from both public and private organizations were interviewed and asked about potential sources of pollution in the watershed. Their responses were summarized and included in the text. Additionally, large format (e-sized) GIS maps with roads, hydrology, subwatershed boundaries and land use were sent to a number of key stakeholders in each watershed for them to identify both point and nonpoint source potential pollution sources or problem areas. These maps were collected and reviewed, then the data were summarized and entered into the GIS. Many of these points were also field checked. This procedure was found to be quite useful in identifying important areas not readily apparent in existing databases or through other conventional methods of pollution source assessment. In addition, the approach provided stakeholders with a meaningful avenue for public participation in both the fact-finding portion of the project and options for implementing the plan.

- <u>Stressed stream analysis sampling and windshield surveys of the watershed-</u> Stressed stream analysis is an integrative, comprehensive approach for determining the environmental health of a watershed and its constituent streams (Makarewicz, 1993)[22]. Within a watershed, the approach can be used to identify impacted subwatersheds and within a particular stream reach, it can be used for determining how and where a stream community is adversely impacted by a pollution source or other disturbance (Makarewicz, 1993). Stressed stream analysis is a technique that divides the watershed into distinct segments, usually above and below major stream branches. Samples are taken at the beginning and end of each unit of the stream to determine the concentration of the pollutant under consideration. If the pollutant levels are higher from one branch than the other, it is likely that the higher levels indicate a pollution source(s) from the respective watershed. In addition, during the stressed stream sampling, windshield surveys or visual observations were made by Cadmus technical staff on the conditions of streambanks, roads, land uses and other potential sources identified by watershed stakeholders. These observations are incorporated into the appropriate text sections and tables that follow.

- <u>GIS and Loading Functions</u>. To estimate the nutrient and sediment loads exported to the reservoir by the watershed, Cadmus used GIS derived land uses for each subwatershed and applied literature loading functions. The purpose of this was to help prioritize future efforts. It will be necessary to apply more detailed models to examine pollutant sources at the subwatershed or finer scale. The next level of detail would be to apply a model such as Generalized Watershed Loading Function (GWLF) that uses the universal soil loss equation (USLE), precipitation data and Natural Resource Conservation Service (NRCS, formerly Soil Conservation Service, or SCS) hydrology methods.

[22] Makarewicz, J.C. 1993. Stressed stream analysis. Waterworks.

3.3 Nonpoint Source Pollution Loading Estimates

There are a number of methods to estimate nonpoint source pollution loading, from simple export coefficients and loading function models to rigorous mathematical research models. Export coefficients are a widely used technique which use representative values for the mass of pollutant generated per unit area per year (Reckhow, et al., 1980; Rast and Lee, 1983; Frink, 1991; Budd and Meals, 1994). As part of the Lake Champlain Basin Program, Budd and Meals reviewed the appropriate scientific literature and identified the following export values for three major land uses:

Table 3-1
Loading Coefficients for Various Land Uses

Parameter	Total Range	Most Frequently Reported	Selected Value
Forested Land			
Total Phosphorus	***0.01-0.90***	***0.04-0.24***	***0.10***
Soluble Reactive Phosphorus	***0.007-0.170***	***0.03-0.07***	***0.05***
Total Nitrogen	***0.10-13.45***	***2.0-5.5***	***3.5***
Agricultural Lands			
Total Phosphorus	***0.10-7.17***	***.025-.081***	***.0.5***
Soluble Reactive Phosphorus	***0.09-4.48***	***0.09-0.22***	***0.15***
Total Nitrogen	***1.2-42.6***	***4.8-14.0***	***7.0***
Urban Lands			
Total Phosphorus	***0.03-11.6***	***1.00-1.91***	***1.50***
Soluble Reactive Phosphorus	***0.03-2.00***	***0.21-1.00***	***0.50***
Total Nitrogen	***1.6-38.5***	***6.1-10.2***	***8.5***

Sediment yields can similarly be estimated using export coefficients with the following coefficients recommended by the EPA:

For each subwatershed in the Little Lehigh Watershed watershed, export coefficients were used to estimate loading of nutrients and sediments using the following equation:

$$LD_k = A_k \text{ x } EC_{k,}$$

Where LD_k = annual load from land use
k; A_k = area in land use k; and
EC_k = areal export from land use k

Land use data derived from the GIS were used in conjunction with the loading export coefficients to estimate areal loading of nutrients and sediments. Estimates from each subwatershed were then used to rank each subwatershed against each other to define priority areas of concern.

Export coefficients are approoximate but useful as Budd and Meals observe:

> The primary advantage of the export coefficient method is its simplicity. The appropriate export coefficient for a particular land use is simply multiplied by the land area devoted to that land use to give the estimated annual load. The accuracy of the technique can be higher than more complex methods, because only one parameter - the export coefficient- must be chosen by the investigator. The simplicity of the method is also its primary weakness-there are no provisions for year to year hydrologic variation; export coefficients are most applicable in years of “average” climatic conditions…

Because this method is being used to compare subwatersheds against each other and not to estimate absolute loading amounts, this is deemed a reasonable approach to make a fair comparison.

3.4 Susceptibility Analysis

Watersheds are large and complex: it is difficult to efficiently and economically evaluate all of the potential sources of pollution. Using traditional methods of rapid evaluation and triangulating the results allows for a more accurate portrayal of the situation. It is important to select methods which can be cross-checked against each other. In addition, the evaluation methods should help identify and/or prioritize pollution reduction implementation efforts that maximize return on investment.

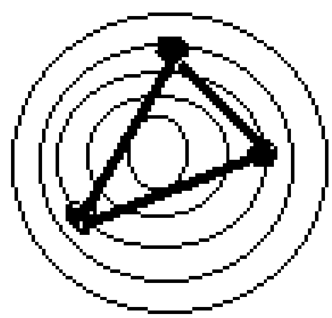


Figure 3–1

Triangulating Multiple Methods Can Increase the Reliability of an Assessment in Locating the "Bulls Eye" of Actual Impact or Importance

Another important consideration is to cast a fairly broad net in terms of evaluating sources of pollution. All potential sources of pollution should be evaluated in some manner to ensure that all possibilities are accounted for and to be "fair" to all land uses. The fairness issue arises particularly when a single land use dominates, such as agriculture. Farmers may feel that they are the only "targets" of a water quality improvement effort, unless it can be demonstrated that everything was considered.

We used three methods of evaluation for rapid watershed appraisal of potential contaminant sources: a) key stakeholder/community informant interviews and database review; b) stress-stream analysis monitoring; and c) nonpoint source pollution loading estimates using GIS and loading coefficients or functions.

3.5 Potential Pollutant Sources

The following data sources were consulted in searching for potential contamination sources in the Little Lehigh Watershed.

3.5.1 Right to Know Environmental On-line Database

The Right to Know Network (RTK NET) (http://www.rtk.net) provides access to governmental databases, and information on conferences on the environment, housing, and sustainable development. RTK Net was established to provide information to the public and to foster involvement in community and government decision-making. The RTK Net can be accessed via the World Wide Web, bulletin boards (bbs), or telnet. The RTK Net is sponsored by the Office of Management and Budget Watch and the Unison Institute, two non-profit organizations formed in response to the Emergency Planning and Community Right to Know Act in 1989. The following list details the environmental databases used in this watershed assessment, the years for which data are available, and the type of data that can be found in that database.

- Permit Compliance System (PCS) Provides information on National Pollutant Discharge and Elimination System (NPDES) Permits from 1990 to the present. The

PCS database provides facility name, address, location (latitude, and longitude), SIC code and description, the year of permit issue and expiration, inspection dates, monitoring requirements, and violations. For some facilities, the water basin and water body receiving the permitted discharge are identified, as well as the amount and type of discharge. The type of permit (i.e., storm water, industrial, etc.) is also provided. For "minor" facilities, PCS data may be incomplete.

- <u>Toxic Release Inventory (TRI)</u> Toxic release information is available for 1987 through 1995. Data are collected nationally from selected industries that manufacture, process, or otherwise use compounds from a list of toxic or hazardous substances greater than applicable thresholds. The company's presence on a list does not mean that it necessarily releases large amounts of material to the environment. For example, a plastic former that molds plastic into shapes and ships them as product would be included if the plastic contains any listed compounds. They would be included on the list even if very little of the material were released to the environment through air, water or land pathways. A further complication is that disposal to a landfill located far away from the facility (and possibly outside of the watershed) would still cause the facility to be listed for a watershed.

  The database shows releases and transfers of toxic chemicals from manufacturers. The database shows the manufacturer's name, address, and latitude and longitude. Detailed accounts of amount and types of chemicals released or transferred are also provided by year of release or transfer. Manufacturers included in TRI should not necessarily be considered point sources of pollution. However, these manufacturers may be considered potential point sources of pollution if accidental spills or releases of chemical toxicants to the environment are deemed possible.

- <u>Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS)</u> CERCLIS provides detailed accounts of Superfund or potential Superfund sites, actions, and enforcement activities. Every known Superfund or potential Superfund site is identified in this database. The names, addresses, location, contact names, and dates of operation of facility sites are provided. Dates of discovery, National Priority List status, and Hazard Ranking are also provided. Responsible parties, the lead agency in the investigation, and financial obligations are identified. The National Priority List (NPL) is also available. The NPL identifies facilities that need to be cleaned up under Superfund. The database identifies the facility location and provides brief descriptions of the site. Records of decision can also be searched through dial up numbers.

- Resource Conservation and Recovery Act Information System (RCRIS) The RCRIS database provides information on hazardous waste permits for generators, receivers, and transporters of hazardous waste. Facility name, address, and location (latitude and longitude) are identified, as well as the type and amount of hazardous waste transported, transferred, recycled, or disposed. Violations are reported. No dates of data availability are reported.

The following databases can also be accessed through the RTK Net, although they were not searched for this watershed assessment. Further research may show these databases to be useful in identifying potential or actual point sources of surface or ground water pollution.

- Accidental Release Information Program (ARIP) This database provides information on accidental releases of pollutants to the environment. Data are available from 1986 through 1996.

- Emergency Response Notification System (ERNS) The ERNS database provides a description of accident reports where an accidental spill or release of an environmental toxicant was reported to the National Response Center. Data are available from 1987 to 1997.

RTK Net also searches: 1) Databases associated with health information, such as the Integrated Risk Information System (IRIS); 2) Roadmaps, a database with information on TRI chemicals; 3) The New Jersey Health Fact Sheets that describe health effects of TRI chemicals; 4) RM1's, which provides information on TRI chemicals; and 5) TSCATS, which provides data relating to the Toxic Substances Control Act. The RTK Net also provides information on enforcement activities through DOCKET, a database of court cases and enforcement actions. The web site also provides links to the Facility Index System (FINDS), the Chemical Update System (CUS), and Census data.

3.5.2 Environmental Protection Agency On-line Database Access

The Surf Your Watershed web site sponsored by the Environmental Protection Agency at http://www.epa.gov/surf provides information on many large-scale watersheds and water basins across the U.S. This site provides links to many of the same databases accessed by the RTK Net including PCS, TRIS (TRI information system), RCRIS, CERCLIS, and ARIP. The EPA site also provides an index of watershed indicators, where available, information provided by States and Tribes, river corridors and wetlands restoration efforts, and provides links to other environmental web sites. Nonpoint source projects in the watershed, community water sources (from the Safe Drinking Water Information System database), historical water data, water resources, water use (1990), and selected USGS abstracts can be accessed from this web site. The Envirofacts Warehouse, a retrieval system for all EPA environmental data, also provides links to air releases, grants information, facility index system (FINDS), and spatial data such as latitude and longitude, and EPA's spatial data library.

Watershed data can be researched by United States Geologic Survey (USGS) Cataloging Unit, by zip code, city, stream, tribe, ecosystem protection efforts, or state. PCS data are presented in tabular form, where each discharge is identified. A description of each chemical, compound, or biological agent discharged is also available by clicking on underlined parameters (i.e., a description of dissolved oxygen, and total ammonia as nitrogen are provided).Links to the USGS allow users to access stream flow and water quality data from both current and discontinued gauging stations. Searches through the USGS site can be performed using Station gauge numbers, river or stream names, and water basins.

3.5.3 Commercial Databases

The following commercial products were used during this project. Each of them was relatively economical and was useful subject to the limitations described below.

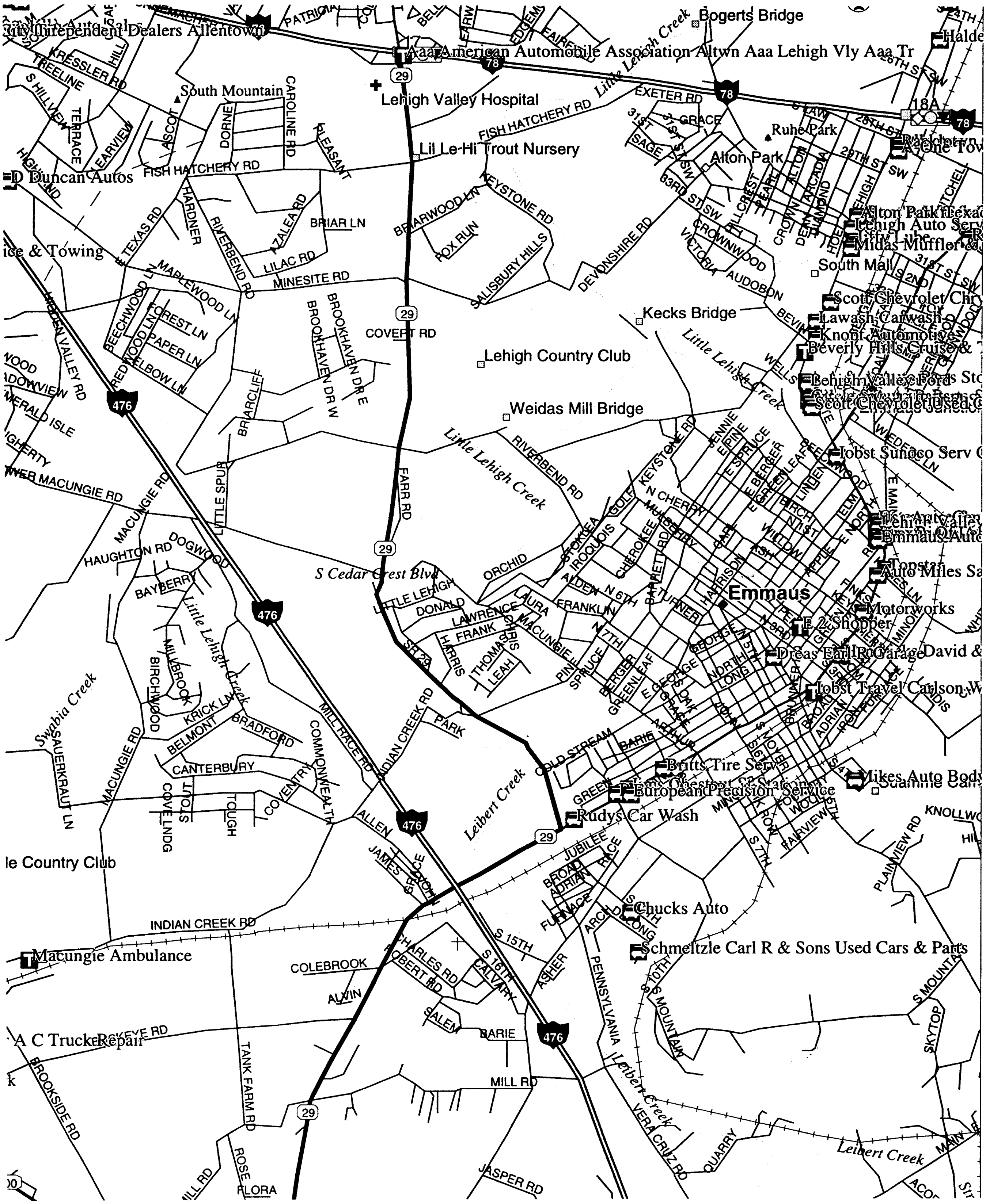
- Dun & Bradstreet Corporation Information Services—Dun's Direct Access Database. This on-line dial-up database was used to locate the address, (Keep the "and", I can't figure out how to delete the strike-through.)latitude, and longitude of businesses within the watershed. The database is relatively economical, costing roughly $.22 per abbreviated record, relatively simple to use, and much more complete than other commercial databases that we used for this project. Nevertheless, not all facilities could be located due to name changes, address changes, or inconsistencies in facility name reporting. Where addresses of potential point sources of pollution were known, this problem was overcome. The database also provides SIC codes and descriptions of each business.

- Delorme CD-ROM Set—Phone Search USA, version 3.0 (6 CDs), (1997) with Delorme Street Atlas USA, version 5.0 (1997). Cost: $69. Phone Search was used to locate addresses of facilities within the watershed. The primary feature of the software is that businesses or residences can be searched for by state, city, zip code, name, phone number, SIC (standard industrial classification) code, or street address. Search results can then be mapped using Street Atlas USA. This feature is powerful and allows a user to search for example, for all SIC codes beginning with "50" in a particular zip code. This list can be pared down to a subset of interest and mapped using the Street Atlas Program. An example of such a map is shown in Figure 3-2. The facility is located to the street level by the software. The actual location, confirmed in the field, is roughly half-way up the road.

One limitation to the software is that if a business address is for a central office, the actual facility is not located. This Atlas program by itself can be used to locate and map gas stations, service stations, transportation centers (i.e., airports, bus terminals), and auto-related industries. This feature, however, is focused on trip services and is not a reliable locator of all businesses in a region. The maps can be printed, and labeled. This software also calculates routing directions, which maybe useful for field work and for designing field sampling routes.

The primary disadvantage to using the Delorme software was that it was not as complete as the Dun and Bradstreet database. For example, some gas stations located by Cadmus in the watershed were not listed in the Phone Search disk, or identified as a point of interest by the Street Atlas. However, using the Phone Search and Street Atlas disks were adequate starting places to locate possible point sources of water pollution in the watershed. They were also useful for finding map locations for businesses identified in the Dunn and Bradstreet database. The map atlas is also useful locating facilities where the latitude and longitude or street address is known. Because the disks cover all of the US, a statewide watershed effort would spend very little per watershed for these disks. In summary these disks are useful but should be used in conjunction with other data-gathering tools for identifying potential sources of pollution.

Figure 3-2: Delorme Map Example



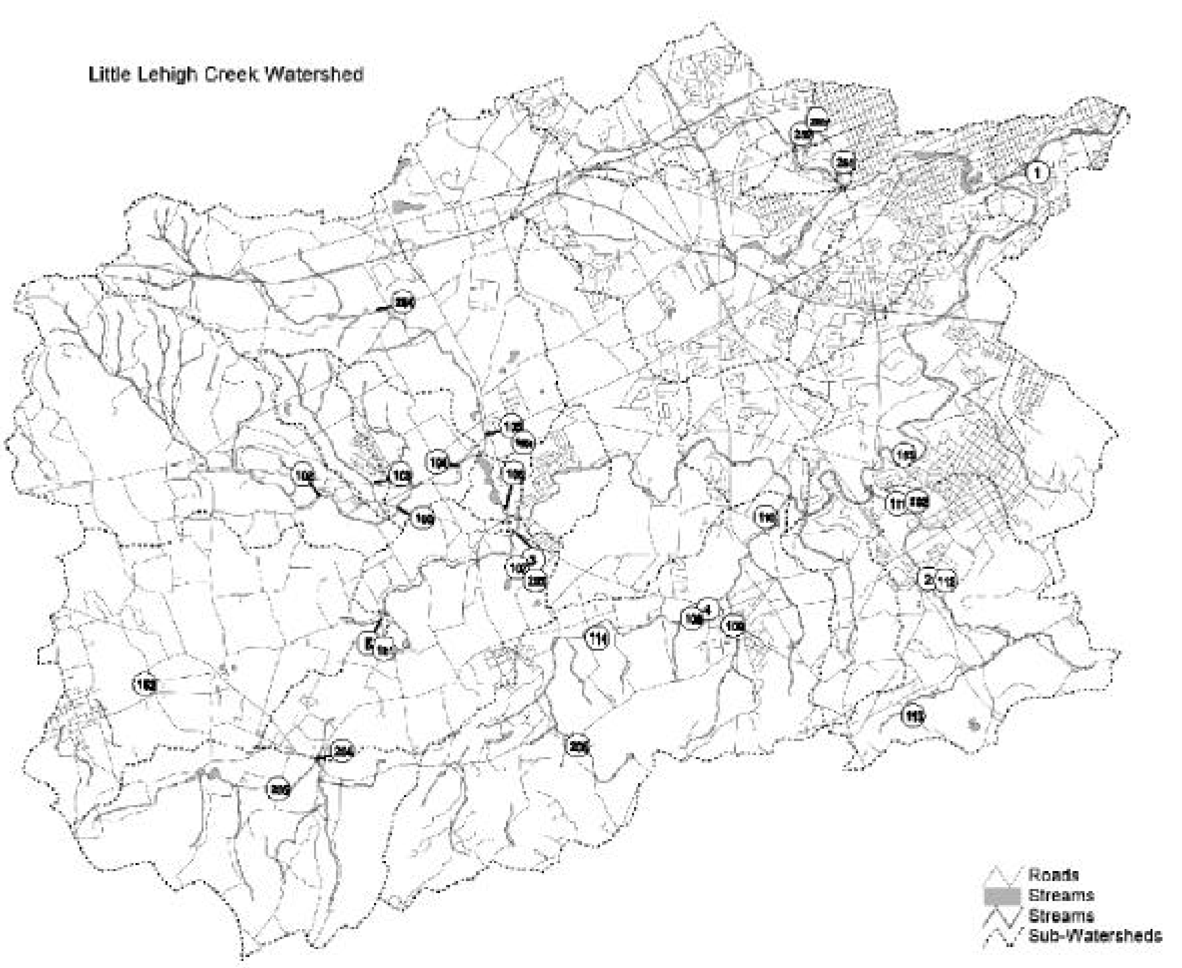
3.6 Sampling Methods

Cadmus sampled the watershed on two occasions: June 4, and July 29-30. Cadmus performed general observations and collected samples for analysis of ammonia, nitrate, total kjeldahl nitrogen, total phosphorus, total suspended solids (TSS), and fecal coliform bacteria. Cadmus used a combination of LaMotte field test kits and laboratory analysis for the nitrate and total phosphorus samples. Routine nitrate samples were submitted for laboratory analysis and tested in the field to check the accuracy of the field test kits and sampling procedures. In general, the accuracy of the kits was quite good. For total phosphorus the kits were used as a screening tool to test for the presence of high phosphorus levels. Whenever a level of 0.2 mg/l was found, a sample bottle was collected for later analysis.

The purpose of the sampling was to provide a brief point-in-time view of the watershed and to detect hot-spots of high concentrations of contamination. In keeping with EPA source water guidance these data were intended to supplement existing data and to focus future efforts. They were not intended however, as a complete water quality survey.

Sampling points are illustrated in Figure 3-3. They cover much of the Little Lehigh and its tributaries. Sampling data are also listed Appendix 3-1 in Table form.

Figure 3-3: Project Sampling Locations



4.0 ALLENTOWN ISSUE 1: SEDIMENTATION AND TURBIDITY

Erosion of watershed soils and their ultimate transport to the treatment plant is a key concern of the City, particular during storm events. High levels of turbidity that occur during storm events can create treatment difficulties. The City has several methods to ameliorate episodic high turbidity including use of storage capacity to allow the peak turbidity to bypass the plant and the use of Lehigh River water when the Lehigh's peak turbidity is out of phase with the peak turbidity of the Little Lehigh. Suspended solids also carry pollutants that *adsorb* or chemically attach to them. As the Little Lehigh Watershed continues to urbanize, suspended solids will be the main problem facing the City in protecting the quality of its water supply. The following chapter discusses sources of sediments, provides a coarse estimate of the amount released each year, and offers several recommendations. No program will eliminate the load of suspended solids carried during high flows, however. Even relatively undisturbed watersheds show an increase in suspended solids during storm events.

4.1 Erosion/ Suspended Solids/Sedimentation

A portion of soil material that is eroded in the upper reaches of a watershed is delivered to the lower reaches of a watershed and ultimately to the treatment plant. The erosion and sediment transport process occurs in all watersheds, even undisturbed ones. The key issue is the rate at which these processes occur.

4.2 Soil Erosion and Transport Processes

Erosion is the process that removes soil from its initial location through dissolution or loosening and allows it to be transported. Eroded soil is transported in a stream by several processes, including suspension and bed load. Lighter particles can become suspended in a stream as suspended solids. Typical sampling examines this portion of transported soil. Heavier particles travel along the bottom or bed of the stream and are called bed load. Water quality sampling can miss this material. As suspended material and bed load move down a stream, they can be deposited as sediment when the stream flow slows, because of widening or deepening of the stream. The portion of material that is transported to the bottom of a watershed or subwatershed of interest is termed delivered sediment or sediment yield. The ratio of sediment delivered to the bottom of the watershed to the eroded soil is termed the sediment delivery ratio (SDR).

Based on the Little Lehigh Watershed's area of 108 square miles, the SDR is roughly 9 percent. This means that on average roughly 9 percent of the eroded material in the watershed reaches the bottom of the watershed (i.e., the intake) in a given year. This ratio varies greatly within the watershed and from year to year. For example, soil eroded in the main stem of the Little Lehigh Creek will reach the intake in a much higher proportion. Sediment carried in stormwater that first is detained in a stormwater pond or similar structure may not reach the intake at all if the pond provides sufficient detention time.

4.3 Is Sediment a Water Quality Problem?

Erosion and sediment transport can present several problems to water supplies. High suspended sediment loads that cause high turbidity can complicate water treatment. Turbidity can provide substrates for pathogens, can clog filters or shorten their life, and can make finding cysts more difficult. In Allentown, high turbidity in raw water could interfere with the lamella plate settling basins, and could cause more frequent filter backwashing to be required.

Another sediment-related water quality problem is adsorbed pollutants. Generally pollutants with positive charges adsorb or chemically attach to the clay fraction of sediments. While a portion of these pollutants is strongly attached to the sediments, a portion can become dissolved again if conditions such as pH change. A key adsorbed pollutant is phosphorus. Previous studies have shown that much of annual phosphorus export from a watershed occurs during storm events, and that much of that phosphorus is adsorbed onto sediments. This phosphorus source can fuel eutrophication or enrichment of the streams and can cause undesirable algal growth. The algae can cause taste and odor problems in a water supply. Other adsorbed pollutants include heavy metals.

4.4 Rates of Erosion and Sedimentation

Determining precise rates of erosion and sediment transport in a watershed is difficult for several reasons:

- Erosion is determined by field-scale practices. Changes in land cover practices from year to year can change erosion rates by a factor of two or more.

- Erosion is partly caused by physical forces associated with rainfall and water flow over land. For example, the extent to which heavy rainfall is correlated with the timing of plowing in a given year can affect the rate of erosion that year.

- A relatively small portion of eroded soil reaches the outlet of a watershed in a given year. The ratio of delivered material, or the SDR, can be as low as 5 percent for a large watershed. The SDR for a given subwatershed is a function of the soils of that watershed, the ratio of channel length to watershed area and other factors.

Detailed modeling of the watershed's erosion and sedimentation was not a focus of this project. However, several observations based on existing work and limited review of GIS data can help illustrate the magnitude of the sediment load and the uncertainty in precisely determining it.

- Cadmus developed a first-order erosion estimate based on literature loading functions. The erosion rate was estimated at roughly 1.96 million tons per year. Using an estimated sediment delivery ratio of 9 percent, this is 120,000 metric tons per year that passes by the intake for the City's water system, a portion of which is drawn into the treatment plant. Because a large portion of the sediment is carried during peak storm events, the City's strategy of allowing the turbidity plume from a storm to bypass the plant ensures that most of the suspended material is not drawn into the plant.

We recommend that a thorough study using detailed soil characteristics and wet-weather sampling be completed to better understand soil erosion and sedimentation. This sedimentation study should include use of a low to moderately complex model such as the Generalized Watershed Loading Function (GWLF) to investigate sediment loading, and should be done in cooperation with the local conservation district and the NRCS, the local practitioners of soil conservation.

4.5 Sources of Sediment

Cadmus applied a loading function approach to estimate sediment loads by land use and by subwatershed. Because erosion is a field specific process, and because this estimate is intended for prioritizing future efforts, these values should be used for comparison purposes only. Using loading functions for land use types at a subwatershed scale and summing the calculated loads by land use type gave an estimate of eroded sediment. Applying the average sediment delivery ratio yields the results in Table 4-1. Developed land contributes the largest portion by far followed by row cropping. Because this method did not calculate sediment delivery at a fine scale, these totals are estimates. Because the lower portions of the watershed are developed and row crops remain in the far reaches of the watershed, the actual contribution may be lower for row crops. Conversely where stormwater is effectively retained by stormwater ponds a high percentage of sediment may be trapped in those ponds and may not reach the Creek. The point of the table is to show that efforts should be focused on stormwater from urban areas, with some additional work on agricultural areas.

Table 4-2 shows erosion rates analyzed by subwatershed. Estimates of sediment contribution to the intake are not made on this basis because the sediment delivery ratio will vary greatly between subwatersheds, generally decreasing as the distance from the intake increases. For example, proportionally less erosion from the Toad Creek and Schaefer Run subwatersheds will be delivered to the intake than from the Lower Little Lehigh and from Cedar Creek.

Table 4-1
Estimated Sediment Load by Land Use Category

	Land Area (hectares)	Fraction of Total	Total Phosphorus (kg)	SRP (kg/yr)	Total Nitrogen (kg)	Soil Loss (metric tons)	fraction of total
Developed	6,641	27.0%	9961	2989	50806	134,207	83.5%
Pasture/ Open	5,737	23.3%	2868	795	37114	58	0.0%
Row Crops	7,241	29.4%	3620	1073	50092	26,339	16.4%
Forested	4,947	20.1%	749	245	17132	10	0.0%
Wetlands	58	0.2%	0	0	0	-	0.0%
Barren	13	0.1%	19	6	107	56	0.0%
Total	24,636	100.0%	17218	5108	155250	160,670	100.0%

TP – Total phosphorus TN - Total Nitrogen

SRP - Soluble, reactive phosphorus

Table 4-2
Estimated Annual Erosion by Subwatershed

Subwatershed	Land Area (hectares)	Proportion	Erosion (tons)	Proportion	Delivery Ratio
Toad Creek	1,831	7.4%	98,104	5.0%	Moderate
Swabia	3,171	12.9%	89,277	4.5%	Moderate
Schaefer	3,248	13.2%	100,412	5.1%	Moderate
Upper Little Lehigh	3,222	13.1%	66,753	3.4%	Moderate
Iron Run	2,836	11.5%	276,813	14.1%	Moderate
Cedar	2,499	10.1%	406,553	20.7%	High
Liebert	1,609	6.5%	179,448	9.1%	Moderate
Little Cedar	1,235	5.0%	167,840	8.5%	High
L Little Lehigh	4,985	20.2%	578,477	29.5%	High
Total	24,636	100.0%	1,963,676	100.0%	

We sampled few sites for total suspended solids (TSS) because in our experience dry weather sampling is not indicative of the sediment transport that takes place during rain events. During June and July, Cadmus sampled nine sites for TSS to examine baseline conditions (Table 4-3). There had been little rain the week before and little variation in sediment concentration was expected. None of the sites except for the stormwater pipe had extremely high sediment levels, they ranged from 2 to 19 milligrams per liter (mg/l).

The highest level (84) was measured at a stormwater pipe on the Little Cedar immediately after a brief rain shower. This value is illustrative of the fact that sediment is carried during rain events.

Table 4-3
TSS Analyses for the Little Lehigh Creek Watershed

Sample ID	Location	Sampling Date	TSS (mg/l)
1	Little Lehigh @ Lehigh Pkwy	June 3, 1998	7
2	Liebert Creek @Shimmerville Rd.	June 3, 1998	10
3	Little Lehigh @ Rt. 100 and Creamery Rd.	June 3, 1998	9
4	Swabia Creek @Macungie (Rt. 100)	June 3, 1998	8
5	Toad Creek @ Hilltop Road	June 3, 1998	7
113	Leibert Creek on German Road near mouth	July 28, 1998	19
153	Little Lehigh at Pool Sanctuary	July 28, 1998	2.0
252X	Little Cedar at Tilghman, stormwater pipe	July 29, 1998	84
253/254	Iron Run at Nestle Road	July 29, 1998	8.4

During the watershed survey, moderate sediment deposits were noted in many of the tributaries to the Little Lehigh. An earlier study by the Wildlands Conservancy found numerous areas with sediment deposits. The focus of their findings differed somewhat from this report because their focus included a stream ecology component.

Erosion of stream channels themselves also contributes to sediment load. While the precise contribution of eroded channels is difficult to quantify without very specific investigations, the contribution of this source is probably overwhelmed by developed and agricultural land uses. Consider, for example, the Toad Creek subwatershed. It produces roughly 98,000 tons of erosion per year, from an area of 1,831 hectares. The length of the main channel is approximately 5 miles. Hypothetically assuming that roughly 5 percent of the channel was eroding badly, losing 6 inches of soil per year from a 3-foot high bank gives 1,980 cubic feet of eroded soil. Assuming a bulk density of 2 g/cm^3, this is 120 tons of soil, much less than the roughly 98,000 tons discussed above. Even allowing for a much greater sediment delivery ratio from the eroded stream banks, this example demonstrates that the field soil erosion is roughly 1000 times greater than stream bank erosion. Therefore, while it is important to control stream bank erosion, controlling erosion on the land adjacent to the stream is even more important. That said, there are areas in the Little Lehigh Watershed where streambank erosion is a problem. For example, the Little Cedar Creek is badly eroded where it passes through the Allentown Municipal Golfourse.

4.6 How Can Erosion and Sediment Delivery be Decreased?

There are essentially two main strategies for reducing sediment load in the Creek and in raw water: 1) reduce erosion upstream in the watershed; and 2) reduce delivery of eroded soils to the intake. As described previously, the majority of the watershed's sediment load is derived from developed areas with a moderate amount still contributed by row cropping. Therefore, any sediment reduction strategy needs to focus on development and croplands.

Techniques for reducing sediment load can be categorized into nine strategies offered by Morris and Fan[23]:

1. Fit the activity to the soil, climate, and terrain
2. Minimize the area and duration of soil disturbance
3. Protect denuded soils
4. Maximize vegetative cover
5. Maximize infiltration
6. Manage slopes to prevent flow concentration
7. Prepare drainage ways to handle concentrated flows
8. Trap sediment before it leaves site
9. Protect and preserve vegetation in natural riparian buffers

Of the above principles, Strategy #1 is a large planning task involving federal and state programs that encourage farmers not to farm in areas such as wetlands and on highly erodible soils. Strategies #2 through #7 are the principles behind many forestry, construction, and agricultural best management practices (BMPs). Strategy 8 can involve both BMPs and riparian buffers. The last strategy can include a combination of farm assistance programs, cooperative stream bank programs, water system ownership or leasing of riparian lands, and land preservation.

[23] Morris G. L., and J. Fan. Op. Cit.

Construction Site BMPs

During this project we observed extensive construction in the central and western portions of the watersheds. Development included new housing tracts, road construction, and commercial construction. There has been extensive development in the Iron Run Watershed in the established industrial parks in the last 10 years. We understood that construction site soil conservation practices are largely the purview of the local conservation district office.

Construction sites greater than five acres are also regulated by Pennsylvania and EPA through the NPDES stormwater program. Under the program a notice of intent (NOI) form is filed for construction projects that will release stormwater to surface receiving waters.

There is extensive literature on construction sediment control BMPs including guidance issued by EPA for the NPDES construction site stormwater program.[24] Sediment control practices include:

- Hay bale fences
- Silt fencing
- Temporary siltation ponds
- Hydroseeding
- Netting and mulching

While the City does not have responsibility for construction site practices, they have a strong interest in sediment control. One role the City could play is in having water bureau staff inspect the watershed regularly. As part of the inspection regime, the staff

24 United States Environmental Protection Agency

could review current construction sites and review sediment control practices. While we saw no lacking practices during the project, it is the author's experience that insufficient sediment control is relatively common in the projects outside the watershed that they have reviewed.

There are many resources describing the design, installation, and performance of agricultural BMPs, and many can be accessed by the NRCS. The local Conservation District focuses primarily on construction activities. Following is a list of selected organizations providing resources about BMPs.

Table 4-4
Information Sources for Agricultural BMPs

Organization	Website	Address	Focus
The Soil and Water Conservation Service	www.swcs.org	7515 NE Ankeny Rd. Ankeny, IA 50021	Soil conservation, books, journal
Conservation Technology Information Center	www.ctic.purdue.edu	1220 Potter Dr., Room 170, West Lafayette, IN, 47906	Membership, BMP materials
Natural Resource Conservation Service	www.ncg.nrcs.usda.gov	Local and state offices	Agricultural conservation practices

There are also numerous federal, state, and local information sources on this topic. Usually, funding, education, and recruitment of individual farmers are larger limiting factors than a lack of technical information.

Following is an abbreviated list of agricultural BMPs designed to reduce erosion and sediment transport that Cadmus observed in place in the watershed:

- Contouring

- Strip Cropping
- Riparian Grass Filter Strips
- Grassed Waterways
- Terraces

The degree to which the use of these and other BMPs can be increased is a matter of funding, farm level education, and to a degree the staffing available at the local and regional level for implementation. NRCS staff noted that EQIP monies and other funding sources are insufficient to respond to farmers in the watershed wanting to participate in conservation programs.

We strongly recommend that the City initiate a sediment reduction program in cooperation with agricultural service agencies, it's own land management activities and the local conservation district. Additional recommendations are discussed in the next section. An upstream sediment reduction program is not a panacea, however. Morris and Fan[25] caution that there are limitations to what watershed management can accomplish in terms of reducing sedimentation. Although they refer to a reservoir they also apply to a run-of-river intake such as Allentown's:

> Even when successful, erosion control does not necessarily represent a complete solution to sedimentation problems. Erosion control requires a long-term commitment, and produces long term rather than short-term results. Land use changes that reduce erosion may not produce a short-term reduction in downstream sediment yield. Finally because erosion can never be reduced to zero, erosion control alone cannot achieve a sediment balance across a reservoir. Additional measures will eventually be required to remove sediment if the reservoir is to remain in operation, although erosion control can greatly delay this

[25] Morris G. L., and J. Fan. Op. Cit.

requirement.

For the reasons discussed above, it can be difficult to measure short-term results in changing sedimentation estimates. Because the SDR in large subwatersheds can be 15 percent or lower, only a portion of the erosion reduction can be measured downstream. Other tools, including model simulation, field level measurement, and simple calculations like the universal soil loss equation USLE, can be used to verify results.

4.7 Recommendations

Cadmus recommends the following activities and actions. The degree that a watershed protection effort will be successful depends greatly on the degree that can be achieved through cooperation between local parties, and the extent to which resources can be pooled. Any effort faces resource constraints, as we observed in each of the three pilot Pennsylvania watersheds. In each of them, funding through EQIP was inadequate to fully serve the needs of farmers wanting to participate in farm-scale cost sharing programs. As discussed later, there may be some opportunity for sharing and leveraging local resources in this area. The Wildlands Conservancy, has teams of volunteers and is seeking a funding grant for study in the larger Lehigh River watershed. In another regional watershed, the company Orvis has funded habitat protection programs. Other sources of funding include 319 nonpoint source funds. [See funding section and main recommendation section]

<u>Specific recommendations include:</u>

1. Cadmus recommends that the City undertake a detailed sedimentation study that would include some additional wet-weather sampling, and moderate-level modeling of sediment and erosion.

2. Develop a watershed protection subcommittee to focus on sediment transport arising from construction and stormwater runoff. The subcommittee could contain municipal officials concerned with stormwater, the conservation district, the local NRCS office, and on a part time basis a DEP staff member that works with Act 167 or other stormwater programs. Through this subcommittee the City could be an advocate for effective stormwater treatment in the watershed. This issue is difficult and has faced opposition before. A key approach must be effective recruitment of stakeholders from local townships for support of sediment control.

3. Expand the current water sampling effort by the Water Bureau staff to include basic level watershed inspections. Part of these inspections would be a review of sediment control practices by the numerous construction projects in the Watershed.

4. Explore with the NRCS and the local conservation district the use of federal and state programs for riparian protection. Focusing on these areas will not prevent erosion, but it can reduce the SDR. Other avenues for riparian protection have included funding by the Pennsylvania Fish and Boat Commission. The Chester Water Authority has completed several projects linking Commission funding with Authority resources and volunteer labor.

5. Consider seed grants from the City for innovative buffer zone protection. A key to successful coalitions is perception of benefit by participants. There is precedence for funding by water systems of watershed activities, for example in Syracuse, New York. The City and its customers are benefiting from the use of water from the watershed. The City may want to provide some level of resources to encourage upstream conservation efforts. These resources could be in the form of seed funding, equipment, labor, or laboratory services.[26] Explore purchasing or leasing riparian lands in the lower reaches of the watershed where SDR is high. As outlined above, lands near stream channels and stream channels in the lower watershed have higher SDRs, and should receive priority for action.

6. Prioritize subwatersheds for study and action.

[26] This discussion is intended as a starting point for the watershed coalition to tailor a program to their watershed. Cadmus as an outside participant can suggest alternatives for resource sharing, but only stakeholders themselves can determine an equitable distribution of costs and benefits.

7. Target BMP support in selected subwatersheds. Based on sampling and analysis, priority subwatersheds should be slated for implementation.

5.0 POTENTIAL POLLUTANT SOURCES

Much of the Little Lehigh watershed is either urbanized or is changing in its character from rural to moderate density residential and commercial land use. The northwest portions of the watershed, particularly in the Iron Run subwatershed, are shifting to commercial development. These types of land use can contribute contaminants from chronic sources such as stormwater runoff from roofs and parking lots, and from rarer, but more acute, sources such as accidental spills and other contamination incidents.

Cadmus examined potential pollutant sources in the watershed using the following methods:

- Stakeholder Interviews
- Site Visits of Selected Dischargers
- Review of Federal and State Databases
- Review of Commercial Databases
- Windshield Survey of Watershed

The following section discusses potential point and nonpoint sources of pollution. Most, but not all of these sites are regulated by state and federal agencies. The Bureau of Water Resources faces the challenge of striking a balance between building a watershed coalition and serving as an advocate of pollution control and reduction.

5.1 Point Sources

A list of point sources found in existing studies and various databases is shown in Table 5-1. Most of the discharges are stormwater related. Several of the industrial permits are no longer active although we did not investigate individual discharges. The only municipal plant discharging in the watershed is the Topton Plant with a design flow of 0.3 MGD. Additional data on these sources can be gathered through the PCS database described in Chapter 3 by state or City staff. Cadmus found no direct evidence of current water quality problems linked to dischargers.

The City may want to establish a dialogue with some or all of these sources. Discussions of permit compliance, however, should handled with care by the City. While the City has a strong vested interest in discharges being legal and proper, it has no legal authority to compel discharges to alter their behavior. Further, over-exuberant pursuit of dischargers could damage a coalition and leave potential stakeholders distrusting the City. The City needs to consider local stakeholders and consult with the DEP sanitarian or appropriate DEP NPDES officials, prior to approaching issues of permit compliance.

We recommend that the City open a dialogue with these permittees for informational purposes. It is in the permittee's interest to work the City to minimize potential problems before they grow, and to publicize their efforts at maintaining or improving their environmental performance (i.e., good press).

Table 5-1
Point Source Discharges in the Lake Little Lehigh Watershed

Facility Name	Address	CERCLIS ID #	Discharge	Data Source	Comments
Agway Petroleum Corp	P.O. Box 98 Emmaus, PA18049	PA0070084		3, 4, 5	
Air Products and Chemicals, Inc.	2801 Mitchell Ave Allentown, PA 18103	PA0011185		1, 3	
Allen Organ Company	Rr 100 Macungie, PA 18062	PA0012203		3, 4, 5	
Atlas Minerals and Chemicals	1227 Valley Rd Mertztown, PA 19539	PA0012998		1, 3	
BP Oil Macungie Terminal	Tank Farm Rd Macungie, PA 18062	PA0041009		1, 3	
Caloric Corp.	Heffner St and Washington St Topton, PA 19562	PA0011754		1	Facility no longer discharges from this site.
Carpenter ER Co. Inc./Olin Corporation	57 Olin Way Fogelsville, PA 18051	PA0022063		1, 3	
Carpenter Insulation Co.	57 Olin Way Fogelsville, PA 18051	PAR232202	Storm water (to Iron Run and Little Lehigh Creek)	2	Permit expired on 11/6/97. No further information is available.
Dorney Park/Wild Water Kingdom	3830 Dorney Park Rd Allentown, PA 18104	PA0053791		1	
Farm and Home Oil Co.	Term 2 Macungie, PA 18062	PA0062782		1, 3	
F&M Assoc Green Hills Wat Co.	1132 W Hamilton St, Allentown, PA 18101	PA0051811		3	Address is downstream of water plant. No location data for discharge listed in permit databases.
Leffler, Carlos R., Inc.	5088 Indian Creek Rd Emmaus, PA 18049	PA0055361		3, 4	

Facility Name	Address	CERCLIS ID #	Discharge	Data Source	Comments
Mack Trucks Inc.	2100 Mack BLVD Allentown, PA 18103	PA0053643		1	
Packaging Corp of America	7452 Cetronia Rd Trexlertown, PA 18087			3	
Ryder Truck Rental, Inc.	1327 Bulldog Dr, Allentown, PA 18104	PA0053694		3, 4	
Square D Co.	Minor St and 6th Emmaus, PA 18049	PA0051624		1, 3	
Stout, Henry	6427 Saddle Rd New Tripoli, PA 18066	PA0062766		1	
Stroh Brewery Co.	Rtes 22 and 100 Fogelsville, PA 18051	PAR122203	Storm water (to Iron Run)	2	
Topton Borough Municipal Sewer Authority	44 W Rd 1, Mertztownn, PA 19539	PA0020711		3	
Travel Ports of America Inc.	Upper Macungie TWP, PA 18104	PA0063495		2	
Tyler Pipe Ind-East Penn Foundry	Route 100 and Church St Macungie, PA 18062	PA0011916	Standard Permit	2, 3	Permit expired on 10/9/95. No further information available in databases.
Tyler Pipe	Route 100 and Church St Macungie, PA 18062	PAR202218	Storm water (to Swabia Creek)	2	Storm water permit; expired on 11/6/97

1. Environmental Protection Agency, On-line databases including Toxic Release Inventory, Superfund, Permit Compliance System, and Accidental Release Information
2. The Right to Know Network On-line Database System sponsored by OMB Watch and The Unison Institute, two non-profit agencies. Http://rtk.net.
3. Wildlands Conservancy, Little Lehigh Creek Stream Corridor Conservation Project, Stream Status Report, January, 1994.
4. Dunn & Bradstreet Corporation Information Services. Dun's Direct Access Database. On-line dial-up database.
5. Delorme, Phone Search USA. Database of names, addresses, and phone numbers of businesses and residences across the USA.

5.2 Industrial and Commercial Sites

Depending on their operational procedures and on the material that they handle, the threats that industrial and commercial sites can pose to drinking water sources vary from inconsequential to significant. To find industrial and commercial facilities, Cadmus reviewed the federal databases described above, used the Phone Search CD, queried a Dun and Bradstreet on-line database, and performed limited review during field work. Superfund and TRI sites are listed in the following sections.

5.2.1 Industrial and Commercial Users of Toxic Materials

The Toxic Release Inventory (TRI) collects data nationally from selected industries that manufacture, process or otherwise use compounds from a list of toxic or hazardous substances greater than applicable thresholds. The general thresholds are: manufacture or process greater than 25,000 pounds per year, or otherwise use greater than 10,000 pounds. Therefore a facility that uses greater than roughly 1,200 gallons of a cleaner or solvent per year would be required to report. Inclusion on the list does not mean that the facility has been in any way irresponsible, or that it poses a threat to surface and groundwaters. It simply indicates that the facility processes in some way, a moderate to large amount of material that has the potential to be toxic or hazardous. We obtained the list and present it here as a starting point for the City. The City and other stakeholders may want to review the list. An outreach effort should probably include mailings to these facilities to alert them to the efforts that Allentown is making. A facility that is located adjacent to a stream or that there is local concern about may warrant further contact by the City or by other groups. Facilities listed in TRI located in the watershed are listed in Table 5-2.

5.2.3 Superfund Sites

The Superfund program was established in 1980 to address sites contaminated with hazardous materials. Contaminated sites judged by EPA to need further action are assessed and scored according to the threat that they pose. Sites with a high score are placed on a National Priority List (NPL). Once a site is listed, various clean up alternatives are investigated. In some cases the sites are left in their present state and in other cases they are actively cleaned. Facilities listed as superfund sites and located in the watershed are listed in Table 5-3. Of the nine sites, two are listed on the final NPL. A preliminary assessment is complete for a third site. State staff should be contacted for further information on these sites.

5.2.2 Automobile-Related Commercial Facilities

Auto-related services, including automobile body shops, repair shops, and gas stations, are potential sources for numerous contaminants harmful to the watershed. Several inorganic and volatile organic drinking water contaminants regulated under the Safe Drinking Water Act (SDWA) are commonly found in these businesses, as indicated in Table 5-4.

Table 5-2
Facilities Reporting to the TRI in the Little Lehigh Creek Watershed

Facility Name	Address	Latitude	Longitude	ID #	Data Source
A Treat Bottling Company	2001 Union BLVD Allentown, PA 18103	40.3632	-75.2536		1
Air Products and Chemicals, Inc.	2801 Mitchell Ave Allentown, PA 18103	40.55265	-75.590756		1
American National Can Co.	100 National Dr Fogelsville, PA 18051	403415	-753743		1
Atlas Minerals and Chemicals	1227 Valley Rd Mertztown, PA 19539	403027	-753956		1
Caloric Corp.	Heffner St and Washington St Topton, PA 19562	403024	-754150		1
Carpenter ER Co. Inc.	57 Olin Way Fogelsville, PA 18051	403641	-753701		1
E. Penn Foundry Co,/Tyler Pipe	Church St. P.O. Box 35 Macungie, PA 18602	40.51806	-75.554167		2
Electro-Space Fabricators, Inc.	300 W High St Topton, PA 15137	403013	-754216		1
Exide Corp.	2001 Lehigh St Allentown, PA 18103	403428	-752847		1
Hubbard Milling Co.	6821 Ruppsville Rd Allentown, PA 18106	40.58467	-75.602776		1
Kraft General Foods Inc.	7352 Industrial Blvd Allentown, PA 18106	403422	-753622		1
Lebanon Chemical Corp.	19th and W. Lawrence Allentown, PA 18105	403530	-752930		1
Lehigh Cultured Marble, Inc.	111 Lehigh St Macungie, PA 18062	40.51722	-75.554722	PAD987325883	1, 2
Mack Trucks Inc.	7000 Alburtis Rd Macungie, PA 18062	40.50079	-75.584624	PAD060493582	1, 2
Mancor Inc.	160 Olin Way Allentown, PA 18106	405012	-752004		1
Packaging Corp of America	7451 Cetronia Rd Trexlertown, PA 18087	403009	-753630		1
Pet Inc.	2132 Downyflake Rd Allentown, PA 18103	403653	-752723		1
Prior Coated Metals, Inc.	2233 26th St SW Allentown, PA 18103	403401	-752838		1
Scotts-Sierra Horticultural Co.	6656 Grant Way Allentown, PA 18106	403401	-752838		1
Spirax Sarco Inc.	1951 Glenwood & 2 Allentown, PA 18103	403358	-752912		1

Facility Name	Address	Latitude	Longitude	CERCLIS ID #	Data Source
Stanley Vidmar Inc.	11 Grammes Rd Allentown, PA 18103	403431	-752921		1
Stroh Brewery Co.	Rtes 22 and 100 Fogelsville, PA 18051	403434	-753743	PAD056605959	1, 2
Trimet Technical Products Div	2409 Cedar Crest BLVD Allentown, PA 18105	403820	-753152		1
Tyler Pipe Industries (Penn Div)	Route 100 and Church St Macungie, PA 18062	403106	-753322		1
Victaulic Co of America	8023 Quarry Rd Alburtis, PA 18011	403053	-753559		1

1. Environmental Protection Agency, On-line databases including Toxic Release Inventory, Superfund, Permit Compliance System, and Accidental Release Information

2. The Right to Know Network On-line Database System sponsored by OMB Watch and The Unison Institute, two non-profit agencies. Http://rtk.net.

3. Wildlands Conservancy, Little Lehigh Creek Stream Corridor Conservation Project, Stream Status Report, January, 1994.

4. Dunn & Bradstreet Corporation Information Services. Dun's Direct Access Database. On-line dial-up database.

5. Delorme, Phone Search USA. Database of names, addresses, and phone numbers of businesses and residences across the USA.

Table 5-3
Superfund Sites in the Little Lehigh Creek Watershed

Facility Name	Latitude	Longitude	NPDES or CERCLIS ID #	Data Source	Comments
Atlas Minerals and Chemicals	403027	-753956	PAD000428441	1	Preliminary Assessment completed 06/01/83
Dorney Road Landfill	4031400	-7539150	PAD980508832	2	On the Final NPL, has 14 enforcement activities.
Enamelstrip Site Facility	4036120	-7531300	PAD981736952	2	Not on NPL, No further remedial action planned.
Hebelka Auto Salvage Yard	4034360	-7540040	PAD980829329	2	On the Final NPL, has 5 enforcement activities.
Mack Trucks Inc.	4031000	-7533240	PAD060493582	2	Not on NPL, No further remedial action planned. This is an Environmental Priority Initiative Site
Reeser's Landfill	4031000	-7531160	PAD980829261	2	Deleted from Final NPL.
Rodale MFG Co Inc.	**40.530368**	**-75.494142**	**PAD981033285**	**1**	**Purchased by Square D in 1975, discharge ended shortly thereafter**
Thomas Groundwater	4030420	-7539480	PAD897279643	2	Not on NPL. No further remedial action planned.
Tri-City Marble	**40.588441**	**-75.56916**	**PAD060494416**	**2**	

1. Environmental Protection Agency, On-line databases including Toxic Release Inventory, Superfund, Permit Compliance System, and Accidental Release Information

2. The Right to Know Network On-line Database System sponsored by OMB Watch and The Unison Institute, two non-profit agencies. Http://rtk.net.

Table 5-4
Compounds Potentially Found in Material Used in Automotive-Related Activities

Gas Stations	
cis 1, 2-Dichloroethylene	Tetrachloroethylene (Perk)
Trichloroethylene (TCE)	1,1,2,2-Tetrachloroethane
Automobile, Body Shops/Repair Shops	
Arsenic	Lead
Barium	Mercury
Benzene	Nickel
Cadmium	Tetrachloroethylene (or Perk)
Chlorobenzene	1,1,1-Trichloroethane
Copper	Trichloroethylene (or TCE)
Dichloromethane (or Methylene Chloride)	1,1,2,2-Tetrachloroethane
cis 1,2-Dichloroethylene	Xylene
1,4-Dichlorobenzene	

It is important, particularly in unsewered areas, to know how these businesses handle and dispose of the materials that may contain these contaminants. In areas without sewers, wastewater from automobile service stations flows to floor drains to a pump-out tank, septic tank, or dry well. Disposal to the latter two devices can eventually contaminate local supplies of drinking water, either through percolating to groundwater. In other words, what is poured down the drain today may appear in your drinking water tomorrow.

Problems sometimes occur because the business does not realize their responsibilities or the problems that they may cause. There are best management practices that can be implemented to protect groundwater and surface water drinking water sources. Sending an informational brochure or paying a visit to the site to hand-deliver educational materials will increase their awareness and may improve handling and disposal methods.

There are a variety of automotive-related commercial sites spread throughout the watershed, particularly in its eastern half. To locate these facilities, Cadmus reviewed the federal databases described above, used the Phone Search CD, queried a Dun and Bradstreet on-line database, and performed limited review during field work. Automobile-related businesses are illustrated in Figure 5-1. They are also listed in Appendix 5-1. (Some of the businesses for which there is no exact location (latitude, longitude) are listed in the table but not shown on the map.) In general the facilities are located throughout the watershed. Of most concern are ones that are located adjacent to a stream, where material that inadvertently entered the Creek would be directly transported to the water intake. Other sites located away from a stream channel can pose a *potential* threat to groundwater but pose less of a *potential* threat to the water system.

5.2.3 Other Commercial Facilities

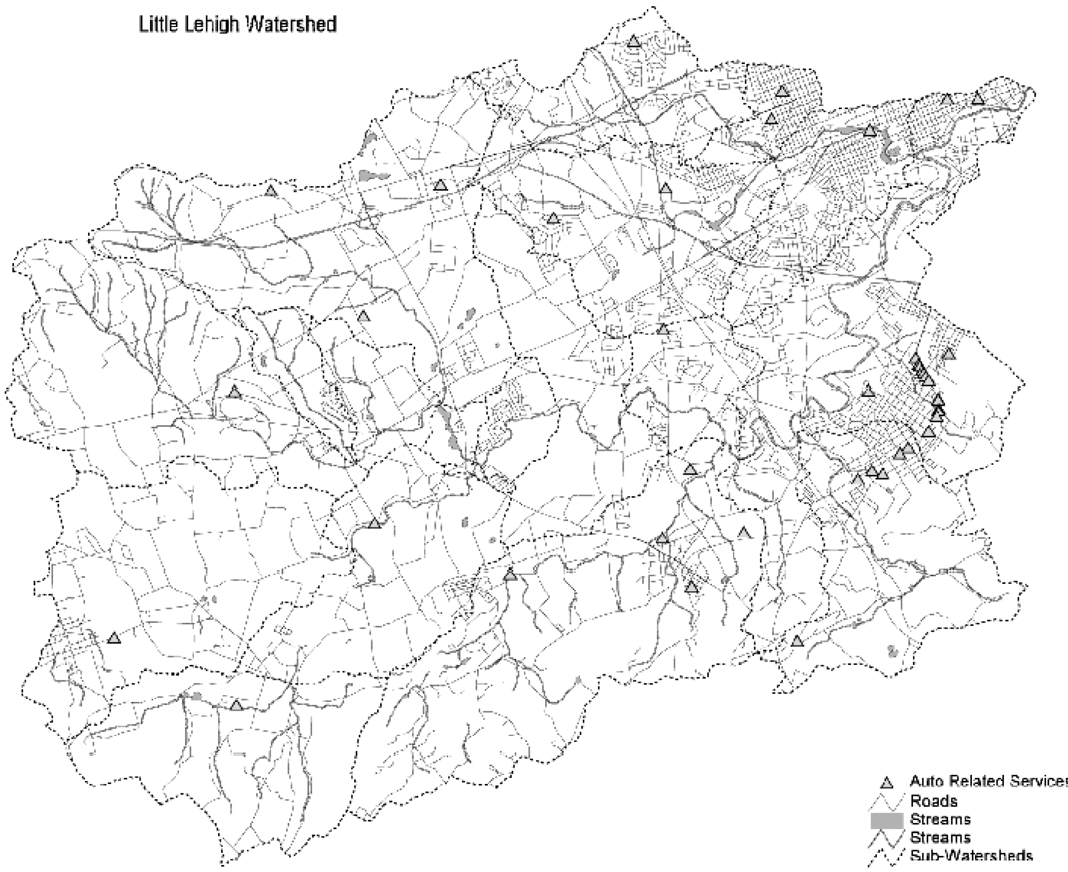
There a variety of other miscellaneous commercial facilities not otherwise listed in TRI, in lists of point sources, or in the list of automotive-related businesses. Most of them are small and pose limited or no potential threat to the water system. In this report we have identified several tools for located such facilities including Dun and Bradstreet and the Phone and Street Map Atlas CDs. The most valuable method of determining potential threats is local knowledge. Local knowledge is not always accurate, however, in some cases suspicions of pollutant problems prove unfounded. Nevertheless, knowledge of watershed inhabitants and past studies is a good starting point for further investigations.

5.3 Stormwater Runoff

When a new site is developed, a means for disposing of stormwater must be designed, where a separate stormwater or combined sewer system does not exist. A designer has several options including subsurface disposal such as dry wells and infiltration trenches and surface detention and disposal using a constructed stormwater pond with an outlet. There are many variations in stormwater designs including detention ponds with a dry well subsurface drain at their central low point.

Pennsylvania Act 167 requires that a stormwater plan for each drainage basin be completed and adhered to. Unlike some other states where all sites must not change the runoff from the site from its undeveloped condition, the requirements of Act 167 vary with the basin plan. For some areas in a basin the plan may call for full flow detention, in other areas some flow detention, and in other areas no detention at all. The reason for this is an effort to ameleorate the stormwater hydrograph of the larger basin. Some states, Massachusetts for example have gone beyond regulation of quantity and require that a large percentage of the pollutants in stormwater be retained on the site. By allowing some sites to pass stormwater directly to the Little Lehigh, little or no treatment of the contaminants carried in the stormwater takes place.

Figure 5-1: Automobile-Related Facilities



A challenge that the City faces in protecting its water supply is in being an advocate for stormwater control and treatment within the context of Act 167 and within the regulations that the City itself faces. As the watershed develops further, a larger portion of the stream's higher flows will essentially be runoff from parking lots. The greater the stormwater flows can be retained to allow solid pollutants to settle, the better. A second role the Bureau can play is in working with the DEP to reach out to commercial and industrial sites and provide information on preventing accidental spills from reaching their stormwater systems. For example, a spill at a loading dock can on some sites flow into a catch basin and into the site's stormwater system. Subsequent rain events can carry the contaminants into the local receiving water. Appropriate measures including spill booms can prevent this transfer of pollutants. While not the City's regulatory responsibility, they could become advocates for information transfer and training. Their efforts could interface with NPDES stormwater requirements.

5.3.1 Stormwater Related Problems and Sites Identified by Stakeholders

As part of this project, Cadmus sent large format maps of the watershed to stakeholders for their comments on actual or potential threats to water quality. Most of the comments returned related to nonpoint stormwater sources, particularly sources of sediments. Figure 5-2 shows sites with numbers that key them to specific comments by one or more stakeholders. The numbered comments are listed in Table 5-5. The first 21 are from one group and the second portion from an individual. These observations were not evaluated independently because they were received after fieldwork was complete and because a full investigation was beyond the scope of this study. They were lightly

Table 5-5
Stakeholder Comments on Sites of Concern

Note: Comments are those of stakeholders and not necessarily those of this project.

Key	Comment
1	Proposed stormwater diversion through stream and then wetlands in Trexler Park.
2	Many gabion-style single arm deflectors through stretch in Parkway cause streambank erosion and hold back water in high water
3	Heavily eroded streambanks along almost entire Parkway. Mowing to edge of streambank exacerbating problem.
4	Runoff from Myron Haydt subdivision near I-78 on northern streambank.
5	Discharge pipe for New Seasons and Wienerville stormwater from parking lots and buildings piped directly into wild trout section of stream.
6	Gravel from road in city park just west of I-78 on south side of stream washes into stream.
7	Discharge pipe from Devonshire Apts. Discharges into LCC at bend in river just below Keck's bridge.
8	Keck's Bridge is a major discharge point for drainage basin of 2000+ acres, causing heavy erosion and siltation , particularly in area east of bridge and south of stream which floods in heavy rains.
9	Odors detected again from sewer manholes that were overflowing between 1979-1983, after which a bypass was installed to correct the bottleneck.
10, 11	Two Class 1 streams, rip-rapped in 1980's to carry runoff from Devonshire development, see heavy runoff velocity and volume as stream mantle of streams is destroyed.
12	Flooding is occurring as Lehigh Street acts as a detention pond in heavy rains.
13	Failing stormwater management in Lehigh Parkway. (During storm events lab results demonstrate higher suspended solids and turbidity from the Parkway to the Wildlands Conservancy than in upper parts of the watershed. Keck's Bridge is the highest for both parameters.)
14	Question regarding significance and need for low-head dams on the Little Lehigh. Proposal to remove dams to improve water quality and the aquatic environment.
15	Better stream corridor management needed in local golf courses – Lehigh Country Club (15A), Brookside Country Club (15B), and Indian Creek Golf Course (15C).
16	New sewer pump station along Little Lehigh Creek on Spring Creek Road has had one emergency shutdown already. Road will be relocated and a new school and shopping area are under construction, potentially affecting water quality.
17	Severe erosion problems above and below Smith Land according to PA Fish and Boat Commission surveys and Wildlands Conservancy reports.
18	High phosphates (0.636 mg/L) at Schaeffer Run 1.5 days after a rain event.
19	Temperature, suspended solids, and nitrate numbers high at Mertz Lane in Toad Creek.
20	Samples by Wildlands Conservancy showing numbers above recommended levels for phosphates, nitrates, pH, temperature, and suspended solids below Topton Sewage Treatment Plant in Toad Creek.
21	Improved farming practices and fencing needed in Western Lehigh and Berks Counties areas of the watershed, where there is significant agricultural use.
22	Basin St. Outfall
All	• All of Parkway is part of the Federal Urban Trail System. • Five archeological sites – one is a Paleo Indian site (10 & 11). • Historic sites eligible for National Historic designation verified by State Museum Commission.

Note: Comments are those of stakeholders and not necessarily those of this project

22	Basin St. Outfall -- storm water discharge into Trout Creek and the Little Lehigh Creek from Mountainville Shopping Center. Garbage in stream. Past history of industrial pollution in this area which discharged into the creek(old incinerator).
23	Lake Muhlenburg -- Heavy nitrate and fecal source from over-populated geese in the lake. Lake acts like an in-stream sediment pond. Must find alternatives to resolve this problem by not feeding the geese or find a way to eliminate the lake from being within the stream.
24	Allentown Golf Course -- severe bank erosion from poor stream management practices and mowing too close to streams edge. Potential nitrate source for Cedar Creek.
25	Area of with in-stream sinkholes and poor farming practices. Northern branch of Cedar Creek acts more like a stormwater channel than a creek. Gabion walls line the streambank in places. Local development continues without regard to the poor condition of the stream .
26	Cement Company -- possible nonpoint source pollutant discharges from this site.
27	Greentree Nursery -- possible nonpoint source pollutant discharges from this site.
28	Dorney Park -- possible nonpoint source of pollutants. Dorney Park adjusts stream levels for water rides in early summer, which has resulted in poor aquatic conditions for the Cedar Creek.
29	Schantz Rd -- Cedar Creek is extended by a manmade conveyance channel as a result of development. NPS will be a problem for the existing wetlands in this area.
30	Tilghman Shopping Center -- possible NPS. Large basins discharge into a stone channel overlaying sewer interceptors from Upper Macungie and South Whitehall Townships.
31	Dam at Leiberts Creek -- Dam in poor condition heavy siltation behind the dam.
32	Emmaus Park -- Poorly stabilized stream banks. Existing swimming pool has had a history of leaks into Leiberts Creek.
33	Vera Cruz -- on-going septic failures with constant discharges into Leiberts Creek.
34	Colonial Crest Apartments -_ Stream banks severely eroded from mowing too close to edge of stream.
35	Mill Creek Rd. -- history of dumping garbage into stream at this point.
36	Spring Creek Rd. -- history of flooding, sewage overflows and a failed septic system.
37	Ancient Oaks Subdivision and Trexler Shopping Mall and Center -all stormwater outfalls go directly into stream -- NPS problem.
38	Spring Creek Rd. -- History of poor farming practices. NPS a major problem.
39	Swabia Creek -- poor farming practices. NPS a major problem.
40	Breinigs Run/Schaeffer Run Creeks -- severely eroded banks, plowing through streambeds. NPS problems.
41	Dorney Landfill -- EPA Superfund site.
42	stormwater conveyance channel when plant is overwhelmed with sewage flows. Severe groundwater problem results in constant pumping of water into this stormwater channel around the plant.
43	Iron Run Creek -- sinkholes in streambed prevent constant flow of water during dry periods. Used more as a stormwater channel for industrial development than a creek. NPS a major problem.
44	New drainage swale conveyance channel -- large water quality problem. This channel receives industrial stormwater runoff from several properties, Penn Industrial Park and 1-78. This was an intermittent stream in the early 1970's but is now a major stormwater conveyance. Channel is also littered with sinkholes that have caused turbidity problems in nearby LCA wells.
45	Bell Atlantic Basin - Full of sediment with trees growing in it. Has not been cleaned out. Upper Macungie knows this a major problem.

edited or were exerpted to provide the main point of the observation without publishing strong viewpoints not necessarily shared among stakeholders. The main purpose of including the comments is to point out potential threats and areas for further study.

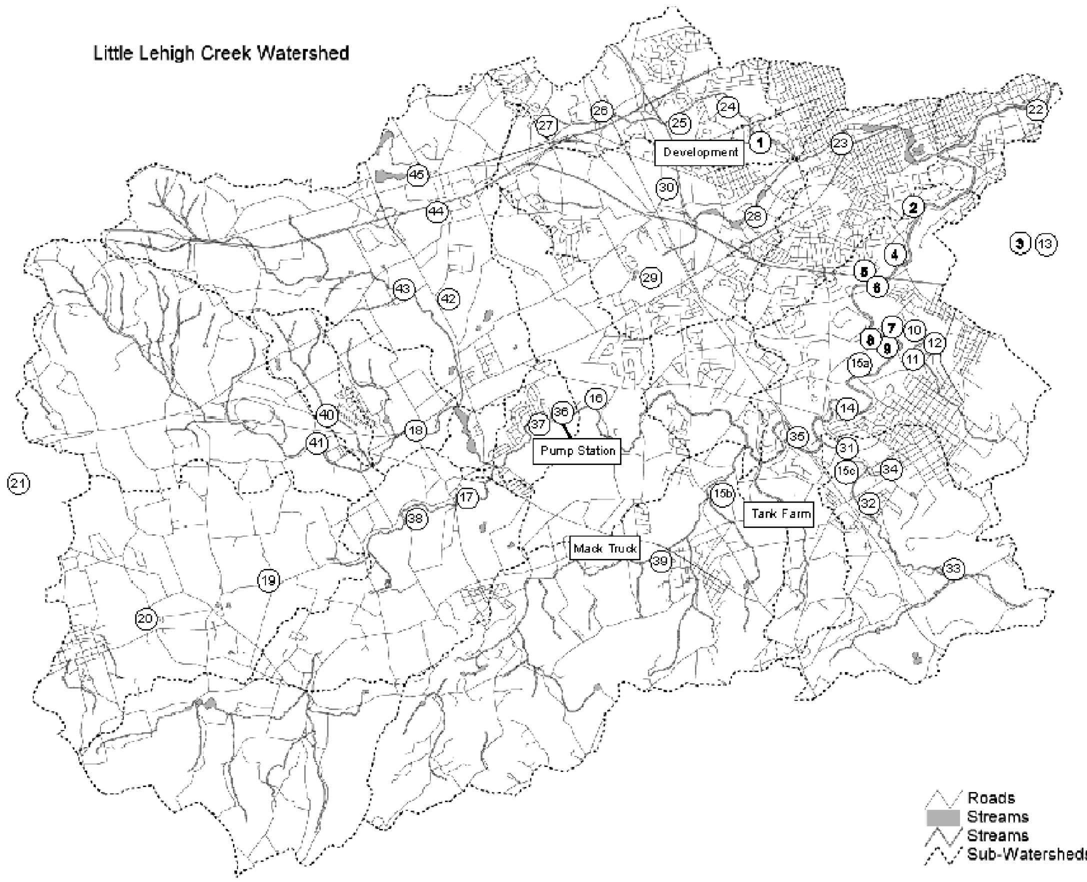
In aggregate, the observations show that the main concern in the watershed is erosion and stormwater impacts. Some of the observations are similar to those made by this project, for example, #24 erosion in the Allentown Municipal Golf Course.

5.3.2 Field Observations

During Cadmus field investigations in early June and late July staff noted numerous areas with sediment deposits. Swabia Creek at Route 100 in Macungie had extensive sediment deposits, some of them below a large stormwater pipe. Little Cedar Creek also had extensive sediment deposits in the area of Tilghman Road downstream of the municipal golf course. While the deposits noted were not as extensive as those we have observed in intensively farmed watersheds, they are significant in that they degrade aquatic habitat and contribute to turbidity in raw water.

Many commercial and industrial facilities handle materials that are potentially toxic including solvents, cleaners, and industrial raw materials. The potential threat to water quality and the related susceptibility of the water system is related to the following factors:

Figure 5-2: Keyed Locations of Stakeholder Comments



- Nature of the material
- Operating and handling procedures
- Distance from a Stream Channel
- Distance to the water intake by stream

The first two factors are under the control of the facility and can be affected to some degree by the City and a watershed coalition. We recommend that the City begin an outreach program to commercial and industrial facilities communicating the need for careful handling procedures for materials and for stormwater. PA DEP may be able to help with its programs in commercial and industrial stormwater, Class V well[27], and hazardous waste programs.

In general, facilities with no subsurface disposal, responsible material handling procedures, and little contact between their materials and rainwater pose little or no threat to ground and surface waters. Facilities with outdoor activities including use of fluids or fuels can pose some threat to surface waters. Facilities with floor drains tied to dry wells or septic systems can pose a threat to groundwaters.

Recommendations:

- Examine the lists of facilities provided.
- Field check the list as needed.
- Discuss potential threats with local stakeholders.

[27] Class V wells include septic systems, dry wells and other similar devices that can direct flow under the ground surface.

- Send outreach materials on the drinking water system and on good stormwater practices.
- Determine if any of them deserve further attention. For example, does the facility have a history of problems? Is the facility located adjacent to a stream?
- Contact facilities as needed to gain their support.

6.0 FECAL CONTAMINATION

While it is important to guard a water supply against fecal contamination, it is not the leading concern in this watershed because much of the watershed is sewered with the discharge located below the water treatment plant, and there are few livestock on the farms in the watershed. Contamination by *Giardia lamblia* and *Cryptosporidium parvum* is of potential importance, however, for two reasons. Fecal contamination by wildlife especially birds in the Cedar and Little Cedar subwatersheds has been identified in previous studies. These populations are potential contributors of these two organisms. In addition, some portion of *Giardia lamblia* and *Cryptosporidium parvum can* survive conventional treatment processes in wastewater plants, and may be passed to the receiving waters. In addition, Toad Creek receives the discharge from the Topton wastewater plant.

6.1 General Discussion

Two protozoan parasites of concern for public water supply systems are the organisms *Giardia lamblia* and *Cryptosporidium parvum*. Although other parasitic and disease-causing organisms may occur in source water, these two are most problematic due to their relative resistance to commonly applied disinfection schemes[28] and the limitations of currently available methods for monitoring their occurrence and determining viability[29].

[28] USEPA. *Cryptosporidium Drinking Water Health Advisory*. HECD Office of Science and Technology, Office of Water, 1993.

[29] Juranek, D.D., et al. Cryptosporidiosis and public health: workshop report. *Jour. AWWA*, 87:9:69

6.2 Public Health Implications of Protozoan Parasites in Watersheds.

Both *Giardia* and *Cryptosporidium* cause acute diarrheal illness, with significant health implications for immunodeficient individuals. *Cryptosporidium* presents the greatest challenge of the two because its disinfection resistance is several-times higher than that of *Giardia* cysts - far exceeding commonly applied chlorine-based inactivation methods.

Disinfection resistance of *Giardia* and *Cryptosporidium* is attributed to the environmental resistance of their waterborne life cycle stages. These metabolically inert stages, *Giardia* cysts and *Cryptosporidium* oocysts, each have a tough outer wall, which is not easily compromised by practical doses of oxidizing agents. Water treatment processes, which physically remove these pathogens from water, are therefore necessary to protect the public health from organisms in source water. Oocyst survival has been reported to exceed several months in cold, dark environments, and to last up to a year in low turbidity water.

Source water protection programs that address these protozoans may provide a significant reduction in the number of organisms reaching a potable water treatment facility. Reducing the overall number of organisms in the source water, minimizing the occurrence of sporadic high-concentration spikes of organisms, and optimizing water treatment performance to provide consistently high levels of particle removal all contribute to a greater assurance that viable organisms will not reach consumers. Unfortunately, the success of protection programs and targeted activities are not easily measurable in quantifiable terms given the limitations of analytical methodologies used to isolate and identify the organisms (see *"Measuring Success"*).

6.3 Sources of Giardia and Cryptosporidium in Watersheds

Occurrence of *Giardia* and *Cryptosporidium* in a particular watershed is determined by the different sources of the pathogens and the effect of precipitation and runoff events. The environmentally resistant stages of the life cycles of these protozoans are fecal in origin. Therefore, their contamination of a watershed may be caused by wastewater treatment plant effluent, other means of human waste disposal, direct deposition of animal waste, and runoff carrying animal waste. Both organisms are known to be carried by a myriad of mammalian animals with humans, cattle, lambs and pigs known to be capable of contributing large numbers of oocysts. While runoff and animal waste discharges may contribute sporadic plumes of pathogens in large numbers, wastewater treatment plant discharges are believed to contribute oocysts on a fairly continuous basis.[30]

Even source waters with relatively low occurrence of cysts and oocysts in the raw water may experience large concentration spikes at the water treatment plant. This may occur if runoff washes contaminated waste material into the waterway, or if failure of a waste handling facility occurs and results in release of waste material into the source water. Other large concentration spikes may be caused by recycling backwash water to the plant headworks transporting previously captured cysts and oocysts back into the plant's raw water feed.

[30]LeChevallier, et.al. Occurrence of Giardia and Cryptosporidium spp. In Surface Water Supplies. Applied and Environmental Micro. Sept. 1991 p 2610-2616.

6.4 Sources Of *Giardia* And *Cryptosporidium* And Other Fecal Related Contamination In the Little LehighWatershed.

In the Little Lehigh Watershed, concern over contamination of watercourses by human fecal material is limited because a large portion of the area is sewered. Wildlife and to some extent cattle are potential sources of fecal contamination in the watershed. These sources of fecal pollution may be assumed, to a varying degree, to also be potential sources of *Giardia* and *Cryptosporidium*. cysts and oocysts. Potentially significant sources of *Giardia* and *Cryptosporidium* include the following. For comparison purposes, Table 6-1 shows rough numbers of microorganisms found in untreated domestic wastewater:

- Point sources are potential sources of protozoans. There is one wastewater treatment plant located in the drainage basin, the Topton WWTP.

- Septic systems that are either malfunctioning, or have inadequate leach fields, are a source of cysts and oocysts. There are septic systems in the western regions of the basin. Regulation of septic systems in Pennsylvania is discussed in Appendix 6-1.

- Nonpoint source pollution from stormwater runoff on agricultural lands, particularly runoff from pasturelands of livestock operations also contributes contaminants. There are relatively few livestock in the watershed with several small cowherds in the Toad Creek watershed.

- A previous study of Cedar and Little Cedar Creeks found elevated levels of fecal coliform throughout these watersheds, particularly during high flows. Peak values in excess of 10,000/ 100-ml sample were attributed to resident waterfowl populations. The source of coliforms at one site (N4--near source of Little Cedar Creek and Route 22) were not determined.

Table 6-1

Type and Numbers of Microorganisms Typically Found in Untreated Domestic Wastewater [31]

Organism	Concentration (number/ml)
Total coliform	100,000 – 1,000,000
Fecal coliform	10,000 – 100,000
Fecal streptococci	1,000 – 10,000
Enterococci	100 – 1,000
Shigella	present
Salmonella	1 – 100
Pseudomonas aeroginosa	10 – 100
Clostridium perfringens	10 – 1,000
Mycobacterium tuberculosis	present
Protozoan cysts	10 – 1,000
Giardia cysts	0.1 – 100
Cryptosporidium cysts	0.1 – 10
Helminth ova	0.01 – 10
Enteric virus	10 - 100

Other potential sources of cysts and oocyst contamination include recreational uses of the Creek, and miscellaneous stormwater sources of fecal contamination.

To place concern over fecal contamination in context, no confirmed viable Cryptosporidium oocysts have been found in finished water to date. Therefore, the discussion over fecal contamination is one of a potential threat, but not one of a demonstrated health concern in treated water. That said, increasing concern over *Cryptosporidium*, places a greater burden on treatment systems. Minimizing upstream fecal contamination, especially human sources, affords an additional layer of public health protection by increasing the quality of raw water prior to treatment.

Where there is no limit for raw water in the Safe Drinking Water Act, Pennsylvania limits fecal coliform levels for various waters in its water quality standards.

[31] Tchobanoglous, George, and F. L. Burton. 1991. Wastewater Engineering: Treatment, Disposal, and Reuse. Metcalf and Eddy, Inc., McGraw-Hill Publishing Company: New York. Page 110.

- In recreational waters, fecal coliforms are limited to 200 per 100 ml for the swimming season and 1,000 per 100 ml for the remainder of the year.

- For waters with a designated use of drinking water, total coliforms are limited to a monthly average of 5,000 per 100 ml. Where there is not a set ratio between total and fecal coliforms, it is roughly 5:1. Therefore this limit is equivalent to a fecal limit of roughly 1,000 per 100 ml.

6.4.1 Point Sources

There is one wastewater treatment plant located in the drainage basin, the Topton WWTP. Additional point source dischargers (identified by PA DEP permits) are listed in Table 6-2.

Cryptosporidium can pass through wastewater plants. Any plant could, therefore be a source of these protozoans. Thinking on the fate, transport, and sampling procedures for these protozoans is still evolving. There is probably little for a water coalition to do regarding these plants at present. Long term, regulations and practices in wastewater may change as understanding in this area evolves.

6.5 Bacteriological Sampling

Bacteriological sampling by Cadmus, Allentown Bureau of Water Resources, and Pennsylvania DEP is summarized below.

Table 6-2
Point Source Discharges in the Little Lehigh Watershed

Facility Name	Address	Data Source	Comments
Agway Petroleum Corp	P.O. Box 98 Emmaus, PA18049	3, 4, 5	
Air Products and Chemicals, Inc.	2801 Mitchell Ave Allentown, PA 18103	1, 3	
Allen Organ Company	Rte 100 Macungie, PA 18062	3, 4, 5	
Atlas Minerals and Chemicals	1227 Valley Rd Mertztown, PA 19539	1, 3	
BP Oil Macungie Terminal	Tank Farm Rd Macungie, PA 18062	1, 3	
Caloric Corp.	Heffner St and Washington St Topton, PA 19562	1	Facility no longer discharges from this site.
Carpenter ER Co. Inc./Olin Corporation	57 Olin Way Fogelsville, PA 18051	1, 3	
Carpenter Insulation Co.	57 Olin Way Fogelsville, PA 18051	2	Storm water (to Iron Run and Little Lehigh Creek). Permit expired on 11/6/97. No further information is available.
Dorney Park/Wild Water Kingdom	3830 Dorney Park Rd Allentown, PA 18104	1	
Farm and Home Oil Co.	Term 2 Macungie, PA 18062	1, 3	
F&M Assoc Green Hills Wat Co.	1132 W Hamilton St, Allentown, PA 18101	3	Address is downstream of water plant. No location data for discharge listed in permit databases.
Leffler, Carlos R., Inc.	5088 Indian Creek Rd Emmaus, PA 18049	3, 4	
Mack Trucks Inc.	2100 Mack BLVD Allentown, PA 18103	1	
Packaging Corp of America	7452 Cetronia Rd Trexlertown, PA 18087	3	
Ryder Truck Rental, Inc.	1327 Bulldog Dr, Allentown, PA 18104	3, 4	
Square D Co.	Minor St and 6th Emmaus, PA 18049	1, 3	
Stout, Henry	6427 Saddle Rd New Tripoli, PA 18066	1	
Stroh Brewery Co.	Rtes 22 and 100 Fogelsville, PA 18051	2	Storm water (to Iron Run)

Facility Name	Address	Data Source	Comments
Topton Borough Municipal Sewer Authority	44 W Rd 1, Mertztownn, PA 19539	3	
Travel Ports of America Inc.	Upper Macungie TWP, PA 18104	2	
Tyler Pipe Ind-East Penn Foundry	Route 100 and Church St Macungie, PA 18062	2, 3	Permit expired on 10/9/95. No further information available in databases.
Tyler Pipe	Route 100 and Church St Macungie, PA 18062	2	Storm water (to Swabia Creek). Storm water permit; expired on 11/6/97

1. Environmental Protection Agency, On-line databases including Toxic Release Inventory, Superfund, Permit Compliance System, and Accidental Release Information
2. The Right to Know Network On-line Database System sponsored by OMB Watch and The Unison Institute, two non-profit agencies. Http://rtk.net.
3. Wildlands Conservancy, Little Lehigh Creek Stream Corridor Conservation Project, Stream Status Report, January, 1994.
4. Dunn & Bradstreet Corporation Information Services. Dun's Direct Access Database. On-line dial-up database.
5. Delorme, Phone Search USA. Database of names, addresses, and phone numbers of businesses and residences across the USA.

6.5.1 Project Sampling--July 1998

Cadmus performed a screening level of sampling looking for evidence of fecal contamination. The following discussion outlines potential problem areas. Additional study to determine exact sources, such as dye studies were beyond the scope of this study. Cadmus collected 7 fecal coliform samples throughout the watershed on July 28 and 29, 1998. Sampling results are presented in detail in Table 6-3. Sample locations were illustrated in Figure 3-3. Concentrations were greater than 1,000 per 100 ml in five of the seven samples and greater than 10,000 in the two samples underlined in the table:

Table 6-3
Fecal Bacteria Concentrations July 1998

Sample ID	Location	Sampling Date	Fecal coliform (count/100 ml)
102	Schaefer Run at Trexler Road	July 28, 1998	1,650
109	Tributary to Swabia Creek on Rte. 100	July 28, 1998	860
110	Swabia Creek at Sauerkraut Lane	July 28, 1998	2,400
150	Schaefer Run at Brookdale Road	July 28, 1998	20,000
152	Toad Creek at Park Rd., Approximately 1/4 mile downstream of the Topton POTW	July 28, 1998	16,000
203	Small pond outlet near Liebert Creek on Indian Creek Road	July 29, 1998	1,650
206	Unnamed tributary to Swabia Creek on Mountain Road in Berks County	July 29, 1998	180

It is difficult to discern between human- and animal-derived nonpoint sources of fecal material without detailed study. The high reading downstream of the Topton Plant deserves further study although no other evidence of potential problems with the Plant's treatment system were found during this study.

6.5.2 Sampling by Allentown Bureau of Water Resources

The City of Allentown has historically tested its raw water for fecal coliform. As part of this project data from 1994 and 1995 were reviewed. Concentrations were generally low during dry weather but peaking during of just after rain events. This pattern points to wash off of non-point sources contributing to the peaks in fecal coliform concentrations. Data are summarized in Table 6-4:

Table 6-4
Raw Water Fecal Coliform Concentrations 1994 - 1995

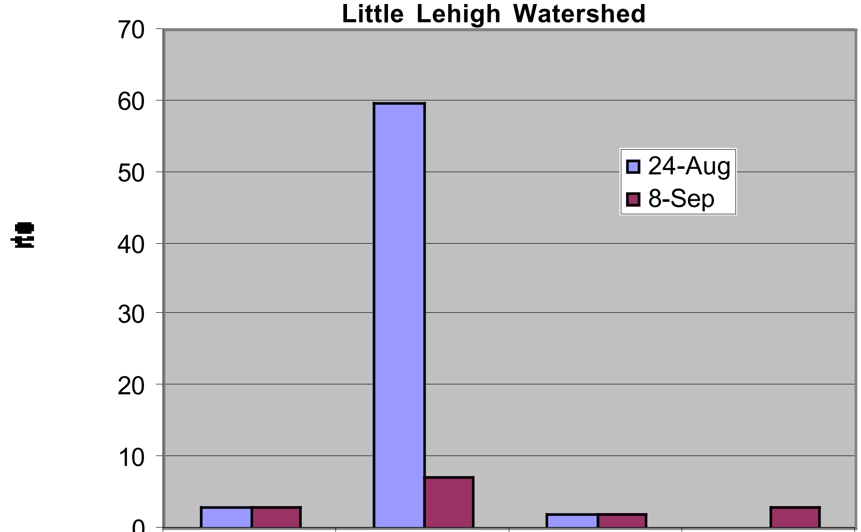
	Year	
	1994	**1995**
Minimum	40	12
Maximum	7,500	24,800
Mean	837	1,329
# of samples	51	51

6.5.3 *Giardia* and *Cryptosporidium* And Sampling by Pennsylvania DEP--1998

On August 24 and September 8 the Pennsylvania DEP sampled 4 sites in the watershed for *Giardia* and Cryptosporidium. The results are presented in Tables 6-5 and 6-6. Sample locations and sample date weather comments are presented in Table 6-7. Sample sites are pictured in Figure 6-1.

The data for *Giardia* and Cryptosporidium vary between sites and sampling events. Counts for *Giardia* were low at Sites A1, A2, and A4 for both sampling dates. Counts at Site A2 (just downstream of the Topton POTW) showed a marked increase over Site A1. *Cryptosporidium* counts were more variable with high relatively counts in Toad Creek but no discernable pattern between Sites A1 and A2. Based on these data and on fecal coliform data collected during this project, both Toad Creek and the Topton POTW deserve further study.

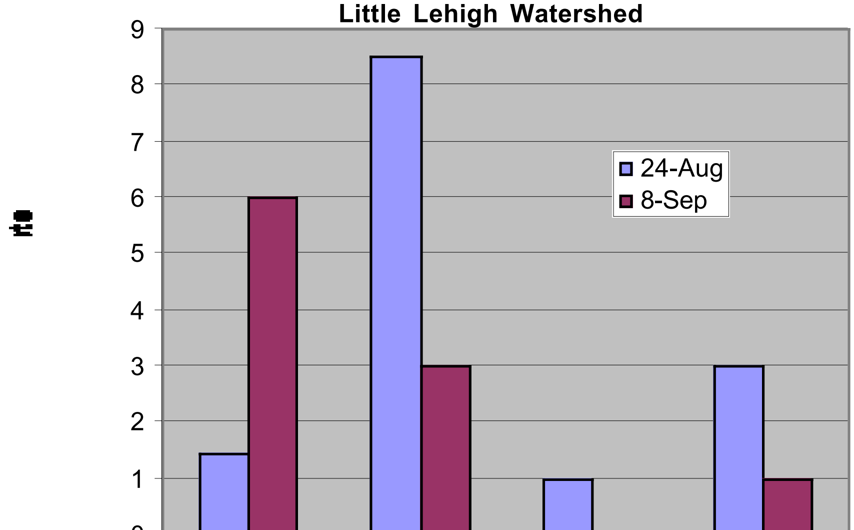
Table 6-5
Giardia Cysts in the
Little Lehigh Watershed



	A1	A2	A3	A4
24-Aug	2.84	59.6	2	0
8-Sep	3	7	2	3

Sample Sites

Table 6-6
Cryptosporidium Oocysts in the
Little Lehigh Watershed



	A1	A2	A3	A4
24-Aug	1.42	8.5	1	3
8-Sep	6	3	0	1

Sample Sites

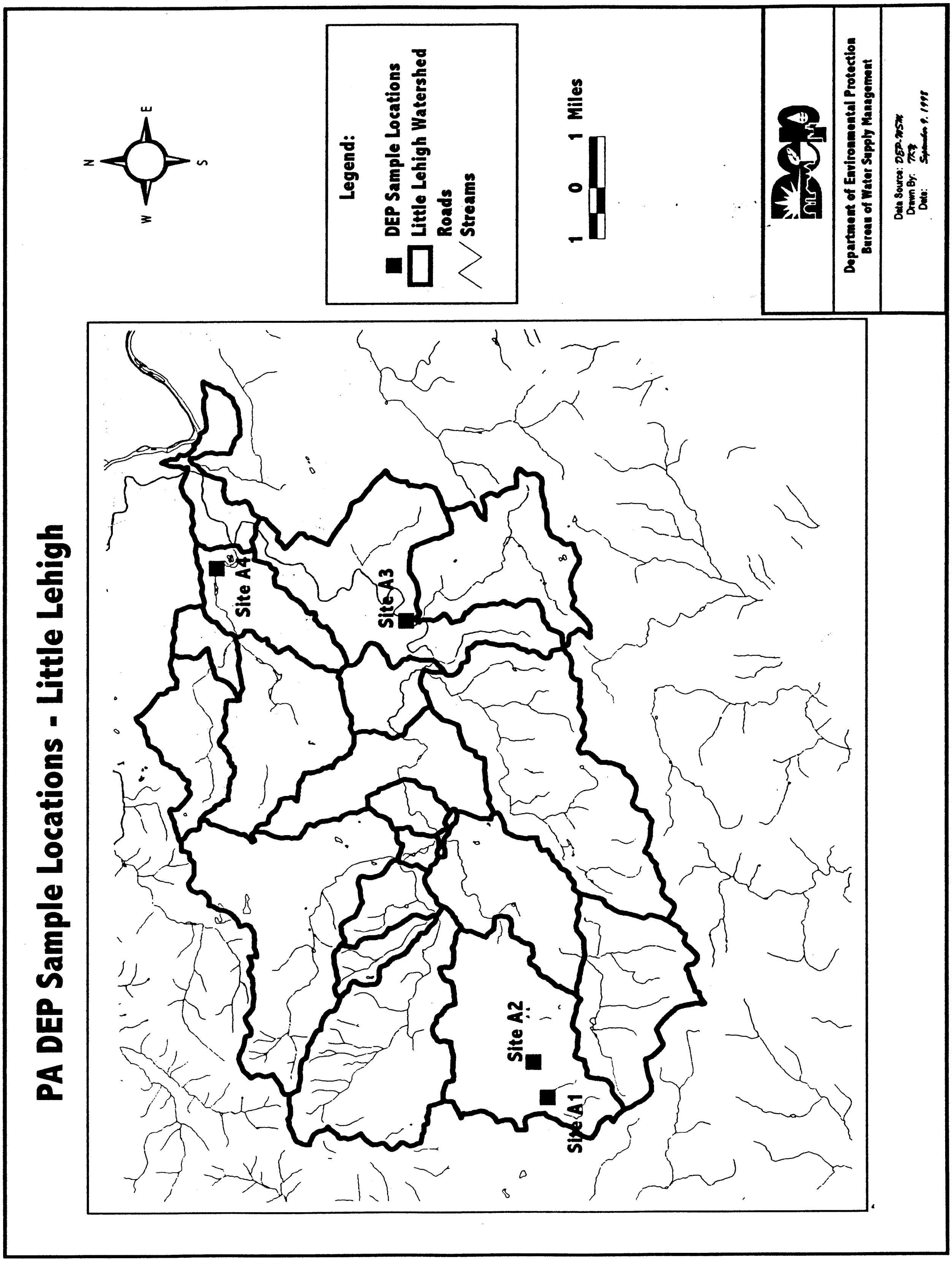
Table 6-7
Sampling Weather Notes and Locations

Date	Weather
8-24-98	No weather notes
9-8-98	No weather notes
Sample Site	**Location**
Site A1	Toad Creek Upstream of Topton POTW
Site A2	Toad Creek Upstream of Topton POTW
Site A3	Little Lehigh Creek, hear Emmaus.
Site A4	Cedar Creek

6.6 Recommendations

In this chapter we identified a location with possible fecal contamination and additional locations with high counts of indicator bacteria. We recommend that the Bureau and coalition now forming examine fecal contamination in the watershed. Additional sampling is necessary to further determine the source of the identified problems. A coalition might pool resources to conduct regular sampling, where different parties contribute various components. For example, Wildlands Conservancy might supply volunteer labor. The Bureau of Water Resources could analyze samples if the laboratory schedule allows. DEP could provide guidance in sample plan development. This is an example of a cooperative arrangement. The actual details must be agreed by the coalition members.

Figure 6-1: Sampling Sites



6.6.1 Watershed Coalition and Subcommittee

A coalition could help publicize the need for action in problem areas and locate sources of assistance. Key coalition members might include the Lehigh Planning Commission, the Bureau of Water Resources, the Wildlands Conservancy, local municipal officials, Pennsylvania health officials, and the Pennsylvania DEP, Division of Drinking Water Management. The coalition would coordinate activities, set goals, and examine results of sampling programs. Related activities would include:

- Establishing a monitoring program for indicator organisms to detect chronic and episodic sources of fecal contamination.
- Examining the practicality of developing a *Giardia* and *Cryptosporidium* sampling program.
- Developing links with the Topton Wastewater Plant and other potential sources of contamination.

6.6.2 Sampling

To design and implement a successful monitoring program, reasonable expectations and goals must be established. Because potential sources of cysts and oocysts exist in the watershed, it would be reasonable to assume that some degree of contamination of the source water by these protozoans will continuously occur.

A source water protection plan for protozoan parasites should concentrate on minimizing the contributions of controllable activities. A monitoring program could be targeted to measure the success of project sites or monitor the success of implementing BMPs at high-risk sources of cysts and oocysts (such as livestock operations involving calves or lambs). It may also be appropriate to incorporate *Giardia/Cryptosporidium* sampling downstream of wastewater discharge.

Data collected for this type of study must be evaluated within the limitations of the analytical methodologies used. A risk with current analytical methods is that they do not detect subtle increases or decreases in the concentration of organisms. They may also indicate the absence of the parasites when low levels occur. In addition sampling intervals may not capture sporadic high-concentration spikes.

Analytical methodologies currently employed to recover and identify cysts and oocysts from water are limited by poor recovery efficiencies and a low analytical precision rate. In particular, high concentrations of algae and other particulate material significantly confound currently available methods. Investigators of waterborne occurrence of these parasites also report difficulties discerning the significance of low and undetectable levels of the organisms in source water[32]. Additionally, some sources of these parasites in Allentown's watershed would be expected to produce sporadic releases of the organisms in highly variable concentrations.

Considerations for sample collection location include ensuring an adequate depth in the water column, whether the protozoan 'plume' is homogeneously mixed in the stream, and maintaining the required distance from shore to capture representative samples. Timing of samples is critical to obtain concentration spikes associated with runoff events or waste disposal system failures. Collecting an adequate number of

[32] Crockett, C.S. and C.N. Haas. Understanding Protozoa in Your Watershed. Jour. AWWA. 89:9:62 (Sept. 1997)

samples is necessary to adequately characterize occurrence, given a diverse set of variables influencing contamination of the source water.

Despite these drawbacks, some utilities have established watershed-monitoring programs. (Generally the systems utilize in-house analytical capability to limit costs.) They find the information useful to identify aberrations in raw water concentrations that trigger investigations of watershed activities, and to locate areas of the watershed warranting focused improvement programs. Often the sample collection and analysis procedures are modified to suit conditions at the sample site. Some flexibility is available in the methods, however, detection limits, recovery and viability remain key issues regardless of the technique used.

Another strategy is to monitor for indicator organisms. Fecal coliform, while a useful test for general fecal contamination has a shorter survival time than many pathogens, particularly protozoan cysts. Fecal streptococci and *Clostridium perfingens* are other indicators that are of fecal origin. They are relatively easy to recover and survive better than coliforms in the environment.[33] Cadmus recommends that Allentown consider monitoring for these indicators in a watershed-sampling program.

[33] The Cadmus Group, August 1996. Cane Creek Reservoir Watershed Study. Page 4-28.

6.6.3 Suggested Efforts to Reduce Fecal Contamination in Allentown's Watershed

While it is not feasible to completely eliminate *Giardia* and *Cryptosporidium* in the watershed, limiting manure transport to the waterway, and eliminating direct sources of human waste will likely concurrently limit cyst/oocyst contribution.

Agricultural best management practices that manage livestock watering facilities, limit soil erosion, and eliminate direct animal access to streams will minimize direct fecal contamination of the waterway. Implementing manure-handling programs that prevent transport of fecal material during runoff events will also be beneficial.

Addressing the possibility of failing septic systems or untreated wastewater discharges to the watershed will reveal if these are potential sources of cysts/oocysts. Because much of the watershed is sewered, these sources are relatively minor.

Establishing a communications link between the Topton wastewater treatment plants and the water filtration facility would allow advanced notice of treatment upset or other potential causes of increased cyst/oocyst discharge. This would enable water treatment plant operators to prepare for changes in raw water quality and treatment effectiveness.

Summary Recommendations:

- Establish Watershed Coalition
- Establish Sampling Effort

- Implement Efforts to Reduce Fecal Contamination in Allentown's Watershed

7.0 PESTICIDES

7.1 Pesticide Use on Corn-National Summary

Pesticides are now used on almost all of the cropland in the U.S. that is planted with corn. Pesticides are usually applied in the spring but the exact timing of the application depends on the time of planting, which can vary between states by more than a month. In southern states, the heaviest planting periods usually begin in mid to late March and end in mid to late April. In the northern states, on the other hand, the most common planting period is usually during the month of May [34].

The five most heavily applied pesticides are, in descending order of total pounds applied, atrazine, metolachlor, acetochlor, cyanazine, and alachlor. The pesticides that are used on the largest percentage of corn acreage are atrazine (71% of acres), metolachlor (30%), dicamba (25%), acetochlor (22%), and cyanazine (13%). Atrazine is occasionally applied twice a year but the rest of the chemicals are generally only applied once[35].

There are few studies that reliably assess the nationwide occurrence of pesticides in ground and surface water. The U.S. Geological Survey (USGS), however, is currently running the National Water Quality Assessment (NAWQA) Program to determine the extent to which pesticides and other contaminants are present in the water resources of

[34] U.S. Department of Agriculture (USDA). December 1997. *Usual Planting and Harvesting Dates for U.S. Field Crops.* Agricultural Handbook Number 628, National Agricultural Statistics Service.

[35] U.S. Department of Agriculture (USDA). September 1997. *Agricultural Chemical Usage, 1996 Field Crops Summary.* National Agricultural Statistics Service.

the United States. According to early results of the NAWQA program, in agricultural areas where corn is the dominant crop, atrazine (55% of samples) and metolachlor (42%) were detected the most frequently (of the pesticides mentioned above) while alachlor (12%) and cyanazine (5%) were detected much less frequently (Kolpin et al.)[36]. Dicamba (<1%) was rarely detected in ground water studies while acetochlor was rarely sampled for because it did not come into use until 1994. In surface water studies of streams draining agricultural areas, although not necessarily corn areas, atrazine (77% of samples), metolachlor (73%), alachlor (36%), and cyanazine (28%) were all frequently detected while dicamba (<1%) was, once again, only rarely detected[37].[38]

7.2 Pesticide Use on Corn-Berks, Chester, Lancaster, and Lehigh Counties, Pennsylvania

Pesticide use on corn in Berks, Chester, Lancaster, and Lehigh Counties in Pennsylvania is somewhat different from pesticide use in other areas of the country. Corn is generally planted in Pennsylvania in the month of May but the actual time of planting may vary from year to year based on factors such as temperature and

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[36] Kolpin, Dana W., Jack E. Barbash, and Robert Gilliom. U.S. Department of the Interior. 1998. *Occurrence of Pesticides in Shallow Ground Water of the United States: Initial Results from the National Water-Quality Assessment Program.* U.S. Geological Survey.

[37] U.S. Department of the Interior. July 1998. *Pesticides in Surface and Ground Water of the United States: Summary Results of the National Water Quality Assessment Program (NAWQA)-Provisional Data.* U.S. Geological Survey.

[38] It should be noted that there were different detection limits for some of these pesticides, a factor that may influence the percent of samples with detections.

precipitation[39]. Pesticides are generally applied in this area in late April to early May but this varies with the time of planting.[40]

There is not much information available on pesticide use by county, however pesticide use on corn can be examined at the state level. The pesticides that are applied in the heaviest quantities in Pennsylvania are, in descending order, atrazine, metolachlor, acetochlor, 2,4-D, and dicamba. The pesticides which are applied to the greatest percent of acres planted with corn are, in descending order, atrazine, dicamba, 2,4-D, nicosulfuron, and metolachlor. Within Pennsylvania, 98% of the acres planted with corn are treated with herbicides and 54% with insecticides.[41]

A survey of farmers in the Pequea and Mill Creek watersheds in Lancaster County from 1989-1991 found that the two most commonly used pesticides on corn crops in the watershed were atrazine and metolachlor. Atrazine was applied to 79% of the total acres planted with corn. The annual application rate for atrazine ranged from 0.16 to 2.0 pounds per acre and an average rate of 0.90 pounds per acre. Metolachlor, which was applied in the greatest quantity over the three-year period, was applied to 63% of all corn acres at an average application rate of 1.20 pounds per acre (the application rate ranged from 0.21 to 4.0 pounds per acre). Alachlor was the third most heavily applied chemical. It was applied to 17% of corn acres with an average annual application rate of 1.39 pounds per acre. (This pattern of use is significantly different from current low statewide estimates of alachlor use.) Pendimethalin was the fourth most frequently used herbicide

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[39] USDA Dec. 1997. Op. Cit.

[40] Andersen, Robert J. July 1998. Lancaster County Extension Office. Personal Communication.

[41] USDA Sept. 1997. Op. Cit.

in the Pequea and Mill Creek watersheds. It was used on 16% of corn acreage and was applied at a rate of 0.99 pounds per acre. Cyanazine was applied to 11% of the corn acres at an annual average rate of 1.5 pounds per acre. Dicamba, 2,4-D, and nicosulfuron, three of the chemicals which are currently commonly used in Pennsylvania, were used in the study but were not among the top five chemicals in pounds used or acres treated.[42]

The reason that chemical use patterns in these two watersheds differ from use patterns on a statewide level may be related to either local conditions that lead farmers to choose one chemical over another or to changes in pesticide use practices between 1991 and 1996. For example, there was a downward trend in the alachlor application rate from 1.55 to 1.28 pounds per acre over the course of the study period[43] . Thus, alachlor use in the county may have continued to decline and it may have been replaced by another chemical.

The survey also asked the farmers if they used domestic water supply wells and whether they had had those wells tested. Half of those who reported that they had tested for pesticides had detections of pesticides in their wells. Of the five most commonly used pesticides in the Pequea and Mill Creek watersheds, atrazine, alachlor, metolachlor, and cyanazine were identified as priority leachers (defined in Bingaman et al. as commonly used pesticides that have a high potential to leach to ground water).

[42] Bingaman, D.D., G.M. Heistand, and C.K. Greene. November 1994. *Lancaster County Agricultural Pesticide Use Practices Report for the Pequea-Mill Creek Watersheds.* Pennsylvania Department of Agriculture.

[43] Bingaman. Op. Cit.

The USGS has conducted several studies on the effect of pesticide use on ground water and surface water quality in southeastern Pennsylvania. It should be cautioned before examining the results of these studies, however, that it is impossible to study only the occurrence of pesticides applied to corn crops since there are other crops in the area that may receive applications of the same pesticides. The studies, though, provide an indication of the extent to which pesticides used on corn are found in the water resources of the area.

One study conducted by Fishel and Lietman[44] was to determine the extent to which herbicides are found in ground water in the Upper Conestoga River Basin. This basin is mostly in Lancaster County but it does include small sections of Berks and Chester Counties. Atrazine, simazine, alachlor, and metolachlor were the herbicides that were detected most frequently in wells in agricultural areas. The number of wells with detections remained relatively constant throughout the year but there were variations in the seasonal concentrations that were detected. Atrazine and metolachlor were found at their highest concentrations in the spring while simazine was found at its highest concentration in the summer and alachlor was found at its highest concentrations in the fall. Atrazine and alachlor were found at concentrations equal to or greater than the MCL in some of the samples during the spring and fall, respectively.

[44] Fishel, David K. and Patricia L. Lietman. 1986. U.S. Department of the Interior. *Occurrence of Nitrate and Herbicides in Ground Water in the Upper Conestoga River Basin, Pennsylvania.* Water Resources Investigations Report 85-4202, U.S. Geological Survey.

One study by Reed and Koerkle[45] examined the concentrations of herbicides in the Conestoga River and Pequea Creeks, streams that drain much of Lancaster County. During stormflow periods[46] from 1992-1995,samples were collected to test whether concentrations of pesticides in streams and rivers were higher in the first few months after planting than during other times of the year. Concentrations were generally found to be higher during the period from May-July than during any other time of the year. Concentrations of atrazine exceeded the MCL of 3 g/L in over 10 percent of the samples collected.

The USGS, as part of the NAWQA Program, conducted an assessment of water quality in the lower Susquehanna River basin that includes most of Lancaster and parts of Chester and Berks counties. Only 10 of the hundreds of samples collected from wells and stream water in the basin had concentrations of pesticides that exceeded drinking water standards. Most of the sampling was done during periods of dry weather, but 8 of the 10 samples that had pesticide concentrations that exceeded the MCL were affected by storms. The most commonly detected pesticides in the study area were atrazine, metolachlor, simazine, prometon, alachlor, and cyanazine. All of these pesticides, except prometon and simazine, are commonly used on corn (Lindsey et al.). One of the NAWQA studies found a statistically significant relationship between the percent of a basin planted in corn and alachlor, metolachlor, atrazine, and cyanazine yields in surface

[45] Reed, Lloyd A. and Edward H. Koerkle. U.S. Department of the Interior. 1997. Herbicide Concentrations in and Loads Transported by the Conestoga River and Pequea Creek, Lancaster County, Pennsylvania, 1992-1995. Water-Resources Investigations Report 97-4124, U.S. Geological Survey.

[46] A stormflow period is defined as a period during which the level of the stream is 0.2 feet higher than it is during the prevailing base flow conditions.

water[47]. Seasonal variations in pesticide concentrations were found in streams but the extent of these variations differed depending on the timing of pesticide applications in the area and the type of bedrock (which influences the extent to which pesticides will either runoff or infiltrate into ground water) in the area[48] .

7.3 Sampling, Existing Data, and Observation

Screening for herbicides at four sites showed no measurable levels of common herbicides, although the sampling may have been conducted before most herbicides would be applied. In another Pennsylvania watershed Cadmus observed the practice of filling a pesticide sprayer from a local creek. This practice includes some risk of washing pesticide residues directly into creeks.

Data submitted to the EPA by the City showed no detections for the following components of herbicides, pesticides, and fumigants[49]:

- Alachlor
- 1,2-Dibromo-3-chloropropane
- Dichlorobenzene
- Dichloromethane

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[47] Hainly, Robert A. and Joan M. Kahn. U.S. Department of the Interior. "Factors Affecting Herbicide Yields in the Chesapeake Bay Watershed, June 1994." *Journal of the American Water Resources Association.* 32(5) (October 1996).

[48] Lindsey, Bruce D., Kevin J. Breen, Michael D. Bilger, and Robin A. Brightbill. U.S. Department of the Interior. 1998. *Water Quality in the Lower Susquehanna River Basin, Pennsylvania and Maryland, 1992-1995.* Circular 1168, U.S. Geological Survey.

[49] Review of SDWIS Data, 1998.

- Ethylene dibromide (EDB)
- Pentachlorphenol (preservative)
- Simazine

7.4 Recommendations

We recommend sampling in one or more subwatersheds with agricultural activity soon after the time of herbicide application. The City should work with the local agriculture service agencies to understand the timing of applications in the watershed and conduct at least one round of sampling concurrently. Sampling at the intake, while a true indication of the contaminant threat at that moment of sampling, will not detect pesticides in most cases, because of their relatively short life in the environment. A positive result from a sample collected in the subwatershed will indicate whether material is entering a particular Creek, although it does not necessarily indicate a raw water problem for the City because of the ability of modern pesticides to degrade.

8.0 NUTRIENTS

Nitrogen and phosphorus are the primary nutrients of concern for water quality. Phosphorus is primarily a surface water concern, where in excessive amounts, it promotes algae blooms and lake eutrophication. Accordingly it can contribute to an increase of trihalomethane (THM) precursors. In most fresh waters it is the limiting nutrient for algae growth (i.e., it is the nutrient in shortest supply in relation to algae nutrient requirements). Elevated levels of phosphorus typically found in surface or groundwater are not known to be a human health concern.

Nitrogen, in the form of nitrate, can be a nonpoint source pollutant in both surface and groundwater and is a potential health concern at elevated levels. Nitrogen enrichment, primarily in marine systems such as the Chesapeake Bay, has been linked to low dissolved oxygen, and decreased numbers of aquatic animals and plants[50]. Some freshwater surface waterbodies with excessive loadings of nitrates can undergo eutrophication when nitrogen is the limiting nutrient.

Consumption of water with elevated levels of nitrate (generally greater than 100 mg/l) has caused over 2,000 cases of methemoglobinemia or "blue-baby syndrome" worldwide.[51] Blue-baby syndrome is a potentially fatal health condition where nitrates are converted to nitrites, reducing the oxygen-carrying capacity of the blood, causing

[50] Fisher, 1989.
[51] Shuval and Gruener, 1972

babies to appear blue.[52] Nitrites are known to react with other compounds including many pesticides to form nitrosamine compounds that are known animal carcinogens.[53]

To protect the public from this problem, the EPA has set the maximum contaminant level (MCL) for nitrate in drinking water at 10 mg/l. Not surprisingly, livestock are also susceptible to nitrate problems similar to humans. Drinking water or feeds high in nitrate can cause methemoglobinemia in livestock. Severely elevated nitrates (exceeding 50 mg/l) have also been shown to cause stillbirths in both cattle and humans. As discussed in this chapter, the main stems of the Little Lehigh have nitrate levels near or below 5 mg/l or half of the MCL. Based on samples of Toad Creek with nitrates near the MCL, private wells (if they exist) in that area of the watershed may be at or above the MCL for nitrate.

Other problems associated with high nitrogen levels include chlorination disinfection problems. Another large water system in Pennsylvania finds that during runoff periods when organic and other forms of nitrogen are high, they experience difficulty in controlling their disinfection chemistry.

8.1 Agricultural Use of Nutrients

Agriculture is the top ranking industry in Pennsylvania and requires efficient use of nutrients from manure and commercial fertilizers to be productive.[54] When nutrients are applied in the right amounts, at the right time and the right way, using the principles

[52] Van Es, H., S.D. Klausner, and W.S. Reid. 1991. *Nitrogen and the environment*. Info. Bull. 218. Cornell University, Ithaca, NY.
[53] Murdock, 1988
[54] Westmoreland, 1994

of a nutrient management planning, environmental problems can be minimized.[55] Improper use of nutrients has been shown to cause water quality problems in both surface and groundwater, both on and off the farm.[56] While nutrient management employed according to agronomic standards has been shown to reduce nitrate levels in groundwater by 30%, nitrate levels in groundwater may still exceed EPA standards particularly on highly permeable soils.[57] A bibliography of selected nutrient management literature is included in Appendix 8-1.

Nitrogen, phosphorus and potash are the three major nutrients used for agricultural production. Other micronutrients and maintenance of pH levels are also essential for effective production. Nitrogen and phosphorus are the primary nutrients of concern for water quality.

There are several sources of nutrients in this watershed, with stormwater from developed land and agriculture the primary ones, but there are also several golf courses, homes and horticulture centers that could be additional sources. Cadmus saw evidence of good agricultural conservation practices, but didn't formally survey agricultural practices. Cadmus staff noted examples of grassed waterways, strip cropping, contour plowing, and riparian buffers. From conversations with the NRCS district office we noted that formal

[55] Beegle, D.B., L.E. Lanyon and J.C. Myers. 1997. *DRAFT Manure management for environmental protection: field application of manure.* Penn State University and USDA-NRCS. University Park, PA. 42 pp.

[56] Hall, D.W. and D.W. Risser. 1993. Effects of agricultural nutrient management on nitrogen fate and transport in Lancaster County, Pennsylvania. Water Resources Bulletin. 29(1):55-76.

[57] Ibid.

nutrient planning is limited and varies greatly between farms. Because there are few livestock herds, manure spreading is not a large problem in the Little Lehigh Watershed.

8.2 Sampling for Phosphorus and Nitrogen

Cadmus sampled the watershed on two occasions: June 4 and July 28 and 29, 1998. Cadmus collected samples for analysis of ammonia, nitrate, and total phosphorus. Cadmus used a combination of LaMotte field test kits and laboratory analysis for the nitrate and total phosphorus samples. Routinely nitrate samples were submitted for laboratory analysis and tested in the field to check the accuracy of the field test kits and sampling procedures. In general the accuracy of the kits was quite good. The purpose of this study was to find "hot spots", or sources of contamination, rather than to perform a detailed study of the phosphorus dynamics of the watershed. For this reason field test kits were used to screen for high phosphorus levels. Where a level of ≥0.2 mg/l was found, a sample bottle was collected for later analysis. Sampling results are summarized in Table 8-1.

In general, levels of total phosphorus were low reflecting its role as a limited nutrient. Plant materials rapidly take up available phosphorus. Most samples had total phosphorus levels of less than 100 ppb, the detection limit of the field kits. Exceptions were Toad Creek just downstream of the Topton POTW, with a concentration of 2,900 ppb (this is typical of the effluent from a secondary level treatment system) and a stormwater pipe draining a parking lot into the Little Cedar Creek with a concentration of 550 ppb.

Table 8-1
Nutrient Sampling

Station #	Location	Sampling Date	NO3 + NO2[58] (mg/l)	Total Phos.[59][60] (mg/l)
1	Little Lehigh @ Lehigh Pkwy	June 4, 1998	(5) 4.7	(0) 0
2	Liebert Creek @Shimmerville Rd.	June 4, 1998	(3)	(0)
3	Little Lehigh @ Rt. 100 and Creamery Rd.	June 4, 1998	(6)	(0)
4	Swabia Creek @Macungie (Rt. 100)	June 4, 1998	(1)	(0)
5	Toad Creek @ Hilltop Road	June 4, 1998	(10) 7.3	(0.1) 0.19
102	Schaefer Run at Trexler Road	July 28, 1998	(3.0)	(0)
103	Breinig Run off of Rte. 222	July 28, 1998	(2.5) 4.0	(0)
104	Schaefer Run at Rte. 222 eastbound after Cornshock Road	July 28, 1998	(4.0)	(0)
105	Iron Run on Rte. 222 next to Fire Company No. 1	July 28, 1998	(3.0)	(0)
105A	Iron Run on Rte. 222 next to Fire Company No. 1, Drainage Pipe Effluent	July 28, 1998	(4.0)	(0)
106	Spring Creek on Spring Creek Rd off of Rte. 100	July 28, 1998	(6.0)	(0)
107	Little Lehigh Creek at Rte. 100 right after RR crossing	July 28, 1998	(5.0-6.0) 6.0	(0)
108	Swabia Creek off of Rte. 100 and Race Street	July 28, 1998	(3.0)	(0)
109	Tributary to Swabia Creek on Rte. 100	July 28, 1998	(3.0) 0.62	(0)
110	Swabia Creek at Sauerkraut Lane	July 28, 1998	(2.0)	(0.08)
111	Leibert Creek on Indian Creek Road	July 28, 1998	(1.0)	(0)
112	Leibert Creek on Shimmerville Road	July 28, 1998	(2.0)	(0)
113	Leibert Creek on German Road near mouth	July 28, 1998	(1.0)	(0)
114	Swabia Creek on Schoenek Road	July 28, 1998	(1.0) 0.34	
115	Swabia Creek	July 28, 1998	(0.25)	(0)
150	Schaefer Run at Brookdale Road	July 28, 1998		
151	Toad Creek at Hilltop Road	July 28, 1998	(9.25)	(0.1)

[58] Values in parentheses are by LaMotte field analysis method. The resolution is roughly 1 mg/l.

[59] Values in parentheses are by LaMotte field analysis method. The resolution is roughly 0.2 mg/l.

[60] There was good agreement between the laboratory analysis and field analyses for nitrate-plus-nitrate and total phosphorus. The variation (10 versus 7.3) in Toad Creek (sample 5) is partially explainable by our observation that it is hard to match the colormetric test at values of 8 to 10 mg/l. Nevertheless, the field test kits give results sufficient for screening analyses. Their benefit is that they are inexpensive and that they give immediately results.

152	Toad Creek at Park, Approximately 1/4 mile downstream of the Topton POTW	July 28, 1998	(10.0) 10.2 (Nitrite 0.11)	(>) 2.9
153	Little Lehigh at Pool Sanctuary	July 28, 1998	(7.0) 5.1	(.1)
200	Cedar Creek at Union Terrace	July 29, 1998	4.0	ND
201	Little Lehigh @Klein's Bridge	July 29, 1998	4.3	ND
202	Little Lehigh @Keck's Bridge	July 29, 1998	6.3	ND
203	Small Pond Outlet near Leibert Creek on Indian Creek Road	July 29, 1998	1.6	
204	Little Lehigh Creek at State Road in Berks County	July 29, 1998	(0.75)	(0)
205	Little Lehigh Creek on unnamed Road off of Longsdale Road in Berks County	July 29, 1998	(0.5)	(0)
206	Unnamed tributary to Swabia Creek on Mountain Road in Berks County	July 29, 1998	(0.5) 0.64 Nitrite: ND	(0)
251	Little Cedar at Trexler Park	July 29, 1998		(0)
252	Little Cedar at Tilghman Road	July 29, 1998	(5.5)	(0)
252X	Little Cedar at Tilghman, stormwater pipe	July 29, 1998	(5.5) 4.1 Nitrite = 0.06 Ammonia = 3.9	(0.3) 0.55
253/254	Iron Run at Nestle Road	July 29, 1998	2.2 Nitrite = 0.04	

Cadmus sampled for nitrates at 33 locations. Nitrate was elevated (>5 mg/l) in the following locations:

- Toad Creek at Hill top Road (10*, 7.3, 9.25* mg/l)
- Toad Creek, at Park Road (10.2 mg/l)
- Little Lehigh at Route 100 (6.0 mg/l)
- Little Lehigh at Keck's Bridge (6.3 mg/l)
- Little Cedar at Tilghman Road (5.5* mg/l)

* By field test kit.

8.3 Estimates of Nitrogen and Phosphorus Loading

It is difficult to estimate nutrient contributions by nonpoint sources precisely without detailed modeling of hydrology and of fate and transport processes. For the purposes of simply establishing priorities for action and for further study export coefficient estimations are often sufficient. Cadmus applied literature values to estimate the load of phosphorus and nitrogen from various land uses for each of nine subwatersheds. (Cadmus divided the watershed into nine subwatersheds to examine variability of estimate loads in the watershed.) Table 8-2 shows estimated total phosphorus, soluble reactive phosphorus (SRP) and total nitrogen loads for each major land use in the watershed. The primary contributor of phosphorus is runoff from developed lands, with row crops and pasture contributing smaller amounts. Because phosphorus strongly attaches to soil particles, well functioning septic systems will not be a significant source of phosphorus. Failing septic systems may supply phosphorus in limited locations but will not be a significant contributor to the watershed as a whole. Developed lands and row crops are also the largest contributors of total nitrogen. Because these estimates are derived from loading functions, they should be viewed as approximate and useful for planning purposes only. If more precise estimates of nutrient loading are necessary, a study focusing on nutrient transport should be undertaken. Currently a graduate student from Lehigh University is performing a nutrient export study of parts of the Little Lehigh.

By subwatershed, the Lower Little Lehigh and Cedar Creeks contribute the most phosphorus. The Lower Little Lehigh is a large contributor because it has the largest area at nearly 5,000 hectares. The largest contributors per unit area, however, are Toad Creek and Little Cedar Creek. The main cause for the high value for Toad Creek is the phosphorus contribution of the Topton POTW. The Lower Little Lehigh is also the largest contributor of nitrogen loading again because of its large area. The largest contributors per unit area are Toad Creek (because of the treatment plant load) and Little Cedar Creek.

Table 8-2
Estimates of Nitrogen and Phosphorus Loading by Land Use

Land Use Type	Land Area (ha)	Percent	Total Phosphorus (kg)	Percent	SRP (kg/yr)	Total Nitrogen (kg)	Percent
Developed	6,641	27.0%	9,961	54.3%	2989	56,448	32.8%
Pasture/Open	5,737	23.3%	2,868	15.6%	795	40,156	23.4%
Row Crops	7,241	29.4%	3,620	19.7%	1073	50,684	29.5%
Forested	4,947	20.1%	749	4.1%	245	20,767	12.1%
Wetlands	58	0.2%	-	0.0%	0	-	0.0%
Barren	13	0.1%	19	0.1%	6	107	0.1%
Point Source	N/A	N/A	1,120	6.1%	*	3,696	2.2%
Total	24,636	100.0%	18,338	100.0%	5108	171,858	100.0%

* No estimate was made for the portion of phosphorus from point sources that is SRP. Probably the majority of it is SRP because less labile forms are removed in wastewater sludge.

Table 8-3
Estimates of Nitrogen and Phosphorus Loading by Subwatershed

Subwatershed	Land Area (ha)	Percent	Total Phos. (kg)	Percent	Load kg/ha	Total Nit. (kg)	Percent	Load kg/ha
Toad Creek *	1,831	7.4%	2,199.89	12.0%	1.20	16,750	9.7%	9.15
Swabia	3,171	12.9%	1,076	5.9%	0.34	16,130	9.4%	5.09
Schaefer	3,248	13.2%	1,475	8.0%	0.45	20,873	12.1%	6.43
Upper Little Lehigh	3,222	13.1%	1,039	5.7%	0.32	17,033	9.9%	5.29
Iron Run	2,836	11.5%	2,335	12.7%	0.82	20,641	12.0%	7.28
Cedar	2,499	10.1%	2,837	15.5%	1.14	19,725	11.5%	7.89
Liebert	1,609	6.5%	1,346	7.3%	0.84	10,989	6.4%	6.83
Little Cedar	1,235	5.0%	1,515	8.3%	1.23	12,912	7.5%	10.45
L Little Lehigh	4,985	20.2%	4,515	24.6%	0.91	36,805	21.4%	7.38
Total	24,636	100.0%	18,338	100.0%	0.74	171,858	100.0%	6.98

* Loading in Toad Creek includes the Topton POTW discharge.

Nitrogen is an important and essential plant nutrient. Crops obtain N from many sources including: soil organic matter, biological fixation, crop residues, animal manures and fertilizers. While N is found in many organic and inorganic forms, only inorganic ammonium and nitrate is available for crop uptake. A primary objective of N management is to have adequate nitrate available during the growing season, but to minimize the amount during fall, winter or early spring when nitrate may be transported to surface and groundwater.[61] The key to nitrogen fertilization without excessive losses is to calculate the crop nitrogen requirement, determine how much of this can be met from existing sources, and supplement the remainder with fertilizer nitrogen using proper timing and placement techniques.[62]

8.4 Sources of Nitrogen

- **Legumes and Grass Sods**-Legumes fix atmospheric N in sufficient quantities to meet their N requirements. When killed or plowed under, the organic N is mineralized, releasing inorganic N to the following crop. An economic fertilizer N rate of 130 to 150 pounds per acre is typical for continuous corn without manure. The table below illustrates the value of organic N from legumes:[63]

Corn Rotation	Economic Fertilizer N Rate (lbs./acre)
1st Year after alfalfa	20
2nd Year after alfalfa	60
3rd Year after alfalfa	130

[61] Klausner, S.D. 1997. Nutrient Management: crop production and water quality. Info. NRAES 101. Cooperative Extension, Cornell University, Ithaca, NY. 40 pp.

[62] Van Es, 1991. Op Cit.

[63] Klausner, 1997. Op Cit.

- **Manure**-Manure is difficult to manage, but can provide a significant credit of nutrients and therefore reduce or eliminate the need for commercial fertilizer inputs.[64] Manure also enhances the soil organic matter, improving water retention and nutrient availability.[65] The high nutrient content of manure permits a recycling of plant nutrients from crop to animal and back to crop again.[66] There are two forms of N in manure: unstable organic N in the form of urea and stable organic N. Microorganisms must decompose both forms, but the urea component, representing up to 50% of the total, is rapidly available. The urea fraction must be incorporated in the soil and taken up by plants immediately or it is lost in the form of ammonia. The more stable organic N fraction present in the feces is more slowly released and is based on a decay series of .35-.12-.05-.02. The sequence means: 35% of the organic N is mineralized during the year applied (available), 12% of the initial organic N is available the second year, 5% in the third year and 2% in the fourth year.[67] *The value of N from manure as a replacement for fertilizer depends on the rate of application, degree of ammonia conservation and the number of years applied.*

- **Soil Organic N** consists of plan and animal residues, soil organisms and by-products from these organisms. Organic matter releases many nutrients including N during decomposition. The rate of organic N mineralization is variable, depending on the soil and organic matter content, however ranges are typically between 40 to 80 pounds of N per acre annually. Soil organic N is an important source of available N and must be accounted for when determining fertilizer requirements.

- **Fertilizer N** is readily available to crops and is needed when other sources of N are not sufficient to meet the crop requirements. Excessive applications of fertilizer are wasteful, do not improve yields and will result in either ground or surface water contamination.

[64] Klausner, 1997. Op Cit.
[65] Van Es, 1991. Op Cit.
[66] Van Es, 1991. Op Cit.
[67] Klausner, 1997. Op Cit.

8.5 Components of Nutrient Management Planning

Strategic nutrient management is being encouraged in Pennsylvania's Nutrient Management Act and Penn State University's agronomy program.[68] A number of recent fact sheets found in the bibliography by Beegle and Lanyon describe Pennsylvania's approach to nutrient management.[69] The following components highlight some of the best management practices included in a sound nutrient management plan.

- **Soil Testing**-This is the most important and least expensive component of nutrient management. Maintain a good soil-testing program to monitor nutrient status of fields and to determine supplemental nutrient needs. Use PSNT testing to determine N amounts for corn before sidedressing.

- **Manure Testing**-Analyze samples periodically for nutrient content. At first, analyze several times a year until a reasonable nutrient content is determined. Manure application rates should be based on crop needs and other N credits.

- **Credit residual nitrogen from previous crops-**Legumes are sources of N that are often not credited sufficiently for their N value. A 50-75% alfalfa stand, for example, can supply 110 lbs./acre of N to the following crop.

- **Determine nutrients and value of manure-**Manure provides tremendous benefits to the soil beyond the three major nutrients including: calcium, sulfur, boron, magnesium, copper, and zinc. It also improves tilth, aeration, and water-holding capacity, reduces erosion, and promotes the growth of beneficial

[68] Beegle, 1997. Op Cit.
[69] Beegle. D.B. 1997. Agronomy fact 54 Pennsylvania's nutrient management act: who will be affected? Penn State University. University Park, PA. 4 pp.

Beegle. D.B. 1997. *Agronomy fact 55 Estimating manure application rates*. Penn State University. University Park, PA. 4 pp.

Beegle, D.B., L.E. Lanyon and D.D. Lingenfelter. 1997. *Agronomy facts 40 nutrient management legislation in Pennsylvania: a summary of the final regulations.* Penn State University. University Park, PA. 8 pp.

organisms in the soil. On a 50 cow dairy, approximately 1,400 tons of manure is produced per year. Depending on how it is stored and handled, that equates to: 7,000 pounds of N, 5,600 pounds of P, and 11,200 pounds of potash. Using a value of $3.68/ton, amounts to $5,152 in fertilizer value.[70]

- **Determine how and when to apply manure**-Manure is often applied where it is the most convenient; near to the barn. In order to take advantage of the value of manure, it must be spread around the farm in an efficient and effective manner.[71] While there are many methods to consider, such as daily spreading, spray irrigation or subsurface injection and many timing options, such fall, winter, spring or summer, the following recommendations avoid excessive losses to volatilization, runoff and leaching:

  - determine rate by analyzing manure and the requirement of crop
  - apply just before spring planting and incorporate as soon as possible to avoid odors and runoff
  - conserve the high nutrient content of the liquid fraction during handling
  - give first priority to fields that require high nitrogen rates and low P and potash
  - spread manure as uniformly as possible.[72]

- **Determine manure rate-**After determining expected crop yields, soil test results, manure analysis, manure amounts, residual nitrogen from legumes, determine the rate at which manure can be applied. Fields should be selected that require nutrients that already have or soon will have a growing crop. The availability of nitrogen will depend on the decay series described above. Nitrogen is most often the critical nutrient for determining manure application rates in Pennsylvania.[73] Since P levels in manure tend to be in higher concentrations than most crops need, P tends to build up in the soil and may cause eutrophication problems in receiving waterbodies. To minimize this problem, water conservation best management

[70] Westmoreland Conservation District. 1994. Making nutrient management work for you-Getting more from animal manure and fertilizer. Greenburg, PA. 13pp.

[71] Wright, P. 1995. An even spread is a better spread. What's Cropping up? Vol. 5:1. Cornell University, Ithaca, NY. 2 pp.

[72] Van Es, 1991. Op Cit.

[73] Beegle, 1997. Op Cit.

practices (contour strips, buffer strips near streams, conservation tillage) to reduce runoff should be used. Crop rotations that balance soil nutrients are also important. Corn has a high nitrogen demand and relatively low P requirement, resulting in P build-up in the soil. Rotating corn with alfalfa will not only provide nitrogen corn needs, but the alfalfa requires large amounts of P and potash.

- **Determine additional fertilizer needs-**To determine additional fertilizer needs for each field depends on crop requirements, soil test results, manure credits, legume credits, and starter amount. Use the fertilizer recommendation from Penn State's Agronomy Guide and available Penn State worksheets or computer programs that help calculate nutrient requirements and application rates.[74] For corn, a new approach for reducing excessive amounts is called the pre-sidedress nitrogen test (PSNT) or quick test. The approach involves using a starter fertilizer and before sidedressing fertilizer when the plants are 6-12" tall, measure available nitrogen using a PSNT kit. Apply sidedress amounts based on N concentrations in the soil.[75]

- **Calibrate spreader-**Calibration of the manure spreader is often one of the most overlooked activities on the farm. Spreading manure uniformly at a known rate ensures that crops will receive the recommended nutrient levels. Spreader calibration can be accomplished using several easy methods, depending on the type of manure (solid or liquid) and the type of available equipment.[76]

- **Consider erosion/runoff-**A sound nutrient management plan will optimize crop nutrient uptake, but may still result in water quality problems if erosion, runoff or infiltration are not taken into consideration. The following practices should be followed to minimize problems: use water conservation best management practices (contour strips, buffer strips near streams, conservation tillage), control runoff from barnyards, do not spread manure within 100 feet of open sinkhole unless manure is incorporated within 24 hours, do not spread manure within 100 feet of drinking water wells, do not spread manure in concentrated water flow

[74] Beegle, 1997. Op Cit.

[75] Klausner, S.D. 1992. *A pre-sidedress nitrogen soil test for corn.* What's Cropping Up? Vol. 2:1, Cornell University, Ithaca, NY. 2 pp.

[76] Beegle, 1997. Op Cit.

areas when soil is frozen, snow covered or wet, do not spread manure within 100 feet of watercourses when the soil is frozen, snow covered or wet, or within 200 feet of watercourses when the slope is greater than 8% during times when the soil is frozen, snow covered, or saturated.[77]

- **Conduct yearly review-**The nutrient plan should be reviewed on an annual basis. Many factors can change on the farm that will need to be considered including: different types of crops grown, changes in equipment, feed inputs, amount of land used, number of livestock, water, bedding, etc. These factors will influence not only the amount of nutrients needed, but also the rate, timing and methods at which nutrients should be applied

8.6 Recommendations

Nutrient management recommendations for stormwater and agricultural sources of nutrients are discussed below. Golf course maintenance and lawn care practices could be targeted by outreach to decrease the use of excessive fertilizer.

8.6.1 Technical Recommendations--Stormwater

Nutrient contribution by stormwater will vary greatly between sites and between storms. While this project did not include wet-weather sampling, one stormwater sample showed high nitrogen and phosphorus concentrations. To further understand contribution by stormwater and design appropriate actions a wet-weather sampling program should be undertaken. Stormwater detention is an effective method for reducing nutrient content of stormwater. It will also greatly reduce the suspended solid load of the stormwater. Stormwater controls were further discussed in Chapter 4.

[77] Beegle, 1997. Op Cit.

8.6.2 Technical Recommendations--Agricultural

- **Control Runoff-**promote the use of standard, NRCS water conservation practices to reduce erosion and water runoff. These include contour strips, buffer strips near streams, conservation tillage (no-till or zone tillage), and cover crops. There is an excellent brochure titled "Pasture Management and Stream Fencing…What's in it for Me?" put out by the PA Chesapeake Bay Program that Allentown may want to include in mailings along with the brochure written by Cadmus for this project.

- **Manure Application**-manure should be tested to evaluate nutrient content and credited appropriately. Applications should be based on a plan as described above. Farmers should avoid applications before/during storm events. Temporary storage may be needed to provide this flexibility. If manure is spread daily, fields with low runoff potential should be used during wet periods.

- **Fertilizer Application**-Use soil tests and apply recommended amounts of fertilizer, not exceeding 150 lbs. of N/acre. Make sure manure and sod from previous rotations are credited appropriately. Use a split fertilizer application approach. Use 20-30 lbs. N of starter fertilizer and use PSNT testing when corn is 6-12" to determine side-dress rates. Avoid spraying N in combination with herbicides.

- **Target Areas**-If funding is available to target areas, focus on farms near tributary streams where direct discharges are likely. Do not exclude, however, other willing and respected farmers who want to cooperate. Developing a sense of trust in the practices and momentum in solving problems may not fall within the target areas in the early stages.

8.6.3 Organizational Recommendations

Many farmers in the watershed have cooperated with farm service agencies such as the USDA Natural Resources Conservation Service to review and implement conservation practices. An enhanced or more focussed effort could be initiated to address the problems in the watershed, if additional sources of funding can be found. A cooperative, interagency approach where the farmers, agencies and other interested/responsible organizations are brought together in a non-confrontational manner to work cooperatively to address the problems has proven useful in other watersheds, for example in the Tulpehocken in Pennsylvania. Joe Hoffman of the Berks County Conservancy has taken a lead role in that project and can speak to methods used in that effort. Stormwater management needs to be addressed in cooperation with municipalities and the DEP.

9.0 RECOMMENDATIONS

This chapter outlines recommendations for developing a source water protection program for the Allentown Water System. It summarizes topic-specific recommendations contained in Chapters 4 through 8 and presented additional recommendations for structuring the effort of both the City and a wider coalition.

Recommendations discussed in this Chapter include the following:

- Develop an Active Watershed Coalition (section 9.1)
- Draw Up a Set of Short and Long-Term Goals (section 9.1)
- Focus on Key Issues (section 9.1)
- Develop Long-Term Sources of Funding and In-Kind Services (section 9.2)
- Develop a Long-Term Monitoring Program (section 9.3)
- Consider Hiring a Part-Time Watershed Inspector (section 9.4)

Additional recommendations from previous Chapters are summarized in section 9.5.

9.1 Watershed Coalitions

One of the key recommendations of this study is that the City should initiate a coalition for protecting the watershed that has strong involvement from the City but that extends beyond the reach and the interests of the City. This section outlines why a coalition is a valid approach. It is drawn from the direct experience of one of the report authors in developing successful multi-group coalitions.

9.1.1 Why Form a Watershed Coalition?

Long-term, sustainable high water quality depends on watershed protection. Watersheds, however, are not easily protected from potential sources of pollution, at least without a concerted effort and thoughtful process. One of the obvious problems in "managing a watershed" is a lack of control. No one entity has total watershed responsibility or authority and pollution will not respect the boundaries set by individuals, corporations or political entities. Further, all uses of lands and activities in the watershed contribute in some way to the overall integrity of the water reaching a municipal intake. And, the risk, fate and transport of pollutants vary from one land use or activity to the next.

While this scenario makes water quality protection a seemingly impossible task for a water purveyor, understanding this reality is the first step towards creating an effective watershed control program. It is the very notion of "lack of control" or no one agency can solve problems alone and a shared responsibility for the problem that helps to create an opportunity to join forces with other watershed stakeholders. While other stakeholders may not have the same interests or derive the same benefits, i.e., irrigation, private drinking water, fishing, boating, etc., most can be brought to the "table" because of a shared dependence or recognition of the importance of the water resource.

Bringing together other stakeholders to form a partnership or coalition is an essential and proven approach to manage water quality in a watershed. At the heart of a watershed coalition is the recognition that cooperation and a long-term commitment to shared decision-making is required to minimize pollution and solve problems over the long run. A watershed coalition or partnership creates a focus for cooperation and problem-solving that goes beyond the means and capability of any one entity. Having the resources and talents of all stakeholders at the table leads to a more creative and a community-centered approach, as opposed to a "one-sized fits all" scheme that often emerges from one entity. Indeed, many potential sources of pollution simply cannot be regulated away. Homeowners who dump waste oil on the ground or over-fertilize their lawns will not be stopped by regulations. They need a good dose of education on a regular basis of the importance of water quality protection and what behaviors constitute good stewardship. Other land users require financial assistance to make significant improvements for water quality protection (i.e., installation of agricultural best management practices).

The Canandaigua Lake watershed in New York State, for example, first approached source water protection as an engineering problem needing regulatory solutions. The result was neither practical nor acceptable to the community. A coalition approach was used as a focus for cooperation and management. Sixteen sources of pollution were analyzed and implementation plans were created for each source. For agriculture, all the agriculture stakeholders (farmers, farm service agencies, farm organizations, and businesses) were invited to participate in a Agriculture Advisory Committee. The committee was chaired and largely made up of watershed farmers, with the support of the agriculture service agencies. The committee came up with a vision, goals, objectives and a strategy for a comprehensive farm assessment approach. Sources of funding were also identified to help put the program into action. The result has not only been successful in terms of participation, implementation and pollution reduction (over $500,000 in state and federal grants were received in the last year for implementation), but the agricultural community is much more supportive of watershed protection now that they have a voice in the process.

The Canandaigua example also highlights another important advantage of establishing a viable watershed coalition: funding. At this point and time, there are a number of state and federal grant programs available for water quality protection. All of them place a great importance on having a watershed partnership in place, recognizing the fact that more can be accomplished by working together than apart. Well organized and effective watershed coalitions are much more competitive when seeking water quality funding.

Obviously, coalitions hang on the concept of cooperation and shared decision-making. Building relationships and trust with and among key stakeholders is a critical element of any partnership. This takes time and patience, and a willingness to commit key personnel and resources to the process. Many coalitions falter when they do not recognize and promote this important aspect of forming and sustaining a coalition.

What are some other lessons learned from other successful watershed coalitions from around the country? It helps when there is convincing evidence of watershed problems, such as over-development or agricultural pollution, and monitoring data to support these claims. And more importantly, if these threats are tied to the economic value of the resource, such as a potential loss of property values or drinking water cost will rise.

There needs to be a demonstrated willingness to cooperate in solving problems by the key stakeholders. It is not enough to talk about it, there needs to be a few key individuals who are committed to the concept of a coalition and are able to organize and generate thinking among others. After the coalition is assembled, a clear vision and obtainable goals need to be established and there needs to be a demonstrated advantage to stakeholders for participating. If people/organizations are brought into the process, they need to be able to take ownership of the project in a meaningful way.

Another critical element in the concept of a coalition found elsewhere is public participation. In successful watershed coalitions in the Finger Lakes Region of New York State, public participation is primarily represented by citizen lake or watershed associations. These citizen organizations are particularly effective in a coalition because they have a keen interest (often an economic interest) in protecting water quality, a pool of volunteers for coalition projects and they often have important political influence.

While watershed coalitions may seem like the long way around to solve pollution problems, it turns out it is the only tested and proven way to minimize pollution over the long term. The achievements and rewards of a successful partnership often go beyond the imagination of any one stakeholder because of the synergistic effects of cooperative learning and problem-solving.

9.1.2 Key Stakeholders

As outlined in the following sections, a coalition should be built on enlightened self-interest in the watershed and should be grown as issues demand. Starting too large and arbitrarily including groups without an interest can sometimes reduce the effectiveness of a watershed effort. In one state-wide watershed coalition in a northeast state, the main obstacle the effort faced was that it was too inclusive including agency staff that did not understand the link between their job and the watershed coalition. The effort would have been much more effective had it started with a core of key staff and built outwards.

A partial list of parties that should be invited to participate include:

- The City of Allentown Bureau of Water Resources
- Town managers
- Wildlands Conservancy
- Lehigh Planning Commission
- Natural Resource Conservation Service
- The Conservation District
- Cooperative Extension
- Individual farmers
- Environmental Groups

This list is a starting point and is almost certainly not complete. The job of recruiting partners will be spread among stakeholders including the Bureau of Water Resources.

9.1.3 Watershed Coalition Principles

Everyone lives, works and plays in a watershed. And almost everything we do impacts the health of the watershed's natural, economic and social resources. How we manage watersheds also can impact economic health.

Through its work with watershed partnerships, the Conservation Technology Information Center has compiled the following "Top Ten Hint List" for successful watershed coalitions or partnerships.

- Think small. The smaller the watershed, the easier the partners can relate or connect to it. In addition, the smaller the watershed, the faster it will react to changes in management practices such as precision farming or land issues such as green strips.

- Bring everyone to the table. Successful watershed efforts include everyone who has a stake in the watershed. This enables the group to build consensus on what needs to be done and how to do it. Leaving a critical stakeholder out of the process at any step may cause unnecessary problems later.

- Great leaders plant seeds and nurture them. They facilitate the group to reach consensus, plant new or different ideas when necessary and assist the group in nurturing those new ideas. Effective watershed leaders are great communicators. They listen and expand on others' ideas, and make sure every idea is explored and that all stakeholders are heard.

- Ask for free advice and in-kind services. For example, if you need a video, ask the local television station for script and production assistance. If you need monitoring, assistance, work with you local water department and your local school system. And don't forget that saying thank you in public will go a long way toward getting additional help the next time. No one gives money to a group without a plan for how to use it. Financial assistance can come from unusual places and innovative sources once the group has a solid plan.

- Encourage teaching. Allow watershed stakeholders to teach each other. No idea is too simple to be discussed. For example, a farmer can teach the basics of watering, fertilizer application and pest management to homeowners.

- Seek common interests, not positions. By working to find the common interest of all stakeholders, you'll establish a strong foundation for an effective watershed management plan. One way to do this is to get past opposing positions by asking why a stakeholder has taken a particular position. Keep asking why again and again. It usually takes seven layers of "whys" to uncover an interest that is common to other stakeholders.

- Celebrate your successes. Regardless of how small, celebrate progress. Whether your group measures progress by the number of canoe trips, miles of buffer strips or acres of no-till farming, reaching milestones are important. One more bonus tip: Be kind to each other; you may need that person to agree with you later.

- Ask not “do you like it?” but ask “can you live with it?” Remember, you probably will propose many ideas before the group reaches a common point of agreement. What’s important in reaching consensus is that everyone can agree to live with a decision.

- Conflict can be healthy-if managed positively. Conflicting views or ideas often become a third view or idea that can be near healthy for the group’s efforts and the watershed’s health.

- Patience. Patience. Patience. We didn’t get to where we are today overnight, and we won’t get to where we’re going tomorrow. When you set a lofty goal, break it down in smaller steps. Before you know it, you’ll have reached your goal.

9.2 Financing A Watershed Effort

Critical to the success of any management plan is adequate financing. This section offers an overview of resources available from federal sources, Pennsylvania, and non-profit and private organizations. The list is not exhaustive, but it does flag several significant funding channels to fund critical water quality protection projects, such as conservation buffers, wetland restoration, and cropland retirement. Other programs provide resources for planning and technical assistance needed to determine the best route to water quality protection.

A useful resource is the comprehensive guide to funding and technical assistance programs, “Wetland and Riparian Stewardship in Pennsylvania”. The guide is a publication by the Bureau of Watershed Conservation in the PA DEP, and summarizes all of the programs listed below as well as many others. To obtain a copy, contact the Bureau at P.O. Box 8555, Harrisburg, PA 17110 (717) 787-5259 or the Alliance for the Chesapeake Bay at (717) 236-8825.

9.2.1 Federal programs:

U.S. Department of Agriculture , Farm Service Agency (FSA)

Conservation Reserve Program (CRP)

The CRP protects highly erodible and environmentally sensitive lands with grass, trees, and other long-term cover. This voluntary long-term cropland retirement program provides farmers an annual per-acre rent plus the cost of establishing a permanent land cover (usually grass or trees). Land eligible for enrollment includes cropland that is physically and legally capable of being cropped in a normal manner, and that has been planted in any 2 years from 1992 to 1996. Annual payments amount to approximately $50 per enrolled acre, based on the soil's productivity prior to submitting a bid. In exchange, the participant converts highly erodible or environmentally sensitive cropland from production to vegetative cover for 10 to 15 years.

Acreage accepted into the program is evaluated according to several environmental factors, as well as the cost of the annual rental rates requested by each producer. The environmental criteria include water quality benefits from reduced erosion, runoff, and leaching; on-farm benefits of reduced erosion; long-term retention benefits; air quality benefits from reduced wind erosion; and wildlife habitat benefits. Some parcels are designated Federal Conservation Priority Areas (e.g., the Chesapeake Bay and surrounding areas). A State also may designate up to 10 percent of their remaining cropland as a State Conservation Priority Area. Filter strips and riparian buffer areas adjacent to water bodies along waterways are eligible for a 10 percent incentive payment to promote their enrollment.

Producers may submit bids for high priority conservation practices yielding highly desirable environmental benefits at any time. The practices include filter strips, riparian buffers, shelter belts, field windbreaks, living snow fences, grass waterways, shallow water areas for wildlife, salt-tolerant vegetation, and certain EPA-designated wellhead protection areas. For other lands, periodic sign-ups take place. The most recent was in March 1997. A meeting among Pennsylvania FSA offices about the next general sign-up will be held in mid-October of this year. Contact your county FSA or Conservation District, or the State Office of the USDA FSA at Suite 320, One Credit Union Place, Harrisburg, PA 17110. Contact: Rex Wright (717) 782-4547.

Conservation Reserve Enhancement Program

The FSA is developing a variation on the CRP program called the Conservation Reserve Enhancement Program that will require some level of state matching funds for high priority areas such as water quality, wildlife habitat, or erosion control. Details will be coming out shortly in the federal register. Maryland had the first pilot program installing buffers around waters affected by the pfiesteria organism. Other states drafting plans are Illinois, Minnesota, New York, Oregon, Delaware, Pennsylvania, Virginia, Washington, and Wisconsin. Acreage will be limited to 100,000 acres per state. Check with State Farm Agency officials for details, or to recommend priority areas. Mary Ann Rozum is the Program Leader - Water Quality. USDA CSREES Ag Box 2210, Room 803. Washington, D.C. 20250-2210 (202) 401-4533

U.S. Department of Agriculture, Natural Resources Conservation Service

Environmental Quality Incentives Program (EQIP)

The 1996 Farm Bill established EQIP to encourage agricultural best management practices. EQIP works primarily in locally identified areas where there are significant natural resource concerns such as soil erosion, water quality and quantity, wildlife habitat, wetlands, and forest and grazing lands. The program provides funding to farmers and ranchers for implementation of voluntary structural, vegetative, and land management practices called for in 5- to 10-year contracts. The program pays up to 75 percent of the costs of conservation practices, with a limit to any one person of $10,000 annually and $50,000 for the life of the contract.

Examples of projects that can be funded through cost-sharing payments include animal waste management facilities, terraces, filter strips, tree planting and creation of permanent wildlife habitat. Cost sharing may pay up to 75 percent of the costs of certain conservation practices. Nationally, half of the funding for EQIP is targeted to livestock-related natural resource concerns and the remainder to other significant conservation priorities.

Priority is given to areas where State or local governments offer financial, technical, or educational assistance and to areas where agricultural improvement will help meet water quality objectives. The proposals are submitted from the District offices to the NRCS State Conservationist, who selects the projects. The District Offices base their recommendations on input and information from a wide range of interests, including agriculture, local government, environmental groups, water and sewer authorities, and area planning organizations. The coalition built through the system's efforts for watershed protection and the results of this study can be used to help promote the system's need for funding, elevating its status in the priority ranking. The water supply should contact the local NRCS office to discuss how the system could help the office in its efforts to secure funding.

Watershed Surveys and Planning

The Watershed and Flood Prevention Act (P.L. 83-566) authorized this program. The program is designed to assist Federal, State, and local agencies and tribal governments in their efforts to protect watersheds from damage caused by erosion, floodwater, and sediment. A second purpose is to conserve and develop water and land resources. Resource concerns 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.

The types of surveys and plans prepared include watershed plans, river basin surveys and studies, flood hazard analyses, and flood plain management assistance. The plans are to identify solutions that use land treatment and nonstructural measures to solve resource problems.

Wetlands Reserve Program

The program is a voluntary program to restore wetlands, which allows landowners to control access to their land. In exchange for a permanent conservation easement, the landowner receives payment up to the agricultural value of the land and 100 percent of the cost of restoring wetlands. For a 30-year easement, landowners can receive up to 75 percent of the value of what would be provided for a 30-year easement on the same site and 75 percent of the restoration cost. Easements set limits on how the lands may be used in the future.

If no easement is involved, voluntary agreements can be drawn up for a minimum of 10-years that establish wetland protection and restoration as the primary land use for the duration of the agreement. The agreements can provide for 75 percent of the restoration cost.

Conservation Districts often refer projects from interested landowners to Ducks Unlimited, a private organization devoted to habitat restoration and improvement for wildlife. Ducks Unlimited partners with NRCS and the US Fish and Wildlife Service on these projects, contacting the farmers and helping put them in touch with various funding sources, including the wetlands reserve program. (For example, Ducks Unlimited also works with the Wildlife Habitat Incentives Program through NRCS, which provides financial incentives to develop habitat for fish and wildlife on private lands.) Contact the County Conservation District or Ducks Unlimited.

U.S. Department of the Interior, Fish and Wildlife Service

Partners for Wildlife

Restoring fish and wildlife habitat through reestablishment of wetlands, riparian areas, and native grasslands is the main focus of the program. The project partners include Ducks Unlimited, Natural Resources Conservation Service, County Conservation Districts, private landowners, and the National Fish and Wildlife Foundation, among others. The program offers technical assistance and projects meeting certain criteria may be eligible for a cost-share or total coverage by the U.S. Fish and Wildlife Service.

Contact Dave Putnam, Partners for Wildlife Coordinator, U.S. Fish and Wildlife Service, 315 South Allen Street, Suite 322, State College, PA 16801. (814) 234-4090.

9.2.2 State Programs

Department of Conservation and National Resources, Bureau of Forestry

Keystone Fund

The program provides two types of funding: Planning, Implementation, and Technical Assistance Grants (PITA) grants to municipalities and appropriate organizations for planning, acquisition, development, and/or rehabilitation of public park, recreation, and conservation areas and facilities, rails-to-trails projects, and rivers conservation projects. Appropriate organizations are non-profit organizations dedicated to the preservation and protection of rail corridors for future use or conservation and protection of river resources and values.

Keystone Acquisition and Development Grants involve acquisition, development, and rehabilitation of the projects described in the PITA grants.

Community grants are available for municipalities to explore linear corridors of open space along streams, shorelines, wetlands, etc, as well as to inventory important natural areas, habitats for species of special concern, significant plant communities, and areas important for open space, recreation, and wildlife habitat. (Inventories are done on a county or multi-county level.)

Other grants are provided to municipalities and organizations to develop river conservation plans, studying watersheds or rivers to identify significant river resources, potential threats to these resources, and recommend restoration, maintenance, or enhancement actions. A final river conservation plan must be prepared, and grantees may petition to place the studied river or river segment on the Pennsylvania Rivers Conservation Registry.

Rivers on the Registry are eligible for grants to resolve specific projects identified in the conservation plan, such as easements or land acquisition, stream bank stabilization, and construction type activities..

The PITA and acquisition and development program grants fund up to 50 percent of eligible costs for rivers conservation projects, with a maximum $50,000 grant. There is no maximum limit for other kinds of projects. In-kind services, including the salary, certain fringe benefits, and mileage of the grantee's paid staff or documented donated services and volunteer time, may be used to qualify for the match. Applicants may submit one application per program (community, rivers, or rails-to-trails program) and no more than two grant applications per funding cycle.

An open enrollment period is active now, August 10-October 30, 1998. Contact the Central Office of the DCNR, Bureau of Recreation and Conservation, P.O. Box 8475, Harrisburg, PA 17105-8475, (717) 787-7672 for an application. Applicants may be referred to field staff, who work closely with local government officials, organizations, and citizens regarding the grant application procedures and process. The Central Office and field offices coordinate selection and administration of projects.

Statewide Nonpoint Source Pollution Program, Federal Clean Water Act - Section 319 Nonpoint Source Implementation Grants

The program provides grants for local, nonpoint source pollution projects. Agriculture, silviculture, construction, urban runoff, resource extraction, on-lot septic systems, and stream bank modifications are the types of eligible projects. Projects must be implementation-oriented, demonstrate new techniques, and document environmental improvements. Comprehensive watershed projects are encouraged.

Funding for two-year implementation periods with grants of $2 to $3 million per grant, the program requires that 25 percent of construction costs come from non-federal sources. The State must prove 40 percent matching funds.

Department of Environmental Protection

Pennsylvania State Revolving Loan Fund

Under the 1996 Amendments to the Safe Drinking Water Act, federal funding is available to states every year between 1997-2004, as long as states provide a 20 percent match. The funds can be used to provide low interest loans to public water systems to improve the treatment and distribution of water. A percentage of the funds can be used for source water assessment and protection activities. Eligible activities include an assessment program, a source water protection/source water petition program, purchase of land or conservation easements, and a wellhead protection program.

This project was conducted with funds available from the set-aside for the assessment program. (An assessment is designed to delineate the boundaries of areas providing source waters for the system and identify the origins of regulated and unregulated contaminants in the delineated area to determine the system's susceptibility to such contaminants.)

The source water petition program allows States to assist systems or local government with development of voluntary, local, incentive-based partnerships to reduce the presence of contaminants, provide technical or financial assistance, and develop recommendations for long-term source water protection strategies. Petitions must address either regulated pathogenic organisms or contaminants at levels that the State has determined are not reliably and consistently below the health risk-based maximum contaminant level promulgated by EPA.

Loans are available for acquiring land or conservation easements to protect source waters and to implement voluntary measures to facilitate compliance with national primary drinking water regulations (such as wellhead protection programs).

Pennsylvania Game Commission

Pasture Stream Bank Fencing Program

The program establishes wildlife habitat along stream corridors accessible to the public for hunting. Participating landowners must be enrolled in the Pennsylvania Game Commission's Public Access Program, which opens private land to public hunting and trapping. The project installs electric fencing and plants trees and shrubs suitable for streambank stabilization and wildlife food and cover. The program provides funding ranging from donated shrubs from local organizations to an all-expense paid stream bank fencing project. Landowners must agree to maintain the fencing in place for a 10-year period to allow the vegetation a chance to establish and generally the fence must be placed at least 10 feet from the streambank.

The program uses contractors to install fencing, and prefers to wait until they have accepted several projects for the same area. This point can delay the project for up to three years, in some cases.

Contact Dennis Neideigh, Pennsylvania Game Commission, Bureau of Land Management, 2001 Elmerton Avenue, Harrisburg, PA 17110-9797. (717) 787-6400.

Pennsylvania Department of Agriculture

Clean and Green Tax Incentives (The Pennsylvania Farmland and Forest Land Assessment Act)

The County Board of Assessment can grant a preferential assessment for ten or more contiguous acres of land devoted to agricultural, forest reserve, or open space purpose. Land is assessed at the use value rather than the prevailing market value.

Contact the Pennsylvania Department of Agriculture, 2301 N. Cameron Street, Harrisburg, PA 17110, (717) 783-3167.

9.2.3 Nonprofit Organizations

MARSH Program, *Ducks Unlimited*

This privately funded organization frequently partners with local, State, and Federal organizations to provide technical assistance and funding for implementation of projects protecting habitat for waterfowl.

One project funded by cost-share assistance of up to 50 percent is the Matching Aid to Restore States Habitat (MARSH Program). Public agencies and private conservation groups can submit applications for projects that protect or restore North American Waterfowl Management Plan sites.

Contact the regional MARSH coordinator. David Wise (717) 733-0301, or National Headquarters at 1155 Connecticut Avenue, NW #800, Washington, DC 20036.

American Greenways Dupont Awards

Grants between $500 and $2,500 are available to community groups, nonprofit organizations, and public agencies that promote greenway development. The American Greenways Dupont Awards, a partnership project of DuPont, The Conservation Fund, and the National Geographic Society, provides small grants to stimulate the planning and design of greenways in communities throughout America. The Fund is now collaborating in Pennsylvania with the state's Environmental Council, Department of Conservation and Natural Resources, and Rails-to-Trails Conservancy chapter to begin a greenway effort. The ambitious goal: to create a system of linked open spaces in urban, suburban, and rural areas of Pennsylvania. The William Penn Foundation and the Howard Heinz Endowment provided seed funding for the project.

Land Trusts

These private, nonprofit corporations seek to protect land and land resources for wildlife habitat or natural areas, open spaces, recreational land (especially trail and river corridors), and farmland. The land is protected either through direct acquisition or through conservation easements. Conservation easements protect the land from development in perpetuity, but the landowner retains ownership and becomes eligible for some tax benefits.

9.3 Long Term Water Quality Monitoring

During this study Cadmus employed a variety of data collection techniques including review of historical studies, analysis of GIS land use maps, interviews with various parties, and direct field observation and water quality analysis. While each of the techniques proved valuable, there is no substitute for targeted water quality data.

Water quality data is useful for a variety of purposes including the following:

- Understanding the general water quality of the streams and the reservoir for the period that sampling is taking place. The data can be extended to understand un-monitored periods to a limited extent.
- Understanding variation in water quality between sites and over time.
- Identifying hot-spots that require further study and possible remediation action. For example this study identified several areas where bacteria counts are elevated.
- Demonstrating the need for action and the general sources of contaminants.

The Bureau of Water Resources has a good start in their monitoring program. We encourage them to continue to monitor and to review and adjust their program as data is available and analyzed.

9.3.1 Where to Sample?

The Bureau has established an extensive network that will be useful in identifying problem areas. If problems are detected, the Bureau will want to perform more more detailed short-term sampling until the problem is identified. Once it has been corrected the fhine scale sampling can cease.

9.3.2 When and How Often to Sample?

The answer to when and how often to sample is dependant somewhat on budget constraints. Assuming a moderately-funded program we recommend sampling at least quarterly, preferably once per month for the first year. To start the program off the Bureau sampled even more often to build a base line of data. These sample runs can be scheduled in advance and would usually capture conditions during base flows (because there are more days without storms than there are with storms).

We also recommend that the Bureau (or coalition depending on how tasks are divided) plan to sample at least two storm events during the first year of sampling. As discussed in the next subsection, key parameters to sample are total suspended solids, phosphorus, and nitrogen. Because sampling during rain storms is time-consuming, and extra care must be taken we recommend cutting the sample stations down to less than ten unless multiple sampling crews operate simultaneously.

9.3.3 What to Sample?

As above, the number and type of analyses will be constrained by budget. The analyses performed should serve two purposes:

- Provide additional information on key water quality problems already identified (i.e., bacteria, sediment, nutrients)
- Keep watch for the appearance of new contaminants, or those missed by earlier sampling.

We recommend that most of the effort be spent on the first point with a lesser amount on screening for new contaminants. The base sampling for dry weather should include at a minimum TSS, total phosphorus, nitrate plus nitrite nitrogen, and bacterial indicators (these can be sampled on a different schedule as currently practiced). For suspected or known sources of wastewater, ammonia or TKN should be added

Although they do not directly relate to drinking water quality temperature and dissolved oxygen are fundamental ecological indicators and should be added if other coalition members want them.

9.3.4 How to Extend Limited Sampling Resources

There are a variety of strategies for extending what can be accomplished with limited sampling resources. Following are several examples:

- In this study resources were conserved by using a Lamotte field test kit for phosphorus. Whenever the test kit showed a positive reading (>0.2 mg/l), a sample was collected for later laboratory analysis. The cost of the kit analysis was roughly \$0.50 per sample, while the laboratory cost was roughly \$20 per sample. In this manner, the cost for screening for sites with high phosphorus was greatly decreased without a loss of accuracy. This method would not be appropriate, however, where an accurate reading of total phosphorus was needed for modeling wastewater discharges or for examining biological responses of the stream to phosphorus inputs. As a screen for pollutant sources the method provided a good level of accuracy at a fraction of the cost.

- Cadmus used a Lamotte field test kit for nitrate nitrogen. When the kit reading was either low (<1 mg/l) or high (>5 mg/l) a sample bottle was also generally filled for later laboratory analysis. Test kit and laboratory analyses were compared and the agreement was quite good nearly always within 1 mg/l at the high range (5-10 mg/l), and more accurate at lower concentrations. As with phosphorus, this was a good strategy for minimizing the cost of searching for waste sources. It would not be appropriate for performing a detailed waste load or ecological study.

- To reduce the cost of using a contract laboratory, the City could provide in-kind services to the coalition for parameters already routinely measured. If the samples could be combined with current analyses, additional set-up time could be reduced.

- To reduce sampling labor, volunteers could be used to collect dry weather samples. It is vital that the volunteers receive organized and detailed training. In North Carolina, the Department of Environmental Management makes creative use of monitoring consortia that use a combination of paid and volunteer monitors that are highly trained. For further reading consult an article by Brewer and Clements on monitoring consortia.[78] A current effort in Pennsylvania is making us of knowledgeable senior citizens for monitoring. Chris Kocher of the Wildlands Conservancy[79] has used high school students for a similar purpose.

- Various agencies including the Pennsylvania DEP collect water quality data. The City should keep in contact with the regional DEP to encourage agency monitoring and to gain access to historical data.

9.4 Recommended Additional Activities for the Coalition and City

[78] Brewer, Kimberly, Trevor Clements, The Cadmus Group. Monitoring Consortiums: A key Tool in the Watershed Approach, In Watershed '96: Mooving Ahead Together. June 8-12, 1996, Baltimore Maryland.

[79] Wildlands Conservancy, 3701 Orchid Place, Emmaus, PA 18049, (610) 965-4397.

This section discusses activities discussed elsewhere in the report that can be performed by a coalition by the City, or by other agencies.

9.4.1 Outreach

Once a watershed protection effort is underway, communicating that effort to parties in the watershed is vital. Another function of outreach could be to educate land owners and influence behavior by various parties, for example automotive-related commercial facilities (see Chapter 5). Included with this report is an outreach brochure written by Cadmus for this project. Outreach to the agricultural community is best done in close cooperation with the agricultural agencies. The Berks County Conservancy in Reading and the Wildlands Conservancy in Allentown are very experienced and successful in reaching out to a variety of communities. A video of some of the Wildlands Conservancy's educational efforts is included under separate cover. Following are examples of outreach efforts that Cadmus recommends:

- Work with the agricultural service agencies to publicize the watershed coalition. Encourage participation.
- Approach hunting and fishing groups and agencies to publicize the watershed effort and invite cooperative efforts.
- Discuss with the conservancy strategies for filming and screening a public TV spot.
- Have the coalition included on appropriate web pages including the Pennsylvania Berks County Notebook.
- Approach local chapters of national organizations including Trout Unlimited, Ducks unlimited, and the Nature Conservancy to share information and invite involvement.

- Publicize the effort to local, state, and federal agencies to encourage support, funding, and in-kind services.

9.4.2 Hire Watershed Staff

We recommend that the Bureau allocate hours to a part time watershed inspector function to service the upper watershed beyond the City's land holdings. The position would most likely be filled with an existing staff member and would integrate with current sampling functions. The inspector could perform a variety of functions including the following:

- Conduct regular field visits to observe the watershed.
- Conduct water quality sampling (or continue current arrangement).
- Work with the watershed coalition
- Coordinate in-kind services provided by the City to the Coalition
- Coordinate volunteers
- Help staff subcommittees of the Coalition that would work on issues including bacterial contamination from inadequate sewer and septic systems and nonpoint sources of sediment and nutrients.

9.4.3 Recommended Activities

Following are selected recommendations discussed elsewhere in the report:

- Conduct a detailed sediment study to focus sediment reduction efforts.
- Actively promote protection of stream-side buffer zones. These zones are vital for reducing sediment and nutrient loads. The land now held by the City is a vital resource that should be held and managed. The City should

consider expanding its holdings through lease or purchase of buffer zones in the lower reaches of the watershed.

- Work with appropriate agencies to develop BMP demonstration projects. For example, the Chester Water Authority worked with several groups including the Pennsylvania Fish and Boat Commission to develop stream bank protection projects in the Octararo Watershed.

- Reach out to users of toxic materials to encourage responsible behavior. Approach automobile parts suppliers to encourage oil recycling. Discuss commercial and industrial floor drains with Pennsylvania's Class V well program.[80]

9.5 Summary

In this report Cadmus recommended that the City help convene a watershed coalition that would both focus on the core issues identified: bacterial contamination, and sedimentation, and would also address longer term issues such as non-point sources of nutrients. The process of building a maintaining this effort is long-term and by its nature cooperative. Investment in source water protection will pay dividends in a healthier watershed, an additional layer of drinking water protection, and a deeper understanding and appreciation of the watershed. Should the City have any questions regarding the report or their efforts they can call David Korn at the Cadmus Group, Inc. in Waltham, Massachusetts.

[80] Rural floor drains often drain to dry wells. States often include dry wells in programs termed Class V injection well control.

Apppendix 3-1
Sampling Report, Preliminary Results
and Observations for the Little Lehigh Creek Watershed

June 4 Screening Sampling

On the evening of June 4 we performed a round of screening sampling. We observed 5 sites, performed field analysis of nitrate plus nitrite and total phosphorus, using Hach and LaMotte kits, and collected selected samples for laboratory analysis of total suspended solids, nitrate plus nitrite, and total phosphorus. Field notes and the results of field analyses for nitrate plus nitrite and total phosphorus are presented in Table 1.

Table 1
Field Observations
Little Lehigh and Tributaries--June 4, 1998

Station #	Stream	Location	NO3 + NO2[81] (mg/l)	Total Phos.[82][83] (mg/l)	TSS (mg/l)	Notes
1	Little Lehigh	@ Lehigh Pkwy	(5) 4.7	(0) 0	7	Mowed bank. Little shade canopy. Some turbidity. Rising trout. Insect hatches. Good bank stability.
2	Liebert Creek	Shimmerville Rd.	(3)	(0)	10	Some riparian vegetation. Little canopy. Rising trout. Insect hatches. Good bank stability. Nearby houses.
3	Little Lehigh	@ Rt. 100 and Creamery Rd.	(6)	(0)	9	Good riparian vegetation and extensive shade. Good bank stability. Rising trout. Insect hatches.
4	Swabia Creek	Macungie (Rt. 100)	(1)	(0)	8	Good riparian vegetation and extensive shade. Rising trout. Insect hatches. Some garbage. Silt covered bottom and silt deposits in bridge arches. Large (24”) stormwater pipe.

[81] Values in parentheses are by LaMotte field analysis method. The resolution is roughly 1 mg/l.
[82] Values in parentheses are by Hach field analysis method. The resolution is roughly 0.2 mg/l.
[83] There was good agreement between the laboratory analysis and field analyses for nitrate-plus-nitrate and total phosphorus. The variation (10 versus 7.3) in Toad Creek is partially explainable by our observation that it is hard to match the colormetric test at values of 8 to 10 mg/l. Nevertheless, the field test kits give results sufficient for screening analyses. Their benefit is that they are inexpensive and that they give immediately results.

5	Toad Creek	@ Hilltop Road	(10) 7.3	(0.1) 0.19	7	Adjacent to corn field. Little shade upstream. Shade downstream.

Sampling Commentary

This preliminary sampling was intended as an introduction to the watershed for Cadmus investigators and to provide some preliminary screening. In general, the sites observed had good riparian vegetation and were well shaded. Trout were observed in several of the locations. The sites showed evidence of historical sedimentation, however, the source of the sediment was not observed. Because sediment transport (and transport of the adsorbed fraction of phosphorus) is largely a storm-event phenomenon, we suggest some wet-weather sampling to differentiate between the various tributaries in terms of sediment loading. To capture sediment loading it is necessary to sample throughout several storm events of varying magnitudes.

Based on the results above, Toad Creek is a contributor of nitrate nitrogen to Little Lehigh. However, until we calculate the area of the Little Lehigh's subwatersheds, it is difficult to estimate the relative loading attributable to Toad Creek. TSS analyses are relatively low, which is not unexpected, because we sampled several days after the last rain event. Total phosphorous levels were below the detection limits of the laboratory analysis or below the resolution of the field test kits, with the exception of Toad Creek. Phosphorus is likely to be the limiting nutrient in this watershed, and therefore will contribute to algae growth, particularly in slow moving sections of the streams.

SAMPLING DATE: July 28, 1998

NOTE: All samples collected in the Allentown area consisted of very cold water, compared to that of the other watersheds sampled, unless otherwise noted. Very cold water suggests that ground water mixes with surface water to form many of the streams in this watershed.

Sample 100

Location: Schaeffer Run at Farmington Road off Rte 222 in Berks County

Description: Stream bed was dry. However, stream ran straight through a cornfield, and looked more like a drainage ditch than a stream. No riparian cover, aside from corn stalks, was observed.

Nitrate: N/A

Phosphorous: N/A

Sample 101

Location: Unnamed Tributary to Schaefer Run at Schantz Road

Description: Stream bed was dry. However, stream ran straight through a cornfield, and looked more like a drainage ditch than a stream.

Nitrate: N/A
Phosphorous: N/A

Sample 102

Location: Schaefer Run at Trexler Road
Description: Appeared to be a small pond that flowed though a corn field. Stream banks are extremely eroded. A few trees were scattered along the streambed. The water was dark, and almost brown in color, and had many tadpoles in it.

Nitrate: 3 mg/l
Phosphorous: 0 mg/l

LAB ANALYSIS:
Fecal Coliform: 1,650/100 ml Sample ID = 102C

Sample 103

Location: Breinig Run off of Rte. 222
Description: Breinig Run is a very small stream, approximately 3 feet wide at the time of sampling. There are a few houses and farms within 500 feet of the stream. The stream was bordered by riparian cover both upstream and downstream.

Nitrate: 2.5 mg/l (sample collected for laboratory analysis)
Phosphorous: 0 mg/l

LAB ANALYSIS:
Nitrate: 4.0 mg/l Sample ID = 103A

Sample 104

Location: Schaeffer Run at Rte. 222 eastbound after Cornshock Road
Description: Rice grass surrounded the stream on both sides, upstream and downstream. There was a very thin layer of riparian cover on both sides of the stream (rice grass interspersed with some bushes and a tree or two every 10 to 15 feet). Beyond the stream looking South was an open field, and a residential area (approximately 5 houses). The stream had a soft, sandy (muddy) bottom.

Nitrate: 4 mg/l
Phosphorous: 0 mg/l

<u>Sample 105</u>

Location: Iron Run on Rte. 222 next to Fire Company No. 1

Description: Short riparian cover both upstream and down. Land use appeared to be residential, and commercial (gas station, deli, firehouse). The stream had a silty bottom. A drainage pipe discharged into the stream and was also sampled.

Nitrate: 3 mg/l
Phosphorous: 0 mg/l

Drainage Pipe Effluent:

Nitrate: 4 mg/l
Phosphorous: 0 mg/l

<u>Sample 106</u>

Location: Spring Creek on Spring Creek Rd off of Rte. 100

Description: Spring Creek had a very silty bottom, and was approximately 30 feet wide and 1 foot deep at the time of sampling. Spring Creek had good riparian cover downstream, and a fair amount of cover upstream. Train tracks, a gravel parking lot/gravel pit were within 100 feet of the stream. Houses were located along Rte. 100 near the Creek. A stormwater pipe discharges into the Creek from the yard of a house bordering the creek and Rte. 100. At the time of sampling, the pipe was dry.

Nitrate: 6 mg/l
Phosphorous: 0 mg/l

<u>Sample 107</u>

Location: Little Lehigh Creek at Rte. 100 right after RR crossing

Description: At the sampling point, the creek was approximately 15-20 feet wide, and 4 feet deep. Good riparian cover was found on both sides of the stream, both upstream and downstream. Residential areas were located within 500 feet of the stream, and an open field (grass) was located within 200 feet of the stream.

Nitrate: 5-6 mg/l (sample collected for laboratory analysis)
Phosphorous: 0 mg/l

LAB ANALYSIS:
Nitrate: 5.0 mg/l Sample ID = 107A

Sample 108

Location: Swabia Creek off of Rte. 100 and Race Street

Description: Stream was surrounded by riparian cover (not very thick) maybe 1-2 feet of cover. Stores, and a gas station within 100 feet of creek. Tyler Pipe Company is located approximately 100 feet downstream, and a Crop production services center was located on Race Street across from the gas station. A drainpipe was found in the creek, but was dry at the time of sampling. Downstream, stream banks were severely eroded. Road/work, utility work was being performed at the intersection.

Nitrate: 3 mg/l
Phosphorous: 0 mg/l

Sample 109

Location: Tributary to Swabia Creek on Rte. 100

Description: Upstream: Parkland, downstream, the creek is lined by concrete walls (may be due to severe erosion/sedimentation in the past, or to stabilize the streambed). Some riparian cover was found upstream by the parkland. Downstream, little to no riparian cover was observed.

Nitrate: 3 mg/l (sample collected for laboratory analysis)
Phosphorous: 0 mg/l

LAB ANALYSIS:
Nitrate: 0.62 mg/l Sample ID = 109A
Fecal Coliform: 850/100 ml Sample ID = 109C

Sample 110

Location: Swabia Creek at Sauerkraut Lane

Description: A trailer park and a small cornfield were located downstream of the creek, approximately 1,000 feet away from the creek.

Nitrate: 2 mg/l
Phosphorous: 0 mg/l

LAB ANALYSIS:
Fecal Coliform: 2,400/100 ml Sample ID = 110C

Sample 111

Location: Leibert Creek on Indian Creek Road

Description: Riparian cover downstream consists of a thin layer of vegetation. The downstream area is surrounded on one side by a home, and on the other side, by open land. Upstream, the stream is surrounded by a lightly wooded area. A golf course is located within 1 mile upstream. Upstream, the stream bank is highly eroded. Sedimentation in this creek seems excessive. Also found algal growth , and a drain pipe that discharges water from what looks to be a man made pond. Bank stabilization techniques have been used in this area to reduce erosion, but parts of the structure still appear to be unstable.

Nitrate: 1 mg/l
Phosphorous: 0 mg/l

Sample 112

Location: Leibert Creek on Shimmerville Road

Description: Downstream, a thin riparian cover runs along the creek. A chlorine station (pre-chlorinating the water?) is near creek. Erosion does not seem to be a large problem in this area. The creek has a rocky, not sandy bottom. Upstream, the stream banks are severely eroded, and surrounded by a very thin riparian buffer (~ 1 ft wide).

Nitrate: 2 mg/l
Phosphorous: 0 mg/l

Sample 113

Location: Leibert Creek on German Road near mouth

Description: Very small stream, heavily wooded, some residences in area. The creek was approximately 1 foot wide, and 4 inches deep at the time of sampling.

Nitrate: 1 mg/l
Phosphorous: 0 mg/l

LAB ANALYSIS:

Total Suspended Solids: 19 mg/l Sample ID = 113D

Sample 114

Location: Swabia Creek on Schoenek Road

Description: Downstream of the Creek has a good riparian cover. Riparian cover is also found upstream, but the Creek runs along a cornfield which is approximately 20 feet away from the Creek.

Nitrate: 1 mg/l (sample collected for laboratory analysis)
Phosphorous: 0 mg/l

LAB ANALYSIS:
Nitrate: 0.34 mg/l Sample ID = 114A

Sample 115
Location: Swabia Creek
Description: The stream ran next to some small cornfields, and through a residential area. Cornfields were located approximately 20 feet from the creek. Thin layer of riparian cover was found both upstream and down.

Nitrate: 0.25 mg/l
Phosphorous: 0 mg/l

Sample 150
Location: Schaefer Run at Brookdale Road
Description: Small stream, very turbid, nearly no flow. Riparian grasses are visible, approximately 2 to 3 feet wide, and 6 inches deep.

Nitrate: NA
Phosphorous: NA

LAB ANALYSIS
Fecal Coliform 20,000/100 ml Sample ID = 150

Sample 151
Location: Toad Creek at Hilltop Road
Description: Extensive algal growth is visible in creek. Water is cold, likely influenced by ground water. Looking North up Toad Creek from Mertztown Road, there is extensive solid algae and duck week in the creek. There is a chemical company on Valley Road in Mertztown, near Toad Creek. At Barclay Road, Toad Creek is moving at approximately 1 cfs, and has some algae. At Barclay and Meadow Roads near Toad Creek, there are 2 small dairy herds.

Nitrate: 9.0 mg/l
Phosphorous: 0.1 mg/l

Sample 152

Location: Toad Creek at Park, Approximately _ mile downstream of the Topton POTW

Description: Some algal growth is visible in the Creek. Shade on the South side, grass on the North.

Nitrate: 10.0 mg/l
Phosphorous: out of range

LAB ANALYSIS:

Nitrate:	10.2 mg/l	Sample ID = 152A
Nitrite	0.11 mg/l	Sample ID = 152A
Total Phosphorous:	2.9 mg/l	Sample ID = 152B
Fecal Coliform:	16,000/100 ml	Sample ID = 152F

Sample 153

Location: Little Lehigh at Pool Sanctuary

Description: This is a 2 feet deep pool above a shallow dam. It is approximately 35 feet wide with Canada Geese, goose excrement was visible.

Nitrate: 7.0 mg/l (sample collected for laboratory analysis)
Phosphorous: 0-0.1 mg/l

LAB ANALYSIS:

Nitrate:	5.1 mg/l	Sample ID = 153A
Total Suspended Solids:	2.0 mg/l	Sample ID = 153C

SAMPLING DATE: July 29, 1998
WATERSHED: Allentown

Sample 200

Location: Cedar Creek at Union Terrace

All samples collected for laboratory analysis

LAB ANALYSIS:

Nitrate: 4.0 mg/l Sample ID = 200A

Total Phosphorous: ND mg/l Sample ID = 200B

<u>Sample 201</u>

Location: Little Lehigh @Klein's Bridge

All samples collected for laboratory analysis

<u>LAB ANALYSIS:</u>

Nitrate: 4.3 mg/l Sample ID = 201A

Total Phosphorous: ND mg/l Sample ID = 201B

<u>Sample 202</u>

Location: Little Lehigh @Keck's Bridge

All samples collected for laboratory analysis

<u>LAB ANALYSIS:</u>

Nitrate: 6.3 mg/l Sample ID = 202A

Total Phosphorous: ND mg/l Sample ID = 202B

<u>Sample 203</u>

Location: Small Pond Outlet near Leibert Creek on Indian Creek Road

Description: All samples collected for laboratory analysis

<u>LAB ANALYSIS:</u>

Nitrate: 1.6 mg/l Sample ID = 203A

Fecal Coliform: 1,650/100 ml Sample ID = 203

<u>Sample 204</u>

Location: Little Lehigh Creek at State Road in Berks County

Description: The stream is surrounded upstream by strip cropped rows of corn fields. Little to no riparian cover ran along the stream. Riparian cover was seen looking downstream, but beyond the cover (approximately 2 feet thick) was an open field. There were no observable point source discharges into the creek.

Nitrate: 0.75 mg/l

Phosphorous: 0 mg/l

<u>Sample 205</u>

Location: Little Lehigh Creek on unnamed Road off of Longsdale Road in Berks County

Description: The stream was surrounded by cornfields, both upstream and downstream. Good riparian cover was found, a few houses were found within 1,000 feet of the stream.

Nitrate: 0.5 mg/l
Phosphorous: 0 mg/l

<u>Sample 206</u>

Location: Unnamed tributary to Swabia Creek on Mountain Road in Berks County

Description: Many houses in the area, seemed to be a residential area. The Creek had a very sandy bottom, with a thin layer of riparian cover upstream and downstream. Beyond the riparian cover were houses, open yards, interspersed with trees.

Nitrate: 0.5 mg/l
Phosphorous: 0 mg/l

<u>LAB ANALYSIS:</u>

Nitrate:	0.64 mg/l	Sample ID = 206A
Nitrite:	ND mg/l	Sample ID = 206A
Fecal Coliform:	180/100 ml	Sample ID = 206C

<u>Sample 251</u>

Location: Little Cedar at Trexler Park

Description: Upstream, there is extensive Riparian corridor shade trees. Downstream, there is extensive Riparian corridor shade trees, then the road. Some mesh netting and store channeling.

Nitrate: NA
Phosphorous: 0.0 mg/l (sample collected for laboratory analysis)

<u>Sample 252</u>

Location: Little Cedar at Tilghman Road

Description: The sample was taken from below an arch bridge. Apartment buildings were located near the creek. There was stormwater discharge from road run off. Many large trout were visible. Stream bank had plants surrounding it, mesh netting, rock deflector, and rock habitat.

Nitrate: 5.5 mg/l
Phosphorous: 0.0 mg/l

Stormwater:

Nitrate: 5.5 mg/l (sample collected for laboratory analysis)
Phosphorous: 0.3 mg/l (sample collected for laboratory analysis)

LAB ANALYSIS:

Nitrate:	4.1 mg/l	Sample ID = 252A
Nitrite	0.06 mg/l	Sample ID= 252A
Total Phosphorous:	0.55 mg/l	Sample ID = 252B
Ammonia:	3.9 mg/l	Sample ID = 252B
TSS:	84 mg/l	Sample ID = 252C

Sample 254

Location: Iron Run at Nestle Road
Description:

Nitrate: mg/l (sample collected for laboratory analysis)
Phosphorous: mg/l

LAB ANALYSIS:

Nitrate:	2.2 mg/l	Sample ID = 254A
Nitrite:	0.04 mg/l	Sample ID = 254A
TSS:	8.0 mg/l	Sample ID = 254C

Sampling Report, Preliminary Results and Observations for the Little Lehigh Creek Watershed

Sample ID	Location	Sampling Date	Sampling Results*	Laboratory Results*
100	Schaeffer Run at Farmington Road off Rte 222 in Berks County	July 28, 1998	N/A	N/A
101	Unnamed Tributary to Schaefer Run at Schantz Road	July 28, 1998	N/A	N/A
102	Schaefer Run at Trexler Road	July 28, 1998	Nitrate: 3.0 Phosph: 0.0	Fecal coliform: 1,650 per 100 ml
103	Breinig Run off of Rte. 222	July 28, 1998	Nitrate: 2.5 Phosph: 0.0	Nitrate 4.0
104	Schaefer Run at Rte. 222 eastbound after Cornshock Road	July 28, 1998	Nitrate: 4.0 Phosph: 0.0	N/A
105	Iron Run on Rte. 222 next to Fire Company No. 1	July 28, 1998	Nitrate: 3.0 Phosph: 0.0	N/A
105A	Iron Run on Rte. 222 next to Fire Company No. 1, Drainage Pipe Effluent	July 28, 1998	Nitrate: 4.0 Phosph: 0.0	N/A
106	Spring Creek on Spring Creek Rd off of Rte. 100	July 28, 1998	Nitrate: 6.0 Phosph: 0.0	N/A
107	Little Lehigh Creek at Rte. 100 right after RR crossing	July 28, 1998	Nitrate: 5.0-6.0 Phosph: 0.0	Nitrate 6.0
108	Swabia Creek off of Rte. 100 and Race Street	July 28, 1998	Nitrate: 3.0 Phosph: 0.0	N/A
109	Tributary to Swabia Creek on Rte. 100	July 28, 1998	Nitrate: 3.0 Phosph: 0.0	Nitrate 0.62 Fecal coliform: 860 per 100 ml
110	Swabia Creek at Sauerkraut Lane	July 28, 1998	Nitrate: 2.0 Phosph: 0.08	Fecal coliform: 2,400 per 100 ml
111	Leibert Creek on Indian Creek Road	July 28, 1998	Nitrate: 1.0 Phosph: 0.0	N/A
112	Leibert Creek on Shimmerville Road	July 28, 1998	Nitrate: 2.0 Phosph: 0.0	N/A
113	Leibert Creek on German Road near mouth	July 28, 1998	Nitrate: 1.0 Phosph: 0.0	TSS 19
114	Swabia Creek on Schoenek Road	July 28, 1998	Nitrate: 1.0 Phosph: 0.0	Nitrate 0.34

Sample ID	Location	Sampling Date	Sampling Results*	Laboratory Results*
115	Swabia Creek	July 28, 1998	Nitrate: 0.25 Phosph: 0.0	N/A
150	Schaefer Run at Brookdale Road	July 28, 1998	N/A	Fecal coliform: 20,000 per 100 ml
151	Toad Creek at Hilltop Road	July 28, 1998	Nitrate: 9.25 Phosph: 0.1	
152	Toad Creek at Park, Approximately _ mile downstream of the Topton POTW	July 28, 1998	Nitrate: 10.0 Phosph: Out of range	**Nitrate: 10.2** **Nitrite: 0.11** **Phosph: 2.9** Fecal Coliform: 16,000 per 100 ml
153	Little Lehigh at Pool Sanctuary	July 28, 1998	Nitrate: 7 Phosph: 0- 0.1	Nitrate: 5.1 TSS: 2.0
200	Cedar Creek at Union Terrace	July 29, 1998	N/A	Nitrate 0.62 Phosph: ND
201	Little Lehigh @Klein's Bridge	July 29, 1998	N/A	Nitrate 4.3 Phosph: ND
202	Little Lehigh @Keck's Bridge	July 29, 1998	N/A	Nitrate 6.3 Phosph: ND
203	Small Pond Outlet near Leibert Creek on Indian Creek Road	July 29, 1998	N/A	Nitrate: 1.6 Fecal Coliform: 1,650 per 100 ml
204	Little Lehigh Creek at State Road in Berks County	July 29, 1998	Nitrate: 0.75 Phosph: 0.0	N/A
205	Little Lehigh Creek on unnamed Road off of Longsdale Road in Berks County	July 29, 1998	Nitrate: 0.5 Phosph: 0.0	N/A
206	Unnamed tributary to Swabia Creek on Mountain Road in Berks County	July 29, 1998	Nitrate: 0.5 Phosph: 0.0	Nitrate: 0.64 Nitrite: ND Fecal Coliform: 180 per 100 ml
251	Little Cedar at Trexler Park	July 29, 1998	Nitrate: N/A Phosph: 0.0	N/A
252	Little Cedar at Tilghman Road	July 29, 1998	Nitrate: 5.5 Phosph: 0.0	N/A
252X	Little Cedar at Tilghman, stormwater pipe	July 29, 1998	Nitrate: 5.5 Phosph: 0.3	Nitrate: 4.1 Nitrite: 0.06 Phosph: 0.55 Ammonia: 3.9 TSS: 84
253/254	Iron Run at Nestle Road	July 29, 1998	N/A	Nitrate: 2.2 Nitrite: 0.04 TSS: 8.4

Appendix 5-1

Auto Related Businesses in the Little Lehigh Watershed

COMPANY	TRADE NAME	ADDRESS	CITY	ZIP	LATITUDE	LONGITUDE
15th Street Shell		15th & Gordon STS	Allentown	18102	40.607100	-075.47790
Agnew R Hoch		401 E Main St	Macungie	180621736	40.509200	-075.54820
Allentown Car Care Center Inc	Allentown Car Wash	1636 W Tilghman St	Allentown	181022054	40.606300	-075.49610
Anthony J Reno	Fogelsville Exxon	P O Box 88	Fogelsville	180510088	40.585400	-075.64850
Atlantic Refining & Marketing	A Plus	1201 W Hamilton St	Allentown	181024304	40.599200	-075.48220
Auto Cosmt Auto Bdy & Car Sls		312 Hunterforge Rd	Macungie	180628510	40.512400	-075.59250
Blackman Cycle Inc		4911 Buckeye Rd	Emmaus	180491015	40.490400	-075.51810
Brian Barrell	East Penn Rv	27 Bowers Rd	Mertztown	195399775	40.503000	-075.75000
Brian Barrell	East Penn Rv	27 Bowers Rd	Mertztown	195399775	40.503000	-075.75000
Cedar Crest Exxon		301 N Cedar Crest Blvd	Allentown	181044604	40.596500	-075.52550
Clemens Auto Body Shop		804 State St	Mertztown	195399145	40.489100	-075.66040
Clemens Auto Body Shop		804 State St	Mertztown	195399145	40.489100	-075.66040
D K Ziegler Realtors	Downtown Auto	133 N Jefferson St	Allentown	181023711	40.600900	-075.48420
Dales A-Plus Mini Market		1501 Mauch Chunk Rd	Allentown	181021034	40.616800	-075.49710
Daniels Cadillac-Bmw Inc		P O Box 716	Allentown	181050716	40.608100	-075.49000
Dave Dorris Auto Body & Towing		112 S 9th St	Allentown	181024849	40.599200	-075.47470
Daves Interior Restoration	Daves Interior Restoration	525 Chestnut St	Emmaus	180492403	40.534000	-075.49420
Dillon Companies Inc	Turkey Hill 110	602 Chestnut St	Emmaus	180492225	40.533000	-075.49630
Dreisbachs Auto Service & Sls		614 N 18th St	Allentown	181044106	40.604600	-075.49870
First Leisure Enterprises Inc	Kawasaki of The Lehigh Valley	1410 W Tilghman St	Allentown	181022115	40.607600	-075.49130
Fulmers Service Station		4094 Chestnut St	Emmaus	180491012	40.667900	-075.51910
Getzs Service Station		P O Box 48	Breinigsville	180310048	40.561600	-075.62670
H & S Service Center Inc	Shell	1915 Brookside Rd	Macungie	180629730	40.518200	-075.55510
Haines Exxon Service Center		1530 Mauch Chunk Rd	Allentown	181049702	40.617300	-075.49860
Haldeman Ford Inc		1741 W Tilghman St	Allentown	181044158	40.605700	-075.49810
Haldeman Ford Inc		18th and Tilghman STS	Allentown	18104	40.601600	-075.52260
Hausmans Precision Welding		4140 Robert Rd	Emmaus	180493318	40.490400	-075.51810
Heidecker Enterprises Inc	Heidecker Auto World	4580 Chestnut St	Emmaus	180495359	40.667900	-075.51910
Heimbachs Auto Body Inc		105 W Walnut St	Allentown	181024916		
Helfrich Accessory Sales		4831 Shimer Rd	Emmaus	18049	40.498300	-075.52280
Hendricks David & Sons Auto		202 Main St	Emmaus	180492736	40.537000	-075.48910

Hinnerschietz Recon Inc	Hinnerschietz Auto Service	4845 Buckeye Rd	Emmaus	180491032	40.490400	-075.51810
Iobst Tire & Auto Center Inc		464 State Ave	Emmaus	180493026	40.547100	-075.48940
J H Bennett Inc	Bennett Infiniti	4800 W Tilghman St	Allentown	181049365	40.583800	-075.55180
J W Sonoco		1845 W Liberty St	Allentown	181045048	40.602600	-075.49900
Jack Brunner	Jacks Auto Trim	1446 N 18th St	Allentown	181041566	40.617500	-075.50490
Jim Kellar	Jims Chestnut Street Station	945 Chestnut St	Emmaus	180492021	40.529900	-075.50330
K & P Auto Parts	Mikes K P Auto Parts	5006 Chapmans Rd	Allentown	181049222	40.611800	-075.55870
Kelly Buick Inc	Kelly Car & Truck Center	P O Box 629	Emmaus	180490629	40.547700	-075.48990
Kelly Imports Inc	Kelly Mitsubishi	P O Box 749	Emmaus	180490749	40.548300	-075.49030
Kelly Jeep-Eagle Inc	Kelly Car/Truck Center	501 State Ave 23	Emmaus	180493027	40.547700	-075.48990
Kelly Saturn Inc	Saturn of The Valley	P O Box 629	Emmaus	180490629	40.549100	-075.49080
Kistlers Service Station		P O Box 84	Mertztown	195390084	40.489100	-075.66040
Kistlers Service Station		P O Box 84	Mertztown	195390084	40.489100	-075.66040
Krause Inc	Krause Toyota	P O Box 608	Fogelsville	180510608	40.585400	-075.64850
Krauss Auto Service		Rur Rte 1	Mertztown	195399801	40.502400	-075.68990
Krauss Auto Service		Rur Rte 1	Mertztown	195399801	40.502400	-075.68990
Kuhnsville Car Wash		5627 W Tilghman St	Allentown	181049383	40.583800	-075.55180
Mad Waxer		613 N Saint George St	Allentown	181044169	40.604400	-075.49950
Magic Clean		4836 Buckeye Rd	Emmaus	180491031	40.490400	-075.51810
Mikes Auto Collision		3720 Allen St	Emmaus	180491801	40.544800	-075.50360
Mikitz Gordon St Collision Ctr	Gordon Street Auto Body	229 W Gordon St	Allentown	181023122	40.610700	-075.46370
Nader Bros Exxon		1510 W Tilghman St	Allentown	181022036	40.607100	-075.49330
No 1 Service Center		1637 W Tilghman St	Allentown	181022053	40.606300	-075.49610
Norman Krauss	K & S Garage	50 Haas Rd	Mertztown	195398712	40.489100	-075.66040
Norman Krauss	K & S Garage	50 Haas Rd	Mertztown	195398712	40.489100	-075.66040
Outten Chevrolet Inc		P O Box 688	Allentown	181050688	40.606100	-075.49710
Parker Inc	Hale Trailer Brake & Wheel	P O Box 3305	Allentown	181060305	40.579000	-075.57960
Paul Auto Service	Pauls Auto Service	P O Box 114	Mertztown	195390114	40.489100	-075.66040
Paul Auto Service	Pauls Auto Service	P O Box 114	Mertztown	195390114	40.489100	-075.66040
Persing Auto Bdy Mech Repr Sp	Amercian Parkway Auto Sales	301 W Union St	Allentown	181025417	40.602700	-075.46110
Peter Kemmerers Used Cars		950 N 7th St	Allentown	181021643	40.616100	-075.47860
Pine Ridge Auto Inc		130 State Ave	Emmaus	180493020	40.543000	-075.48660
Pine Ridge Auto Sales Inc		126 State Ave	Emmaus	180493020	40.542900	-075.48660
Pioneer Glass & Mirror		106 Main St	Emmaus	180494009	40.539800	-075.48710
Queens Auto Body Inc		5629 Buckeye Rd	Macungie	180621740	40.518800	-075.53500
Randolph Toth	Randys Gulf	506 State Ave	Emmaus	180493028	40.547800	-075.48990

Robert J Ganci	Ganci Exxon Service Center	917 N 4th St	Allentown	181021805	40.617100	-075.47190
Ronald J Gerlach Inc	Coachworks	1546 N 18th St	Allentown	181041559	40.619100	-075.50570
Rothrock Motor Sales Inc		& 15th St RR 22	Allentown	18104	40.601600	-075.52260
Rudy & Sons Inc	Emmaus Texaco	1137 Chestnut St	Emmaus	180491904	40.528300	-075.50680
Ruhe Motor Corporation		15 W Tilghman St	Allentown	181025128	40.616400	-075.45940
Ruhe Motors Inc		1501 W Tilghman St	Allentown	181022035	40.607300	-075.49300
Saturn of Valley		P O Box 629	Emmaus	180490629	40.607100	-075.47790
Schearer Sales & Service Inc		116 Chestnut St	Mertztown	195399115	40.352500	-075.63150
Schearer Sales & Service Inc		116 Chestnut St	Mertztown	195399115	40.352500	-075.63150
Schmoyers Auto Body Repair	Auto Body Specialists	3893 Tank Farm Rd	Emmaus	180491009	40.490400	-075.51810
Scott Chevrolet Inc	Scott Lot	606 State Ave	Emmaus	180493030	40.549500	-075.49110
Scott Chevrolet Inc	Scott Saab	3333 Lehigh St	Emmaus	18049	40.529300	-075.50070
Sellersville Rental & Leasing	Auto Mile Sales & Credit Co	17 Main St	Emmaus	180494006	40.540800	-075.48660
Smith Auto Sales & Garage		8595 Mertztown Rd	Mertztown	195399406	40.522500	-075.62540
Smith Auto Sales & Garage		8595 Mertztown Rd	Mertztown	195399406	40.522500	-075.62540
Spectrum Cycles Inc		1190 Dorney Rd	Breinigsville	180311123	40.548000	-075.65880
Sports Chalet Inc		1535 Hausman Rd	Allentown	181049349	40.583800	-075.55180
Star Enterprise	Texaco Food Mart	1537 N Cedar Crest Blvd	Allentown	181042302	40.611300	-075.53280
Sterners Used Cars		99 Five Points Rd	Mertztown	195399215	40.489100	-075.66040
Sterners Used Cars		99 Five Points Rd	Mertztown	195399215	40.489100	-075.66040
Sunoco	A Plus 7307	240 N Route 100	Breinigsville	180311506	40.585600	-075.60690
Supreme Auto Body Works Inc		2011 Walbert Ave	Allentown	181041434	40.616600	-075.50880
TC Motor Car Inc	Lexus of Lehigh Valley	133 State Ave	Emmaus	180493019	40.543000	-075.48660
Top Star Enterprises Inc	Exxon	14 E Main St	Emmaus	180494013	40.541200	-075.48650
Topper Petroleum Company Inc		14 E Main St	Emmaus	180494013	40.541200	-075.48650
Top-Star Inc		14 E Main St	Emmaus	180494013	40.541200	-075.48650
Top-Star Inc	19th & Ross	1325 N 19th St	Allentown	181042720	40.615100	-075.50620
Total Prfmce Collision Ctr		8951 Hamilton Blvd	Breinigsville	180311230	40.561600	-075.62670
Trevin Inc	Par 4 Golf Car Sales & Service	P O Box 3363	Wescosville	181060363	40.557500	-075.55330
Trexler Plaza Inc		P O Box 307	Fogelsville	180510307	40.583800	-075.55180
Triple K Enterprises Inc	West End Service	2114 W Hamilton St	Allentown	181046403	40.593900	-075.50140
Tru 2 Form Corp	Valley Automotive Services	P O Box 249	Fogelsville	180510249	40.585400	-075.64850
USA Auto Center Inc		421 State Ave	Emmaus	180493025	40.546300	-075.48880
Vinart Enterprises Inc	Lehigh Valley Acura	675 State Ave	Emmaus	180493029	40.550700	-075.49180
Wendling Restorations		5729 Buckeye Rd	Macungie	180621727	40.531200	-075.54770
West End Sales & Service		2746 Walbert Ave	Allentown	181042441	40.615900	-075.52650

William Roy	Hydrex Sales-Autocrafters	P O Box 87	Emmaus	180490087	40.551300	-075.48370
Yeagers Fuel Inc	Pacific Pride	1431 W Green St	Allentown	181021233	40.608300	-075.49220
Zellers Service Center		741 N Cedar Crest Blvd	Allentown	181043409	40.596500	-075.52550

Appendix 6-1

Septic System Management and Regulation

Sewage Enforcement Plans

Act 537, enacted by the Pennsylvania legislature in 1966, requires every municipality to develop and maintain an up-to-date sewage enforcement plan.[84] DEP's Water Program can reimburse up to 50 percent of the implementation costs.

Although DEP has the statutory and regulatory power to require these plans, municipal governments (such as a township board of supervisors, borough council or city council) are charged with developing and implementing an approved official sewage facilities plan that addresses existing or anticipated sewage disposal needs or problems. These plans may be updated when the municipality determines that the current plan is inadequate to meet the municipality's needs, or when DEP deems that a revision is necessary. In many cases, the plans are updated when new subdivisions are proposed. A municipality is responsible for administering its sewage disposal plan, and for operating and maintaining existing sewage facilities.[85] Many communities may not have completed the plans, however, according to interviews with the sewage enforcement officers, who are charged with overseeing the installation and compliance of on-lot septic systems (SEOs).

A resident of or a property owner in a municipality may request that DEP order the municipality to revise or implement its official plan. The resident or property owner must be able to show that the official plan is not being implemented; is inadequate to meet the resident's or property owner's needs; or that existing sewage facilities within the municipality are not being properly operated and maintained. This demand can only be made after a prior written demand had been submitted to the municipality, followed by either a written refusal from the municipality or a failure by the municipality to respond to the complainant within 60 days.

If DEP orders the municipality to revise or implement its official plan, the municipality and the DEP will work out a timetable. If the municipality fails to revise or implement its plan within an acceptable time period, the plan will be placed in a disapproved status.

On-Lot Sewage Disposal Systems

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[84]The sewage disposal regulations of Pennsylvania's Department of Environmental Protection (DEP) are described in Title 25, Chapter 71 of the Commonwealth of Pennsylvania Code. They are promulgated under the Pennsylvania Sewage Act (Act 537).

[85]Act 537 of 1966, as amended; Pennsylvania Code, Title 25, ß 71.11, 71.12, and 71.71.

Responsibilities for on-lot sewage disposal systems lie with local agencies. They are responsible for investigating and resolving any disputes or malfunctions. A local agency may be any local government agency (such as a single municipality, a combination of municipalities, or a county or joint county Department of Health) that is able to administer its on-lot sewage disposal permit program. The local agency employs one or more certified SEOs to issue, deny, or revoke septic system permits in accordance with state regulations and standards; inspect newly-installed systems to ensure proper installation; and investigate and resolve septic system malfunctions. SEOs have jurisdiction over on-lot sewage systems that have a capacity of 10,000 gallons a day or less. SEOs also have jurisdiction over any individuals or restaurants that discharge directly into streams.

DEP provides grants and reimbursements to local agencies and SEOs for permitting and other enforcement activities. DEP may issue a formal order to any municipality that does not adequately administer its sewage disposal program, or it may place the municipality's plan in disapproved status. Disapproved status means that a limitation will be placed on the issuance of on-lot system permits and that the Department will not issue any further permits that may be needed under the Clean Streams Law.[86]

Complaints about malfunctioning on-lot septic systems should be reported directly to the local agency, SEO, or the local government officials with jurisdiction in the municipality where the malfunction exists. Depending on the local agency, complaints may have to be received in writing.

The SEO will conduct an initial site investigation to document the conditions. If there is a malfunction, the SEO will try to determine the causes of the malfunction and to decide the extent of the repair needed. The local agency may issue a letter notifying the property owner of the alleged malfunction and allowing for voluntary compliance if a malfunction exists, or, he or she may issue a Notice of Violation. A Notice of Violation requires the submission of a sewage permit application for proper system repair.

After any necessary site testing has been done and an acceptable system design has been submitted, the SEO will issue the responsible property owner a permit to repair or replace the malfunctioning system,. If the responsible property owner fails to repair the malfunction, the SEO has the authority to fine or pursue legal action against the responsible property owner.

If the SEO fails to respond to the complaint in a satisfactory manner, the person making the complaint should go back to the local agency and renew the complaint. DEP will only take action if there is a pattern of unresponsiveness on the part of an SEO or municipality. DEP action could include the suspension or revocation of an SEOs certification or the withholding (or

[86]Act 537 of 1966, as amended; Pennsylvania Code, Title 25, ß 71.12, 71.32, 71.73, 71.74.

reduction) of a local agency's reimbursement for the administration of the on-lot septic system program.

Role of SEOs in Berks County

In Berks County, there is approximately one SEO for each municipality. Many municipalities hire engineering firms to perform the functions of the SEO.

Procedures for Further Funding

Under PA Act 537, DEP provides up to 50 percent reimbursement for sewage improvements based on Plans developed by communities. A community must first develop such a plan to be considered for funding. James Novinger of the DEP at (717) 705-4707 is a contact for discussing the plan writing and funding process for small communities.

Appendix 8-1
Biography of Selected Nutrient References

Beegle. D.B. 1997. *Agronomy fact 54 Pennsylvania's nutrient management act: who will be affected?* Penn State University. University Park, PA. 4 pp.

Describes PA 1993 Nutrient Management Act and what farms will be affected. Farms with an animal density of 2 animal equivalent units per acre are required to submit nutrient management plans.

Beegle. D.B. 1997. *Agronomy fact 55 Estimating manure application rates*. Penn State University. University Park, PA. 4 pp.

Describes how to manage manure to optimize the economic returns and minimize the potential environmental impact. Includes tables and worksheets for a variety of animal operations.

Beegle, D.B., L.E. Lanyon and J.C. Myers. 1997. *DRAFT Manure management for environmental protection: field application of manure.* Penn State University and USDA-NRCS. University Park, PA. 42 pp.

A detailed manual describing the approved manure management practices which will allow application of animal manure to land for agronomic production without first obtaining a permit ofrom the PA Department of Environmental Resources. The approach is based on using only the rate to cropland that will supply the amount of nutrients the crop needs for realistic yields.

Beegle, D.B., L.E. Lanyon and D.D. Lingenfelter. 1997. *Agronomy facts 40 nutrient management legislation in Pennsylvania: a summary of the final regulations.* Penn State University. University Park, PA. 8 pp.

Describes the main points of the PA Nutrient Management Act and the regulations.

Eghball, B and J.F. Power. 1994. *Beef cattle feedlot manure management.* J. of Soil and Water Conservation. Mar.-Apr. pp. 113-121.

Provides an overview of beef feedlot manure management on a national basis, efficiency of manure management practices and environmental considerations.

Ferguson, G.A., S.D. Klausner and W.S. Reid. 1989. *Nitrogen management for water quality.* Cornell Cooperative Extension Fact Sheet Series. Pg. 103.00. Cornell Unversity, Ithaca, NY. 4 pp.

Basic overview of nitrogen cycle, agricultural and environmental consequences of nitrate mobility, and implications for fertilizer management.

Ferguson, G.A. and W.S. Reid. 1987. *Sampling soils for soil-test nutrient analysis and recommednations.* Cornell Cooperaitve Extension Fact Sheet Series. Pg. 100.00. Cornell Unversity, Ithaca, NY. 4 pp.

Describes the use of chemical soil tests for agricultural production, soils information, Cornell soil testing program and procedures for obtaining soil samples.

Hall, D.W. and D.W. Risser. 1993. *Effects of agricultural nutrient management on nitrogen fate and transport in Lancaster County, Pennsylvania. Water Resources Bulletin. 29(1):55-76.*

Examines the inputs and outputs of nitrogen on a 55 acre farm site and the impact of nutrient management on nitrate levels in ground and surface waters. Results indicate a significant reduction in nitrate levels, however, they were still considerably above the MCL for drinking water.

Jacobs, E. 1995. *PSNT saves money-the pre-sidedress nitrogen test can cut fertilizer costs and control problems created from excess nitrogen*. American Agriculturist. 5:5.

Use of the pre-sidedress nitrogen test (PSNT) has proven to be 80% accurate and studies by Cornell show savings of $14,642 per farmer or $12/acre. The PSNT determines the availability of plant useable N close to the time when plants need it most.

Klausner, S.D. 1997. *Nutrient Management: crop production and water quality*. Info. NRAES 101. Cooperative Extension, Cornell University, Ithaca, NY. 40 pp.

A complete guide describing nutrient management for crop production and water quality protection including: nutrient balance, nutrient cycling, nutrient behavior, testing, and field management. Excellent graphics, tables and examples.

Klausner, S.D. 1992. *A pre-sidedress nitrogen soil test for corn.* What's Cropping Up? Vol. 2:1, Cornell University, Ithaca, NY. 2 pp.

An early discussion of the PSNT approach, prior to the development of the quick field testing equipment available today.

Klausner, S.D. 1995. *Fine tune your fertilizer program for corn..* What's Cropping Up? Vol. 5:1, Cornell University, Ithaca, NY. 2 pp.

Briefly describes the results of corn fertilizer responses in field trials and verifies the importance of following fertilizer recommendations based on soil testing.

Klausner, S.D. 1995. *Nutrient management strategy..* What's Cropping Up? Vol. 5:3, Cornell University, Ithaca, NY. 2 pp.

Briefly describes the important components of a good nutrient management program and the rationale for each.

Lanyon, L.E. 1994. *Dairy manure and plant nutrient management issues affecting water quality and the dairy industry. J. Dairy Science. 77:1999-2007.*

Describes the requirements of a statewide or regional dairy manure management to protect water quality from nutrient pollution from a theoretical perspective.

Lanyon, L.E. 1995. *Agronomy facts 38d A nutrient management approach for Pennsylvania: exploring performance criteria.* Penn State University. University Park, PA. 4 pp

Explores the concept of performance criteria for nutrient management in PA. Performance criteria is based on achieving results, not just implementing practices presumed to minimize pollution.

Lanyon, L.E. and D.B. Beegle. 1989. *The role of on-farm nutrient balance assessments in an integrated approach to nutrient management.* J. Soil and Water Cons. 44(5):164-167.

Describes a framework and importance of nutrient balance assessments (input/output) on farms, including a case study which illustrates the points.

Lanyon, L.E. and D.B. Beegle. 1993. *Agronomy facts 38-a A nutrient management approach for Pennsylvania: introduction to concepts.* Penn State University. University Park, PA. 4 pp.

Describes an introduction to the concepts of nutrient management in PA, including: decision-making, elements of the process, management strategy and time, performance criteria, and support for nutrient management.

Lanyon, L.E. and D.B. Beegle. 1993. *Agronomy facts 38-b A nutrient management approach for Pennsylvania: plant nutrient stock and flows.* Penn State University. University Park, PA. 8 pp.

Considers the concepts of nutrient stocks and flow on farms and their implication for nutrient mangement on regional or statewide basis. Also develops a classification system for farms into three nitrogen categories: 1) low nutrient status where manure available on the farm is not adequate to meet crop demands; 2) manure available could meet most, if not all of crop requirements; 3) manure exceeds crop demands.

Lanyon, L.E. and D.B. Beegle. 1993. *Agronomy facts 38c A nutrient management approach for Pennsylvania: nutrient management decision-making..* Penn State University. University Park, PA. 8 pp

Discusses the elements of nutrient management decision-making including strategic, tactical, and operational. Strategic focuses on comprehensive planning, while tactical focuses on implementation, and operational is an activity of the farm manager to direct farm labor in specific task.

Lichtenberg, E., J.C. Hanson, A.M. Decker and A.J. Clark. 1994. *Profitability of legume cover crops in the mid Atlantic region.* J. Soil and Water Cons. 49(6)582-585.

Data from agronomic field trials in Maryland were used to construct nitrogen response functions for no-till corn following four cover crops and winter fallow.

NRAES. 1996. *Animal agriculture and the environment. Nutrients, pathogens, and community relations.* Proceedings from the Animal Agriculture and the Environment North American Conference. Publ. NRAES-96. Cooperative Extension, Cornell University, Ithaca, New York. 386 pp.

Provides an in-depth view of animal agriculture and environmental concerns including: pathogens, nitrogen and phosphorus impacts, manure handling to protect the environment, neighbor relations, economic considerations, composting, and a number of case-studies and examples.

NRAES. 1996. *Nutrient management software.* Proceedings from the Animal Agriculture and the Environment North American Conference. Publ. NRAES-100. Cooperative Extension, Cornell University, Ithaca, New York. 60 pp.

A supplement to NRAES-96, describing available nutrient management software from Cornell, Penn State, and other institutions, with detailed information of what the software includes and how to use it.

NRAES. 1997. *Nutrient management workbook.* Publ. NRAES-102. Cooperative Extension, CornellUniversity, Ithaca, New York. 17 pp.

Farmer nutrient management workbook prepared by Cornell and compatible with soil analysis and nutrient recommendations from the Cornell soil testing program.

NRAES. 1997. *Estimating a mass nutrient balance.* Publ. NRAES-103. Cooperative Extension, Cornell University, Ithaca, New York. 8 pp.

This is a set of worksheets to be filled out by a producer to determine the nutrient inputs/outputs or mass balance on the farm. Completing a mass balance will help the producer to make better management decisions, improve profitability through reduce fertilizer and feed costs, and improve crop production.

PA Dept. of Environ. Protection. 1994. *Manure management for environmental protection.* Bureau of Soil and Water Conservation. Harrisburg, PA 717-782-4403

PA guidelines for manure management for compliance with the statewide nutrient management law. Includes an introduction to nutrient management, properties of manure, recommended manure application methods, timing, and rates, management systems, planning, and managing excess manure.

Pacenka, S., M.J. Heather, K. Porter, K. Hoover, B. Silverman, and L. Maller. 1984. *Protecting ground-water supplies in river valley communities.* Cornell Cooperative Extension Publ. 131, Cornell University, Ithaca, NY. 28 pp.

Provides an overview of groundwater behavior, flow, contamination from nitrate sources, and protecting pubic drinking water supplies.

Trautman, N.M., K.S. Porter, and R.J. Wagenet. 1989. *Nitrogen: the essential element.* Fact Sheet. 400.06. Cornell University, Ithaca, NY. 4 pp.

A basic discussion of nitrogen cycles, sources, fate and transport in the environment. Includes a short discussion of agricultural considerations and best management practices to reduce nitrate contamination.

Van Es, H., S.D. Klausner, and W.S. Reid. 1991. *Nitrogen and the environment*. Info. Bull. 218. Cornell University, Ithaca, NY.

A similar article as Trautman (1989), but includes a more in-depth discussion of agricultural nitrogen management.

_______. 1990. *Soil nitrate-nitrogen test kit.* Spectrum Technologies, Plainfield, IL.

Directions for using the PSNT kit, interpreting results and making nitrogen fertilizer recommendations based on the results.

Westmoreland Conservation District. 1994. *Making nutrient management work for you-Getting more from animal manure and fertilizer*. Greenburg, PA. 13pp.

A basic guide for farmers on nutrient management. Describes ten easy steps to develop a nutrient management plan: 1) test soil; 2) test manure; 3) credit residual N from previous crops/manure; 4) determine nutrients in manure; 5) how/when to apply manure; 6) what manure rate; 7) determine fertilizer needs; 8) calibrate spreader; 9) consider erosion/runoff; 10) yearly review of plan.

Wright, P. 1995. An even spread is a better spread. What's Cropping up? Vol. 5:1. Cornell University, Ithaca, NY. 2 pp.

Describes the importance of managing manure like fertilizer and making sure it is spread evenly to maximize fertilizer value.

Web Sites:

Penn State Nutrient Management:

http://www.cas.psu.edu/docs/CASDEPT/AGRON…XTENSION/NMPennState/NMPennStateHome.html

Includes a number topics on nutrient management and links to other agencies and sources of information. The home page includes: 1) agronomy fact sheets (summaries of above Beegle and Lanyon articles); 2) Pennsylvania interagency newsletter; 3) Farm economic newsletter; 4) registration for workshops; 5) nutrient management planning; 6) other nutrient mgt. Web sites; 7) Penn State Agronomy.

Purdue University's Conservation Technology

http://ctic.pudue.edu

Provides a number of pages on conservation technology and best management practices, research papers, and special topics of interest including nutrient management