LITTLE LEHIGH CREEK WATERSHED

- ACT 167 -

STORM WATER MANAGEMENT PLAN

UPDATE

This is the text prepared by the Lehigh Valley Planning Commission on behalf of Lehigh County and Berks County. It contains revisions, as necessary, based on comments received from the Little Lehigh Creek Watershed Advisory Committee, the Little Lehigh Municipal Engineers Committee, the Little Lehigh Lawyers Advisory Committee, the affected municipalities, the general public, the Berks County Planning Commission and the Lehigh County Board of Commissioners.

The preparation of this report was financed through the Pennsylvania Storm Water Management Grant Assistance Program administered by the Department of Environmental Protection. This grant program provides for seventy-five percent (75%) State funding with twenty-five (25%) local match provided by Lehigh County.

Final Plan June 1999
Adopted by Lehigh County September 1999
Adopted by Berks County November 1999
Approved by DEP June 2000

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CHAPTER 1. INTRODUCTION

The Pennsylvania Storm Water Management Act, Act 167 of 1978, provides the framework for improved management of the storm runoff impacts associated with the development of land. The purposes of the Act are to encourage the sound planning and management of storm runoff, to coordinate the storm water management efforts within each watershed and to encourage the local administration and management of a coordinated storm water program. The Act also specifies the need to periodically update plans. This guarantees a dynamic system of runoff control sensitive to changing study area characteristics. The original *Little Lehigh Creek Watershed Act 167 Storm Water Management Plan* was adopted by Lehigh County in March 1988. This update incorporates significant hydrologic changes in the watershed and analyzes the effectiveness of the original Plan in minimizing the runoff impacts of new development.

Prior to adoption of the original Act 167 Plan, storm water management decisions were made at the municipal level through enforcement of local ordinances based upon whatever storm runoff control philosophy each of the 13 Lehigh and Berks county municipalities opted to use. Because this fragmented system does not allow for or require analysis of impacts beyond municipal boundaries, adequate runoff control at-site in one municipality could have a detrimental impact on a municipality downstream. The Act 167 Plan includes an evaluation of how sites relate to the entire watershed in terms of the timing of peak flows, contribution to peak flows at various downstream locations and the impact of the additional runoff volume generated by development of sites. To effectively implement an Act 167 program it is necessary to understand the following strengths and limitations of the process:

Strengths

- An Act 167 Plan provides a watershed-wide analysis of runoff impacts associated with new land development to address the needs of all watershed municipalities.

- An Act 167 Plan provides engineering standards for individual site evaluation and design in a model ordinance applicable to all watershed municipalities.

- An Act 167 Plan retains the decision-making authority at the municipal level for approval of drainage designs as part of the subdivision and land development process.

- This Act 167 Plan provides assistance to local municipalities in the consistent application of the design standards through an advisory, county-level engineering review. This review also provides greater assurances to local municipalities that the standards are being met throughout the watershed.

- An Act 167 Plan provides standards to help ensure that peak runoff flows throughout the watershed will not increase with development to help prevent the creation of new problem areas or the worsening of existing problems.

Limitations

- Storm runoff criteria are based on controlling “design” storm events applied uniformly over the entire watershed. Natural storms, which may vary in duration, intensity, total depth of rainfall throughout the watershed and pre-storm conditions such as frozen ground and snow or ice accumulation, may, in certain instances, create runoff events which cannot be effectively controlled.

- The runoff control standards developed as part of an Act 167 plan will not correct existing drainage problem areas.

- An Act 167 plan will not prevent the inundation of floodplain areas. These areas are intended by nature to carry storm runoff.

It is also important to understand that an Act 167 plan is not a land use plan. Runoff controls developed in the Plan are not based upon controlling the location, type, density or rate of development throughout the watersheds. The storm water runoff performance standards are based on the assumption that development will occur throughout the watersheds. The Plan is designed to provide for new development yet control the associated storm runoff impacts.

The most important aspect of an Act 167 plan is that it establishes a process for decision-making. It establishes the existing interrelationships between the various parts of a watershed in terms of peak flows and the “timing” of those peak flows. The peak flows and timing relationships provide for development of a runoff control philosophy geared towards minimizing the storm runoff impacts of new development.

Act 167 is essentially a three-step process of runoff control which works as follows:

1 - Documentation of the existing state of storm runoff in the study area. Included herein is the documentation of the existing physical characteristics of the study area (e.g. land use, soils, slopes, storm sewers, etc.), documentation of existing storm drainage problems and flow obstructions, and documentation of the peak flow and timing relationships. The existing condition establishes the baseline situation against which all runoff control measures will be judged.

2 - Preparation of the Plan to control storm runoff from new development. The Plan includes runoff control performance standards for new development *and* a process for site specific evaluation and design. The performance standards do not dictate the control methods to be used but rather will indicate the necessary end product. The runoff control philosophy is designed to prevent new problem areas from developing.

3 - Development of priorities for implementation. With the accomplishment of the first two aspects of the Act 167 process the third aspect involves developing a prioritized list of actions aimed at improving the current state of storm runoff in the study area. Essentially,

this means preparing a strategy for dealing with the existing storm drainage problem areas within each municipality.

One especially important aspect of the Act 167 process is the need to periodically update the plan. Act 167 specifies that a plan must be updated every five years. This guarantees a dynamic system of water control sensitive to changing study area characteristics.

The "Little Lehigh Creek Watershed - Act 167 - Storm Water Management Plan Update" has been prepared for Lehigh and Berks Counties by the Lehigh Valley Planning Commission. Lehigh County has designated the LVPC to prepare the watershed plans for all watersheds on its behalf.

To ensure the involvement of the municipalities and agencies which will be impacted by the Storm Water Management Plan, Act 167 requires that a Watershed Advisory Committee be formed. The purposes of the Committee are to assist in the development of the Plan and familiarize the municipalities involved with the storm water management concepts evolving from the Plan process. Each municipality in the study area plus the County Conservation District are required to be represented on the Committee. Representation by additional agencies and interest groups is optional at the discretion of the County. Listed in Table 1 are the names and affiliations of the persons who participated on the Little Lehigh Creek Watershed Advisory Committee:

TABLE 1
LITTLE LEHIGH CREEK WATERSHED ADVISORY COMMITTEE

Municipality/Organization	**Name**
Lehigh County:	
Borough of Alburtis	Louise Stahley
City of Allentown	Richard H. Rasch
Borough of Emmaus	Daniel A. DeLong
Lower Macungie Township	William Erdman
Borough of Macungie	Lucy Ackerman
Salisbury Township	Janet B. Keim
South Whitehall Township	Gerald Gasda
Upper Macungie Township	Porter Krisher
Upper Milford Township	Linden Miller
Weisenberg Township	Thomas Wehr
Lehigh County Conservation District	Paul Sell
Natural Resources Conservation Service	Peter Zakanycz
Wildlands Conservancy	Chris Kocher
Berks County:	
Longswamp Township	Peter Evans
Maxatawny Township	Gary Englehardt
Borough of Topton	K. Ray Stauffer
Berks County Conservation District	John Ravert

At the request of DEP, two additional committees were added to the Little Lehigh update process. First, a Municipal Engineers Committee was organized consisting of the engineers who would be involved with implementing the plan. The purpose of this committee was to familiarize the municipal engineers with the technical background of the plan and with the design standards to be implemented in their municipalities. Second, a Lawyers Advisory Committee was organized to familiarize the municipal solicitors with the model ordinance which each municipality will be required to adopt. Tables 2 and 3 list each committee's participants and their affiliations.

TABLE 2
LITTLE LEHIGH CREEK MUNICIPAL ENGINEERS COMMITTEE

Municipality	Name	Organization
Lehigh County:		
Borough of Alburtis	Allison Bradbury	Martin, Bradbury & Griffith, Inc.
City of Allentown	Neal Kern	City of Allentown
Borough of Emmaus	Bryan Bollinger	McTish, Kunkel & Associates
Lower Macungie Township	William Erdman	Keystone Consulting Engineers, Inc.
Borough of Macungie	William Erdman	Keystone Consulting Engineers, Inc.
Salisbury Township	J. Ralph Russek, Jr.	G. Edwin Pidcock Company
South Whitehall Township	J. Ralph Russek, Jr.	G. Edwin Pidcock Company
Upper Macungie Township	Dean Haas	Keystone Consulting Engineers, Inc.
Upper Milford Township	Allen O'Dell	O'Dell Engineering Company
Weisenberg Township	Roy Stewart	Keystone Consulting Engineers, Inc.
Berks County:		
Longswamp Township		Hanover West Engineering Assoc.
Maxatawny Township		Weiser Engineering
Borough of Topton		Great Valley Consultants

TABLE 3
LITTLE LEHIGH CREEK LAWYERS ADVISORY COMMITTEE

Municipality	Name	Organization
Lehigh County:		
Borough of Alburtis	David Knerr	
City of Allentown	James Martin	
Borough of Emmaus	Jeffrey Bartges	
Lower Macungie Township	Blake Marles	
Borough of Macungie	Timothy Siegfried	
Salisbury Township	Maria Mullane	
South Whitehall Township	Blake Marles	
Upper Macungie Township	William Schantz	
Upper Milford Township	Marc Fisher	
Weisenberg Township	Emil W. Kantra II	
Berks County:		
Longswamp Township		O'Pake, Malsnee & Orwig
Maxatawny Township		O'Pake, Malsnee & Orwig
Borough of Topton		Rhoda, Stoudt & Bradley

The general framework for the Little Lehigh Creek Act 167 Plan has been developed from three sources, namely Act 167 itself, the DEP Storm Water Management Guidelines, which represent the Department's interpretation of the Act, and the several pilot watershed studies performed prior to the initiation of the State's regular program.

The basic methodology used to quantify the watershed rainfall-runoff response function and to develop the runoff control criteria for new development has been adapted to the Little Lehigh Creek Watershed from the original Little Lehigh Plan and other Act 167 Studies done in Lehigh and Northampton Counties.

As part of the development of the Little Lehigh Creek Plan update, the LVPC has used the Geographic Information System (G.I.S.) and the ArcInfo Software. The existing land use data was digitized in to the LVPC system. Land use, soils and zoning coverages were also used in the watershed modeling process.

CHAPTER 2. STUDY AREA CHARACTERISTICS AND HYDROLOGIC RESPONSE

A. General Characteristics

The Little Lehigh Creek is a major tributary to the Lehigh River and is located within the Delaware River Basin. The confluence of the Little Lehigh Creek and Lehigh River is located within the City of Allentown approximately 16 miles upstream of the Lehigh and Delaware Rivers confluence. A location map of the study area is presented in Figure 1 with the municipal boundaries highlighted. The study area has a drainage area of 107.5 square miles, 88.8 square miles of which are located within Lehigh County and 18.7 square miles of which are located in Berks County. Six major tributaries plus the mainstem Little Lehigh comprise the study area as shown in Figure2. Drainage areas of the six tributaries and the mainstem are listed in Table 4.

TABLE 4
LITTLE LEHIGH CREEK WATERSHED DRAINAGE AREA BY TRIBUTARY

Watershed	Drainage Area (Square Miles)
Toad Creek	8.94
Schaefer Run	23.79
Swabia Creek	12.37
Leibert Creek	6.37
Cedar Creek	15.08
Trout Creek	8.08
Mainstem	32.87
Total Watershed	107.50

A seventh major tributary, the Jordan Creek, is large enough (82 sq.mi.) that it has been designated for a separate Act 167 study and will not be addressed herein.

The headwaters of the Little Lehigh Creek are underlain by the noncarbonate rocks of the Reading Prong within Berks County but the Lehigh County geology is dominated by the Beekmantown and Allentown limestone formations of the Great Valley section of the Valley and Ridge Physiographic Province. South Mountain is the most prominent Lehigh County representation of the Reading Prong and forms the boundary of the Little Lehigh Creek Basin to the south and east.

The topography of the limestone-underlain portion of the watershed is a low, gently rolling land surface containing a high degree of closed depressions. Approximately one-third of the closed depressions are Karst features associated with solution of the carbonate rock. The remaining two-thirds of the closed depressions in the basin are glacial and quarrying

FIGURE 1
LITTLE LEHIGH CREEK STUDY AREA
LOCATION MAP

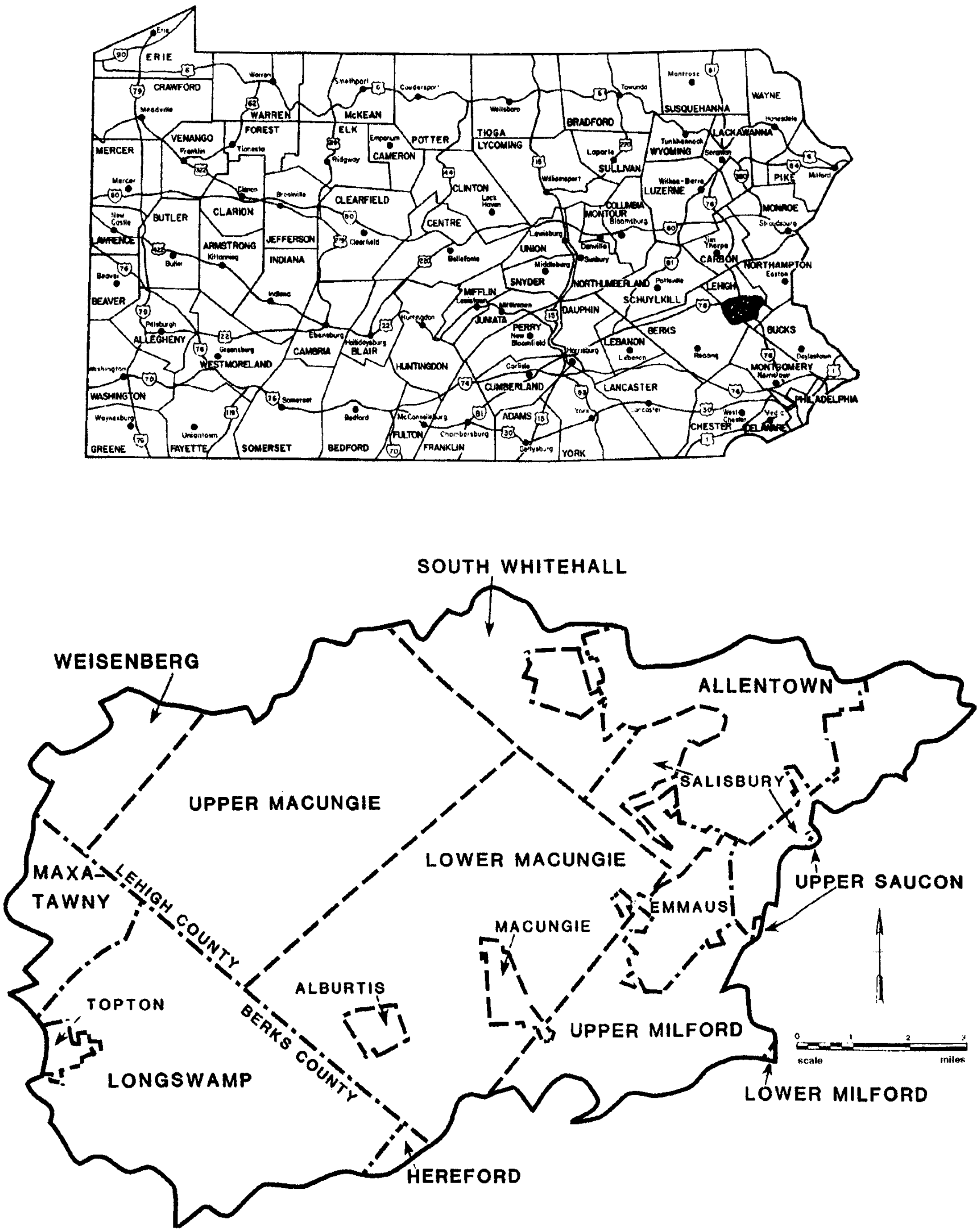


FIGURE 2

Figure 3
Geology

features. The extent to which storm water runoff drains to closed depressions has an impact on the rainfall-runoff relationship especially with regard to drainage into sinkholes. Characteristic of the main branch of the creek are the well-developed meanders associated with a mature stream in carbonate terrain. The western mainstem is also characterized by a very flat broad floodplain with long-standing ponds and pools after rainfall events.

The predominant soils found in the Little Lehigh Creek Watershed are classified into Hydrologic Soil Group B. Hydrologic Soil Groups (HSG's) are classifications which indicate the relative runoff potential of soils based on infiltration rates for various soil types. Runoff potential increases with decreasing infiltration rates as you progress from HSG A to HSG D soils. HSG A soils are sandy soils with high infiltration rates and low runoff potential. There are no HSG A soils within the Little Lehigh Creek Watershed. Group B soils, which make up 90% of the watershed, have moderate infiltration rates and consist mostly of moderately deep well drained soils. Group C soils, which make up 8% of the watershed, have low infiltration rates. The group consists mostly of soils which impede the downward movement of water. Group D soils, which make up 2% of the watershed, have very low infiltration rates and therefore high runoff potential. The group consists mostly of soils with a clay layer and a permanent high water table. Hydrologic Soil Groups are one element used in determining runoff curve numbers and Rational 'c' values. A map of the study area soils by HSG is included in the map jacket at the end of Chapter 3.

Average annual precipitation in the Little Lehigh Creek Watershed during the period 1951-1980 was 44.31 inches. Average annual streamflow during the period 1946-1986 was calculated to be 15.82 inches, or 35.7% of the average annual precipitation. Evapotranspiration for the basin has been estimated at an annual average of 26.4 inches for the period 1946-1962 and at an annual average of 20.1 inches for the period 1975-1983.

The Little Lehigh Creek Watershed is used extensively for water supply purposes. The City of Allentown obtains water directly from the creek, the Lehigh River and Crystal and Schantz springs at a combined 1997 average use of approximately 19 million gallons per day. Suburban municipalities rely on groundwater withdrawals from the basin totaling more than 7 million gallons per day in 1997. Rural areas continue to rely on individual wells.

Land use in the basin varies from predominantly urban land uses at the lower portion of the watershed (Allentown, South Whitehall, Salisbury and Emmaus) to predominantly rural land uses in the upstream areas (Maxatawny and Longswamp Townships in Berks county, and Weisenberg and Upper Milford Townships in Lehigh County). The mid-reaches of the wateshed include the relatively small, urbanized Boroughs of Macungie and Alburtis and the large rapidly urbanizing Upper and Lower Macungie townships.

The Department of Environmental Protection (DEP) has designated water quality criteria which are designed to protect the water uses within a given watershed. The Little Lehigh Creek has two water uses that are protected. One is the cold water fishes (CWF) category. This category helps to protect aquatic life in that it deals with the maintenance and/or propagation of fish species and flora and fauna which are native to cold water habitats. The other use deals with the special protection of high quality waters (HQ). High quality waters are considered as a stream or watershed with excellent quality water and environment features that require special protection.

The DEP criteria state that high quality waters are to be protected and maintained at their existing quality or enhanced unless it can be shown that any increased discharge of any pollutant is justified as a result of economic or social development which is of significant public value. The best available treatment and land disposal technologies must be used where economically feasible and environmentally sound. A comprehensive discussion of Best Management Practices and techniques to manage water quality impacts of new development can be found in the DEP *Pennsylvania Handbook of Best Management Practices for Developing Areas.*

B. Hydrologic Response

The United States Geological Survey (U.S.G.S.) has maintained a gaging station on the Little Lehigh Creek within the Little Lehigh Parkway since 1946. The station is located approximately 0.8 miles upstream of the confluence with Cedar Creek as shown on Figure 2 and monitors a drainage area of 80.8 square miles. Cedar Creek, Trout Creek and the lower 3.5 square miles of mainstem watershed area are not tributary to the gaging station. The gaging station records the depth of water in the creek at one-hour intervals which is very valuable for establishing the response of the watershed to a given rainfall event. Further, statistical analysis of the gaging station data can establish the probability of occurrence of flows of a given size (flows are determined from the depth data using an established depth-flow relationship for the stream segment in which the gage is located). The Log Pearson Type III probability relationship was applied to the 1946-1996 gaging station data for the Little Lehigh Creek Watershed. The resulting peak flow-return period correlation from that analysis is shown in Table 5.

TABLE 5
LITTLE LEHIGH CREEK U.S.G.S GAGING STATION FREQUENCY DATA*

Return Period	Peak Flow
2-Year	1,385 cfs**
5-Year	3,085 cfs
10-Year	4,796 cfs
25-Year	7,810 cfs
50-Year	10,808 cfs
100-Year	14,566 cfs

*Sources: U.S.G.S. stream gage data for station 01451500 1946-1996 and frequency analysis by Dr. Gert Aron.
** Cubic Feet per Second

Calibration of the hydrologic model involves the adjustment of certain parameters of the model to best reproduce actual conditions. To accomplish the calibration, adjustments were made to a variety of model parameters keyed most directly to the watershed geology and the type of flow in floodplain areas. Specifically, the limestone geology underlying a majority of the Little Lehigh Creek Watershed dictates adjustments to the measured lengths and slopes of overland runoff paths. These adjustments reflect more complicated (longer) and slower flow paths. Adjustments for floodplain areas were based upon the relative velocity of flow between the main channel and the adjacent floodplain. This relative velocity determines how flow in excess of channel capacities is translated through the watershed. Complete details on the calibration adjustments are listed in Plan Appendix A.

The WATERSHED computer model from Tarsi Software Laboratories was selected as the hydrologic model to be applied to the Little Lehigh Creek Watershed. Calibration of the model for design storm events resulted in peak flow values by return period as presented in Table 6. Table 6 shows that WATERSHED produced lower values compared to the frequency curve for the 100- and 25-year return periods and higher values for the 1-, 2-, 10- and 25-year return periods. All calibration adjustments were made systematically across all return periods to achieve the best overall fit for the range of storms studied. Since the study area can be considered homogenous (i.e. similar geology and topography), the same calibration adjustments were applied to each tributary in the study area. The U.S.G.S. gaging station frequency data along with the WATERSHED data at the gage location are presented graphically in Figure 4.

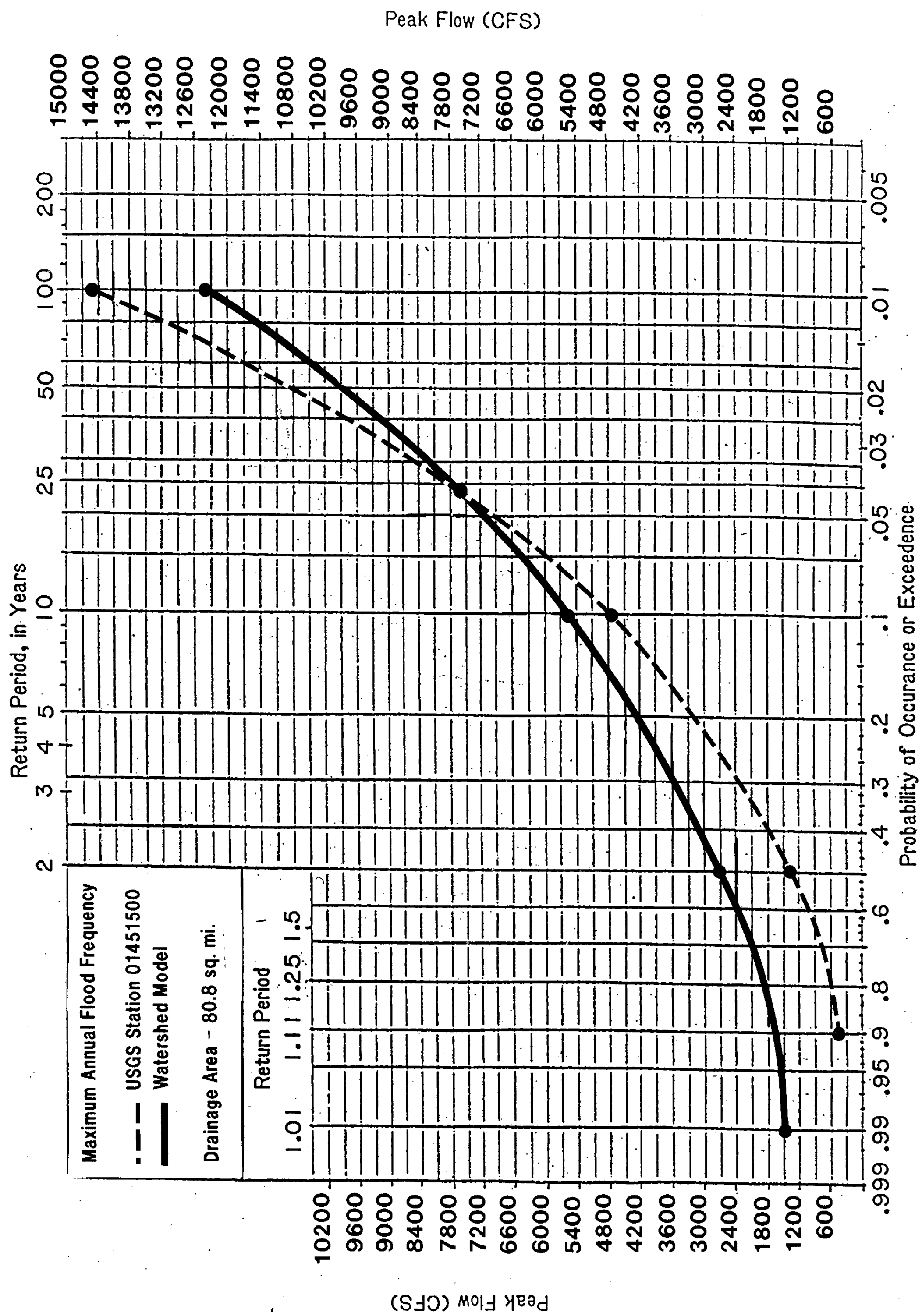
TABLE 6
CALIBRATED WATERSHED PEAK FLOW VALUES VERSUS FLOW TARGETS FROM GAGE DATA

Return Period	**Peak Flow, cfs**		**WATERSHED % Difference***
	WATERSHED	**GAGE DATA**	
1	1,501	455	229.9%
2	2,727	1,385	96.9%
10	5,671	4,796	18.2%
25	7,803	7,810	-0.1%
100	12,346	14,566	-15.2%

*WATERSHED percent difference calculated as the WATERSHED peak flow value minus the Gage Data flow value divided by the Gage Data flow value.

Note that from Table 6, WATERSHED over predicts the 2-year storm and under predicts the 100-year storm. The calibration adjustments that generated the peak flow values listed in Table 6 were accepted for two reasons. First, the frequency gage data is based on a 50 year period of record. In effect, the frequency analysis of the gage data predicts peak flows

Figure 4



Peak Flow (CFS)
Return Period, in Years
Probability of Occurance or Exceedence
Maximum Annual Flood Frequency
USGS Station 01451500
Watershed Model
Drainage Area - 80.8 sq. mi.
Return Period
Peak Flow (CFS)

using an average land use condition over the period of record. Using a constant rate of development, this would mean that the frequency curve may be more accurately predicting flows generated by an early 1970's land use condition, not a 1996 land use condition. Since WATERSHED was modeling a 1996 land use condition, it is reasonable to think that the WATERSHED peak flow values should be somewhat higher than the frequency data. The model could reasonably over predict by a larger margin for the lower return periods since the impact of land development is most noticeable for the more frequent events. In an attempt to further verify the model calibration, our consultant adjusted the frequency curve to represent a 1996 land use condition. The WATERSHED % difference for the 2-year storm when using the adjusted gage data as a target was approximately 45%. Second, a choice needed to be made to be closer to the 2-year target value or to the 25- and 100-year target values. Since ordinances most often require the use of the 25- and 100-year peak flow values when designing channels, storm sewers, culverts and bridges rather than the 2-year peak flow, the calibration attempted to be closer to the higher return period flow values since their accuracy will have a direct effect on designs.

CHAPTER 3. LITTLE LEHIGH CREEK WATERSHED LAND DEVELOPMENT AND RUNOFF IMPACTS

A. General Land Development Impacts of Storm Runoff

The necessity for the preparation of a storm water management plan is created by the fact that land development will, in general, cause a higher percentage of a given rainfall to become runoff. The primary reason for this is the increase in the amount of impervious cover on the land surface, i.e. roof areas, driveways, parking areas, roads, etc. Impervious cover does not allow rainfall to infiltrate into the ground. Rainfall which lands on impervious cover predominantly becomes runoff. The exception to this would be where impervious cover drains onto pervious areas which would provide for some infiltration. The percentage of impervious cover for a given development varies by the type of development. Table 7 below presents the "typical" percent imperviousness associated with the thirteen land use categories considered in this Plan.

TABLE 7
"TYPICAL" PERCENT IMPERVIOUSNESS BY LAND USE

Land Use	Percent Imperviousness
1. Woods	0
2. Open Space	0
3. Agriculture	0
4. Low Density Residential	20
5. Medium Density Residential	38
6. High Density Residential	65
7. Industrial	65
8. Commercial	72
9. Institutional	40
10. Large Impervious Areas	100
11. Water Bodies	100
12. Transportation Uses	30
13. Mining	0

The above typical percent imperviousness figures have been developed from standard Natural Resources Conservation Service[1] methodology. The breakdown between the three residential densities is as follows: low density—less than or equal to 2 units per acre; medium density—between 2 and 5 units per acre; high density—greater than or equal to 5 units per acre.

From Table 7, it is clear that the development of land which currently is in woods, open space, or agriculture could have a dramatic impact on the percentage of impervious cover. It

[1]On November 30, 1995, the Soil Conservation Service changed its name to the Natural Resources Conservation Service. When researching methodology or publications generated prior to this date, the author may still be listed as the Soil Conservation Service.

is also clear that the cumulative impact of this type of development for a rural area like the upper reaches of the Little Lehigh Creek Watershed could be severe without implementation of the proper runoff management controls.

An example of the impact of increases in the amount of impervious cover for a given watershed area is illustrated in Figure 5. The series of curves, or hydrographs, present the runoff response of the watershed area versus time for percent imperviousness ranging from 5% to 25% as generated using the Penn State Runoff Model. The watershed area used for the analysis represents a subarea size of 300 acres. The rainfall event used to produce the hydrographs was a two-hour storm of 1.3 inch depth.

From Figure 5, the peak runoff from the watershed area for 5% impervious cover is approximately 20 cfs (cubic feet per second). Further, each 5% increment in impervious cover produces an additional 20 cfs to the peak runoff such that 25% imperviousness produces 100 cfs peak runoff. If the 5% impervious cover hydrograph represented the "existing" condition of a watershed area, then each 5% increment of impervious cover would produce a 100% increase in the pre-development peak flow. In the Little Lehigh Creek Watershed approximately 46% (104 out of 226) of the watershed subareas (as delineated for modeling purposes) have existing impervious cover of 5% or less. Again, it is clear that the runoff impacts of development of these subareas could be significant.

The amount of impervious cover is not the only factor affecting the amount of runoff produced by a given land area. Irrespective of impervious cover, certain land uses produce more runoff than others for the same rainfall. The Natural Resources Conservation Service (NRCS) has researched the runoff response of various types of land uses, or land cover, and translated the results into a parameter called the runoff curve number. Simply described, the runoff curve number system is a ranking of the relative ability of various land use/cover types to produce runoff. Presented in Table 8 are the runoff curve numbers derived from NRCS which have been used in the Little Lehigh planning process. Higher curve numbers reflect a greater potential for producing runoff.

Figure 5
Impact of Impervious
Cover on Storm Runoff

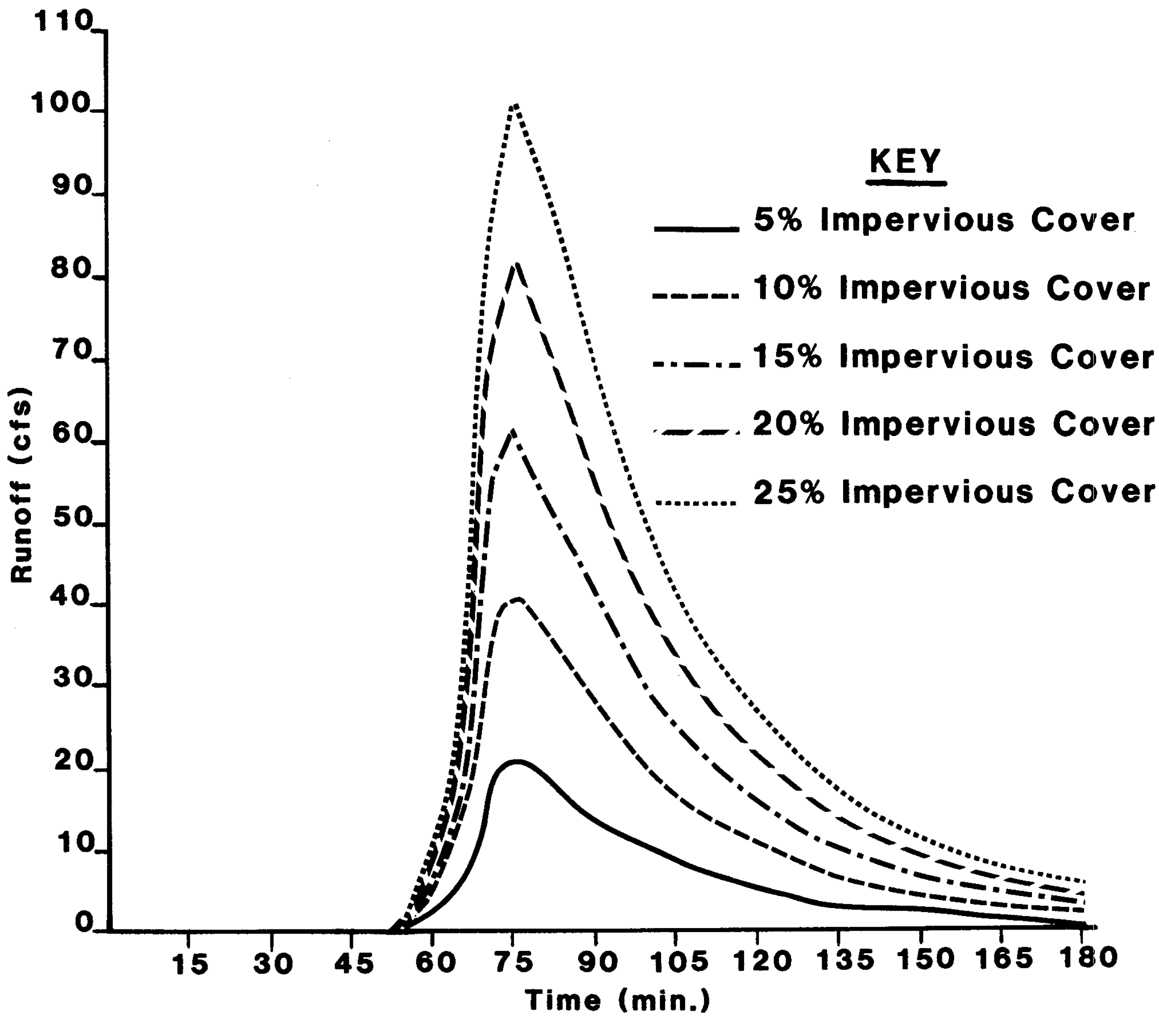


TABLE 8
RUNOFF CURVE NUMBER BY LAND USE CATEGORY*

	Land Use	Runoff Curve Number**
1.	Woods	55
2.	Open Space	61
3.	Agriculture	76
4.	Low Density Residential	68
5.	Medium Density Residential	75
6.	High Density Residential	85
7.	Industrial	83
8.	Commercial	87
9.	Institutional	76
10.	Large Impervious Areas	98
11.	Water Bodies	100
12.	Transportation Uses	72
13.	Mining	0

*Data is for Hydrologic Soil Group B.
**Curve Numbers reflect impervious cover percentages from Table 8.

Note from Table 8 that woods and open space have the lowest two curve numbers at 55 and 61, respectively, and both have zero percent impervious cover associated with them (from Table 7). Agriculture, however, even though it also has zero percent impervious cover, has a higher runoff curve number than both low and medium density residential land uses, which have 20% and 38% impervious cover, respectively.

It is not necessarily true from the above that agriculture will produce more runoff than low or medium density residential development, and in fact, agriculture can produce significantly less runoff than either one. Factors which affect this relationship are the type of crop, the planting method, the slope of the land, the average length of overland flow, the rainfall event and the method of computation, among others.

One final factor affecting the impact of development on storm runoff is difficult to quantify, but perhaps important in the Little Lehigh Creek Watershed. The carbonate geology underlying most of the study area has the characteristic of developing solution channels in the bedrock which can be manifested on the surface as closed depressions and sinkholes. In the "existing" condition, the closed depressions and sinkholes can prevent a significant amount of runoff from entering the stream channel. Closed depressions simply create ponds of water and sinkholes divert surface runoff to groundwater. The obliteration of these depressions and sinkholes with development can increase the storm runoff received by the stream beyond that anticipated by the curve number and percent impervious methodology.

The above-described impacts of development on storm runoff - impervious cover modification, curve number modification and removal of closed depressions - relate to the rate and volume of runoff generated from a land area. An additional potential impact of development, however, is in the manner in which the generated runoff is conveyed downstream. Associated with development may be the construction of a closed pipe system to convey the runoff or the encroachment of the development into the natural conveyance channel, or both. Closed pipe systems typically convey water faster than natural systems such that runoff is transported more quickly downstream. In addition, closed systems do not provide any opportunity for infiltration that exists with natural channels. Encroachment into the natural channel with development could take the form of fill on one or both sides, placement of structures or other modifications of the natural cross-section of the channel. The exact impact on the conveyance characteristics (i.e. depth, width, capacity, velocity) of the channel would depend on the type and extent of encroachment. A key aspect of the watershed plan is the ability of the conveyance facilities to maintain (or attain) adequacy for transporting anticipated runoff. Any modifications to the conveyance network associated with development should be accomplished in such a way as to provide for continuing transport of upstream flows in a safe and efficient manner.

B. Historical Little Lehigh Creek Watershed Development

Land development within the Little Lehigh Creek Watershed prior to 1970 could be described as fairly restricted urban/suburban growth in and around the City of Allentown where public sewage facilities were available. The four boroughs of Topton, Emmaus, Alburtis and Macungie were additional established urban areas but the latter two were inhibited in ther growth potential by the lack of public sewerage. The sewage interceptor network constructed in the early 1970's dramatically changed the growth pattern in the watershed by providing access to sewers in Upper and Lower Macungie Townships as well as Macungie and Alburtis Boroughs. The result has been that Upper and Lower Macungie Townships were two of the most rapidly developing municipalities in Lehigh and Northampton Counties in the 1970's, 1980's and 1990's. Table 9 presents a summary of the land development within the Little Lehigh Creek Watershed for the period 1972 through 1997 by municipality and by type of development. Data for the table has been obtained from LVPC land use records. Note that for municipalities which are not completely within the watershed, the land development figures have been estimated from the corresponding data from the entire municipality. Data is provided by residential, commercial and industrial land development types.

TABLE 9
LITTLE LEHIGH CREEK WATERSHED LAND DEVELOPMENT
1972-1997*
(ACRES)

Municipality	Residential	Commercial	Industrial	Total
Alburtis	51.6	4.7	0.0	56.3
Allentown**	182.1	91.5	35.6	309.2
Emmaus	122.7	41.2	19.0	182.9
Lower Macungie	1293.2	162.0	268.1	1723.3
Macungie	103.2	9.0	0.0	112.2
Salisbury	723.5	66.9	1.7	792.1
South Whitehall**	378.9	83.4	20.9	483.2
Upper Macungie	1042.6	235.2	1050.5	2328.3
Upper Milford**	780.3	5.2	3.7	789.2
Weisenberg**	1397.2	34.2	1.4	1432.8
Lehigh County Totals	6,075.3	733.3	1,400.9	8,209.5
Berks County Total***	n/a	n/a	n/a	2,074.8
TOTAL				10,284.3

*Source: LVPC Lehigh County Records.
**Represent approximated development figures for municipalities with significant areas outside of the Little Lehigh Creek Watershed.
***Berks County Total includes 34.4 acres in Hereford, 1870.6 acres in Longswamp, 125.6 acres in Maxatawny and 44.2 acres in Topton. Breakdowns of these arcreages by land use type were not readily available at the time of printing.

From Table 9, over 10,000 acres of land were developed within the Little Lehigh Creek Watershed over the 25 year period through 1997. For residential development, the acreages can be somewhat misleading in that the density of development may vary significantly between municipalities. The number of units constructed in a given municipality could be disproportionate to the acreage when compared with another municipality.

Development in place as of early 1996 represents the “existing” situation for the preparation of the Little Lehigh Creek Watershed Plan. The existing land use condition was generated using Lehigh County land use records, Allentown’s Geographic Information System land use data and field surveys. A map of the existing land use condition is included in the map jacket at the end of this chapter. Storm water runoff calculated based on the existing land use condition defines the goal of the watershed plan, i.e. no increase in existing peak flows throughout the study area. The “stress” applied to the system is the increase in impervious cover in the study area associated with new land development. Quantification of the stress requires an assumption of a future land use condition throughout the study area. Future land use condition assumptions used in the development of the watershed plan are discussed in the following section.

C. Future Little Lehigh Creek Watershed Development

Projection of a future land use condition for the purpose of determining the runoff impacts of new development is an essential part of the plan preparation process. Only through an understanding of the increase in both volume of runoff and peak rate of runoff associated with development of a watershed can a sound control strategy be devised. Typically, a future land use condition is identified for a given “design year”. The design year would be selected based upon the intended design life of the control strategy. Prudent storm water management would appear to dictate a design life consistent with full development of the watershed. Otherwise, the storm water management controls put in place today might quickly become outdated should development exceed expectations. Conversely, designing a runoff control strategy based upon the “ultimate” land use condition when that level of development may not occur for 10, 20 or even 40 years or more might appear somewhat impractical.

In an effort to help establish the merits of each approach, two future land use conditions, or scenarios, were investigated. The first is a design life-type scenario of estimating the anticipated development for a ten-year period (1998-2008). The second is a form of “ultimate” future land use based upon current zoning. Each of the scenarios is described below.

The land development projected over the period 1998-2008 based on the continuation of the historical development trend from 1972 through 1997 is presented in Table 10.

TABLE 10
LITTLE LEHIGH CREEK WATERSHED
PROJECTED LAND DEVELOPMENT 1998-2008*
(ACRES)

Municipality	Residential	Commercial	Industrial	Total
Alburtis	21	2	0	23
Allentown**	73	37	14	124
Emmaus	49	17	8	74
Lower Macungie	517	65	107	689
Macungie	41	4	0	45
Salisbury	289	27	1	317
South Whitehall**	152	33	8	193
Upper Macungie	417	94	420	931
Upper Milford**	312	2	2	316
Weisenberg	559	14	1	574
Lehigh County Totals	2430	295	561	3286
Berks County Total***	n/a	n/a	n/a	830
TOTAL				4116

*Source: Projected from LVPC 1972-1997 Lehigh County development records.
**Represent approximated development figures for municipalities with significant areas outside of the Little Lehigh Creek Watershed.
***Berks County Total includes 14 acres in Hereford, 748 acres in Longswamp, 50 acres in Maxatawny and 18 acres in Topton. Breakdowns of these acreages by land use type were not readily available at the time of printing.

Approximately, 4116 acres of additional land development would occur within the Little Lehigh Creek Watershed by the year 2008 using the historical trend assumption. By definition, the percentages of development by land use category and by municipality are identical to those described for the historical period.

Table 10 may provide a very reasonable estimate of the Little Lehigh Creek Watershed growth over the next decade. For storm water runoff purposes, however, it is missing a critical element. That is, within a given municipality, the table does not help identify where the growth may occur. As will be discussed in greater detail in subsequent chapters, the runoff control criteria will be developed for small individual watershed areas of approximately 300 acres average size. Obviously, when considering watershed areas this small, the “where” question becomes important. An exaggerated example would be that the 517 acres of residential development listed for Lower Macungie Township could occur in scattered fashion throughout residentially-zoned areas (i.e. scattered watershed areas) or could be concentrated in one or two of the 300-acre areas. The runoff control strategy devised to deal with these two situations could be very different.

The second future land use scenario evaluated is based on the assumption that development would occur throughout the watershed areas based upon current zoning. Municipal zoning districts throughout the Little Lehigh Creek Watershed can be categorized as industrial, commercial, agricultural or residential at various densities. For the purpose of evaluating the future zoned condition land use, a composite zoning map of the study area was prepared. Each of the zoning districts was placed into one of the above categories. The density criteria for residential development were as follows: low density equals 2 or less units per acre; medium density equals between 2 and 5 units per acre; high density equals 5 or more units per acre. Since the allowable density of residential development can vary widely within a given zoning district, an “average” allowable density was determined from the district description and the district was placed into a low-, medium- or high-density classification. The composite zoning map of the study area was color-coded to reflect the categorization.

The future zoned condition land use map represents an “average ultimate” development scenario. It is an ultimate condition because all non-agriculturally zoned areas of the study area are assumed to be developed. It is an average condition because, within a zoning district and consistent with the district description, development could occur at a higher or lower density than that assumed.

The decision regarding which of the two future land use conditions to use in structuring the runoff control philosophy can be made fairly readily when considering the structure of Act 167. The Act is based on the assumption that land development will continue to occur and that the storm runoff impacts associated with that development are to be controlled, but not that the development itself is to be controlled in location, rate, or density. Using the 10-year design period, development data would require assumptions as to the distribution of the development within the municipalities. The assumed distributions could be based upon concentrated development (perhaps adjacent to sewer lines) or based upon uniform scattered development. In either case, the accuracy of the development location assumptions for small watershed areas could suffer dramatically with unanticipated development in a very short period of time. Conversely, the future zoned condition land use would remain valid until either the zoning changed or major exception uses were allowed. Therefore, the future zoned condition land use will be used as the design land use for formulation of the runoff control plan. A map of the future land use condition as used in the development of the runoff control strategy is included in the map jacket following this page.

CHAPTER 4. LITTLE LEHIGH CREEK WATERSHED FLOODPLAIN INFORMATION

A. Floodplain Delineation

The U.S. Department of Housing and Urban Development—Federal Insurance Administration has prepared Flood Insurance Data for each municipality in the Little Lehigh Creek Watersheds. Nine of the studies prepared have been detailed investigations of the hydrology of selected stream segments within the municipal boundaries including flood profiles (depth of water relative to channel evaluations) and detailed mapping of floodplain areas. The remaining four municipalities have preliminary investigations of flood prone areas. Collectively, these studies document the 100-year floodplain within the Little Lehigh Creek Watershed. Each of the floodplain studies is available for inspection at the Lehigh Valley Planning Commission offices as well as the respective municipal offices and is not reproduced here. A list of all the municipal Flood Insurance Studies, including their date of preparation and whether they represent detailed or preliminary data, is presented in Table 11.

TABLE 11
LITTLE LEHIGH CREEK WATERSHED
FLOOD INSURANCE STUDY DATA

Municipality	Publication Date	Type of Data
Lehigh County:		
Borough of Alburtis	December 15, 1978	Preliminary
City of Allentown	January 6, 1995	Detailed
Borough of Emmaus	September 1, 1977	Detailed
Lower Macungie Township	February 2, 1977	Detailed
Borough of Macungie	April 15, 1980	Detailed
Salisbury Township	January 3, 1979	Detailed
South Whitehall Township	February 1, 1978	Detailed
Upper Macungie Township	April 2, 1979	Detailed
Upper Milford Township	May 19, 1981	Detailed
Weisenberg Township	October 15, 1985	Preliminary
Berks County:		
Longswamp Township	November, 1974	Preliminary
Maxatawny Township	November, 1980	Detailed
Borough of Topton	May, 1974	Preliminary

The Federal Emergency Management Agency's Community Rating System uses a system of credits whereby communities that exceed the minimum requirements of the National Flood Insurance Program secure reductions in the flood insurance premiums for their residents. Regulating development through a storm water management plan which has been approved by a state agency, such as an Act 167 Plan, qualifies for additional credits. Erosion and sediment control regulations can also qualify for additional credits.

B. Detailed Versus Preliminary Floodplain Delineation by Stream Segment

Alburtis and Topton Boroughs and Weisenberg and Longswamp Townships have only preliminary Flood Insurance Data. For these municipalities, the defined flood prone areas were delineated based primarily on existing floodplain data and not detailed engineering evaluations. As such, only generalized boundaries of flood prone areas have been determined. For the remaining municipalities in the Little Lehigh Creek Watershed, along selected stream segments, detailed hydrologic investigations have been completed for defining floodplains. Detailed investigations include documented flow values at selected floodplain cross-sections and flood profiles along the stream length. However, within each of these municipalities, the stream sections studied in detail are not necessarily in the study area. If the stream segments within the study area were not included in the detailed portions of the municipality, then they were delineated according to the preliminary method previously described. Presented in Figure 6 is a map of the Little Lehigh Creek Watershed with the delineation of detailed versus preliminary flood mapping by stream segment.

C. Existing and Future Floodplain Development

Currently within the Little Lehigh Creek Watershed floodplains, land use consists largely of open space, agriculture and parks. The City of Allentown maintains an extensive park system in the floodplains of the Trout Creek, Cedar Creek and the mainstem Little Lehigh Creek. In addition to the Allentown parks located within the floodplain, Lehigh County maintains The Cedar Creek Parkway East and West and The Lock Ridge and Furnace Museum as park properties in the floodplain.

The above notwithstanding, there also currently exists many instances of development within the floodplain in the Little Lehigh Creek Watershed. In the upper reaches of the watershed, which is relatively rural, floodplain development takes the form of scattered residences and encroachments associated with road crossings. In many of the downstream urban areas, the natural floodplain has been obliterated by development and the stream bed itself has been channelized or piped.

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

Figure 6
Flood Area Mapping
by Stream Segment

For the purposes of the Little Lehigh Creek Watershed Storm Water Management Plan, the damage potential of existing and future floodplain development will be minimized using the following philosophy:

- Damage potential of existing floodplain development will remain unchanged, for storm events representing the two-year through 100-year return period events, through implementation of the storm water management criteria included in the Storm Water Management Plan for the Little Lehigh Creek Watershed.

- Damage potential for future floodplain development will be minimized by only permitting specific types of development which are damage resistant consistent with the Floodplain Management Act as implemented through municipal floodplain regulations and the Department of Environmental Protection Chapter 105 - Dam Safety and Waterway Management Regulations and Chapter 106 - Floodplain Management Regulations.

- Damage potential of existing and future floodplain development may be reduced with implementation of remedial measures for areas subject to inundation. The effectiveness and design life of any remedial measures would be enhanced by implementation of the Storm Water Management Plan.

CHAPTER 5. LITTLE LEHIGH CREEK WATERSHED EXISTING STORM DRAINAGE PROBLEM AREAS AND SIGNIFICANT OBSTRUCTIONS

A. Existing Storm Drainage Problem Areas

An important goal of Act 167 is to prevent any existing storm drainage problem areas from getting worse. The first step toward that goal is to identify the existing problem areas. Each municipality in the Little Lehigh Creek Watershed was provided with an opportunity to update the documentation of existing drainage problems within its borders. The starting point for the drainage problem inventory was the LVPC *Regional Storm Drainage Plan* (RSDP) which documented ten problems in the study area based on a municipal survey conducted prior to 1975. The 1988 Plan documented a total of 71 existing drainage problems in the study area. The type of problem identified was typically street and/or property flooding. Based on updated municipal information, there are now 62 existing problems in the study area. Figure 7 is a map of the Little Lehigh Creek Watershed indicating the storm drainage problem areas as identified as part of the Storm Water Management Plan. The problem areas on Figure 7 are number coded and keyed to the problem area descriptions presented in Table 12. The “Subarea” and “Reach No.” columns in Table 12 refer to the location of the problem areas relative to the study area breakdown for modeling purposes. A subarea is the finest unit of breakdown of a watershed for which runoff values have been calculated. A reach is the swale, channel or stream segment which drains a particular subarea. Note that 43 of the drainage problems are on an identified reach indicating that peak runoff values are readily available from the modeling process for these problem areas. These runoff values could be used as input for design of remedial measures.

The final column in Table 12 was provided to list generalized solutions suggested by municipal representatives. Proposed solutions listed include specific proposals based on municipal studies of the problem areas, where available, and solutions which are readily apparent to the municipal representatives for the less complicated problem areas. For certain other problem areas, the solutions are not quite so apparent and may require detailed engineering evaluations to determine the most cost-effective solution.

B. Significant Obstructions

An obstruction in a watercourse can be defined borrowing from Chapter 105 of DER’s Rules and Regulations as follows:

> “Any dike, bridge, culvert, wall, wingwall, fill, pier, wharf, embankment, abutment or other structure located in, along, or across or projecting into any … channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.”

Figure 7
Little Lehigh Creek Watershed
Problem Area Map

TABLE 12

LITTLE LEHIGH CREEK WATERSHED
STORM DRAINAGE PROBLEM AREAS

No.	Location	Municipality	Problem Description	Subarea No.	Reach No.	Proposed Solution
TOAD CREEK						
1.	Borough Park	Topton	Flooding and bank erosion	13	12	Dredging and Rip-Rap
2.	W. Franklin St. and Haas St.	Topton	Street flooding	13	12	Dredging and Rip-Rap
3.	Furnace Street	Topton	Street flooding	16	15	Dredging and Channel Modification
4.	Topton Sewage Treatment Plant	Longswamp	Flooding	16	15	Dredging and Rip-Rap
5.	Ash Lane north of Mertztown Rd.	Lower Macungie	Street Flooding	22	21	Channel Dredging/Realignment
LITTLE LEHIGH MAINSTEM						
6.	Mertztown Rd. west of Butz Rd.	Lower Macungie	Street Flooding	24	23	Channel Dredging/Realignment
7.	Smith Lane south of Mertztown Rd.	Lower Macungie	Street Flooding	24	23	Channel Dredging/Realignment
8.	Front Street - west end	Alburtis	Street Flooding	25	-	Enlarged Culvert
9.	Front and Walnut Streets	Alburtis	Street and field flooding	25	-	Enlarged Culvert
10.	Front and Chestnut Streets	Alburtis	Street Flooding	25	-	Enlarged Culvert
11.	Main and East Penn. Ave.	Alburtis	Street and property flooding	25	-	Storm Sewers
12.	West Penn Ave.	Alburtis	Street and building flooding	25	-	Enlarged Culvert

TABLE 12

LITTLE LEHIGH CREEK WATERSHED
STORM DRAINAGE PROBLEM AREAS

No.	Location	Municipality	Problem Description	Subarea No.	Reach No.	Proposed Solution
13.	North of West Penn. Ave	Alburtis	Field flooding	25	-	Channel Improvement
14.	Weilers Rd. at Little Lehigh Creek	Lower Macungie	Street Flooding	27	26	Channel Dredging/Realignment
15.	Creamery Road at Little Lehigh Creek	Lower Macungie	Street Flooding	27	26	Channel Dredging/Realignment
SCHAEFER RUN						
16.	Iron Run near Township School	Upper Macungie	Property flooding	75	74	Stream Cleaning
17.	Rt. 222 west of Trexlertown	Upper Macungie	Street flooding	84	57, 82, 83	Stream Cleaning
LITTLE LEHIGH MAINSTEM						
18.	Spring Creek Rd. between Beech and Laurel	Lower Macungie	Street Flooding	87	86	Channel Dredging/Realignment
19.	Spring Creek Rd. between Heather and Oak	Lower Macungie	Street Flooding	87	86	Channel Dredging/Realignment
20.	Spring Creek Rd.- West of Mill Creek Road	Lower Macungie	Street and field flooding	93	-	Channel Dredging/Realignment
21.	Wild Cherry Lane at Little Lehigh	Lower Macungie	Street Flooding	106	105	Channel Dredging/Realignment

SWABIA CREEK						
22.	Franklin St. at Borough line South	Alburtis	Street flooding	112	111	Church St. Bridge Replacement
23.	Church St. at Borough line East	Alburtis/Lower Macungie	Street flooding	120	118	Bridge Replacement and Channel Dredging/Realignment
24.	Schoeneck Road at Swabia Creek	Lower Macungie	Street flooding	121	120	Channel Dredging/Realignment
25.	Gehman's Road at Swabia Creek	Lower Macungie	Street flooding	123	121	Channel Dredging/Realignment
26.	West Main Street	Macungie	Street flooding	125	124	None Proposed
27.	Vine Street and Carpenter Street	Macungie	Street flooding	127	-	Storm Sewers
28.	Brookside Road at Swabia Creek	Lower Macungie	Street flooding	132	129	Channel Dredging/Realignment
29.	Sauerkraut Lane at Swabia Creek	Lower Macungie	Street flooding	133	132	Channel Dredging/Realignment

LITTLE LEHIGH MAINSTEM						
30.	Chestnut Street	Upper Milford	Street Flooding	138	-	Storm Sewers
31.	Macungie Road at Little Lehigh	Lower Macungie	Street Flooding	139	135	Channel Dredging/Realignment
32.	Millrace Road at Little Lehigh	Lower Macungie	Street Flooding	140	139	Channel Dredging/Realignment
LEIBERT CREEK						
33	East Main Rd. at Acorn Drive	Upper Milford	Street flooding	147	146	Enlarged Culvert
34.	South 12th Street	Emmaus	Street flooding	151	-	Storm Sewers
35.	Emmaus Community Park and Pool	Emmaus	Pool and property flooding	151	150	Channelize/Dredge Stream
36.	Furnace Dam at 10th and Furnace	Emmaus	Property flooding North of dam	152	-	Detention Facility and Enlarged Conveyor Pipe
37.	Broad St. at Fir Street	Emmaus	Street and property flooding	152	-	Enlarged Culvert and Dredge Stream
38.	Indian Creek Road	Upper Milford	Street flooding	154	153	Replace PennDOT Culverts with Bridge

LITTLE LEHIGH MAINSTEM						
39.	Farr Road at Little Lehigh	Lower Macungie	Street Flooding	158	156	Channel Dredging/Realignment
40.	Orchid Place - West Of Orchid Circle	Lower Macungie	Street Flooding	158	156	Channel Dredging/Realignment
41.	Main Street at Klines Lane	Emmaus	Street Flooding	159	159	Enlarged Culverts
42.	South Second Street	Upper Milford	Street and property flooding	159	-	None proposed.
43.	Foundry Alley	Emmaus	Street and property flooding	159	-	None proposed.
44.	South Second St. at Adrian/ Peach/Keystone Sts.	Emmaus	Street and property flooding	159	-	Property Acquisition and Detention Facility
45.	Fox Street	Emmaus	Street Flooding	161	-	Storm Sewers and Detention Facility
46.	Lehigh Street (at South Mall)	Salisbury	Property Flooding	161	-	None proposed.
CEDAR CREEK						
47	Crackersport Rd. near Days Inn	South Whitehall	Street flooding	176	-	None Proposed
48.	Holiday Hills Area (Schantz Rd.)	Upper Macungie	Street, field and lawn flooding	181	-	Strom Sewers
49.	Muth Rd. / Schantz Rd. / Cetronia Rd. area	Upper Macungie	Street and field flooding/erosion	182	181	None Proposed

50.	Glick Avenue	South Whitehall	Street flooding	194	193	Storm Sewers
51.	Mosser Drive and Cedar Crest Blvd.	South Whitehall	Street flooding	198	-	Storm Sewers
52.	Hamilton St. between Saint Elmo and 21st Streets	Allentown	Stream overbanking	202	201	Stream Cleaning, Straightening, Widening
53.	Greenwood Rd. and Mosser St.	Allentown	Property flooding	204	203	Detention Facility
54.	Walnut St. between Lafayette and Saint Elmo Streets	Allentown	Stream overbanking	205	202	Stream Cleaning, Straightening, Widening
LITTLE LEHIGH MAINSTEM						
55.	10th and Martin Luther King Jr. Blvd.	Allentown	Street Flooding	209	-	None proposed.
56.	Lehigh Street at Mill Street	Allentown	Street Flooding and Stream Overbanking	209	208	Stream cleaning at bridge.
TROUT CREEK						
57.	East Mountain Road	Salisbury	Property flooding	215	-	Diversion Ditch
58.	Floodplain in vicinity of Paoli & Chapel Ave. and Trout Creek	Allentown	Street flooding and stream overbanking	215	-	Storm Sewers
59.	South 4th and Brookdale Sts.	Allentown	Street flooding	215	214	None Proposed

60.	Mountainville - Areas Downstream of Walden Park area (S. Church, Euclid, So. 8th Sts.)	Allentown	Street flooding	217	-	Storm Sewers
61.	8th St. at Underpass (Mack Blvd.)	Allentown	Street flooding	220	217, 219	New Culvert
62.	4th St. and Harrison, 4th St. and Auburn	Allentown	Street overbanking	223	222	Future channel improvements

Using the above-definition, 364 obstructions have been identified and measured within the Little Lehigh Creek Watershed. For each of these, an estimated flow capacity has been calculated. For the purposes of Act 167, it is necessary to refine the list of obstructions to include only those obstructions which are "significant" on a watershed basis. For the Little Lehigh Creek Watershed Storm Water Management Plan, the following distinction has been used:

> An obstruction in a stream or channel shall be deemed "significant" if it has an estimated flow capacity which is less than the 10-year return period peak flow from the calibrated hydrologic model of a watershed prepared as part of the Act 167 Plan.

Using the refined definition, 187 significant obstructions have been identified within the Little Lehigh Creek Watershed and are shown in Figure 8. A list of the significant obstructions is presented in Table 13 which indicates the obstruction number, description, municipality and *approximate* flow capacity. Obstruction capacities have been estimated based on their upstream geometry as measured, bed slope and roughness factors (where applicable) consistent with the calibrated WATERSHED Model for the Little Lehigh Creek. The estimates reflect reasonable flow capacities of the obstructions for "open channel" flow conditions (i.e. where the obstructions are not submerged). These estimated capacities are for illustration only and shall not be used as absolute capacities for storm water management decisions. The capacity of any obstruction when used to meet the requirements of this Plan shall be based upon a detailed hydraulic investigation including possible headwater and tailwater conditions, obstruction configuration (abutments, wingwalls, piers, etc.), field measured slopes and other conditions as may affect capacity for design flows.

There are 12 areas where identified significant obstructions coincide with a documented storm drainage problem area as indicated in Table 13. The obstructions which coincide with a drainage problem are footnoted in Table 13 with the corresponding problem area number identified at the end of the table. The importance of the identified significant obstructions and problem areas as part of the development of a runoff control strategy is discussed in Chapter 8.

Figure 8
Little Lehigh Creek Watershed
Significant Obstructions

TABLE 13

LITTLE LEHIGH CREEK WATERSHED SIGNIFICANT OBSTRUCTIONS

Number*	Obstruction	Municipality	Approximate Flow Capacity (cfs)**
1	Longsdale Road	Longswamp Township	51
2	Private Road	Longswamp Township	645
3	Hilltop Road	Longswamp Township	598
4	Ash Lane	Longswamp Township	153
5	Woodside Avenue	Longswamp Township	93
6	Callow Hill	Borough of Topton	32
7	Main Street	Borough of Topton	93
8	Smith Road	Borough of Topton	90
9	Penn Street	Borough of Topton	98
10	Barclay Street	Longswamp Township	150
11	Farmington Road	Longswamp Township	55
12	Brooksdale Road	Longswamp Township	53
13	Mertz Road	Longswamp Township	133
14	Private Road	Longswamp Township	482
15	Private Road	Longswamp Township	747
16	Ash Lane[1]	Lower Macungie Township	636
17	Mertztown Road[2]	Lower Macungie Township	777
18	Smith Lane[3]	Lower Macungie Township	1,265
19	Private Road	Lower Macungie Township	160
20	Spring Creek Road	Lower Macungie Township	2,271
21	Rail Road Bridge	Lower Macungie Township	1,671
22	Creamery Road[4]	Lower Macungie Township	253
23	Route 863 (Independent Road)	Weisenberg Township	59
24	Route 863 (Independent Road)	Weisenberg Township	88
25	Helfrich Road	Weisenberg Township	41
26	Route 863 (Independent Road)	Weisenberg Township	30
27	Route 863 (Independent Road)	Weisenberg Township	79
28	Private Drive	Upper Macungie Township	8
29	Route 863 (Independent Road)	Upper Macungie Township	18
30	Private Drive	Upper Macungie Township	251
31	Private Drive	Upper Macungie Township	15
32	Private Drive	Upper Macungie Township	45
33	Route 863 (Independent Road)	Upper Macungie Township	15
34	Private Drive	Upper Macungie Township	15
35	Zeigel's Church Rd.	Upper Macungie Township	15
36	Route 863 (Independent Drive)	Upper Macungie Township	15
37	Folk Road	Upper Macungie Township	122
38	Private Drive	Upper Macungie Township	58
39	Private Drive	Upper Macungie Township	43
40	Route 863 (Independent Drive)	Upper Macungie Township	444
41	Private Drive	Maxatawny Township	33

TABLE 13

LITTLE LEHIGH CREEK WATERSHED SIGNIFICANT OBSTRUCTIONS

Number*	Obstruction	Municipality	Approximate Flow Capacity (cfs)**
42	Albright Road	Maxatawny Township	98
43	Folk Road	Upper Macungie Township	71
44	Route 863 (Independent Drive)	Upper Macungie Township	136
45	Route 222	Upper Macungie Township	43
46	Picnic Grove Lane	Upper Macungie Township	511
47	Private Drive	Upper Macungie Township	86
48	Trexler Road	Upper Macungie Township	135
49	Wentz Road	Upper Macungie Township	139
50	Brookdale Road	Upper Macungie Township	379
51	Private Drive	Upper Macungie Township	14
52	Pond Inlet	Upper Macungie Township	326
53	Private Drive	Upper Macungie Township	292
54	Weiler’s Road	Upper Macungie Township	128
55	Nestlé Way	Upper Macungie Township	237
56	Route 78	Upper Macungie Township	69
57	Route 78 Ramp	Upper Macungie Township	60
58	Sycamore Road	Upper Macungie Township	199
59	Stroh Drive	Upper Macungie Township	259
60	Railroad	Upper Macungie Township	66
61	Private Drive	Upper Macungie Township	249
62	Private Drive	Upper Macungie Township	417
63	Farm Lane near Twp. School	Upper Macungie Township	32
64	Private Drive	Upper Macungie Township	243
65	Private Drive	Upper Macungie Township	41
66	Off Mancor Drive	Upper Macungie Township	418
67	Penn Drive	Upper Macungie Township	418
68	Schantz Road	Upper Macungie Township	79
69	Parking Lot	Upper Macungie Township	13
70	Route 100	Upper Macungie Township	35
71	Railroad Street	Upper Macungie Township	157
72	Railroad	Lower Macungie Township	2,762
73	Private Drive	Lower Macungie Township	2,874
74	Private Drive	Lower Macungie Township	1,150
75	Seem Road	Lower Macungie Township	1,222
76	Lower Macungie Road	Lower Macungie Township	226
77	Spring Creek Road[5]	Lower Macungie Township	1
78	Private Drive	Lower Macungie Township	282
79	Wild Cherry Lane[6]	Lower Macungie Township	630
80	Mountain Street	Longswamp township	8
81	Gun Club Road	Lower Macungie Township	680
82	Chestnut Road	Lower Macungie Township	759
83	Private Drive	Lower Macungie Township	24

TABLE 13

LITTLE LEHIGH CREEK WATERSHED SIGNIFICANT OBSTRUCTIONS

Number*	Obstruction	Municipality	Approximate Flow Capacity (cfs)**
84	Private Drive	Lower Macungie Township	72
85	Mountain Road	Lower Macungie Township	19
86	Bike Path	Borough of Alburtis	1,321
87	Church Street	Borough of Alburtis	617
88	Private Drive	Lower Macungie Township	25
89	Schoeneck Road[7]	Lower Macungie Township	933
90	Railroad	Lower Macungie Township	816
91	Orchard Road	Lower Macungie Township	673
92	Gehman Road[8]	Lower Macungie Township	208
93	Railroad	Lower Macungie Township	600
94	Railroad	Borough of Macungie	1,238
95	Golf Course Bridge	Lower Macungie Township	274
96	Golf course Bridge	Lower Macungie Township	346
97	East Macungie Road	Upper Milford Township	176
98	Private Drive	Upper Milford Township	106
99	Railroad	Upper Milford Township	220
100	Private Drive	Lower Macungie Township	139
101	Sauerkraut Lane[9]	Lower Macungie Township	395
102	Macungie Road[10]	Lower Macungie Township	1,244
103	Railroad	Upper Milford Township	135
104	Indian Creek Road	Upper Milford Township	121
105	Private Drive	Lower Macungie Township	77
106	Mill Race Road[11]	Lower Macungie Township	1,024
107	German Road	Upper Milford Township	37
108	Main Road East[12]	Upper Milford Township	34
109	Route 29 (Cedar Crest Blvd.)	Borough of Emmaus	262
110	Golf Course Bridge	Borough of Emmaus	188
111	North Street	Borough of Emmaus	103
112	Camp Olympic	Lower Macungie Township	972
113	Camp Olympic	Lower Macungie Township	959
114	Riverbend Road	Lower Macungie Township	5,153
115	Lehigh Country Club	Lower Macungie Township	3,747
116	Lehigh Country Club	Lower Macungie Township	4,173
117	Private	Borough of Emmaus	245
118	Private	Borough of Emmaus	245
119	Harrison Street	Borough of Emmaus	266
120	Off Keystone Road	City of Allentown	574
121	Devonshire Road	City of Allentown	1,830
122	Private Drive	City of Allentown	2,064
123	Private Drive	City of Allentown	2,100
124	Lehigh Parkway North	City of Allentown	2,510
125	Rd. in front of Springhouse Jr. HS	South Whitehall Township	51

TABLE 13

LITTLE LEHIGH CREEK WATERSHED SIGNIFICANT OBSTRUCTIONS

Number*	Obstruction	Municipality	Approximate Flow Capacity (cfs)**
126	Golf Course	City of Allentown	469
127	Golf Course	City of Allentown	517
128	Golf Course	City of Allentown	214
129	Golf Course	City of Allentown	610
130	Golf Course	City of Allentown	175
131	Golf Course	City of Allentown	242
132	Golf Course	City of Allentown	273
133	Golf Course	City of Allentown	374
134	Golf Course	City of Allentown	274
135	Golf Course	City of Allentown	741
136	Trexler Park Path	City of Allentown	953
137	Trexler Park Path	City of Allentown	897
138	Trexler Park Path	City of Allentown	903
139	Werley Road	Upper Macungie Township	36
140	Spring Road	Upper Macungie Township	10
141	Private Drive	Upper Macungie Township	81
142	Private Drive	Upper Macungie Township	361
143	Dorney Park	South Whitehall Township	380
144	Dorney Park	South Whitehall Township	635
145	Dorney Park	South Whitehall Township	815
146	Route 309	South Whitehall Township	202
147	Cedar Creek Park	City of Allentown	1,635
148	Howard Johnson Parking	South Whitehall Township	88
149	Cedar Crest Boulevard	South Whitehall Township	67
150	Route 222 (Hamilton Boulevard)	South Whitehall Township	219
151	College Avenue	City of Allentown	59
152	Cedar Creek Park	City of Allentown	166
153	Ott Street	City of Allentown	2,074
154	Cedar Creek Park	City of Allentown	331
155	Cedar Creek Park	City of Allentown	165
156	Cedar Creek Park	City of Allentown	153
157	Cedar Creek Park	City of Allentown	304
158	Hamilton Boulevard	City of Allentown	1,716
159	Reading Road	City of Allentown	326
160	Foot Bridge	City of Allentown	333
161	Foot Bridge	City of Allentown	590
162	Union Street	City of Allentown	620
163	Union Street	City of Allentown	198
164	Foot Bridge	City of Allentown	192
165	Saint Elmo Street	City of Allentown	1,504
166	Saint Elmo Street	City of Allentown	1,062
167	Foot Bridge	City of Allentown	244

TABLE 13

LITTLE LEHIGH CREEK WATERSHED SIGNIFICANT OBSTRUCTIONS

Number*	Obstruction	Municipality	Approximate Flow Capacity (cfs)**
168	Mosser Street	City of Allentown	376
169	Driveway	City of Allentown	59
170	Driveway	City of Allentown	59
171	Martin Luther King Jr. Drive	City of Allentown	376
172	Private Drive	City of Allentown	490
173	Lehigh Parkway East	City of Allentown	4,687
174	Rail Road Bridge	City of Allentown	4,030
175	Private Drive	Salisbury Township	17
176	Park Entrance	Salisbury Township	51
177	Foot Bridge	Salisbury Township	429
178	Private Drive	Salisbury Township	297
179	Foot Bridge	City of Allentown	650
180	Foot Bridge	City of Allentown	238
181	Foot Bridge	City of Allentown	95
182	Fountain Street	City of Allentown	347
183	Foot Bridge	City of Allentown	611
184	Foot Bridge	City of Allentown	1,136
185	Private Drive	City of Allentown	752
186	Foot Bridge	City of Allentown	611

* Numbers are keyed to significant obstruction map (Figure 8).
** Estimated capacities are for illustration only and should not be used as absolute capacities for storm water management decisions.

[1]Significant Obstruction No. 16 coincides with Problem area No. 5.
[2]Significant Obstruction No. 17 coincides with Problem area No. 6.
[3]Significant Obstruction No. 18 coincides with Problem area No. 7.
[4]Significant Obstruction No. 22 coincides with Problem area No. 15.
[5]Significant Obstruction No. 77 coincides with Problem area Nos. 18, 19 and 20.
[6]Significant Obstruction No. 79 coincides with Problem area No. 21.
[7]Significant Obstruction No. 89 coincides with Problem area No. 24.
[8]Significant Obstruction No. 92 coincides with Problem area No. 25.
[9]Significant Obstruction No. 101 coincides with Problem area No. 29.
[10]Significant Obstruction No. 102 coincides with Problem area No. 31.
[11]Significant Obstruction No. 106 coincides with Problem area No. 32.
[12]Significant Obstruction No. 108 coincides with Problem area No. 33.

CHAPTER 6. STORM RUNOFF CONTROL TECHNIQUES

Chapter 3 identified the impacts of land development on storm water runoff and documented the need to control those impacts with sound storm water management techniques. Chapter 8 presents the performance standards for runoff control for new development applicable to the various watershed areas necessary to achieve sound runoff management from a watershed perspective. Therefore, Chapter3 defines the problem and Chapter 8 identifies the necessary end product. This chapter will identify the runoff control techniques available as the “means” to the desired end product to mitigate the runoff impacts of new development.

The runoff control techniques presented in Sections A and B are “structural” storm water management controls meaning that they are physical facilities for runoff abatement. “Non-structural” controls, described in Section C, refer to land use management techniques geared toward minimizing storm runoff impacts through control of the type and extent of new development throughout the study area. The Little Lehigh Creek Watershed Storm Water Management Plan is based on the assumption that new development of various types will occur throughout the study area (except as regulated by floodplain regulations) and that structural controls will be required to minimize the runoff implications of the new development.

Structural controls for managing storm runoff can be categorized as either volume controls or rate controls. Volume controls are designed to prevent a certain amount of the total rainfall from becoming runoff by providing an opportunity for the rainfall to infiltrate into the ground. Greater opportunity for infiltration can be provided by minimizing the amount of impervious cover associated with development, by draining impervious areas over lawns or other pervious areas or into specific infiltration devices, and by using grassed swales or channels to convey runoff in lieu of storm sewer systems. Rate controls are designed to regulate the peak discharge of runoff by providing temporary storage of runoff which otherwise would leave the site at an unacceptable peak value. Rate controls, much more so than volume controls, are adaptable to regional considerations for controlling much larger watershed areas than one development site.

Presented in Sections A and B is a discussion of the various volume and rate controls available for implementation on a development site (or region). The discussion includes a physical description of the control, the applicability of the particular control, its advantages and disadvantages and maintenance requirements. The runoff control(s) most applicable to a development site may vary widely depending upon site characteristics such as topography, soils, geology, water table, etc., the type of development proposed and the applicable performance standard which the controls must meet. The developer should consider all these factors in designing the control philosophy.

The runoff control technique information presented herein has been derived primarily from two sources; namely, (1) *New Jersey Storm Water Quantity/Quality Management Manual*, February 1981, prepared for the N.J. Department of Environmental Protection by the Delaware Valley Regional Planning Commission, and (2) *Allegheny County Act 167 Pilot Storm Water Management Plans - Girty’s Run, Pine Creek, Deer Creek and Squaw Run,* January 1982, prepared for the Allegheny County Department of Planning by Green International, Inc. and Walter B. Satterthwaite Assoc., Inc. Additional information on the design and applicability of various structural and non-structural controls is available in the *Pennsylvania Handbook of Best Management Practices for Developing Areas,* Spring 1998.

A. Volume Controls

The increase in runoff volume with development, and the management of that increased volume, is a key element in sound runoff management at the watershed level. Any volume controls implemented on-site for a development would help achieve the goals of the watershed plan. As stated above, the basis for volume control is the provision of a greater opportunity for infiltration of rainfall/runoff into the ground. This opportunity may be provided in a passive sense by simply draining impervious areas over pervious areas and relying on the natural infiltrative capabilities of the pervious areas. Conversely, the opportunity for infiltration could be provided in an active sense by directing runoff into infiltration structures designed to remove a given volume of runoff. A different type of volume control is based upon the substitution of porous or semi-pervious materials in place of conventional impervious surfaces. Any or all of these approaches may be applicable to a particular development site.

Volume controls may be used in conjunction with rate controls since volume controls alone would not generally provide complete runoff abatement. The volume controls would, however, provide the benefit of decreasing the size and cost of the rate control facility and would be used to minimize the total cost of on-site runoff control.

1. Infiltration Pits and Trenches

a.) Description

Infiltration pits and trenches usually consist of excavated pits or trenches, backfilled with sand and/or graded aggregates, in which storm water runoff is collected for temporary storage and subsequent infiltration.

Infiltration pits vary in depth from about 6 to several hundred feet, depending upon the depth of the permeable soil strata and the depths to groundwater and bedrock. A "dry well" consists of a perforated structural chamber buried in the ground which is empty or filled with aggregates, depending upon the strength of the structure. Dry wells are commonly used to collect and infiltrate runoff from rooftops and other areas free of sediment and debris.

Infiltration trenches are long narrow excavations with depth normally less than 6 feet. Although a variety of geometries may be used, higher infiltration rates are usually attained from wide, shallow trenches. Where infiltration trenches are not protected by a grating, wheel stops or segmented curbs are necessary to keep off vehicular traffic.

b.) Applicability

These controls may be used where the subsoil is sufficiently permeable to allow a reasonable rate of infiltration and where the water table is sufficiently lower than the design depth of the facility. Not applicable where high concentrations of suspended materials are contained in the runoff without some type of filtering mechanism.

c.) Advantages and Disadvantages

ADVANTAGES

· Can be incorporated into the design of storm sewer systems to reduce the required flow capacity and cost, or to reduce overflow occurrence.

· May help reduce local flood peaks.

· Relatively inexpensive to construct.

· Utilizes existing natural drainage system.

· Groundwater recharge.

DISADVANTAGES

· Susceptible to clogging by sediment.

· Landscaping requirements may produce aesthetically objectionable conditions or safety hazards.

· Dry wells often require an emergency collection basin surrounding the beds since failure causes flooding.

· Maintenance is difficult when the facility becomes clogged.

· Limited in application to small sources of runoff such as roof drains, small parking lots, tennis courts, etc.

d.) Maintenance Requirements

Preventive maintenance is vital to the continued effectiveness of infiltration facilities. Once void areas become clogged, maintenance entails a complete replacement of filter material. The use of filter fabrics over the surface of the facility is helpful, although periodic cleaning or replacement will be necessary. Runoff from roofs and grass covered areas or frequently cleaned parking lots can be stored and infiltrated with minimal problems. In areas where runoff is likely to carry considerable amounts of suspended materials, other measures should be considered.

2. Concrete Grid and Modular Pavement

a.) Description

Pervious pavement systems consisting of strong structural materials containing void areas which can be filled with pervious materials such as sod, gravel, or sand. Categories include:

Poured-in-Place Slabs

Reinforced concrete slabs covering large areas are poured in-place on the ground to be covered. Special forms are used to shape the void areas, and a flat surface results. Because the slab is continually reinforced with steel, this pavement is suitable for heavy loads and has maximum resistance to movement caused by frost heave or settling.

Pre-Cast Concrete Grids

Concrete paving units incorporating void areas, usually precast in a concrete products plant and trucked to a job site for placement on the ground to be covered. However, for large jobs, these units can be formed and cast at the site.

Modular Unit Pavers

Smaller pavers which may be clay bricks, granite sets, or cast concrete of various shapes. These pavers do not have void areas incorporated into their configuration. They are installed on the ground with pervious material placed in the gaps between the units.

b.) Applicability

Most suitable for large parking areas, on-street parking, and as erosion control devices in drainageways and at detention basin outfalls.

c.) Advantages and Disadvantages

ADVANTAGES

- Flexibility - sections can be lifted to plant trees, place signs, maintain utility lines beneath.

- Can be used in some situations where porous asphalt is not suitable. For example, areas subject to sinking or heaving.

- Represents a compromise between a natural grass and an asphalt or concrete surface aesthetically, hydrologically, and quality-wise.

DISADVANTAGES

- Expensive and difficult to lay.
- Fertilizers and de-icing chemicals may have adverse effects on concrete products.
- Can present safety hazards.

d.) Maintenance Requirements

Where turf is incorporated as the porous surface medium, normal turf maintenance (such as watering, fertilizing and mowing) will be necessary. Infrequent mowing is required in high traffic areas. However, use of fertilizers and de-icing chemicals should be restricted as much as possible. Because they are monolithic and maintain a smooth surface, poured-in-place installations can be snowplowed provided damage to the grass cover can be avoided.

3. Porous Asphalt Pavement

a.) Description

Porous asphalt pavement material consists of a graded aggregate held together by asphalt cement and containing sufficient void space to allow a high rate of permeability to water. The nature of each individual site will influence the specific design of the porous pavement. Each design will depend upon soil conditions, expected surface wear, and the particular use of the surface.

b.) Applicability

Most suitable for low-volume traffic areas such as parking areas, residential streets, recreation surfaces, airport runways and wherever subgrade soils have moderate permeability.

c.) Advantages and Disadvantages

ADVANTAGES

- May reduce size of or eliminate additional drainage facilities. For instance, storm sewers, catch basins, curbs and gutters.
- Improved preservation of roadside vegetation.
- Flexible measure to provide storm water detention in both new and existing development.

- Safety improvements such as superior skid resistance during wet conditions and enhanced visibility of pavement markings.

- Provides pavement drainage without the need for a crown slope, thus reducing costs and puddling.

- Offers aesthetic alternatives since color selection is possible.

- Less noisy than conventional pavements.

- Less costly than conventional pavements for most applications.

- Enhances groundwater supply.

DISADVANTAGES

- Technique is relatively new with claims more founded on laboratory results than real-life experiences.

- Open-graded mixtures may be more prone to water stripping than conventional dense aggregate mixtures.

- Increased pressure head on pavement from subsurface drainage on steep slopes.

- Clogging may be a problem in some environments.

- Freezing and thawing may present problems although there is little evidence of this problem.

- Water that freezes within the porous pavement takes longer to thaw and offsets infiltration.

- Motor oil drippings and gasoline spillage may pollute groundwater.

d.) Maintenance Requirements

Maintenance involves removal of debris too coarse to be washed through the pavement system; vacuuming to remove particles that could clog the void space; and patching the surface as needed. Since porous pavements require no more repairs than conventional pavements, maintenance problems can be generally confined to better "housekeeping" and "preventive maintenance" practices and more efficient and effective street cleaning procedures.

4. Grassed Waterways, Filter Strips, and Seepage Areas

a.) Description

This practice utilizes grassed areas for managing storm water runoff by using their natural capacity for reducing runoff velocities, enhancing infiltration, and filtering runoff contaminants. Such measures include:

Grassed Waterways - Concentrated flows of surface runoff are directed through grass covered drainage swales or channels. The grassed surface retards flow velocities and maintains soil porosity while providing relative stable channel lining. In addition, a small amount of runoff filtering occurs due to the velocity reduction, resulting in improved water quality. Whenever possible, grasses native to the site should be selected for use to insure acclimation.

Filter Strips - Sheet flows of surface runoff are directed across grass buffer strips which slow the sheet flow causing the heavier particulates to fall out while simultaneously enhancing infiltration of the runoff. These strips of close growing grasses can be established at the perimeter of disturbed or impervious areas.

Seepage Areas - Surface runoff is directed into small grass covered areas that infiltrate the water and filter out particulate contaminants. Seepage areas are created by excavating shallow depressions in the land surface or by constructing a system of dikes or berms to temporarily pond water over permeable soils.

b.) Applicability

Mostly applicable in new developments of low to moderate density where the percentage of impervious cover is relatively small. These practices also require that subdivision and site designs respect natural drainage patterns so that they can be modified to accommodate post-development runoff volumes.

Successful application is dependent upon such factors as steepness of slopes, anticipated runoff volumes, soil conditions, selection of proper grass cover and proper long-term maintenance.

c.) Advantages and Disadvantages

ADVANTAGES

- Vegetative swales are less expensive to install than curb and gutter systems.
- Roadside ditches keep flow away from the street thereby reducing the potential for hydroplaning.
- Groundwater recharge.

DISADVANTAGES

- Vegetative channels may require more maintenance than curb and gutter systems.

- Streets with swales may require more right-of-way and be less compatible with sidewalk systems.

- Proper selection of filter strip width is presently a subjective decision.

- Roadside ditches become less feasible as the number of driveway entrances requiring culverts increases.

- Local subdivision ordinances may require curbs and gutters, so municipalities may have to amend their regulations to allow this practice.

d.) Maintenance Requirements

Grassed Waterways - Periodic inspections, especially after large storms, are required to evaluate whether erosion controls are needed, to remove accumulated debris, and to check the condition of the vegetation.

Filter Strips - Like grassed waterways, periodic inspections are necessary but it is particularly important to maintain soil porosity. This can be accomplished by periodically removing thatch and/or mechanically aerating the area when necessary.

Seepage Areas - Similar maintenance considerations are required as for grassed waterways and filter strips.

B. Rate Controls

The performance standard criteria presented in Chapter VIII are geared towards controlling the peak rate of runoff after development to a given percentage of the pre-development peak runoff rate. The bases for establishing the performance standards are the pre-development peak rate, the timing of the pre-development peak with respect to other watershed areas and the anticipated increase in volume associated with development. The volume controls described in Part A will remove a portion of the increased volume of runoff and may also help to reduce the peak rate of runoff. It is primarily the rate controls, however, which provide the major peak attenuation by storing a large volume of runoff and releasing it at a predetermined slower rate. The various options available for rate control differ only in the location of the runoff storage provided as described below.

1. Detention Basins

a.) Description

Detention basins are impoundments which are designed to store "excess rate" storm water runoff during a rainfall event and release the stored runoff more slowly. "Excess rate" can be defined as the difference between the uncontrolled post-development hydrograph and the design post-development hydrograph as dictated by the performance standard criteria. Detention basins may be designed as either dry or wet impoundments. Dry impoundments are designed to completely drain after storm events. Wet impoundments are designed to maintain a permanent pool.

The storage volume required for a detention basin is a function of the change in runoff volume and the pre- and post-development peak, the performance standard applicable to the site, the extent to which volume controls are used, the outlet structure configuration and the design storm(s) used.

b.) Applicability

Detention basins are applicable to any development site where rate control is required and sufficient land area exists. Detention basins can be designed for individual site control or to control runoff from multiple development sites or watershed areas.

c.) Advantages and Disadvantages

ADVANTAGES

- Offers design flexibility for adapting to a variety of uses.
- Construction of ponds is relatively simple.
- May allow significant reduction in the size of downstream storm drainage structures.
- Enhances groundwater recharge to some degree.
- Reduces downstream litter and debris.

DISADVANTAGES

- Possible aesthetic and safety considerations.
- Maintenance programs may present problems.
- Consumes land area which then cannot be developed.
- In limestone geology, soil depth and type must be considered in design to minimize possibility of sinkhole occurrence.

d.) Maintenance Requirements

To maintain the design efficiencies of a detention basin, maintenance of the structures and the impoundment areas are essential. To be effective, a formal maintenance plan should be formulated. Elements of such a plan should include:

- Routine inspection of pipe inlets and outlets for accumulated sediment and debris.

- Critical area stabilization and vegetative control.

- Measures to offset the production of fast-breeding insects, as necessary.

- Periodic inspection by a qualified professional engineer to ensure that impoundments remain structurally sound and hydraulically efficient, including evidence of possible sinkhole formation.

2. Parking Lot Storage

a.) Description

Parking lot ponding is usually achieved by using specially designed or modified inlet structures to cause temporary ponding in portions of a parking lot, generally at the perimeter, specifically graded for that purpose. This technique is presently used to deal mainly with relatively small storm events.

b.) Applicability

Where portions of large, paved parking lots can be temporarily used for storm water storage without significantly interfering with normal vehicle and pedestrian traffic. Shopping centers and large employee parking areas are likely places for use of this measure.

c.) Advantages and Disadvantages

ADVANTAGES

- Can contribute to maintaining adequate capacity of downstream drainage facilities.

- Adaptable to both existing and new parking facilities.

- Parking lot storage is usually easy to incorporate into parking lot design and construction.

DISADVANTAGES

- May cause public inconvenience.

- Ponding areas are prone to icing in cold weather.

d.) Maintenance Requirements

- Inspections should be performed periodically and following large storms to assure proper functioning.

3. Rooftop Detention

a.) Description

Rooftop ponding makes use of the structural capabilities of rooftops to detain and release rainfall volumes such that flows are more gradually collected in sewers and streams. This effect is achieved through the use of small perforated weirs or collars placed around the inlets of roof downdrain pipes. When the water exceeds the designed pond depth, overflow occurs and the downdrains are allowed to function at peak capacity. The weirs are also designed such that no water is stored during small storm events. Experience with this practice has indicated that additional surface or subsurface storage is required because the rooftop area is generally too small to hold the required storage.

b.) Applicability

Most applicable to new structures with flat rooftops, although existing structures can be used if they meet specific design requirements. Rooftop detention is believed to be most appropriate in urban areas having 50 percent or more low-rise or commercial establishments.

c.) Advantages and Disadvantages

ADVANTAGES

- No additional land requirements may be needed.
- Not unsightly or a safety hazard.
- Minimal interference with traffic or people.
- Water stored in rooftop reservoirs has great potential for multiple uses such as grass watering and various washing and cleaning operations.
- May be adaptable to existing structures.

DISADVANTAGES

- The effects of just a few applications are negligible on a watershed basis.
- Benefits to a homeowner may not outweigh the costs.
- May require structural modification to buildings.
- May require modifications to building codes before practice can be used.
- Leaks can cause damage to buildings and their contents.

d.) Maintenance Requirements

Routine inspection is desirable to determine how well rooftop detention facilities are meeting their design standards; to check for the possible removal of roof drain control devices (such action may have been taken as a result of leaking roofs); and to determine when cleaning or repairs are needed.

4. Cistern Storage

a.) Description

A cistern is a tank or reservoir in to which runoff is directed. It may be designed as a detention facility with slow release or as a holding tank to store the water for other uses.

b.) Applicability

Since the function of cisterns does not depend upon physiographic conditions and their sizes can vary as necessary, they are applicable practically anywhere. Cisterns can be installed beneath paved areas or other structural facilities, within a building, or above the ground.

c.) Advantages and Disadvantages

ADVANTAGES

- Minimal interferences with traffic or people
- Can be used in existing as well as newly developed areas.
- Potential for multiple use of stored runoff may be possible.

DISADVANTAGES

- Subsurface excavation could be costly depending upon the type and amount of rock encountered.

d.) Maintenance Requirements

Periodic removal of sediment and debris will be necessary to assure maximum operating efficiency. If cistern pumps are employed, routine maintenance and inspections will be necessary to minimize failure.

C. Nonstructural Storm Water Management Techniques

Nonstructural controls refer to land use management techniques geared toward minimizing storm runoff impacts through control of the type, location and density of new development. These techniques can be incorporated in the development design process through alternative zoning ordinance and subdivision and land development ordinance (SALDO) provisions. These alternative provisions in a zoning ordinance and SALDO can minimize impervious surfaces for a given zoning district. Additionally, the basic land use or density provided for in zoning districts could be changed to allow less impervious cover (i.e. high density residential changed to low density residential). Some available zoning and SALDO techniques which may, if properly implemented, reduce the runoff impacts of new development are floodplain regulations, wetland regulations, net buildable area, cluster or open space zoning, transfer of development rights, and agricultural zoning. A discussion of these techniques can be found in the “Surface Water Runoff Study,” September 1991 written by the Federation of Northern Chester County Communities with technical assistance from the Chester County Planning Commission.

For the Little Lehigh Creek Act 167 Plan, existing municipal zoning districts as well as the allowable impervious cover within each district were used to create the future development scenario. The Release Rate Strategy for the study area has been designed to control runoff impacts of development consistent with the existing municipal zoning ordinances. For this reason, revisions to the zoning provisions are not required to control runoff. The techniques in this section are presented to identify options available to municipalities when writing or revising their zoning ordinance and SALDO. Any significant zoning amendments of this type would be cause for re-evaluation of the Release Rate Strategy. Implementation of these nonstructural techniques could serve to lessen the stringency of the overall Release Rate controls necessary for the study area. In summary, the Release Rate Strategy, shown on Plate I in the back of this Plan, has been designed to control the runoff impacts of new development consistent with existing municipal zoning. Although nonstructural techniques are available to municipalities through zoning and SALDO provisions, changes to zoning districts or provisions within districts are not required to control runoff.

CHAPTER 7. REVIEW OF STORM WATER COLLECTION SYSTEMS AND THEIR IMPACTS

A. Existing Storm Water Collection Systems and Their Impacts

As part of an Act 167 Plan, existing storm water collection and conveyance systems throughout the study area are to be documented through correspondence with the municipalities and field surveys. Much of the existing data is available from work performed for the LVPC "Regional Storm Drainage Plan" (RSDP) in the early 1970s. Each municipality is contacted to obtain updated data on the existing storm sewer systems which is added to the RSDP data and mapped on the working base maps of the study area. For each storm sewer system, the area draining to the system is identified from the topography of the area.

The existing storm water collection and conveyance system is incorporated into the computer models of the watersheds as follows:

- Subareas (which represent the smallest watershed breakdown for modeling purposes) are drawn to be consistent with the areas drained by storm sewers, i.e. the area drained by any one storm sewer system would be wholly within one subarea.

- Where applicable, major storm water collection/conveyance facilities are incorporated into the runoff model as "reaches." A reach in the model is a channel segment which forms the link between subareas and establishes the timing relationships between subareas.

Therefore, the existing storm sewer system becomes part of the documented "baseline" condition for both modeling purposes and for development of the study area plan.

There are ten man-made storm runoff conveyance facilities used as reaches in the Little Lehigh Creek hydrologic model. A list of the ten man-made reaches is presented in Table 14 including location, description, model reach number and approximate flow capacity.

TABLE 14
MAN-MADE STORM WATER CONVEYANCE FACILITIES USED AS REACHES IN THE LITTLE LEHIGH CREEK WATERSHED HYDROLOGIC MODEL

No.	Location	Description*	Model Reach No.	Approx. Flow Capacity (cfs)**
1	Toad Creek - Longswamp Twp. along Park Ave. to the Creek	24" circular corrugated metal pipe	17	11 cfs
2	Cedar Creek - S. Whitehall Twp. Springhouse Rd. between Rt. 22 and Trexler Blvd.	53" x 34" concrete box culvert	175	101 cfs
3	Cedar Creek - City of Allentown Trexler Park between Chew St and the creek	22' x 3' concrete box culvert	179	990 cfs
4	Cedar Creek - S. Whitehall Twp. Terminus near Glick Ave. and Washington Ave.	60" circular concrete pipe	193	139 cfs
5	Cedar Creek - S. Whitehall Twp. Along Rt. 222 at Haines Mill Road	18"circular concrete pipe	195	9 cfs
6	Cedar Creek - S. Whitehall Twp. 31st Street under Rt. 222 to the creek	54" circular concrete pipe	197	93 cfs
7	Cedar Creek - City of Allentown College Dr. and Hamilton Blvd. to the creek	4' x 8' concrete box culvert and 42" circular concrete pipe	198	239 cfs
8	Cedar Creek - Salisbury Twp. Greenwood Rd. to the creek	18" corrugated metal circular pipe	203	22 cfs
9	Trout Creek - City of Allentown Creek bed S. 4th St. to Dixon St.	15' x 5.5' concrete box culvert	215	1627 cfs
10	Trout Creek - City of Allentown along Reading RR Vultee St. to the creek	72" circular reinforced concrete pipe	219	188 cfs

*Not all storm sewers identified have uniform cross-sections throughout. The most representative cross-section was used in the model and listed here.
**Calculated using the Manning formula for open channel flow.

Presented in Table 15 is a comparison of the approximate flow capacity of each channel section relative to peak flow values generated by the calibrated WATERSHED Model for the Little Lehigh Creek Watershed.

TABLE 15
MAN-MADE REACH CAPACITIES VERSUS
WATERSHED* PEAK FLOW VALUES

Model Reach Number	Approx. flow capacity (cfs)	TSHED* Peak Flow (cfs) for Return Period:			
		2 yr.	10 yr.	25 yr.	100 yr.
17	11	65	161	236	427
175	101	44	97	136	230
179	990	164	322	431	673
193	139	15	48	116	324
195	9	66	114	145	210
197	93	105	197	257	391
198	239	379	657	854	1307
203	22	82	159	211	329
215	1627	419	781	1003	1627
219	188	378	705	919	1351

* WATERSHED Model calibrated to the Little Lehigh Creek Watershed.

From Table 15, only two of the ten man-made reaches can convey the 2-year through 100-year peak flows.

B. Future Storm Water Collection Systems

As part of the process of documenting the existing storm water collection network throughout the study area, an attempt was also made to identify proposed drainage facilities. In general, data regarding proposed facilities is very sketchy. Typically, storm drainage improvements would be constructed either as part of land developments (by the developer) or as remedial measures as part of the municipal capital or maintenance programs on an as-needed basis. As-needed refers to both the severity of the drainage problem and the public support for an improvement. In this manner, projects are constructed as money becomes available in the capital or maintenance budget. The effect of the approach in most cases is a piecemeal process of storm drainage improvements rather than one based on a comprehensive program keyed to future needs.

The Little Lehigh Creek Watershed Storm Water Management Plan can impact this situation in three ways. First, implementation of the performance standards specified in Chapter 8 would prevent the formation of new storm drainage problems or the aggravation of existing problems by maintaining peak flow values throughout the study area at existing levels. This would allow for the development of a comprehensive remedial strategy based on the assurance that solutions would not eventually be obsolete with additional development. Second, the storm drainage problem area inventory in Chapter 5 provides an excellent basis for development of a storm drainage capital improvements inventory. Actual improvements required would be determined from engineering analysis of the problems. Third, any engineering studies conducted for correcting problem areas could benefit from the flow values generated from the computer modeling of the study area as part of this Plan. Solutions for existing storm water drainage problems may qualify for low interest loans from the Pennsylvania Infrastructure Investment Authority (PENNVEST).

Even without the development of a comprehensive remedial strategy, the Storm Water Management Plan will improve the current situation by specifying a consistent design philosophy for all future storm drainage facilities. This design philosophy will relate to both facilities associated with new development and remedial projects.

C. Existing and Proposed Flood Control Projects

There is one existing flood control project within the Little Lehigh Creek Watershed located in the Trout Creek basin. The Corps of Engineers completed 7,920 feet of modified channel for flood protection in 1960 along the Trout Creek at a cost of $5.4 million. The project is located in an area identified as a Flood Damage Reach by the Soil Conservation Service between Mack Park and Potomac Street. There are no other existing or proposed flood control projects located within the Little Lehigh Creek Watershed based on State Water Plan data.

CHAPTER 8. RUNOFF CONTROL PHILOSOPHY AND PERFORMANCE STANDARDS

Earlier chapters identified the impacts of new development on storm water runoff and the techniques available to control those impacts either on-site or with regional facilities. This chapter will identify the performance standards or goals which need to be met for various areas of the watershed to minimize the adverse storm water impacts of new development. The method used to determine the performance standards was the development of a detailed hydrologic computer model of the watersheds which could be "stressed" under various design conditions to evaluate control options. The specific computer model used was the WATERSHED model from Tarsi Software Laboratories which implements hydrologic modeling procedures developed at Pennsylvania State University. It provides acceptable hydraulic and hydrologic accuracy, has minimal input data requirements, produces total runoff data and not merely peaks, provides for multiple simulation capability to assist in calibration and alternatives analysis. An additional advantage is that the engineering consultants for the watershed plan are two former Pennsylvania State University professors who are familiar with the algorithms in the model.

Construction of the computer model of the Little Lehigh Creek Watershed first involved breaking the watershed down into small pieces of approximately 300 acres average size. These pieces, or *subareas*, are the building blocks of the model. For each of the subareas, the computer model generates a runoff hydrograph (flow versus time) for a particular rainfall event. The Little Lehigh Creek Watershed was divided into 226 subareas. Stream channel data provides the linkage between subareas and establishes the timing relationship of one part of the watershed relative to another. The model provides the tool for analysis of the watershed and determination of an appropriate control strategy. The manner in which the model has been used to develop the control strategy and the actual control strategy itself are discussed in the following sections.

A. Runoff Control Philosophy

Historically, storm water management decisions for new development have predominantly been made using "at-site" philosophy. This has been the case for two reasons. First, before Act 167, not all of the 13 municipalities in the study area required consideration of the downstream impacts of storm runoff from new developments in their subdivision ordinances. Second, the municipal engineers do not have a study area data-base to rely on to quantify any downstream impacts. The bottom line, therefore, is that at-site considerations would typically dictate the recommended controls.

The difference between at-site runoff control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts. Whereas the objective of typical at-site design would only be to control post-development peak runoff rates to pre-development levels from the site itself, a watershed-level design would be geared towards maintaining existing peak flow rates in the entire drainage system. The latter requires knowledge of how the site relates to the entire watershed in terms of the timing of peak flows, contribution to peak flows at various downstream locations and the impact of the additional runoff volume generated by development of the site. The proposed watershed-level runoff control philosophy is based on the assumption that runoff volumes *will* increase with development and, rather than necessarily attempting to reduce post-development volume, seeks to "manage" the increase in volume such that peak rates of runoff throughout a watershed are not increased.

The basic goal, therefore, of both the at-site and watershed-level philosophies is the same, i.e. no increase in the peak rate of runoff. However, simply controlling peak rates of runoff at-site does not guarantee an effective watershed-level control because the increase in total runoff volume could accumulate throughout the watershed and increase peak flows.

1. Release Rate Concept

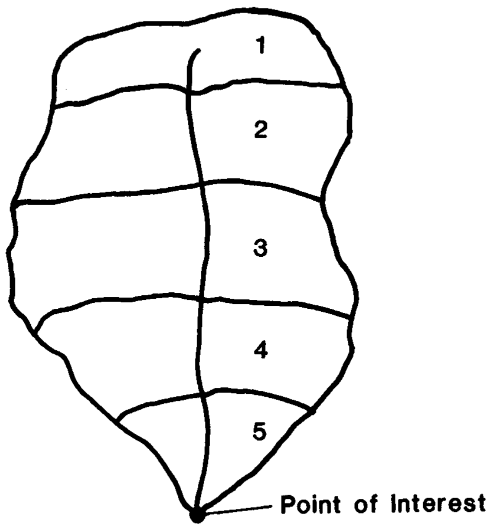
   In certain circumstances it is not quite enough to control post-development runoff peaks to pre-development levels if the overall goal is no increase in peak runoff at any point in the watershed. The reasons for this are how the various parts of the watershed interact, in time, with one another and the increased volume of runoff with development. The critical runoff control criteria for a given site or watershed area is not necessarily its own pre-development peak rate of runoff but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest. This concept is best explained through the use of a simplified chart.

   Figure 9 indicates how the individual runoff contributions from a number of sites or subareas create the total hydrograph at a particular point. Subareas 1 through 5 each have a particular runoff response to a given rainfall event (i.e. each will generate a characteristic hydrograph). Note that the configuration of the watershed is such that all areas will contribute runoff to the point of interest at the downstream end of area 5. The five areas do not contribute at the same time, however. Flows from area 1 have the farthest to travel to get to the point of interest. Area 5 flows contribute immediately to the point of interest flows. The contribution of each area to the hydrograph at the point of interest, therefore, is the individual area hydrograph lagged in time by an amount equal to the travel time from the area to the point of interest. The total hydrograph at the point of interest and the individual contributions from areas 1 through 5 are shown in Figure 9.

   The release rate concept is perhaps best described by looking at how area 4 contributes to the hydrograph at the point of interest. Figure 10 shows the total hydrograph from Figure 9 and the area 4 contribution only. Noteworthy facts regarding the two hydrographs are that area 4 itself peaks before the peak of the total hydrograph (40 minutes versus 50 minutes), the peak flow from area 4 is 100 cfs and the contribution of area 4 to the peak flow at the point of interest is 75 cfs. Also shown on Figure 10 are the possible outcomes of development occurring in area 4. Specifically, the possible area 4 hydrograph assuming development occurs with no storm water controls and the resultant hydrograph if all new development uses the at-site philosophy of controlling to pre-development peak levels are shown. Note that in both cases the flow contribution of area 4 to the peak at the point of interest increases (85 cfs for the "no control" option

Figure 9
"Point of Interest" Hydrograph Analysis Example

Watershed Configuration



Hydrograph Components at Point of Interest

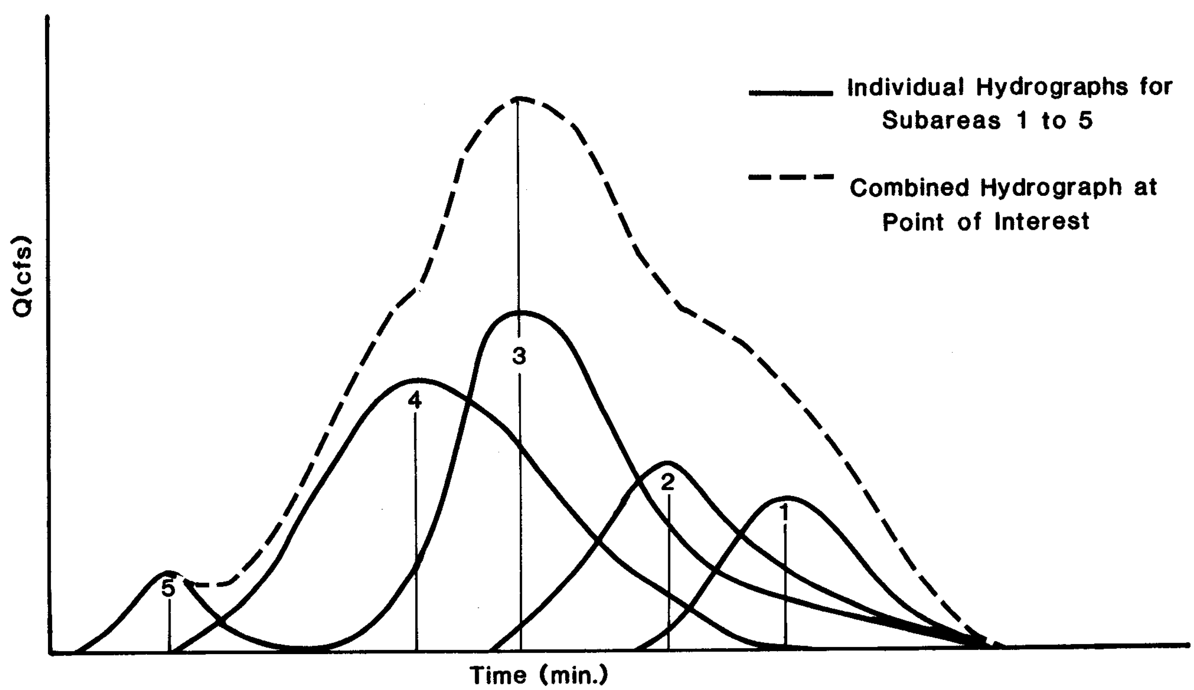
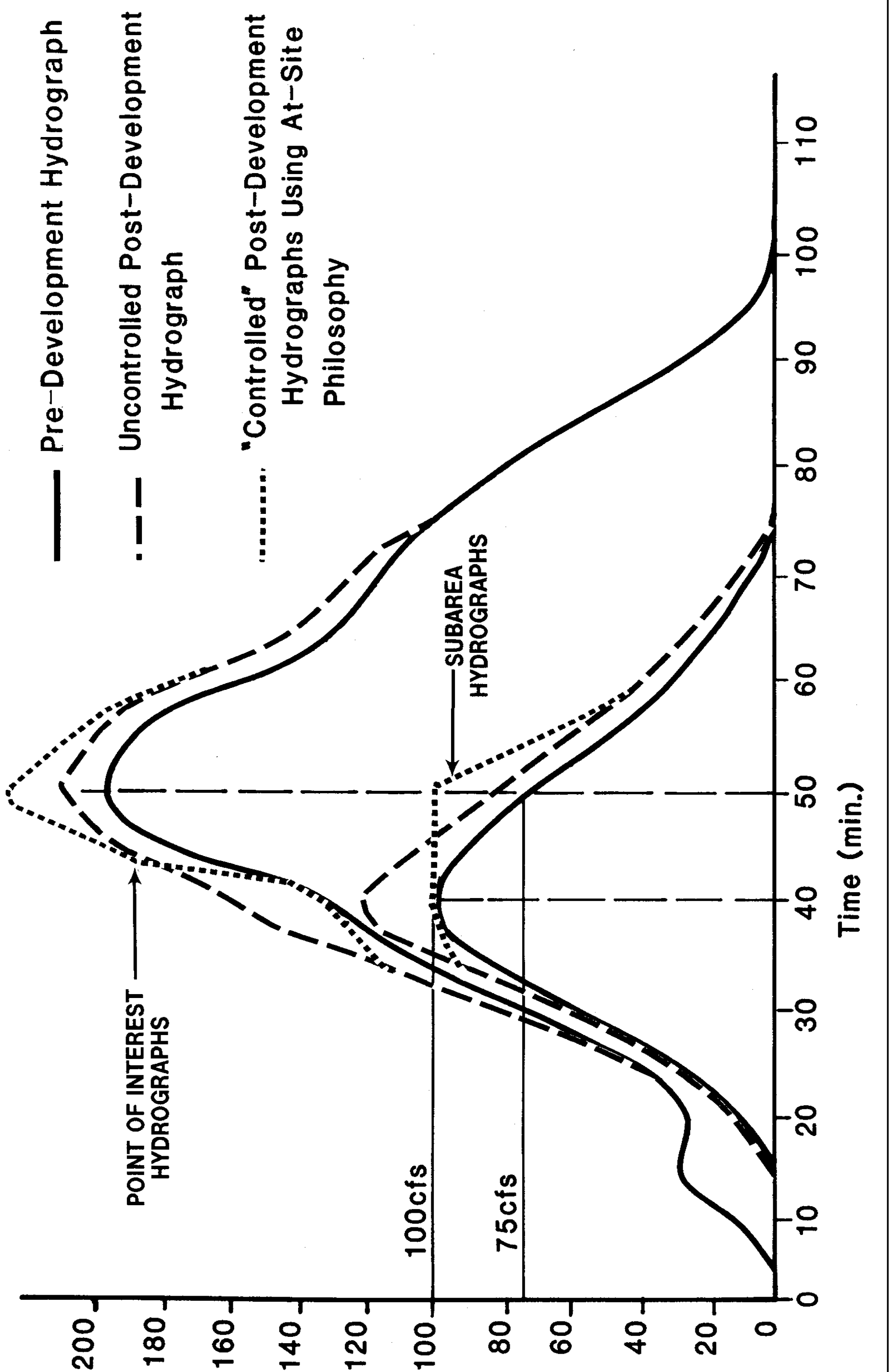


Figure 10
Hydrograph Analysis for Example Subarea 4



and 100 cfs for the "at-site" philosophy option). Therefore, the total peak flow at the point of interest from areas 1 through 5 must increase for both options and neither is an acceptable control strategy. The only acceptable control strategy would be to ensure that the contribution of area 4 to the peak flow at the point of interest does not exceed 75 cfs. Note that the 75 cfs represents 75% of the 100 cfs peak flow from area 4. Herein lies the basis for the release rate concept.

Conventional at-site detention philosophy would control post-development peak runoff flows to 100% of pre-development levels. The release rate concept would dictate a more stringent level of control. For area 4, the release rate would be 75% meaning that each individual development within area 4 would have to control post-development peak runoff rates to 75% of pre-development levels as illustrated in Figure 11. Only through this increased level of control for area 4 would the point of interest peak flows not be exceeded. The conclusion is that in exchange for increased runoff volume with development, the peak rate of runoff will actually need to be reduced relative to pre-development conditions for certain parts of the watershed. The release rate for those watershed areas, or subareas, is defined in equation form as follows:

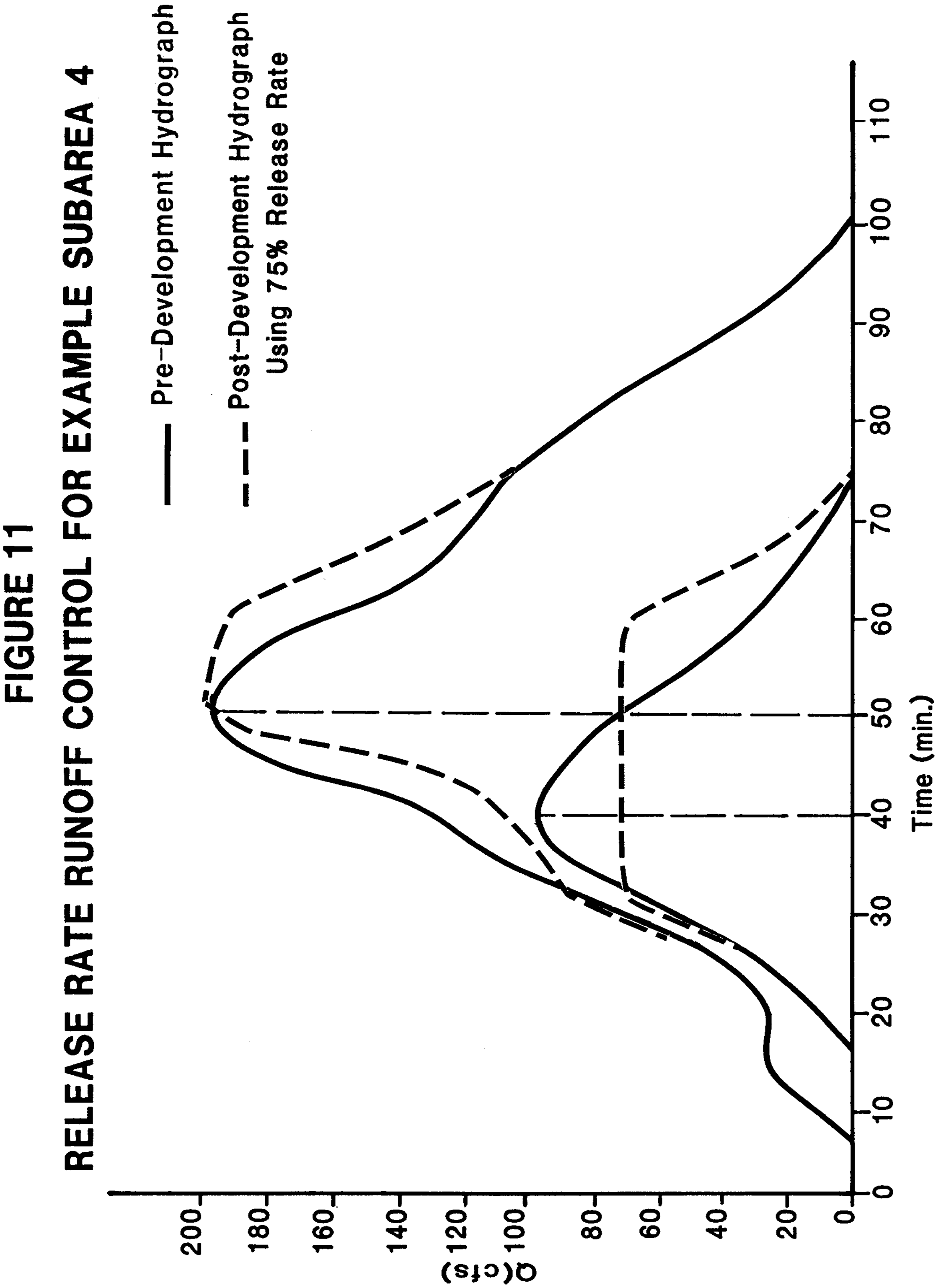
$$\text{Release Rate} = \frac{\text{Subarea Contribution to Point of Interest Peak}}{\text{Subarea Peak Flow}}$$

Note that the release rate concept has been developed using area 4 from Figure 9 as an example. The characteristics of area 4 are that it peaks prior to the point of interest peak *and* it contributes flow to the point of interest peak flow. None of the other areas in the example (1, 2, 3 or 5) exhibit both of these characteristics. As such, the proper method of runoff control applicable to these areas may differ from the basic release rate control strategy as discussed below.

Area 1 peaks later than the point of interest, and does not contribute any runoff to the point of interest peak. The runoff control strategy adopted for Area 1 is nearly inconsequential at the point of interest and could be the no control approach. However, if other points of interest are included in the analysis, the runoff control strategy would need to be to control the peak to 100% or less of existing as explained below.

Area 2 peaks later than the point of interest peak and does contribute to the point of interest peak. The uncontrolled post-development runoff from area 2 could increase the point of interest peak because of the tendency of new development to raise the peak of the drainage area *and* decrease the time to peak. The appropriate control strategy would be to simply provide detention for the drainage area designed to slow the rise of the hydrograph to the pre-development level and control peak flows to the pre-development condition.

Figure 11
Release Rate Runoff Control for Example Subarea 4



Area 3 peaks at exactly the same time at the point of interest peak due to its location in the middle of the watershed. Therefore, 100% of the area 3 peak contributes to the point of interest peak. Detention should be provided to ensure that post-development peak runoff does not exceed pre-development levels.

Area 5 peaks before the point of interest peak and does not contribute to the point of interest peak. The appropriate control, in order to keep this area's contribution to the point of interest peak at zero, would *probably* be to not control at all provided that the unrestricted runoff can be safely transported to the stream channel from each development site. Probably is used because area 5 could conceivably increase the overall watershed peak by itself if its unrestricted runoff was higher than the existing watershed peak.

For the Little Lehigh Creek Watershed analysis, each of the 226 subarea boundaries has been chosen as a point of interest. With multiple points of interest, each drainage area fits into multiple control categories. For example, if the point of interest is the bottom of area 5, area 1 could use no control and have no effect on the point of interest peak. However, if the point of interest peak is the bottom of area 1, the use of no control for area 1 would increase the peak at the point of interest and therefore a 100% release rate or less would be necessary.

There are three key considerations in the Release Rate Concept. First, location in the watershed matters and will make a difference in the release rate required. Second, the only way to be sure that the release rate strategy is protecting the watershed is to model. Third, when modeling, the future land use condition must be used to test the proposed release rate strategy.

2. Release Rate Determination

The 1988 Release Rate strategy was designed to provide for new development within the watershed while maintaining existing peak flows. However, at that time, the computer model being used could not run the entire watershed at one time such that testing of proposed release rates could not be fully accomplished. Therefore, the first step in developing Release Rates for the Plan Update was to verify the performance of the 1988 Release Rates. The results showed that the 1988 Release Rates maintained the existing peak flows at every point in the watershed for the 10-year storm but not for the 2-year storm. Based on experience with other watershed plans in Lehigh and Northampton counties, it was decided to try a 30% release rate control for the 2-year storm for all watershed area except the Conditional No Detention areas.

The watershed model was run using the future land use condition as described in Chapter 3. This condition assumes that the open space and forested areas have no impervious cover (0%). Agriculture was assumed to have 10% impervious cover because agricultural areas usually have buildings (barns, house, etc.) associated with them and 10% is exactly between the value for open space (0%) and the value for low density housing (20%). Under these assumptions, the model was used to test the dual release rates.

The final strategy for the watershed was chosen to have two categories — Conditional No Detention and Dual Release Rates. The 2-year Release Rate in the Dual Release Rate areas is 30%. The 10- through 100-year Release Rates in the Dual Release Rate areas varies from 50% to 100% depending on location in the watershed. This strategy was chosen because it controls future peak flows to existing flows for return periods from 2- up to 100-years. The dual release rate category provides reduced peak flows for the 2-year storm without increasing the cost of runoff control. The WATERSHED model was run for the 1-year storm to see if the final Release Rate strategy would offer any benefit for the more frequent storm. The model showed that the 30% 2-year release rate controls peak flows to within 110% of existing for the 1-year storm. This provides some control for a more frequent storm without adding additional design criteria for the developer. The 30% release rate may also help improve water quality by retaining the first flush of debris-carrying storm water long enough for some of the pollutants to settle out. Each of the two categories in this strategy are described later under the Performance Standards section of this chapter.

B. Performance Standards

1. Description of Performance Standard Districts

A major goal of the Act 167 Plan effort was to determine where in the watersheds detention is appropriate and, just as importantly, where it is not appropriate for new development. A further goal was to determine to what level of control should detention be provided (i.e. in exchange for an increase in runoff volume with development did existing peak rates need to be reduced). All of the factors described in Section A of this chapter have been incorporated into a control strategy for successfully dealing with the runoff impacts of new development. The control plan is based on dividing the Little Lehigh Creek Watershed into two basic districts. Each of the districts is described below:

a.) Conditional No Detention (CND) Districts - These watershed areas peak very early with respect to the total watershed peak flow and contribute very minimal flow to the watershed peak flow. For that reason, these watershed areas could discharge post-development peak runoff without detention without adversely affecting the total watershed peak flow. However, these areas are designated “conditional” because a developer must calculate the capacity of the “local” runoff conveyance facilities to determine the control strategy to be implemented. If the capacity calculations show that adequate capacity to transport runoff from the site to the main channel exists, then no detention can be implemented. If the calculations show that adequate capacity does not exist, then a 100% release rate control must be provided or, alternately, the capacity deficiency(ies) must be corrected.

b.) Dual Release Rate Districts - The anticipated post-development runoff from these areas can be controlled across the range of return periods from 2- through 100-years by implementing a dual system of release rates. Within this district, the 2-year post-development runoff must be controlled to 30% of the pre-development 2-year runoff peak. Further, the 10-year, 25-year and 100-year post-development runoff must be controlled to the stated percentage of the pre-development peak. Release Rates associated with the 10- through 100-year events vary from 50% to 100% depending upon location in the watershed.

A map of the Little Lehigh Creek Watershed performance standard districts is included as PLATE I located inside the back cover of the Plan.

It is important to emphasize that the release rate criteria represent performance standards for the control of post-development runoff from a development site and not necessarily design criteria for detention facilities. The performance standards may be met with any viable combination of volume controls and rate controls as described in Chapter 6. Volume controls have the benefit of providing for groundwater recharge, but must be implemented carefully to avoid any problems of possible groundwater pollution or aggravation of sinkhole prone areas. The most appropriate control philosophy for a site should be determined only after a thorough site evaluation.

2. Performance Standard Implementation Provisions

The performance standards specified above represent one-half of the storm water runoff control strategy for the Little Lehigh Creek Watershed. The other half of the strategy is composed of the provisions necessary to implement the performance standards including the types of new development to which the standards apply, runoff calculation methodology, criteria for determining downstream channel capacity, a “no harm” procedure for deviating from the performance standards for a particular site and provisions to implement regional detention alternatives. Each of these implementation provisions is addressed separately below.

One additional implementation provision is that the criteria and standards for controlling runoff from new development contained herein are *minimum* criteria necessary for management of runoff from a watershed perspective. Municipalities may implement more stringent criteria so long as the increased stringency does not conflict with the Plan. A more detailed explanation of this aspect of the Plan is presented in the introduction to the municipal ordinance in Chapter 9.

a.) “New Development” Subject to the Performance Standards

“New development” to be regulated by the runoff control plan includes subdivisions, land developments, construction of new or additional impervious surfaces (driveways, parking lots, etc.), construction of new buildings or additions to existing buildings, diversion or piping of any natural or man-made stream channel, and the installation of any storm sewer system. The latter two items are included because they may have the impact of modifying significantly the conveyance characteristics which have been built into the design of the Plan and, therefore, impact the effectiveness of the Plan. An exemption will be provided in the Plan for new developments which are expected to have an insignificant impact on the watershed level runoff characteristics. The exemption is that any development which would create 10,000 square feet or less of additional impervious cover would not be required to meet the performance standards of the Plan. The 10,000 square foot criterion is based on the amount of impervious cover which would generate two (2) cubic feet per second (cfs) or less of additional peak runoff for a five-minute duration storm for a 100-year return period rainfall event. This waiver would not apply to stream channel modifications or storm sewer systems.

b.) Storm Runoff Calculation Methodology

The performance standards will apply to the range of design storm conditions from a 2-year return period to a 100-year return period. This means that the applicable release rates must be met for the 2-year, 10-year, 25-year and 100-year return period storm events. In many instances this will mean that detention facilities are designed with multiple stage outlet structures to accommodate the range of return periods.

An important implementation provision is the specification of the runoff calculation methods to be used for development sites within the Little Lehigh Creek Watershed. Engineering evaluations of the applicability of various calculation methods were conducted as part of the Plan preparation and supported by previous research. The conclusion from the research is that all development sites in the basin may use either the Rational Method or the soil-cover-complex method for determining pre- and post-development runoff peak rates. The soil-cover-complex method was developed by the Natural Resources Conservation Service (NRCS, formerly SCS) and its distinguishing characteristic is the use of a parameter called the Runoff Curve Number. NRCS has analyzed the runoff relationship between the various land cover and soil type combinations and has formulated a scale of the relative ability of the various combinations to produce runoff from a given rainfall. Although the soil-cover-complex method was developed by NRCS, there are many calculation methods available which use the curve number methodology which are not otherwise associated with NRCS. The WATERSHED Model is one such calculation method.

Regardless of the runoff calculation method used, the design of any detention facility to meet the performance standards specified in the Plan must be verified by routing the calculated runoff through the basin. Routing refers to the calculation process of taking the post-development runoff and determining if the detention facility's storage-elevation-outflow characteristics are appropriate for meeting the performance standards. Closed depressions are one factor which could affect the magnitude of the peak flows a development will produce. In the "existing" condition, closed depressions can prevent a significant amount of runoff from entering the stream channel. The removal of these depressions with development can increase the storm runoff received by the conveyance facilities beyond the available capacity. For this reason, any development proposal which will remove a significant closed depression must demonstrate adequate capacity in the "local" conveyance facilities from the site to the main channel. Proper analysis of channel capacity is outlined in the following section.

c.) Channel Capacity/Capacity Improvement Criteria

Implementation of the performance standard criteria requires the identification of procedures to deal with two aspects of the CND district, namely downstream channel capacity evaluation and possible capacity improvements. The downstream channel capacity analysis is a requirement for the CND area. Possible channel capacity improvements would be identified as part of a downstream capacity analysis and in certain instances could be implemented in lieu of runoff controls. The procedures involved for each of these implementation aspects are described below.

Proper analysis of channel capacity downstream of a development site for the purpose of discharging greater than pre-development peak flow rates is essential for ensuring that the goal of not aggravating existing drainage problem areas or creating any new problems is achieved. The analysis must include peak flow calculations assuming that the site is developed as proposed and that the remainder of the local watershed is in the existing condition. Additionally, calculations assuming that the entire local watershed is developed per current zoning and is implementing the runoff controls specified by this Plan must be included. The larger of the peak flows calculated will be used in determining if adequate capacity exists. The criteria used to evaluate the adequacy of downstream channel capacity is stated below, all three of which must be met to document adequate downstream capacity:

- Natural or man-made channels must be able to convey the runoff associated with a 2-year return period rainfall event within their banks at velocities consistent with protection of the channels from erosion. Acceptable velocities will be based upon criteria contained in the DEP *Erosion and Sediment Pollution Control Program Manual* (April, 1990).

- Natural or man-made channels or swales must be able to convey the 25-year return period runoff without creating any safety or property hazard.

- Culverts, bridges, storm sewers or any other facilities which must pass or convey flows from the tributary area must be designed in accordance with DEP Chapter 105 regulations (if applicable) and, at minimum, pass the increased 25-year return period runoff.

Any capacity improvements provided in accordance with this Plan must be designed based upon the upstream development assumptions and design criteria as specified for the channel capacity analysis specified above. Capacity improvements would be appropriate where local drainage conditions dictate a more stringent level of control than watershed-level conditions. The capacity improvements could be provided, therefore, in lieu of runoff control facilities for a development site. This approach has the benefit of minimizing detention facilities provided solely for local reasons.

Further, it provides an excellent mechanism for dealing with existing local storm drainage problems caused by existing capacity deficiencies.

d.) "No Harm" Option

The control philosophy as described above incorporating CND Districts and Dual Release Rate Districts, downstream capacity analyses and capacity improvements is based on the goal of maintaining (as nearly as possible) existing peak flow values throughout the study area, or otherwise ensuring that any increase in peak runoff would not adversely impact persons or property. In certain instances, however, the control strategy may be more restrictive than absolutely necessary to achieve the above-stated goal due to special circumstances associated with a given development. For this reason, a "no harm" option is also included as part of the Plan. The purpose for the "no harm" option is to provide a developer with an opportunity to prove that special circumstances exist for his development site which would allow him to deviate from the Plan control strategy, but which would cause "no harm" to persons or property downstream. "Special circumstances", as used above, are defined as any hydrologic or hydraulic aspects of the development itself not specifically considered in the development of the Plan runoff control strategy. Two aspects of the Plan runoff control strategy which may particularly provide a developer with a basis for pursuing the "no harm" option are as follows:

(1) The Release Rate strategy is based upon controlling peak rates of flow throughout the watersheds after development occurs to near existing levels. In certain instances, the existing drainage network may be capable of safely transporting peak flows significantly in excess of existing flows. A developer may, therefore, be able to prove "no harm" even though peak flows would increase by using a different control strategy than that included in the Plan.

(2) The Release Rate strategy is based on the assumption that the *volume* of runoff will increase with development of a particular site. In certain instances, however, either due to volume controls proposed by the developer or due to an unusual combination of pre- and post-development conditions, the volume of runoff leaving the site after development may be less than or equal to that prior to development activities. In these instances, it may be possible to discharge peak runoff rates in excess of the Plan criteria without causing harm.

The two key elements of the "no harm" option are that the ability to discharge runoff from a development site at peak rates other than those specified by the Plan is predicated upon sound engineering proof of "no harm" and that the burden of proof is the responsibility of the developer. To be consistent with the Plan, proof of "no harm" would have to be shown from the development site through the remainder of the watershed downstream to the confluence with the Lehigh River since the Plan criteria have been developed consistent with that objective. Conceivably, however, a developer may be able to document the "impact distance" of his proposed actions downstream of which, by definition, no harm would be created. In this way, a developer could limit the downstream extent of the rigorous hydrologic analysis.

Attempts to prove “no harm” based on downstream peak flow versus capacity analysis shall be governed by the following factors:

(1) The peak flow values to be used for downstream areas for various return period storms shall be the values from the calibrated WATERSHED Model for the Little Lehigh Creek Watershed. These flow values would be supplied to the developer by the municipal engineer upon request and are included as Appendix D of the suggested Act 167 Ordinance included in Chapter 9.

(2) Any available capacity in the downstream conveyance system, as documented by a developer, may be used by the developer only in proportion to his development site acreage relative to the total upstream undeveloped acreage from the identified capacity (i.e. if his site is 10% of the upstream undeveloped acreage, he may use up to 10% of the documented downstream available capacity).

(3) Developer-proposed runoff controls which would generate increased peak flow rates at documented storm drainage problem areas would, by definition, be precluded from successful attempts to prove “no harm”, except in conjunction with proposed capacity improvements.

The examples of possible bases to pursue “no harm” justifications as presented above are for illustration purposes and are not intended as the only two means available to prove “no harm”. It would not be possible to foresee all “special circumstances” of development for which the “no harm” option might be successfully applied. The burden, therefore, is on the developer to identify the special circumstances and provide the sound engineering “no harm” documentation. “No harm” justifications would be submitted by a developer as part of the Drainage Plan submission included with the Preliminary Plan submission for a subdivision or land development.

e.) Regional Detention Alternatives

One final aspect of the control philosophy is the provision for regional detention alternatives. The major advantage of a regional facility is the ability to control the runoff from large watershed areas with a single facility rather than one facility for each development site in the tributary area. A single facility may be more aesthetically acceptable than many smaller basins and would offer the benefit of much more efficient maintenance.

There are, however, many disadvantages of regional detention facilities. First, regional detention facilities would require large land areas to control large tributary areas. Either the availability of appropriately located land areas or the cost of the land, or both, could preclude this alternative. Second, the financial arrangements for regional facilities may be very cumbersome involving municipal or multi-municipal financing up-front to be reimbursed by developers as the tributary area is developed, as one example. For large tributary areas, the payback time frame would be very uncertain. Third, the design of a regional facility which has tributary areas in multiple control categories specified by this Plan would be complicated. Fourth, the design of a regional facility outlet release would be keyed to protection of the watershed downstream of the regional control. Development upstream of the basin without implementation of on-site runoff controls could create problems between the development site(s) and the basin. This situation would be contradictory to the goals of Act 167.

The above-stated disadvantages of regional detention facilities notwithstanding, it may be feasible to implement regional detention alternatives within the Little Lehigh Creek Watershed. The most likely alternatives would involve relatively small tributary areas representing several development sites. For the purposes of this Plan, any regional alternatives would require the initiative of a developer or group of developers to propose a regional facility. The funding, design criteria, maintenance provisions and other applicable considerations would be the product of developer-municipal-County discussions. There are no specific recommendations for locations of regional detention facilities incorporated in this Plan. However, as part of the development of the runoff control strategy proposed in the Plan, "regional" detention basins were placed at the outlet of each subarea as delineated for modeling purposes. Acceptable release rates from these basins were determined by running the model several times and varying the release from each basin until the desired post-development hydrograph was achieved for the entire watershed. In the original drawing of the subarea boundaries, an important rationale was to make each subarea small enough such that the hydrograph for each development within the subarea would require the same release rate control as the total subarea. In this way, there would be no difference in design criteria between each development within a subarea and a "regional" facility controlling the entire subarea. Decisions between individual development detention facilities and facilities for entire subareas therefore depend upon the type of development(s) proposed and the cost-effectiveness of each control alternative - an evaluation of which is beyond the scope of this report.

CHAPTER 9. MUNICIPAL ORDINANCE TO IMPLEMENT THE LITTLE LEHIGH CREEK WATERSHED STORM WATER MANAGEMENT PLAN

The implementation of the runoff control strategy for new development will be through municipal adoption of the appropriate ordinance provisions. As part of the preparation of the update to the Little Lehigh Creek Watershed Storm Water Management Plan, a model ordinance has been prepared which would implement the Plan provisions presented in Chapter 8. The ordinance is a single purpose ordinance which could be adopted essentially as is by the municipalities. Tying provisions would also be required in the municipal Subdivision and Land Development Ordinance and the municipal Building Code to ensure that activities regulated by the ordinance were appropriately referenced. The updated *Little Lehigh Creek Watershed - Act 167 - Storm Water Management Ordinance* will not completely replace the existing storm drainage ordinance provisions currently in effect in the Little Lehigh Creek Watershed municipalities. The reasons for this are as follows:

- Not all of the municipalities in the Little Lehigh Creek Watershed are completely within the watershed. For those portions of a municipality outside of the Little Lehigh Creek Watershed, the existing ordinance provisions would still apply.

- Only permanent storm water control facilities are regulated by the Act 167 Ordinance. Storm water management and erosion and sedimentation control during construction would continue to be regulated by existing municipal ordinances and DEP criteria. The DEP criteria are provided in the *Erosion and Sediment Pollution Control Program Manual* (April, 1990). DEP standards regarding sediment basin design differ from those required by this Ordinance. An acceptable design would meet both criteria.

- The Act 167 Ordinance contains only those storm water runoff control criteria and standards which are necessary or desirable from a total watershed perspective. Additional storm water management design criteria (i.e. inlet spacing, inlet type, collection system details, etc.) which should be based on sound engineering practice should be regulated under the current ordinance provisions.

- The Act 167 Ordinance contains criteria and standards for runoff control from new development which are the *minimum* criteria from a watershed perspective. Individual municipalities may adopt more stringent ordinance provisions so long as consistency with the Plan is maintained. Note that more stringent criteria will not always be consistent with the Plan. An example would be a municipality requiring detention for all new development when certain parts of the municipality are within a “Conditional No Detention” District. The minimum municipal ordinance requirements for each article are listed in Table 16 on page 9-3.

- The Act 167 Ordinance provides a waiver for certain regulated activities which create less than 10,000 square feet of new impervious cover. Development plans qualifying for this waiver would still be regulated by the current municipal ordinance and Section 13 of the Pennsylvania Stormwater Management Act.

The Act 167 Ordinance is composed of the basic ordinance body and a set of appendices. The body of the document is organized into eight articles including General Provisions, Definitions, Storm Water Management Requirements, Drainage Plan Requirements, Inspections, Fees and Expenses, Maintenance Responsibilities and Enforcement.

The Ordinance Appendices, to be made part of municipal ordinances, should provide maps of the Little Lehigh Creek Watershed, storm water management districts and storm drainage problem areas as well as technical data to be used in the calculation methodology. The Ordinance is intended to be separable from the Plan document itself. The maps in the Ordinance Appendices would be duplicative of those already included in the Plan and are not included in the Plan version of the Ordinance.

Although the actual storm water control provisions may vary significantly from an existing municipal ordinance, the structure of the Ordinance itself is very similar to many ordinances. The actual ordinance adopted by a municipality to implement the Little Lehigh Creek Watershed Act 167 Plan may differ in form from the Ordinance provided herein so long as it includes, at minimum, all of the provisions of the suggested Ordinance. A municipality may tailor the Ordinance provisions to best fit into their current ordinance structure. Two notes on the Ordinance for municipalities to consider are as follows:

- A "hardship waiver" procedure has been included as Section 407 within Article 4 - Drainage Plan Requirements. A municipality may wish to restructure the waiver procedure into a separate article perhaps as a formal municipal hearing provision. The minimum requirement of the hardship waiver procedure as adopted by a municipality is that it include all four of the "findings" included with the Plan version of the provision.

- The maintenance provisions included in Article 7 are structured to eliminate any uncertainty as to the party responsible for continuing maintenance. The elimination of "gray areas" of maintenance responsibilities is the minimum criteria imposed by the Ordinance. A municipality may be able to restructure the maintenance provisions to accomplish this minimum goal and place less of a burden on the municipality itself for continuing maintenance.

The Ordinance contains references to the National Pollutant Discharge Elimination System (NPDES) storm water permit program. Each construction site (where applicable) must meet the NPDES requirements and obtain a proper NPDES permit from the Lehigh or Berks County Conservation District or DEP as applicable. The NPDES references can be found in Article 2, Section 303.P. and Section 404.D.

TABLE 16

MINIMUM MUNICIPAL ORDINANCE REQUIREMENTS

The Act 167 Ordinance contains criteria and standards for runoff control from new development which are the *minimum* criteria required. The model ordinance contains the criteria that the LVPC will use to provide advisory engineering design reviews to the municipality. Municipalities can, however, adopt criteria which are more stringent as long as consistency with the Plan is maintained. The chart below lists each article in the ordinance, the minimum municipal ordinance requirement for the article and *examples* of provisions which are more stringent but still consistent with the Plan. The *examples* listed are not intended to be comprehensive but to provide an idea of the flexibility available to municipalities throughout the ordinance. Note that more stringent criteria will not always be consistent with the Plan. An example would be a municipality requiring detention for all new development when certain parts of the municipality are within a Conditional No Detention District.

ARTICLE	TITLE	MINIMUM REQUIREMENT	MORE STRINGENT REQUIREMENT
1	General Provisions	Include verbatim.	*Section 104* – Reduce impervious cover exemption to less than 10,000 sq. ft.
2	Definitions	Include verbatim.	
3	Storm Water Management Requirements	*Sections 301 A, B, C, E, F, G, and H* – Include verbatim. *Section 301.D.* – Ordinance provision must insure, through deed restriction, easement or other appropriate means, maintenance of this area for the conveyance of storm water runoff.	*Section 301.C.* – Require written approval from affected property owners before allowing proposed concentrated discharge. *Section 301.D.* – Require easements with larger safety factors of design. *Section 303.A.* – Require calculations for additional return periods. *Section 303.J.* – Require entire site, rather than just the impact area, to meet the Release Rate criteria.
4	Drainage Plan Requirements	*Sections 401, 402, 403, 405 and 406* – Include verbatim. *Section 404* – Municipality and LVPC must receive plan submissions. *Section 407* – Municipality must have process for reviewing waiver requests. The five findings must be included verbatim.	*Section 402* – Make pre-development impervious cover that which is in place as of the effective date of the original Little Lehigh Ordinance. *Section 403* – Require additional details on project area maps. *Section 404* – Require additional Drainage Plan sets for submission to the municipality.
5	Inspections	Municipality must have the right to inspect storm drainage facilities.	

TABLE 16 continued			
ARTICLE	**TITLE**	**MINIMUM REQUIREMENT**	**MORE STRINGENT REQUIREMENT**
6	Fees and Expenses	Municipality may collect fees to cover review costs.	
7	Maintenance Responsibilities	Ordinance provision must indicate responsibility for long-term maintenance of storm drainage facilities.	
8	Enforcement	Must be included verbatim in a stand-alone ordinance. If storm water provisions are to be incorporated into an existing SALDO which has enforcement provisions, these sections may not be necessary.	*Section 803* – Include specific dollar amounts to be fined for violations.
	Appendices	Include verbatim.	*Appendix C* – More stringent impervious cover Rational 'c' values.

LITTLE LEHIGH CREEK WATERSHED
ACT 167 - STORM WATER MANAGEMENT ORDINANCE

ARTICLE 1
GENERAL PROVISIONS

SECTION 101. STATEMENT OF FINDINGS

The governing body of the municipality finds that:

A. Inadequate management of accelerated runoff of storm water resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of streams and storm sewers, greatly increases the cost of public facilities to carry and control storm water, undermines floodplain management and flood control efforts in downstream communities, reduces groundwater recharge, and threatens public health and safety.

B. A comprehensive program of storm water management, including reasonable regulation of development and activities causing accelerated erosion, is fundamental to the public health, safety and welfare and the protection of the people of the municipality and all the people of the Commonwealth, their resources and the environment.

SECTION 102. PURPOSE

The purpose of this Ordinance is to promote the public health, safety and welfare within the Little Lehigh Creek Watershed by minimizing the damages described in Section 101.A of this Ordinance by provisions designed to:

A. Control accelerated runoff and erosion and sedimentation problems at their source by regulating activities which cause such problems.

B. Utilize and preserve the desirable existing natural drainage systems.

C. Encourage recharge of groundwaters where appropriate.

D. Maintain the existing flows and quality of streams and water courses in the municipality and the Commonwealth.

E. Preserve and restore the flood carrying capacity of streams.

F. Provide for proper maintenance of all permanent storm water management structures which are constructed in the municipality.

SECTION 103. STATUTORY AUTHORITY

The municipality is empowered to regulate these activities by the authority of the Act of October 4, 1978, P.L. 864 (Act 167), 32 P.S. Section 680.1, *et seq*., as amended, the "Storm Water Management Act" and the (appropriate municipal code).

SECTION 104. APPLICABILITY

This Ordinance shall only apply to those areas of the municipality which are located within the Little Lehigh Creek Watershed as delineated on an official map available for inspection at the municipal office. A map of the Little Lehigh Creek Watershed at a reduced scale is included in Appendix A for general reference.

The following activities are defined as Regulated Activities and shall be regulated by this Ordinance, except those which meet the waiver specifications presented thereafter:

A. Land development.

B. Subdivision.

C. Construction of new or additional impervious surfaces (driveways, parking lots, etc.).

D. Construction of new buildings or additions to existing buildings.

E. Diversion or piping of any natural or man-made stream channel.

F. Installation of storm water systems or appurtenances thereto.

Any proposed Regulated Activity, except those defined in Section 104.E. and 104.F., which would create 10,000 square feet or less of additional impervious cover would be exempt from meeting the provisions of this Ordinance. Development plans qualifying for this waiver would still be required to manage the quantity, velocity and direction of resulting storm runoff as is reasonably necessary to prevent injury to health, safety or other property. For development taking place in stages, the entire development plan must be used in determining conformance with this criteria. Additional impervious cover shall include, but not be limited to, any roof, parking or driveway areas and any new streets and sidewalks constructed as part of or for the proposed regulated activity. Any areas which may be designed to initially be semi-pervious (e.g. gravel, crushed stone, porous pavement, etc.) shall be considered impervious areas for the purpose of waiver evaluation. No waiver shall be provided for Regulated Activities as defined in Sections 104.E. and 104.F.

SECTION 105. REPEALER

Any ordinance of the municipality inconsistent with any of the provisions of this Ordinance is hereby repealed to the extent of the inconsistency only.

SECTION 106. SEVERABILITY

Should any section or provision of this Ordinance be declared invalid by a court of competent jurisdiction, such decision shall not affect the validity of any of the remaining provisions of this Ordinance.

SECTION 107. COMPATIBILITY WITH OTHER ORDINANCE REQUIREMENTS

Approvals issued pursuant to this Ordinance do not relieve the applicant of the responsibility to secure required permits or approvals for activities regulated by any other applicable code, rule, act or ordinance.

SECTION 108. DUTY OF PERSONS ENGAGED IN THE DEVELOPMENT OF LAND

Notwithstanding any provisions of this Ordinance, including waiver provisions, any landowner and any person engaged in the alteration or development of land which may affect storm water runoff characteristics shall implement such measures as are reasonably necessary to prevent injury to health, safety or other property. Such measures shall include such actions as are required to manage the rate, volume and direction of resulting storm water runoff in a manner which otherwise adequately protects health and property from possible injury.

ARTICLE 2
DEFINITIONS

Cistern - An underground reservoir or tank for storing rainwater.

Closed Depression - In a karst area, a distinctive bowl-shaped depression in the land surface. It is characterized by internal drainage, varying magnitude, and an unbroken ground surface.

Conservation District - The Lehigh or Berks County Conservation District, as applicable.

Culvert - A pipe, conduit or similar structure including appurtenant works which carries surface water.

Dam - An artificial barrier, together with its appurtenant works, constructed for the purpose of impounding or storing water or another fluid or semifluid or a refuse bank, fill or structure for highway, railroad or other purposes which does or may impound water or another fluid or semifluid.

DEP - The Pennsylvania Department of Environmental Protection (formerly the Pennsylvania Department of Environmental Resources).

Design Storm - The magnitude of precipitation from a storm event measured in probability of occurrence (e.g., 50-yr. storm) and duration (e.g. 24-hour), and used in computing storm water management control systems.

Detention Basin - A basin designed to retard storm water runoff by temporarily storing the runoff and releasing it at a predetermined rate.

Developer - A person, partnership, association, corporation or other entity, or any responsible person therein or agent thereof, that undertakes any Regulated Activity of this Ordinance.

Development Site - The specific tract of land for which a Regulated Activity is proposed.

Drainage Easement - A right granted by a land owner to a grantee, allowing the use of private land for storm water management purposes.

Drainage Plan - The documentation of the proposed storm water management controls, if any, to be used for a given development site, the contents of which are established in Section 403.

Erosion - The removal of soil particles by the action of water, wind, ice, or other geological agents.

Freeboard - The incremental depth in a storm water management structure, provided as a safety factor of design, above that required to convey the design runoff event.

Groundwater Recharge - Replenishment of existing natural underground water supplies.

Impervious Surface - A surface which prevents the percolation of water into the ground.

Infiltration Structure - A structure designed to direct runoff into the ground, e.g. french drain, seepage pit or seepage trench.

Land Development - (i) the improvement of one lot or two or more contiguous lots, tracts or parcels of land for any purpose involving (a) a group of two or more buildings, or (b) the division or allocation of land or space between or among two or more existing or prospective occupants by means of, or for the purpose of streets, common areas, leaseholds, condominiums, building groups or other features; (ii) a subdivision of land.

"Local" Runoff Conveyance Facilities - Any natural channel or manmade conveyance system which has the purpose of transporting runoff from the site to the mainstem.

Mainstem (main channel) - Any stream segment or other conveyance used as a reach in the Little Lehigh Creek hydrologic model.

Manning Equation (Manning formula) - A method for calculation of velocity of flow (e.g. feet per second) and flow rate (e.g. cubic feet per second) in open channels based upon channel shape, roughness, depth of flow and slope. "Open channels" may include closed conduits so long as the flow is not under pressure.

Municipality - [municipal name], Lehigh or Berks County (as applicable), Pennsylvania.

NPDES Regulations - National Pollutant Discharge Elimination System Regulations.

NRCS - Natural Resource Conservation Service - U.S. Department of Agriculture. (Formerly the Soil Conservation Service.)

Peak Discharge - The maximum rate of flow of stream runoff at a given location and time resulting from a specified storm event.

Penn State Runoff Model (PSRM) - The computer-based hydrologic modeling technique used in previous Act 167 Plans. PSRM was also updated to include water quality modeling capabilities and renamed PSRM-QUAL. The PSRM and PSRM-QUAL calculation methodologies were used as the basis for writing the WATERSHED model.

Rational Method - A method of peak runoff calculation using a standardized runoff coefficient (rational 'c'), acreage of tract and rainfall intensity determined by return period and by the time necessary for the entire tract to contribute runoff. The rational formula is stated as follows: Q = ciA, where "Q" is the calculated peak flow rate in cubic feet per second, "c" is the dimensionless runoff coefficient (see Appendix C), "i" is the rainfall intensity in inches per hour, and "A" is the area of the tract in acres.

Reach - Any of the natural or man-made runoff conveyance channels used for modeling purposes to connect the subareas and transport flows downstream.

Regulated Activities - Actions or proposed actions which impact upon proper management of storm water runoff and which are governed by this Ordinance as specified in Section 104.

Release Rate - The percentage of the pre-development peak rate of runoff for a development site to which the post-development peak rate of runoff must be controlled to avoid peak flow increases throughout the watershed.

Return Period - The average interval in years over which an event of a given magnitude can be expected to recur. For example, the twenty-five (25) year return period rainfall or runoff event would be expected to recur on the average once every twenty-five years.

Runoff - That part of precipitation which flows over the land.

Seepage Pit/Seepage Trench - An area of excavated earth filled with loose stone or similar material and into which surface water is directed for infiltration into the ground.

Soil-Cover-Complex Method - A method of runoff computation developed by NRCS which is based upon relating soil type and land use/cover to a runoff parameter called a Curve Number.

Storage Indication Method - A reservoir routing procedure based on solution of the continuity equation (inflow minus outflow equals the change in storage for a given time interval) and based on outflow being a unique function of storage volume.

Storm Drainage Problem Areas - Areas which lack adequate storm water collection and/or conveyance facilities and which present a hazard to persons or property. These areas are either documented in Appendix B of this ordinance or identified by the municipality or municipal engineer.

Storm Sewer - A system of pipes or other conduits which carries intercepted surface runoff, street water and other wash waters, or drainage, but excludes domestic sewage and industrial wastes.

Storm Water Management Plan - The plan for managing storm water runoff adopted by Lehigh County for the Little Lehigh Creek Watershed as required by the Act of October 4, 1978, P.L. 864, (Act 167), as amended, and known as the “Storm Water Management Act”.

Stream - A watercourse.

Subarea - The smallest unit of watershed breakdown for hydrologic modeling purposes for which the runoff control criteria have been established in the Storm Water Management Plan.

Subdivision - The division or redivision of a lot, tract or parcel of land by any means into two or more lots, tracts, parcels or other divisions of land including changes in existing lot lines for the purpose, whether immediate or future, of lease, transfer or ownership or building or lot ownership.

Swale - A low lying stretch of land which gathers or carries surface water runoff.

Watercourse - Any channel of conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

WATERSHED - The computer-based hydrologic modeling technique adapted to the Little Lehigh Creek Watershed for the Act 167 Plan. This model was written by Tarsi Software Laboratories and uses the same algorithms found in the Penn State Runoff Quality Model (PSRM-QUAL). The model has been “calibrated” to reflect actual flow values by adjusting key model input parameters.

ARTICLE 3
STORM WATER MANAGEMENT REQUIREMENTS

SECTION 301. GENERAL REQUIREMENTS

A. Storm drainage systems shall be provided to permit unimpeded flow in natural watercourses except as modified by storm water detention facilities or open channels consistent with this Ordinance.

B. The existing points of concentrated drainage discharge onto adjacent property shall not be altered without written approval of the affected property owner(s).

C. Areas of existing diffused drainage discharge onto adjacent property shall be managed such that, at minimum, the peak diffused flow does not increase in the general direction of discharge, except as otherwise provided in this Ordinance. If diffused flow is proposed to be concentrated and discharged onto adjacent property, the developer must document that there are adequate downstream conveyance facilities to safely transport the concentrated discharge or otherwise prove that no harm will result from the concentrated discharge. Areas of existing diffused drainage discharge shall be subject to any applicable release rate criteria in the general direction of existing discharge whether they are proposed to be concentrated or maintained as diffused drainage areas.

D. Where a site is traversed by watercourses other than those for which a 100-year floodplain is defined by the municipality, there shall be provided drainage easements conforming substantially with the line of such watercourses. The width of any easement shall be adequate to provide for unimpeded flow of storm runoff based on calculations made in conformance with Section 304 for the 100-year return period runoff and to provide a freeboard allowance of one-half (0.5) foot above the design water surface level. The terms of the easement shall prohibit excavation, the placing of fill or structures, and any alterations which may adversely affect the flow of storm water within any portion of the easement. Also, periodic maintenance of the easement to ensure proper runoff conveyance shall be required. Watercourses for which the 100-year floodplain is formally defined are subject to the applicable municipal floodplain regulations.

E. Any drainage facilities or structures required by this Ordinance that are located on State highway rights-of-way shall be subject to approval by the Pennsylvania Department of Transportation.

F. When it can be shown that, due to topographic conditions, natural drainage swales on the site cannot adequately provide for drainage, open channels may be constructed conforming substantially to the line and grade of such natural drainage swales. Capacities of open channels shall be calculated using the Manning equation.

G. Storm drainage facilities and appurtenances shall be so designed and provided as to minimize erosion in watercourse channels and at all points of discharge.

H. Consideration should be given to the design and use of volume controls for storm water management, where geology and soils permit. Areas of suitable geology for volume controls shall be determined by the municipality. Documentation of the suitability of the soil for volume controls shall be provided by the applicant. Volume controls shall be acceptable in areas of suitable geology where the soils are designated as well drained in the County Soil Survey. Other soils may be acceptable for use of volume controls based on site-specific soils evaluations provided by the applicant.

SECTION 302. STORM WATER MANAGEMENT DISTRICTS

A. Mapping of Storm Water Management Districts - To implement the provisions of the Little Lehigh Creek Watershed Storm Water Management Plan, the municipality is hereby divided into Storm Water Management Districts consistent with the Little Lehigh Creek Release Rate Map presented in the Plan. The boundaries of the Storm Water Management Districts are shown on an official map which is available for inspection at the municipal office. A copy of the official map at a reduced scale is included in Appendix A for general reference.

B. Description of Storm Water Management Districts - Two types of Storm Water Management Districts may be applicable to the municipality, namely Conditional No Detention Districts and Dual Release Rate Districts as described below.

1. Conditional No Detention Districts - Within these districts, the capacity of the “local” runoff conveyance facilities (as defined in Article 2) must be calculated to determine if adequate capacity exists. For this determination, the developer must calculate peak flows assuming that the site is developed as proposed and that the remainder of the local watershed is in the existing condition. The developer must also calculate peak flows assuming that the entire local watershed is developed per current zoning and that all new development would use the runoff controls specified by this Ordinance. The larger of the two peak flows calculated will be used in determining if adequate capacity exists. If adequate capacity exists to safely transport runoff from the site to the main channel (as defined in Article 2), these watershed areas may discharge post-development peak runoff without detention facilities. If the capacity calculations show that the “local” runoff conveyance facilities lack adequate capacity, the developer shall either use a 100% release rate control or provide increased capacity of downstream elements to convey increased peak flows consistent with Section 303.N. Any capacity improvements must be designed to convey runoff from development of all areas tributary to the improvement consistent with the capacity criteria specified in Section 303.C. By definition, a storm drainage problem area associated with the “local” runoff conveyance facilities indicates that adequate capacity does not exist.

2. Dual Release Rate Districts - Within this district, the 2-year post-development peak runoff must be controlled to 30% of the predevelopment 2-year runoff peak. Further, the 10-year, 25-year and 100-year post-development peak runoff must be controlled to the stated percentage of the pre-development peak. Release Rates associated with the 10- through 100-year events vary from 50% to 100% depending upon location in the watershed.

SECTION 303. STORM WATER MANAGEMENT DISTRICT IMPLEMENTATION PROVISIONS

A. Any storm water management controls required by this Ordinance and subject to a dual release rate criteria shall meet the applicable release rate criteria for each of the 2-, 10-, 25- and 100-year return period runoff events consistent with the calculation methodology specified in Section 304.

B. The exact location of the Storm Water Management District boundaries as they apply to a given development site shall be determined by mapping the boundaries using the two-foot topographic contours provided as part of the Drainage Plan. The District boundaries as originally drawn coincide with topographic divides or, in certain instances, are drawn from the intersection of the watercourse and a physical feature such as the confluence with another watercourse or a potential flow obstruction (e.g. road, culvert, bridge, etc.). The physical feature is the downstream limit of the subarea and the subarea boundary is drawn from that point up slope to each topographic divide along the path perpendicular to the contour lines.

C. Any downstream capacity analysis conducted in accordance with this Ordinance shall use the following criteria for determining adequacy for accepting increased peak flow rates:

   1. Natural or man-made channels or swales must be able to convey the increased runoff associated with a 2-year return period event within their banks at velocities consistent with protection of the channels from erosion. Acceptable velocities shall be based upon criteria included in the DEP *Erosion and Sediment Pollution Control Program Manual* (April 1990). Permissible velocities from the DEP manual for selected channels are presented in Appendix C of this Ordinance.

   2. Natural or man-made channels or swales must be able to convey the increased 25-year return period runoff without creating any hazard to persons or property.

   3. Culverts, bridges, storm sewers or any other facilities which must pass or convey flows from the tributary area must be designed in accordance with DEP Chapter 105 regulations (if applicable) and, at minimum, pass the increased 25-year return period runoff.

D. For a proposed development site located within one release rate category subarea, the total runoff from the site shall meet the applicable release rate criteria. For development sites with multiple directions of runoff discharge, individual drainage directions may be designed for up to a 100% release rate so long as the total runoff from the site is controlled to the applicable release rate.

E. For a proposed development site located within two or more release category subareas, the peak discharge rate from any subarea shall be the pre-development peak discharge for that subarea multiplied by the applicable release rate. The calculated peak discharges shall apply regardless of whether the grading plan changes the drainage area by subarea.

An exception to the above may be granted if discharges from multiple subareas re-combine in proximity to the site. In this case, peak discharge in any direction may be a 100% release rate provided that the overall site discharge meets the weighted average release rate.

F. For a proposed development site located partially within a release rate category subarea and partially within a conditional no detention subarea, a significant portion of the site area subject to the release rate control may not be drained to the discharge point(s) located in the no detention subarea except as part of a "No Harm" or hardship waiver procedure.

G. Within a release rate category area, for a proposed development site which has significant areas which drain to a closed depression(s), the design release from the site will be the lesser of (a) the applicable release rate flow assuming no closed depression(s) or (b) the existing peak flow actually leaving the site. In cases where (b) would result in an unreasonably small design release, the design discharge of less than or equal to the release rate will be determined by the available downstream conveyance capacity to the main channel calculated using Section 303.C. and the minimum orifice criteria.

H. Off-site areas which drain through a proposed development site are not subject to release rate criteria when determining allowable peak runoff rates. However, on-site drainage facilities shall be designed to safely convey off-site flows through the development site using the capacity criteria in Section 303.C. and the detention criteria in Section 304.

For development sites proposed to take place in phases, all detention ponds shall be designed to meet the applicable release rate(s) applied to all site areas tributary to the proposed pond discharge direction. All site tributary areas will be assumed as developed, regardless of whether all site tributary acres are proposed for development at that time. An exception shall be sites with multiple detention ponds in series where only the downstream pond must be designed to the stated release rate.

Where the site area to be impacted by a proposed development activity differs significantly from the total site area, only the proposed impact area shell be subject to the release rate criteria. The impact area includes any proposed cover or grading changes.

K. Development proposals which, through groundwater recharge or other means, do not increase the rate and volume of runoff discharged from the site compared to pre-development are not subject to the release rate provisions of the Ordinance.

L. "No Harm" Option - For any proposed development site not located in a conditional no detention district, the developer has the option of using a less restrictive runoff control (including no detention) if the developer can prove that special circumstances exist for the proposed development site and that "no harm" would be caused by discharging at a higher runoff rate than that specified by the Plan. Special circumstances are defined as any hydrologic or hydraulic aspects of the development itself not specifically considered in the development of the Plan runoff control strategy. Proof of "no harm" would have to be shown from the development site through the remainder of the downstream drainage network to the confluence of the creek with the Lehigh River. Proof of “no harm” must be shown using the capacity criteria specified in Section 303.C. if downstream capacity analysis is a part of the “no harm” justification.

Attempts to prove “no harm” based upon downstream peak flow versus capacity analysis shall be governed by the following provisions:

1. The peak flow values to be used for downstream areas for the design return period storms (2-, 10-, 25- and 100-year) shall be the values from the calibrated WATERSHED Model for the Little Lehigh Creek These flow values would be supplied to the developer by the municipal engineer upon request.

2. Any available capacity in the downstream conveyance system as documented by a developer may be used by the developer only in proportion to his development site acreage relative to the total upstream undeveloped acreage from the identified capacity (i.e. if his site is 10% of the upstream undeveloped acreage, he may use up to 10% of the documented downstream available capacity).

3. Developer-proposed runoff controls which would generate increased peak flow rates at storm drainage problem areas would, by definition, be precluded from successful attempts to prove “no harm”, except in conjunction with proposed capacity improvements for the problem areas consistent with Section 303.N.

Any “no harm” justifications shall be submitted by the developer as part of the Drainage Plan submission per Article 4.

M. Regional Detention Alternatives - For certain areas within the study area, it may be more cost-effective to provide one control facility for more than one development site than to provide an individual control facility for each development site. The initiative and funding for any regional runoff control alternatives are the responsibility of prospective developers. The design of any regional control basins must incorporate reasonable development of the entire upstream watershed. The peak outflow of a regional basin would be determined on a case-by-case basis using the hydrologic model of the watershed consistent with protection of the downstream watershed areas. “Hydrologic model” refers to the calibrated version of the WATERSHED Model as developed for the Storm Water Management Plan.

N. Capacity Improvements - In certain instances, primarily within the conditional no detention areas, local drainage conditions may dictate more stringent levels of runoff control than those based upon protection of the entire watershed. In these instances, if the developer could prove that it would be feasible to provide capacity improvements to relieve the capacity deficiency in the local drainage network, then the capacity improvements could be provided by the developer in lieu of runoff controls on the development site. Peak flow calculations are to be done assuming that the local watershed is in the existing condition and then assuming that the local watershed is developed per current zoning and using the specified runoff controls. Any capacity improvements would be designed using the larger of the above peak flows and the capacity criteria specified in Section 303.C. All new development in the entire subarea(s) within which the proposed development site is located shall be assumed to implement the developer's proposed discharge control, if any.

Capacity improvements may also be provided as necessary to implement any regional detention alternatives or to implement a modified "no harm" option which proposes specific capacity improvements to provide that a less stringent discharge control would not create any harm downstream.

O. Compatibility with NPDES Requirements - Any proposed Regulated Activity for which a permanent storm water quality control detention basin is required under the NPDES regulations shall use the more stringent runoff control criteria between this Ordinance and the NPDES requirements.

SECTION 304. CALCULATION METHODOLOGY

A. Storm water runoff from all development sites shall be calculated using either the rational method or the soil-cover-complex methodology.

B. The design of any detention basin intended to meet the requirements of this Ordinance shall be verified by routing the design storm hydrograph through the proposed basin using the storage indication method.. For basins designed using the rational method technique, the design hydrograph for routing shall be either the Universal Rational Hydrograph or the modified rational method trapezoidal hydrograph which maximizes detention volume.

C. All storm water detention facilities shall provide a minimum 1.0 foot freeboard above the maximum pool elevation associated with the 2- through 25-year runoff events. A 0.5 foot freeboard shall be provided above the maximum pool elevation of the 100-year runoff event. The freeboard shall be measured from the maximum pool elevation to the invert of the emergency spillway. The 2- through 100-year storm events shall be controlled by the primary outlet structure. An emergency spillway for each basin shall be designed to pass the 100-year return frequency storm peak basin inflow rate with a minimum 0.5 foot freeboard measured to the top of basin. The freeboard criteria shall be met considering any offsite areas tributary to the basin as developed, as applicable. If this detention facility is considered to be a dam as per DEP Chapter 105, the design of the facility must be consistent with the Chapter 105 regulations, and may be required to pass a storm greater than the 100-year event.

D. The minimum circular orifice diameter for controlling discharge rates from detention facilities shall be three (3) inches provided that as much of the site runoff as practical is directed to the detention facilities.

E. All calculations using the soil-cover-complex method shall use the Natural Resources Conservation Service Type II 24-hour rainfall distribution. The 24-hour rainfall depths for the various return periods to be used consistent with this Ordinance are taken from the *PennDOT Intensity - Duration - Frequency Field Manual (May 1986)* for Region 4:

Return Period	24-Hour Rainfall Depth
1 year	2.40 inches
2 year	3.00 inches
5 year	3.60 inches
10 year	4.56 inches
25 year	5.52 inches
50 year	6.48 inches
100 year	7.44 inches

A graphical and tabular presentation of the Type II-24 hour distribution is included in Appendix C.

F. All calculations using the Rational Method shall use rainfall intensities consistent with appropriate times of concentration and return periods and the Intensity-Duration-Frequency Curves as presented in Appendix C.

G. Runoff Curve Numbers (CN's) to be used in the soil-cover-complex method shall be based upon the matrix presented in Appendix C.

H. Runoff coefficients for use in the Rational Method shall be based upon the table presented in Appendix C.

I. Proposed volume controls shall be designed with sufficient storage volume for a 100-year return period event unless proposed in combination with rate controls to achieve the required performance standard across all return periods. For the return period(s) to be solely controlled by the volume control, the storage volume shall equal or exceed the volume of the Universal Rational Hydrograph for the drainage area to the volume control.

All time of concentration calculations shall use a segmental approach which may include one or all of the flow types below:

Overland Flow (sheet flow) calculations shall use either the NRCS average velocity chart (Figure 15.2, Technical Release-55, 1975) or the modified kinematic wave travel time equation (equation 3-3, NRCS TR-55, June 1986). If using the modified kinematic wave travel time equation, the overland flow length shall be limited to 50 feet for designs using the Rational Method and limited to 150 feet for designs using the soil-cover-complex method.

Shallow Concentrated Flow travel times shall be determined from the watercourse slope, type of surface and the velocity from Figure 3-1 of TR-55, June 1986.

Open Channel Flow travel times shall be determined from velocities calculated by the Manning equation. Bankfull flows shall be used for determining velocities. Manning 'n' values shall be based on the table presented in Appendix C.

Pipe Flow travel times shall be determined from velocities calculated using the Manning equation assuming full flow and the Manning ‘n’ values from Appendix C.

K. All pre-development calculations for a given discharge direction shall be based on a common time of concentration considering both on-site and any off-site drainage areas. All post-development calculations for a given discharge direction shall be based on a common time of concentration considering both on-site and any off-site drainage areas.

L. The Manning equation shall be used to calculate the capacity of watercourses. Manning ‘n’ values used in the calculations shall be consistent with the table presented in Appendix C. Pipe capacities shall be determined by methods acceptable to the municipal engineer.

M. The Pennsylvania DEP, Chapter 105, Rules and Regulations, apply to the construction, modification, operation or maintenance of both existing and proposed dams, water obstructions and encroachments throughout the watershed. Criteria for design and construction of storm water management facilities according to this Ordinance may not be the same criteria that are used in the permitting of dams under the Dam Safety Program.

ARTICLE 4
DRAINAGE PLAN REQUIREMENTS

SECTION 401. GENERAL REQUIREMENTS

For any of the Regulated Activities of this Ordinance, prior to the final approval of subdivision and/or land development plans, or the issuance of any permit, or the commencement of any land disturbance activity, the owner, subdivider, developer or his agent shall submit a Drainage Plan for approval.

SECTION 402. EXEMPTIONS

A. Impervious Cover - Any Regulated Activity which would create 10,000 square feet or less of additional impervious cover is exempt from the Drainage Plan preparation provisions of this Ordinance. This criteria shall apply to the total proposed development even if development is to take place in stages (i.e. the impervious cover associated with the total development shall be used to compare to the waiver minimum, not merely the individual stage impervious cover). Pre-development impervious cover is that which is in place as of the effective date of this Ordinance. Additional impervious cover shall include, but not be limited to, any roof, parking or driveway areas and any new streets and sidewalks constructed as part of or for the proposed Regulated Activity. Any areas designed to initially be gravel, crushed stone, porous pavement, etc. shall be assumed to be impervious for the purposes of comparison to the waiver criteria.

B. Prior Drainage Plan Approval - Any Regulated Activity for which a Drainage Plan was previously prepared as part of a subdivision or land development proposal that received preliminary plan approval from the municipality prior to the effective date of this Ordinance is exempt from the Drainage Plan preparation provisions of this Ordinance *provided* that the approved Drainage Plan included design of storm water facilities consistent with ordinance provisions in effect at the time of approval and the approval has not lapsed under the Municipalities Planning Code. If significant revisions are made to the Drainage Plan after both the preliminary plan approval and the effective date of the Ordinance, preparation of a new Drainage Plan, subject to the provisions of this Ordinance, shall be required.

SECTION 403. DRAINAGE PLAN CONTENTS

The following items shall be included in the Drainage Plan:

A. General

1. General description of project.

2. General description of proposed permanent storm water controls.

B. Map(s) of the project area showing:

1. The location of the project relative to highways, municipalities or other identifiable landmarks.

2. Existing contours at intervals of two (2) feet. In areas of steep slopes (greater than 15%), five-foot contour intervals may be used. Off-site drainage areas impacting the project including topographic detail.

3. Streams, lakes, ponds or other bodies of water within the project area.

4. Other physical features including existing drainage swales, wetlands, closed depressions, sinkholes and areas of natural vegetation to be preserved.

5. Locations of proposed underground utilities, sewers and water lines.

6. An overlay showing soil types and boundaries based on the Lehigh or Berks County Soil Survey, as applicable, latest edition.

7. Proposed changes to land surface and vegetative cover.

8. Proposed structures, roads, paved areas and buildings.

9. Final contours at intervals of two (2) feet. In areas of steep slopes (greater than 15%), five-foot contour intervals may be used.

10. Storm Water Management District boundaries applicable to the site.

13. A schematic showing all tributaries contributing flow to the site and all existing man-made features beyond the property boundary that would be affected by the project.

C. Storm water management controls

1. All storm water management controls must be shown on a map and described, including:

a. Groundwater recharge methods such as seepage pits, beds or trenches. When these structures are used, the locations of septic tank infiltration areas and wells must be shown.

b. Other control devices or methods such as roof-top storage, semi-pervious paving materials, grass swales, parking lot ponding, vegetated strips, detention or retention ponds, storm sewers, etc.

2. All calculations, assumptions and criteria used in the design of the control device or method must be shown.

D. Maintenance Program - A maintenance program for all storm water management control facilities must be included. This program must include the proposed ownership of the control facilities, the maintenance requirements for the facilities, and the financial responsibilities for the required maintenance.

SECTION 404. PLAN SUBMISSION

A. For Regulated Activities specified in Sections 104.A. and 104.B.:

1. The Drainage Plan shall be submitted by the developer to the municipal secretary (or other appropriate person) as part of the Preliminary Plan submission for the subdivision or land development.

2. Four (4) copies of the Drainage Plan shall be submitted.

3. Distribution of the Drainage Plan will be as follows:

a. One (1) copy to the municipal governing body.

b. One (1) copy to the municipal engineer.

c. **(*Lehigh County Municipalities only)*** Two (2) copies to the Lehigh Valley Planning Commission.

4. **(*Lehigh County Municipalities only)*** The Drainage Plan shall be submitted by the developer (possibly through the municipality) to the Lehigh Valley Planning Commission as part of the Preliminary Plan submission for an advisory review of the Drainage Plan for consistency with the Little Lehigh Creek Watershed Storm Water Management Plan.

   1. Two (2) copies of the Drainage Plan shall be submitted.

   2. The LVPC will provide written comments to the developer and the municipality, within a time frame consistent with established procedures under the Municipalities Planning Code, as to whether the Drainage Plan has been found to be consistent with the Storm Water Management Plan.

B. For Regulated Activities specified in Sections 104.C. and 104.D., the Drainage Plan shall be submitted by the developer to the municipal building permit officer as part of the building permit application.

C. **(*Lehigh County Municipalities only)*** For Regulated Activities specified in Sections 104.E. and 104.F.:

   1. The Drainage Plan shall be submitted by the developer to the Lehigh Valley Planning Commission for coordination with the DEP permit application process under Chapter 105 (Dam Safety and Waterway Management) or Chapter 106 (Flood Plain Management) of DEP's Rules and Regulations.

   2. One (1) copy of the Drainage Plan shall be submitted.

D. Earthmoving for all regulated activities under Section 104 shall be conducted in accordance with the current federal and State regulations relative to the NPDES and DEP Chapter 102 regulations.

SECTION 405. DRAINAGE PLAN REVIEW

A. The municipal engineer shall review the Drainage Plan for consistency with the adopted Little Lehigh Creek Watershed Storm Water Management Plan as embodied by this Ordinance and against any additional storm drainage provisions contained in the municipal subdivision and land development or zoning ordinance, as applicable.

B. The municipality shall not approve any subdivision or land development (Regulated Activities 104.A. and 104.B.) or building permit application (Regulated Activities 104.C. and 104.D.) if the Drainage Plan has been found to be inconsistent with the Storm Water Management Plan as determined by the municipal engineer.

SECTION 406. MODIFICATION OF PLANS

A modification to a submitted Drainage Plan for a proposed development site which involves a change in control methods or techniques, or which involves the relocation or redesign of control measures, or which is necessary because soil or other conditions are not as stated on the Drainage

Plan (as determined by the municipal engineer) shall require a resubmission of the modified Drainage Plan consistent with Section 404 subject to review per Section 405 of this Ordinance.

SECTION 407. HARDSHIP WAIVER PROCEDURE

The municipality may hear requests for waivers where it is alleged that the provisions of this (Act 167) Ordinance inflict unnecessary hardship upon the applicant. The waiver request shall be in writing and accompanied by the requisite fee based upon a fee schedule adopted by the municipality. A copy of the waiver request shall be provided to each of the following: municipality, municipal engineer, municipal solicitor and Lehigh Valley Planning Commission. The request shall fully document the nature of the alleged hardship.

The municipality may grant a waiver provided that all of the following findings are made in a given case:

1. That there are unique physical circumstances or conditions, including irregularity of lot size or shape, or exceptional topographical or other physical conditions peculiar to the particular property, and that the unnecessary hardship is due to such conditions, and not the circumstances or conditions generally created by the provisions of this Ordinance in the Storm Water Management District in which the property is located;

2. That because of such physical circumstances or conditions, there is no possibility that the property can be developed in strict conformity with the provisions of this Ordinance, including the “no harm” provision, and that the authorization of a waiver is therefore necessary to enable the reasonable use of the property;

3. That such unnecessary hardship has not been created by the applicant; and

4. That the waiver, if authorized, will represent the minimum waiver that will afford relief and will represent the least modification possible of the regulation in issue.

5. That financial hardship is not the criteria for granting of a hardship waiver.

In granting any waiver, the municipality may attach such reasonable conditions and safeguards as it may deem necessary to implement the purposes of Act 167 and this Ordinance. If a Hardship Waiver is granted, the applicant must still manage the quantity, velocity and direction of resulting storm runoff as is reasonably necessary to prevent injury to health, safety or other property.

A. For regulated activities in Section 104.A. and B., the [municipal governing body] shall hear requests for and decide on Hardship Waiver requests on behalf of the municipality.

B. For regulated activities in Section 104.C., D., E., and F., the Zoning Hearing Board shall hear requests for and decide on Hardship Waiver requests on behalf of the municipality.

ARTICLE 5
INSPECTIONS

SECTION 501. SCHEDULE OF INSPECTIONS

A. The municipal engineer or his designee shall inspect all phases of the installation of the permanent storm water control facilities and the completed installation.

B. If at any stage of the work the municipal engineer determines that the permanent storm water control facilities are not being installed in accordance with the approved development plan, the municipality shall revoke any existing permits until a revised development plan is submitted and approved as required by Section 406.

ARTICLE 6
FEES AND EXPENSES

SECTION 601. GENERAL

A fee shall be established by the municipality to defer municipal costs for Drainage Plan review and processing.

SECTION 602. EXPENSES COVERED BY FEES

The fees required by this Ordinance shall at a minimum cover:

A. The review of the Drainage Plan by the municipal engineer.

B. The site inspection.

C. The inspection of required controls and improvements during construction.

D. The final inspection upon completion of the controls and improvements required in the plan.

E. Any additional work required to enforce any permit provisions, regulated by this Ordinance, correct violations, and assure the completion of stipulated remedial actions.

F. Administrative and clerical costs.

ARTICLE 7
MAINTENANCE RESPONSIBILITIES

SECTION 701. MAINTENANCE RESPONSIBILITIES

The maintenance responsibilities for permanent storm water runoff control facilities shall be determined based upon the type of ownership of the property which is controlled by the facilities.

A. Single Entity Ownership - In all cases where the permanent storm water runoff control facilities are designed to manage runoff from property in a single entity ownership as defined below, the maintenance responsibility for the storm water control facilities shall be with the single entity owner. The single entity owner shall enter into an agreement with the municipality which specifies that the owner will properly maintain the facilities consistent with accepted practice as determined by the municipal engineer. The agreement shall provide for regular inspections by the municipality and contain such provisions as necessary to ensure timely correction of any maintenance deficiencies by the single entity owner. A single entity shall be defined as an individual, association, public or private corporation, partnership firm, trust, estate or any other legal entity empowered to own real estate.

B. Multiple Ownership - In cases where the property controlled by the permanent storm water control facilities shall be in multiple ownership (i.e. many individual owners of various portions of the property), the developer shall dedicate the permanent storm water control facilities to the municipality for maintenance. The developer shall pay a fee to the municipality corresponding to the present worth of maintenance of the facilities in perpetuity. The estimated annual maintenance cost for the facilities shall be based on a fee schedule provided by the municipal engineer and adopted by the municipality. The fee schedule must be reasonable.

In certain multiple ownership situations, the municipality may benefit by transferring the maintenance responsibility to an individual or group of individuals residing within the controlled area. These individuals may have the permanent storm water control facilities adjacent to their lots or otherwise have an interest in the proper maintenance of the facilities. In these instances, the municipality and the individual(s) may enter into a formal agreement for the maintenance of the facilities. The municipality shall maintain ownership of the facilities and be responsible for periodic inspections.

ARTICLE 8
ENFORCEMENT

SECTION 801. RIGHT-OF-WAY

Upon presentation of proper credentials, duly authorized representatives of the municipality may enter at reasonable times upon any property within the municipality to investigate or ascertain the condition of the subject property in regard to any aspect regulated by this Ordinance.

SECTION 802. NOTIFICATION

In the event that a person fails to comply with the requirements of this Ordinance, or fails to conform to the requirements of any permit issued hereunder, the municipality shall provide written notification of the violation. Such notification shall set forth the nature of the violation(s) and establish a time limit for correction of these violation(s). Failure to comply within the time specified shall subject such person to the penalty provisions of this Ordinance. All such penalties shall be deemed cumulative and resort by the municipality from pursuing any and all other remedies. It shall be the responsibility of the owner of the real property on which any Regulated Activity is proposed to occur, is occurring, or has occurred, to comply with the terms and conditions of this Ordinance.

SECTION 803. ENFORCEMENT

Any person found by the municipality to have violated any provision of this ordinance shall be subject to the enforcement provisions in Article V of the Pennsylvania Municipalities Planning Code and/or Section 15 of the Pennsylvania Storm Water Management Act (Act 167).

APPENDIX A

(Not Included in Plan Copy of Ordinance)

A-1 **Map of Little Lehigh Creek Watershed**

A-2 **Municipal Map of Storm Water Management Districts**

APPENDIX B

(Not Included in Plan Copy Text)

B-1 **Map of Storm Drainage Problem Areas**

B-2 **Description of Storm Drainage Problem Areas**

APPENDIX C

C-1 NRCS Type II 24-Hour Rainfall Distribution (Graphic & Tabular)

C-2 Intensity-Duration-Frequency Curves

C-3 Runoff Curve Numbers and Percent Imperviousness Values

C-4 Runoff Coefficients for the Rational Method

C-5 Manning ‘n’ Values

C-6 Permissible Velocities for Channels

PERMISSIBLE VELOCITIES FOR SELECTED CHANNELS

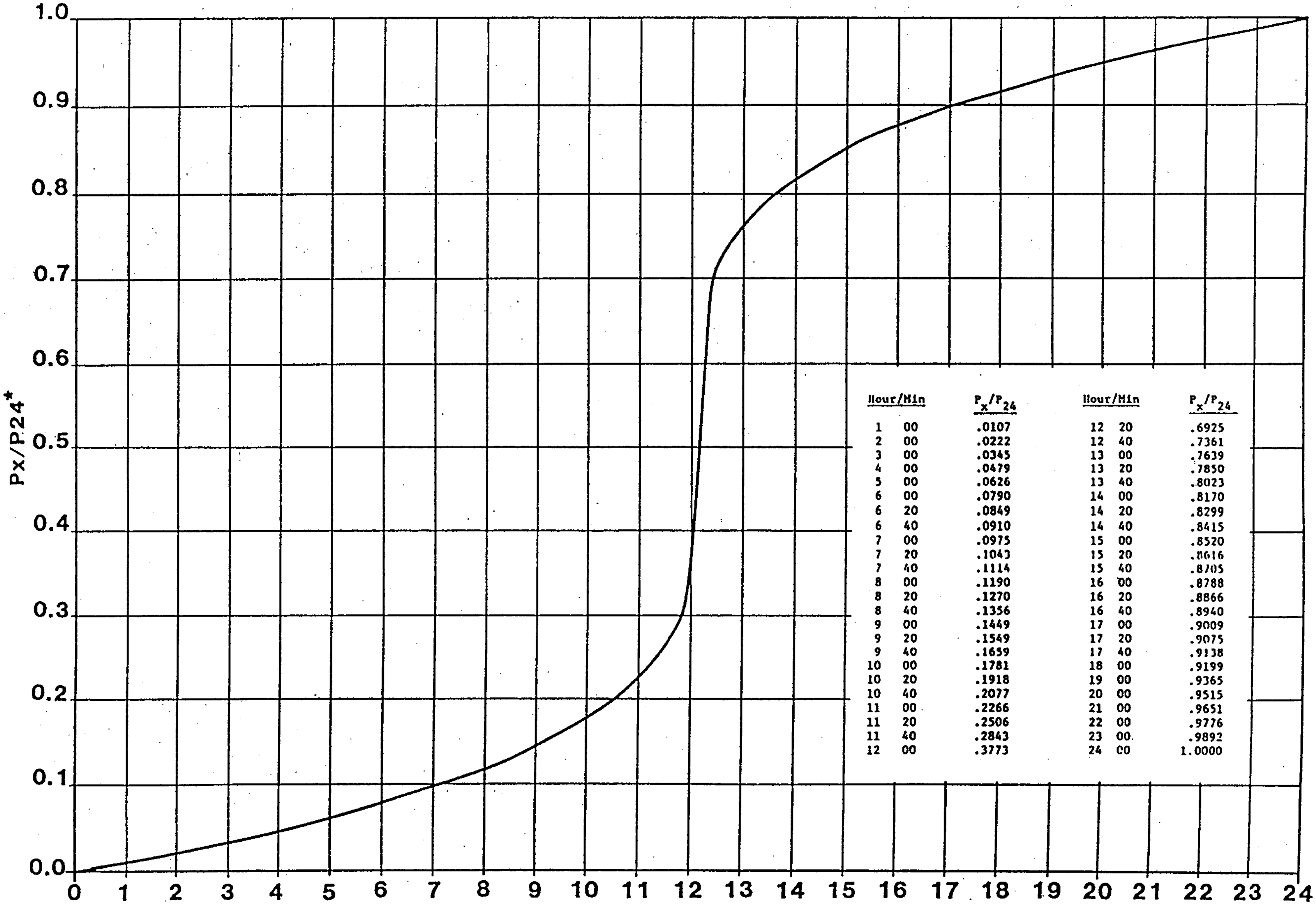
CHANNEL LINING	PERMISSIBLE CHANNEL VELOCITY (FEET PER SECOND)		
Vegetation[1]			
Grass Mixture	4.0	-	5.0
Kentucky Bluegrass	5.0	-	7.0
Kentucky 31 Tall Fescue	3.0	-	6.0
Red Clover or Red Fescue	2.5	-	3.5
Red Top	2.5	-	3.5
Red Canarygrass	3.0	-	4.0
Sericea Lespedeza	2.5	-	3.5
Sudan Grass	2.5	-	3.5
Weeping Lovegrass	2.5	-	3.5
Bare Earth, Easily Eroded[2]			
Fine Sand	1.5		
Sand Loam	1.75		
Silt Loam or Alluvial Silts, Loose	2.0		
Firm Loam	2.50		
Bare Earth, Erosion Resistant[2]			
Fine Gravel	2.5		
Stiff Clay or Alluvial Silts, Firm	3.75		
Loam to Cobbles (Graded)	3.75		
Silt to Cobbles (Graded or Course Gravel)	4.0		
Cobbles and Stones or Shales and Hardpans	6.0		
Rock Lined			
6" Rip Rap	9.0		
9" Rip Rap	11.5		
12" Rip Rap	13.0		

[1] Maximum permissible velocities dependent on soil erodibility and slope.

[2] Maximum permissible velocities in bare earth channels - for straight channels where slopes <0.02 ft./ft.

Source: Department of Environmental Protection, *Erosion and Sediment Pollution Control Program Manual*, April 1990.

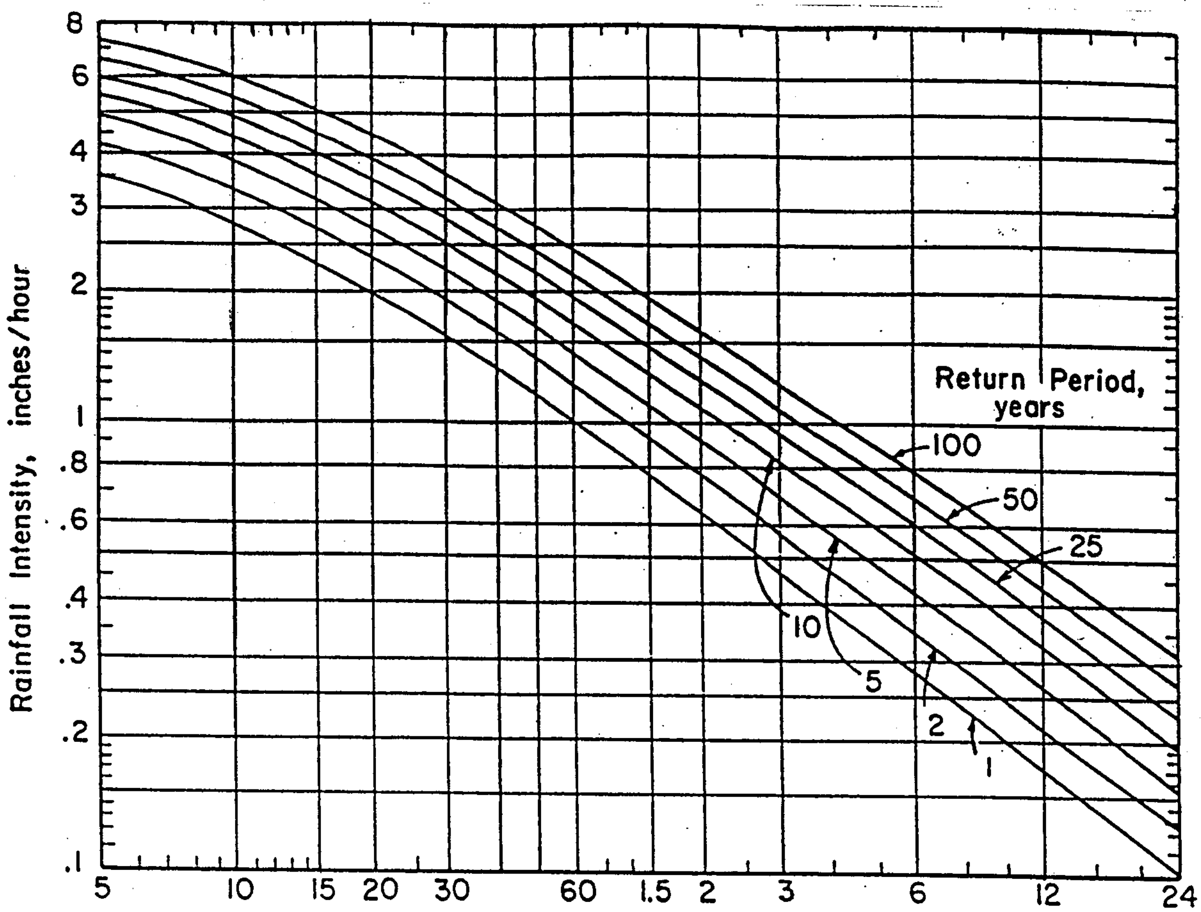
NRCS TYPE II RAINFALL DISTRIBUTION

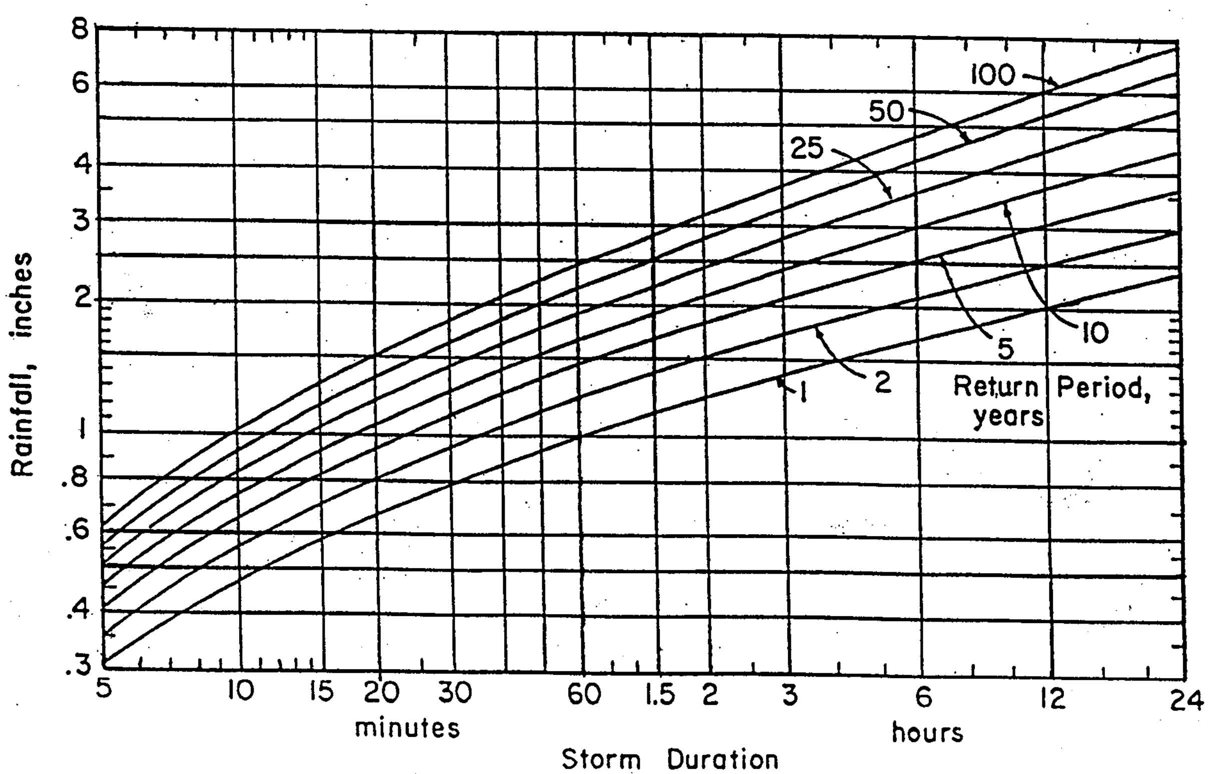


Hour/Min	P_x/P_{24}	Hour/Min	P_x/P_{24}
1 00	.0107	12 20	.6925
2 00	.0222	12 40	.7361
3 00	.0345	13 00	.7639
4 00	.0479	13 20	.7850
5 00	.0626	13 40	.8023
6 00	.0790	14 00	.8170
6 20	.0849	14 20	.8299
6 40	.0910	14 40	.8415
7 00	.0975	15 00	.8520
7 20	.1043	15 20	.8616
7 40	.1114	15 40	.8705
8 00	.1190	16 00	.8788
8 20	.1270	16 20	.8866
8 40	.1356	16 40	.8940
9 00	.1449	17 00	.9009
9 20	.1549	17 20	.9075
9 40	.1659	17 40	.9138
10 00	.1781	18 00	.9199
10 20	.1918	19 00	.9365
10 40	.2077	20 00	.9515
11 00	.2266	21 00	.9651
11 20	.2506	22 00	.9776
11 40	.2843	23 00	.9892
12 00	.3773	24 00	1.0000

*Px/P24 equals cumulative percentage rainfall as a fraction of the total 24 hour rainfall.

INTENSITY–DURATION–FREQUENCY CURVES*





*Source: Pennsylvania Dept. of Transp. Design Rainfall Curves (1986).

RUNOFF CURVE NUMBERS AND PERCENT IMPERVIOUSNESS VALUES*

Cover Description		Curve numbers for hydrologic soil group**			
Land Use/Cover Type	Average percent impervious area	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Good condition (grass cover greater than 75%) . .		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way) .		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Urban districts:					
Commercial and business . . .	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
⅛ acre or less (townhouses)	65	77	85	90	92
¼ acre	38	61	75	83	87
⅓ acre	30	57	72	81	86
½ acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Woods		30	55	70	77
Agriculture		Refer to Table 2-2b in source document (TR55) by crop type and treatment.			

*Source: Natural Resources Conservation Service Technical Release No. 55, Second Edition, June 1986.

**Hydrologic Soil Group based on the County Soil Survey latest edition.

RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD*

HYDROLOGIC SOIL GROUP AND SLOPE RANGE**

	A			B			C			D		
LAND USE	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Cultivated[A]	[a]0.18 [b]0.23	0.23 0.29	0.28 0.34	0.24 0.30	0.29 0.36	0.33 0.40	0.30 0.36	0.34 0.41	0.38 0.45	0.33 0.39	0.37 0.44	0.41 0.48
Pasture[B]	0.09 0.12	0.13 0.17	0.17 0.23	0.19 0.24	0.24 0.30	0.29 0.36	0.27 0.33	0.31 0.38	0.36 0.43	0.31 0.37	0.35 0.42	0.39 0.46
Meadow, Lawn[C]	0.05 0.07	0.08 0.12	0.12 0.17	0.15 0.19	0.20 0.25	0.24 0.30	0.23 0.28	0.28 0.34	0.32 0.39	0.28 0.33	0.32 0.39	0.36 0.43
Forest, Woods	0.03 0.04	0.05 0.08	0.08 0.12	0.11 0.15	0.16 0.21	0.20 0.26	0.20 0.25	0.25 0.31	0.29 0.36	0.25 0.31	0.30 0.37	0.34 0.41
Gravel	0.24 0.30	0.29 0.36	0.33 0.40	0.32 0.38	0.36 0.43	0.40 0.47	0.35 0.42	0.39 0.46	0.43 0.50	0.37 0.44	0.41 0.48	0.44 0.51
Parking, Other Impervious	0.72 0.84	0.76 0.88	0.80 0.92	0.72 0.84	0.76 0.88	0.80 0.92	0.72 0.84	0.76 0.88	0.80 0.92	0.72 0.84	0.76 0.88	0.80 0.92
Residential, Commercial, Industrial And Other "Developed"	Runoff coefficients should be calculated based upon weighted average of impervious area coefficients and pervious area coefficients from above based upon soil type, slope and the particular development proposal.											

*Based on Rossmiller Equation for translating NRCS curve numbers into Rational Method 'c' values.
**Hydrologic Soil Group based on the county soil survey latest edition.

a—Runoff coefficients for storm recurrence intervals less than 25 years.
b—Runoff coefficients for storm recurrence intervals of 25 years or more.

[A]Represents average of cultivated land with and without conservation treatment from TR-55, January 1975. These values are consistent with several categories of cultivated lands from TR-55, June 1986.
[B]Represents grasslands in fair condition with 50% to 75% grass cover.
[C]Represents grasslands in good condition with greater than 75% grass cover.

APPENDIX D

D-1 to D-6 Calibrated WATERSHED Peak Flow Values

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**
Little Lehigh Creek										
1	20.1 (cfs)	20.1	41.6 (cfs)	41.6	157.8 (cfs)	157.8	253.2 (cfs)	253.2	504.4 (cfs)	504.4
2	26.3	43.6	58.4	96.7	226.9	378.6	364.7	608.4	730.9	1210.4
3	26.4	26.4	51.1	51.1	158.6	158.6	250.7	250.7	488.1	488.1
4	39.8	101.5	71.0	202.9	192.6	684.6	295.3	1071.2	551.5	2036.5
5	30.8	30.8	47.9	47.9	140.1	140.1	217.8	217.8	405.7	405.7
6	52.8	52.8	81.6	81.6	194.6	194.6	304.8	304.8	692.9	692.9
7	8.8	90.3	16.6	144.2	48.2	356.6	73.8	554.9	133.2	1128.8
8	38.3	117.7	81.7	206.6	254.8	571.3	405.7	884.7	801.6	1738.8
9	45.8	213.8	74.7	423.9	185.4	1361.7	275.4	2087.5	509.2	3811.4
10	61.6	232.2	107.9	477.3	266.0	1482.3	395.1	2225.6	728.1	3938.5
11	31.1	251.0	54.5	518.5	149.7	1572.0	229.5	2341.3	439.1	4073.5
Toad Creek										
12	32.5	32.5	54.9	54.9	122.2	122.2	176.1	176.1	314.5	314.5
13	87.0	114.5	126.6	171.2	250.6	346.7	338.4	475.8	541.0	782.5
14	44.4	44.4	65.3	65.3	131.4	131.4	181.7	181.7	302.5	302.5
15	17.8	175.6	24.4	258.3	44.4	509.4	58.2	690.4	88.2	1113.2
16	48.9	212.3	75.9	316.8	166.5	623.4	235.9	844.5	405.3	1384.2
17	39.9	39.9	65.1	65.1	160.8	160.8	235.8	235.8	427.1	427.1
18	4.5	241.5	9.8	367.5	31.7	790.0	50.2	1104.5	98.1	1875.1
19	100.0	227.0	160.6	370.6	384.4	886.4	562.4	1272.5	1007.9	2125.6
20	28.9	28.9	54.9	54.9	175.8	175.8	277.1	277.1	537.1	537.1
21	14.7	261.8	33.1	448.3	109.9	1113.6	175.1	1597.0	345.3	2639.7
22	7.2	260.1	15.4	445.2	48.6	1102.7	77.1	1578.7	147.6	2604.9
Little Lehigh Creek										
23	3.5	469.5	7.1	930.7	21.2	2476.0	33.1	3534.3	61.4	5882.1
24	14.0	472.1	29.4	930.5	91.2	2464.8	143.2	3519.0	275.6	5841.5
25	56.2	56.2	87.7	87.7	197.8	197.8	283.3	283.3	495.1	495.1
26	35.8	505.0	62.4	983.2	167.9	2561.6	256.2	3644.7	486.0	6005.5
27	22.3	510.6	36.1	991.7	86.7	2572.4	127.2	3656.7	228.7	6010.8
Schaefer Run										
28	31.0	31.0	48.2	48.2	108.0	108.0	158.2	158.2	286.8	286.8
29	23.6	22.0	38.4	38.4	91.5	91.5	135.0	135.0	228.4	228.4
30	50.5	98.1	84.7	160.8	217.1	360.0	327.9	518.9	585.6	862.4
31	20.6	20.6	35.4	35.4	88.0	88.0	127.1	127.1	220.1	220.1
32	23.0	141.1	39.6	229.2	98.9	515.4	142.9	740.0	238.5	1237.2
33	15.4	15.4	26.8	26.8	70.1	70.1	106.1	106.1	186.9	186.9
34	21.3	171.6	39.7	288.0	115.1	664.8	176.5	943.0	326.8	1569.8
35	21.6	21.6	36.5	36.5	91.5	91.5	139.8	139.8	265.6	265.6
36	16.9	206.7	30.4	349.3	80.7	807.3	122.8	1149.2	222.9	1917.8
37	19.5	19.5	34.8	34.8	89.6	89.6	134.5	134.5	239.8	239.8
38	16.7	235.8	33.4	404.4	98.9	955.2	154.4	1371.0	295.7	2281.9
39	3.7	235.3	7.7	403.8	23.3	955.4	36.5	1365.9	69.8	2279.5
40	24.6	24.6	42.9	42.9	109.2	109.2	162.1	162.1	293.1	293.1
41	67.2	87.0	115.0	150.1	295.8	394.3	445.2	595.5	837.8	1100.2

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**
Schaefer Run, cont.										
42	8.7 (cfs)	94.0	16.9 (cfs)	164.9	48.5 (cfs)	441.0	74.6 (cfs)	666.7	141.3 (cfs)	1229.0
43	7.1	331.8	14.7	573.7	45.0	1393.9	70.5	2023.4	134.5	3449.8
44	27.7	27.7	51.3	51.3	138.9	138.9	210.0	210.0	389.8	389.8
45	67.1	373.7	100.1	650.2	200.4	1578.1	276.7	2281.5	457.7	3867.2
46	133.2	393.3	185.6	673.6	345.2	1599.8	458.7	2296.5	710.8	3851.1
47	15.2	404.9	30.5	696.5	89.0	1665.1	137.6	2387.2	261.3	4004.1
48	11.6	404.5	22.0	699.3	68.0	1674.7	104.7	2394.9	205.9	3992.4
49	18.1	18.1	31.3	31.3	79.8	79.8	119.2	119.2	213.2	213.2
50	22.0	39.3	39.7	69.2	106.6	181.7	161.1	273.5	298.6	501.0
51	56.6	73.5	84.4	114.8	166.3	263.2	225.5	371.8	366.0	658.2
52	6.0	77.9	9.6	121.3	23.1	277.6	34.0	391.8	61.9	682.5
53	12.4	448.3	20.6	770.0	50.6	1811.8	75.5	2566.2	139.3	4231.8
54	23.0	457.2	38.7	779.7	97.8	1817.7	146.9	2562.2	273.2	4216.8
55	25.7	25.7	39.9	39.9	88.3	88.3	125.9	125.9	218.9	218.9
56	16.4	468.4	25.9	795.4	61.7	1838.6	90.4	2581.4	163.2	4222.4
57	17.2	469.7	28.9	793.8	75.3	1824.5	113.7	2557.8	212.7	4170.1
58	35.9	35.9	61.0	61.0	158.4	158.4	238.8	238.8	443.5	443.5
59	71.2	100.4	119.4	169.6	293.1	428.6	437.9	645.2	795.9	1160.5
60	24.1	123.7	40.5	207.7	103.5	528.9	157.5	785.1	297.2	1410.5
61	23.9	131.2	42.5	233.8	116.7	612.1	179.3	914.4	343.2	1603.5
62	12.8	12.8	21.7	21.7	57.0	57.0	86.6	86.6	159.1	159.1
63	28.7	40.8	53.4	73.5	146.5	192.6	224.5	286.3	406.2	505.2
64	2.2	171.8	4.2	300.4	10.9	753.1	15.5	1093.9	24.9	1867.2
65	16.5	184.7	32.1	325.8	93.4	820.5	144.6	1194.0	276.5	2030.3
66	28.9	5.6	48.7	11.3	124.4	46.2	188.4	69.4	353.8	95.4
67	4.6	190.3	8.0	333.3	24.3	852.9	36.5	1254.2	66.3	2120.1
68	8.3	197.3	15.7	345.7	43.1	878.2	66.1	1285.9	126.9	2159.1
69	37.9	37.9	58.0	58.0	127.6	127.6	181.7	181.7	316.4	316.4
70	34.4	218.3	56.9	388.4	124.3	970.4	179.1	1403.4	314.9	2324.5
71	73.9	73.9	103.1	103.1	188.0	188.0	242.9	242.9	361.4	361.4
72	59.3	235.7	86.4	410.6	165.2	1011.5	218.9	1455.2	336.3	2396.1
73	20.5	20.5	38.2	38.2	104.3	104.3	158.6	158.6	285.7	285.7
74	35.1	252.5	53.4	434.7	115.9	1050.5	163.8	1503.6	280.5	2447.8
75	13.1	263.8	26.8	453.1	82.2	1083.5	128.6	1538.0	246.6	2489.7
76	232.6	232.6	342.7	342.7	673.1	673.1	904.7	904.7	1427.2	1427.2
77	175.1	400.0	251.1	578.1	482.1	1099.7	639.0	1455.0	979.5	2229.8
78	84.7	429.6	120.9	603.1	232.8	1107.1	309.0	1450.6	476.7	2205.1
79	25.0	409.8	36.4	571.6	69.1	1032.2	92.4	1348.1	146.1	2040.2
80	40.7	640.8	62.6	906.7	133.9	1708.2	187.6	2269.2	317.6	3510.5
81	73.8	654.0	110.1	923.1	222.0	1746.8	301.9	2323.7	483.8	3605.2
82	158.7	668.7	218.6	948.3	390.6	1797.4	500.9	2385.8	762.3	3698.0
83	12.2	12.2	26.5	26.5	85.6	85.6	135.9	135.9	265.7	265.7
84	20.2	891.8	29.0	1347.1	56.3	3064.5	76.6	4264.9	124.5	6809.1
85	27.5	890.6	47.1	1351.3	123.4	3061.3	188.0	4257.2	355.6	6787.4
Little Lehigh Creek										
86	11.5	1263.7	16.9	2164.2	34.4	5079.1	47.3	7120.2	77.8	11576.6

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK
Little Lehigh Creek, cont.										
87	100.8	1275.1	150.2	2186.2	315.0	5128.1	434.7	7180.4	714.0	11649.5
88	62.7	62.7	97.6	97.6	222.8	222.8	319.2	319.2	557.5	557.5
89	18.6	18.6	27.7	27.7	57.5	57.5	80.2	80.2	135.8	135.8
90	34.7	98.7	49.4	146.9	91.3	312.0	120.3	437.1	183.9	744.7
91	34.1	106.8	52.1	160.1	112.5	351.2	158.1	499.9	268.6	866.9
92	12.9	1305.2	19.4	2241.4	41.6	5243.9	58.4	7330.0	99.4	11860.6
93	11.8	1306.9	20.8	2242.7	54.6	5242.7	83.4	7324.0	159.3	11840.3
94	32.9	32.9	54.8	54.8	137.1	137.1	205.4	205.4	381.3	381.3
95	6.8	36.9	14.4	64.0	46.3	172.3	73.2	266.2	142.5	507.7
96	13.5	1328.0	22.8	2276.7	55.3	5299.5	81.7	7389.4	149.4	11919.2
97	22.9	22.9	34.3	34.3	68.1	68.1	92.5	92.5	149.3	149.3
98	20.0	1333.7	32.0	2284.6	75.6	5309.2	110.3	7402.6	197.8	11931.7
99	44.6	44.6	63.7	63.7	123.6	123.6	166.4	166.4	266.5	266.5
100	9.0	1336.1	17.2	2287.4	48.6	5311.0	75.9	7399.3	148.7	11917.6
101	2.9	1335.8	4.5	2286.8	10.9	5309.2	15.7	7395.8	27.6	11910.3
102	87.9	1337.2	128.9	2288.4	261.0	5304.4	355.6	7382.0	576.2	11873.1
103	43.0	43.0	63.0	63.0	126.4	126.4	171.2	171.2	276.1	276.1
104	43.8	43.8	65.4	65.4	140.6	140.6	195.4	195.4	327.0	327.0
105	18.8	1344.0	31.5	2298.4	81.7	5316.4	123.0	7392.8	229.9	11879.5
106	3.0	1343.0	6.3	2295.9	20.0	5308.3	31.5	7379.4	61.5	11852.4
107	15.8	1342.2	25.2	2294.3	56.5	5302.5	80.5	7369.8	141.2	11832.9
Swabia Creek										
108	99.5	99.5	172.7	172.7	489.6	489.6	738.3	738.3	1402.1	1402.1
109	78.0	75.6	144.6	137.2	368.7	343.4	555.8	514.8	1043.3	972.0
110	15.0	189.8	26.8	333.7	61.8	881.2	88.4	1352.5	148.5	2533.5
111	26.1	199.9	46.8	353.1	109.2	948.3	159.9	1439.5	292.7	2696.0
112	27.1	210.8	44.4	379.8	104.2	1016.8	150.5	1544.2	268.9	2780.6
113	22.7	22.7	36.1	36.1	87.3	87.3	122.3	122.3	212.7	212.7
114	21.9	21.9	35.7	35.7	91.3	91.3	129.1	129.1	230.9	230.9
115	26.4	67.3	54.8	116.9	190.7	349.8	293.9	518.4	554.0	947.9
116	9.7	9.7	18.4	18.4	50.8	50.8	75.2	75.2	132.9	132.9
117	11.3	86.4	20.2	152.7	52.8	450.4	79.1	645.0	141.1	1172.8
118	16.1	304.3	27.2	530.4	71.5	1482.6	108.2	2237.8	200.9	4015.1
119	16.0	16.0	28.3	28.3	81.3	81.3	128.1	128.1	251.5	251.5
120	51.5	296.4	81.5	552.4	194.0	1588.7	284.4	2376.5	517.9	4239.6
121	28.0	294.3	46.2	557.7	115.1	1620.8	171.7	2413.5	316.1	4272.2
122	13.8	13.8	29.4	29.4	91.4	91.4	143.2	143.2	274.4	274.4
123	39.2	206.4	64.8	583.8	163.7	1638.8	247.6	2401.2	464.0	4156.5
124	53.8	309.3	77.5	588.2	147.4	1642.2	195.9	2395.0	305.1	4116.8
125	100.6	318.6	143.8	605.8	270.8	1667.9	357.3	2426.2	549.0	4150.6
126	37.0	37.0	68.1	68.1	205.0	205.0	308.1	308.1	586.9	586.9
127	58.3	93.6	80.8	143.1	155.3	337.5	205.5	475.1	328.1	827.5
128	45.7	337.0	64.3	652.2	125.1	1763.8	169.1	2542.9	265.6	4311.1
129	30.0	338.7	45.5	657.9	95.3	1772.5	131.7	2551.5	218.2	4306.0
130	50.7	50.7	84.6	84.6	203.7	203.7	292.9	292.9	529.6	529.6
131	53.1	92.8	78.1	142.1	158.5	301.9	220.5	418.7	370.9	739.1

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**
Swabis Creek , cont.										
132	111.5	437.4	160.6	718.9	317.9	1877.1	426.8	2672.8	682.1	4449.8
133	43.7	432.1	67.0	727.0	147.8	1871.0	210.4	2649.9	364.7	4381.5
Little Lehigh Creek										
134	1.8	1450.5	6.1	2473.2	18.3	5642.7	28.2	7816.6	49.7	12476.2
135	2.6	1450.3	6.8	2472.4	19.8	5640.8	29.3	7815.3	49.7	12474.2
136	27.5	27.5	45.7	45.7	106.2	106.2	153.7	153.7	276.8	276.8
137	31.7	55.5	51.5	90.5	126.1	213.8	181.2	297.6	321.2	530.9
138	88.1	133.4	128.5	200.3	256.4	412.2	346.5	531.7	557.3	862.2
139	32.8	1463.6	53.9	2489.7	135.3	5665.9	201.5	7844.9	372.8	12511.1
140	32.1	1460.3	47.7	2482.9	123.5	5649.7	176.9	7819.6	307.0	12462.9
141	23.6	1461.2	39.7	2483.0	94.0	5646.7	136.4	7808.6	243.7	12437.1
Leibert Creek										
142	15.6	15.6	25.3	25.3	65.7	65.7	97.3	97.3	173.9	173.9
143	50.3	59.6	84.8	97.4	193.0	213.8	276.7	295.3	489.7	519.7
144	16.3	65.3	29.3	112.6	80.3	274.6	126.6	407.2	245.7	732.3
145	15.1	15.1	26.5	26.5	78.2	78.2	122.4	122.4	234.4	234.4
146	5.7	20.4	13.5	39.8	36.5	113.7	57.3	177.9	111.3	335.1
147	52.1	109.6	89.8	202.7	206.0	509.3	297.8	760.6	529.5	1368.1
148	17.9	116.6	34.8	225.0	115.9	572.0	177.6	836.7	342.5	1476.3
149	25.6	130.4	40.2	242.5	91.9	622.8	130.7	913.7	227.0	1612.8
150	35.6	157.2	54.7	265.7	120.2	683.7	167.1	1002.3	280.9	1759.5
151	48.1	187.9	68.5	300.9	133.1	720.4	176.5	1050.0	274.6	1833.8
152	200.0	199.6	288.5	287.0	567.8	561.3	755.1	744.7	1177.4	1156.8
153	81.2	435.1	116.2	635.8	222.2	1192.9	293.8	1517.2	451.7	2325.1
154	41.1	431.0	60.2	626.9	126.0	1197.3	171.8	1554.4	278.6	2433.1
Little Lehigh Creek										
155	2.2	1498.7	6.7	2536.3	20.5	5725.0	32.3	7900.4	62.1	12552.9
156	10.2	1496.9	17.0	2532.3	39.5	5714.1	57.2	7886.0	102.4	12524.9
157	16.7	16.7	24.4	24.4	56.6	56.6	79.5	79.5	137.2	137.2
158	71.4	1495.8	105.8	2527.9	240.7	5701.1	336.8	7863.5	577.5	12481.0
159	100.0	100.0	144.0	144.0	293.9	293.9	392.4	392.4	621.7	621.7
160	74.9	142.7	113.1	204.1	249.8	427.7	343.3	577.3	567.2	941.0
161	151.6	151.6	207.4	207.4	384.5	384.5	496.6	496.6	744.7	744.7
162	179.2	414.3	254.1	575.7	482.1	1021.4	633.4	1289.2	963.9	1901.0
163	9.4	1503.0	20.8	2538.1	84.6	5711.0	131.4	7871.3	258.2	12480.1
164	10.2	1501.6	16.0	2534.9	41.7	5701.8	59.7	7857.9	106.3	12455.0
165	16.6	16.6	25.9	25.9	62.0	62.0	89.3	89.3	159.1	159.1
166	54.8	1503.3	85.0	2536.0	200.9	5700.2	285.5	7853.8	498.0	12443.9
167	1.2	1503.2	3.2	2535.6	14.9	5699.7	23.2	7851.7	44.8	12440.1
168	74.2	1502.6	106.9	2533.5	216.2	5691.0	290.6	7838.0	460.3	12412.3
169	102.8	1502.6	148.2	2532.3	301.7	5685.0	406.7	7825.2	647.2	12385.5
170	61.8	1500.6	88.1	2527.4	180.6	5671.1	248.4	7803.2	403.0	12345.7
171	46.6	1498.8	66.2	2523.0	133.9	5657.8	178.7	7783.2	285.3	12308.9
Cedar Creek										
172	64.0	64.0	93.1	93.1	184.5	184.5	252.3	252.3	413.8	413.8
173	33.1	33.1	49.4	49.4	99.5	99.5	137.1	137.1	227.1	227.1

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK
Cedar Creek, cont.										
174	66.6	153.4	102.0	222.3	202.0	420.5	274.6	569.3	445.9	886.0
175	30.0	30.0	44.3	44.3	97.3	97.3	136.0	136.0	230.3	230.3
176	253.2	369.1	372.0	533.1	733.0	998.9	984.6	1301.4	1560.5	1972.5
177	51.4	375.8	77.5	540.7	175.9	1017.1	244.7	1316.1	410.6	2010.4
178	23.9	375.6	38.8	570.9	103.2	1037.1	149.6	1367.4	268.6	2131.5
179	112.1	112.1	163.7	163.7	322.6	322.4	431.1	430.8	673.1	672.5
180	15.6	438.8	22.2	659.7	51.2	1161.2	70.4	1526.4	114.6	2369.7
181	139.4	139.4	203.2	203.2	402.8	402.8	541.1	541.1	854.5	854.5
182	73.9	183.6	112.1	266.7	243.2	527.3	339.1	711.4	568.0	1141.7
183	137.3	137.3	184.3	184.3	319.2	319.2	417.1	417.1	612.9	612.9
184	16.4	104.0	25.6	143.2	54.2	252.4	76.1	322.6	132.1	473.7
185	3.8	270.2	6.2	381.9	14.8	723.4	21.2	963.7	36.1	1510.0
186	92.6	92.6	140.2	140.2	291.1	291.1	400.9	400.9	659.2	659.2
187	66.2	367.6	98.1	535.1	204.5	1059.9	286.6	1436.2	488.3	2291.3
188	133.4	133.4	182.4	182.4	347.7	347.7	460.2	460.2	720.3	720.3
189	158.1	421.6	224.7	608.5	429.1	1260.7	568.6	1713.0	882.7	2779.4
190	117.4	508.7	162.7	619.5	292.5	1290.8	376.1	1756.7	564.7	2803.5
191	75.4	510.6	108.0	628.8	210.7	1315.5	279.8	1798.9	433.5	2869.8
192	12.6	895.8	17.4	1277.0	35.4	2304.5	46.7	3142.1	74.5	5058.2
193	70.3	10.5	101.0	15.3	202.3	47.8	271.3	115.7	427.8	324.4
194	114.6	118.6	157.7	162.6	292.6	299.8	377.5	386.4	576.8	586.3
195	48.1	48.1	66.0	66.0	113.6	113.6	145.1	145.1	209.8	209.8
196	14.7	178.3	19.4	243.4	34.0	428.9	42.2	552.7	60.0	8369.2
197	74.9	74.8	104.9	104.8	197.1	196.7	257.9	257.2	392.8	391.3
198	31.5	276.8	44.1	378.9	94.5	656.5	129.7	854.1	215.0	1306.6
199	163.6	907.4	222.6	1259.2	428.3	2442.2	560.9	3303.2	881.6	5241.4
200	36.0	897.5	51.0	1245.8	98.7	2436.6	130.8	3293.0	202.2	5215.3
201	49.4	899.8	68.8	1246.7	127.9	2446.0	167.0	3290.5	256.2	5205.5
202	68.9	894.2	96.7	1244.1	179.2	2447.9	233.3	3290.2	349.7	5202.1
203	57.1	57.1	81.5	81.5	159.1	159.1	211.3	211.3	328.7	328.7
204	97.1	891.5	10.3	1247.6	254.5	2463.6	334.0	3307.6	525.6	5219.1
205	21.0	21.0	29.4	29.4	56.2	56.2	74.7	74.7	120.6	120.6
206	9.2	888.1	14.1	1244.9	34.5	2462.8	49.6	3303.2	86.9	5207.3
207	12.4	884.8	17.5	1241.1	36.2	2457.1	48.5	3297.5	79.0	5198.0
Little Lehigh Creek										
208	12.7	1545.7	18.9	2588.5	42.2	5753.7	58.8	7895.1	98.5	12443.2
209	336.1	1542.7	456.7	2579.5	819.9	5724.5	1071.7	7851.4	1623.6	12364.5
Trout Creek										
210	24.1	24.1	36.9	36.9	87.5	87.5	123.0	123.0	211.7	211.7
211	52.2	75.9	76.4	111.2	170.2	249.7	232.4	343.0	381.0	569.4
212	10.2	10.2	16.0	16.0	77.1	77.1	119.3	119.3	230.1	230.1
213	122.6	184.0	172.4	249.4	352.6	446.5	472.9	630.1	754.1	1086.6
214	79.5	250.4	116.3	341.9	283.4	682.9	394.2	876.0	664.3	1498.4
215	70.4	306.1	100.0	418.6	197.6	780.6	262.6	1003.0	407.4	1627.4
216	10.7	315.9	17.5	435.4	56.7	831.3	83.4	1072.8	152.7	1760.4
217	196.8	475.9	285.2	668.6	581.9	1133.8	782.7	1451.2	1240.4	2261.9
218	87.2	87.2	127.3	127.3	259.8	259.8	349.9	349.9	552.9	552.9

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK
Trout Creek, cont.										
219	223.1	271.0	314.7	378.2	584.5	705.2	762.5	919.3	1142.4	1351.1
220	66.4	704.4	89.5	971.8	165.5	1712.8	215.0	2105.6	332.2	3071.0
221	73.0	718.4	103.3	988.9	194.4	1759.2	354.6	2175.7	386.4	3168.9
222	68.6	704.3	92.6	968.5	175.3	1750.5	228.1	2190.2	353.9	3209.0
223	39.7	705.5	52.1	972.0	97.2	1753.7	127.7	2198.0	196.9	3219.9
Little Lehigh Creek										
224	6.5	1558.8	9.4	2596.9	20.9	5748.8	28.1	7877.3	44.2	12393.2
225	114.1	1551.7	156.6	2593.1	280.9	5737.4	365.5	7859.2	553.2	12360.8
226	132.8	1554.8	188.8	2594.7	367.5	5738.7	487.3	7859.5	753.2	12359.8

CHAPTER 10. PRIORITIES FOR IMPLEMENTATION OF THE PLAN

The Little Lehigh Creek Watershed Storm Water Management Plan preparation process is complete with the Lehigh County and Berks County adoption of the draft Plan and submission of the final Plan to DEP for approval. Procedures for the review and adoption of the Plan are included in Chapter 11. Subsequent activities to carry out the provisions of the Plan are considered by DEP to be part of the implementation of the Plan. The initial step of Plan implementation is DEP approval. Plan approval sets in motion the mandatory schedule of adoption of municipal ordinance provisions to implement the storm water management criteria. Little Lehigh Creek Watershed municipalities would have six months from DEP approval within which to adopt the necessary ordinance provisions. Failure to do so could result in the withholding of all state funds to the municipality(ies) per Act 167.

Additional implementation activities are the formal publishing of the final Plan after DEP approval, development of a local program to coordinate with DEP regarding permit reviews for stream encroachments, diversions, etc., and development of a systematic approach for correction of existing storm drainage problem areas. The priorities for Plan implementation are presented in detail below in (essentially) chronological order.

A. DEP Approval of the Plan

Upon adoption of the Plan by Lehigh (and Berks) County, the Plan is submitted to DEP for approval. The DEP review process involves determination that all of the activities specified in the approved Scope of Study have been satisfactorily completed in the Plan. Further, the Department will only approve the Plan if it determines the following:

1. That the Plan is consistent with municipal floodplain management plans, State programs which regulate dams, encroachments and other water obstructions, and State and Federal flood control programs; and

2. That the Plan is compatible with other watershed storm water plans for the basin in which the watershed is located and is consistent with the policies and purposes of Act 167.

DEP action to either approve or disapprove the Plan must take place within ninety (90) days of receipt of the Plan by the Department. Otherwise, the Plan would be approved by default.

B. Publishing the Plan

Consistent with the Little Lehigh Creek Watershed Scope of Study, the LVPC will publish additional copies of the study area Plan after DEP approval. One copy of the Plan will be provided to each municipality. Additional separate copies of the *Little Lehigh Creek Watershed - Act 167 - Storm Water Management Ordinance* will be published for use by the municipalities.

C. Development of a Local Program to Coordinate with DEP Regarding Chapter 105 and Chapter 106 Permit Application Reviews

Stream encroachments, stream enclosures, waterway diversions, water obstructions and other activities regulated by Chapter 105 and Chapter 106 of DEP's Rules and Regulations may have a bearing on the effectiveness of the runoff control strategy developed for the Little Lehigh Creek Watershed. Activities of this type may modify the conveyance characteristics of the study area and, hence, impact on the relative timing of peak flows and/or the ability of the conveyance facilities to safely transport peak flows. Therefore, to ensure that the DEP permitting process is consistent with the adopted and approved Plan, a local review of Chapter 105 and Chapter 106 permit applications should be coordinated with the DEP review process.

The local review for Lehigh County would be performed by the LVPC and would be accomplished through monitoring of the applications as published in the *Pennsylvania Bulletin*. The LVPC would be responsible for providing comments consistent with the adopted Act 167 Plan within the stated DEP review period. Further, the LVPC would keep records of applications reviewed and the DEP action.

D. Municipal Adoption of Ordinance Provisions to Implement the Plan

The key ingredient for implementation of the Storm Water Management Plan is the adoption of the necessary ordinance provisions by the Little Lehigh Creek Watershed municipalities. Provided as part of the Plan is the *Little Lehigh Creek Watershed - Act 167 - Storm Water Management Ordinance* which is a single purpose storm water ordinance that could be adopted by each municipality essentially as is to implement the Plan. The single purpose ordinance was chosen for ease of incorporation into the existing structure of municipal ordinances. All that would be required of any municipality would be to adopt the ordinance itself and adopt the necessary tying provisions into the existing subdivision and land development ordinance and zoning ordinance. The tying provisions would simply refer any applicable regulated activities within the Little Lehigh Creek Watershed to the single purpose ordinance from the other ordinances.

It is not required, however, that a municipality adopt the single purpose ordinance. At the municipality's discretion, it may opt to incorporate all of the necessary provisions into the existing ordinances rather than adopt a separate ordinance. In this event, the municipality must ensure that the amended ordinance satisfactorily implements the approved Plan.

E. Development of a Systematic Approach for Correction of Existing Storm Drainage Problem Areas

Correction of the existing storm drainage problem areas in the study area is not specifically part of the Act 167 planning process. However, the development of the Plan has provided a framework for their correction for the following reasons: (1) existing storm drainage problems have been documented through interaction with the Watershed Advisory

Committee; (2) implementation of the runoff control criteria specified in the Plan will prevent the existing drainage problems from becoming worse (and prevent the creation of new drainage problem areas); and (3) the hydrologic model developed to formulate the runoff control criteria could be used as an analytical tool for designing engineering solutions to existing drainage problems.

With the above in mind, each municipality within the Little Lehigh Creek Watershed should take the following steps to implement solutions to the existing storm drainage problem areas:

1. Prioritize the list of storm drainage problems within the municipality based on frequency of occurrence, potential for injury to persons or property, damage history, public perception of the problems, and other appropriate criteria.

2. For the top priority drainage problems in the municipality, conduct detailed engineering evaluations to determine the exact nature of the problems (if not known), determine alternative solutions, provide cost estimates for the alternative solutions, and recommend a course of municipal action. The number of drainage problems to be evaluated by a municipality as a first cut from the priority list should be based on a schedule compatible with completing engineering studies on all problem areas within approximately five years. The Little Lehigh Creek hydrologic model would be available at the LVPC office to provide flow data as input to the engineering studies.

3. On the priority and cost bases, incorporate implementation of recommended solutions to the drainage problems in the annual municipal capital budget or the municipal maintenance budget as funds are available. Solutions for existing storm water drainage problems may qualify for low interest loans from the Pennsylvania Infrastructure Investment Authority (PENNVEST). The number of drainage problems corrected in a given year should be based on a maximum ten-year schedule of resolving all existing documented drainage problems in the municipality for which cost-effective solutions exist.

The above-stated procedure for dealing with existing storm drainage problem areas is not a mandatory action placed on municipalities with the adoption of the Plan. Rather, it represents one systematic method to approach the problems uniformly throughout the study area and attempt to improve the current runoff situation in the basin. The key elements involved in the success of the remedial strategy will be the dedication of the municipalities to construct the corrective measures and the consistent and proper application of the runoff control criteria specified in the Plan. The latter element is essential to ensure that remedial measures do not become obsolete (under-designed) by increases in peak flows with development.

CHAPTER 11. PLAN REVIEW, ADOPTION AND UPDATING PROCEDURES

A. Plan Review and Adoption

The opportunity for local review of the draft Storm Water Management Plan is a prerequisite to county adoption of the Plan. Local review of the Plan is composed of four parts, namely Watershed Advisory Committee review, Legal Advisory Committee review, municipal review and County reviews. Local review of the draft Plan is initiated with the completion of the Plan by the LVPC and distribution to the Watershed Advisory Committee and Legal Advisory Committee. Presented below is a chronological listing and brief narrative of the required local review steps through County adoptions.

1. Watershed Advisory Committee Review — This body has been formed to assist in the development of the Little Lehigh Creek Watershed Plan. Municipal members of the Committee have provided input data to the process in the form of storm drainage problem area documentation, storm sewer documentation, proposed solutions to drainage problems, etc. The Committee met on four occasions to review the progress of the Plan. Municipal representatives on the Committee have the responsibility to report on the progress of the Plan to their respective municipalities. Review of the draft Plan by the Advisory Committee will be expedited by the fact that the members are already familiar with the objectives of the Plan, the runoff control strategy employed and the basic contents of the Plan. The output of the Watershed Advisory Committee review would be a revised draft Plan for municipal and County consideration.

Legal Advisory Committee Review — This body has been formed to educate the municipal solicitors on the ordinance adoption and implementation requirements of the Plan. The committee will meet one time to receive comments and direction in the development of the model ordinance. The output of the Legal Advisory Committee review would be a revised draft model ordinance for municipal and County consideration.

3. Municipal Review — Act 167 specifies that prior to adoption of the draft Plan by the County, the planning commission and governing body of each municipality in the study area must review the Plan for consistency with other plans and programs affecting the study area. Of primary concern during the municipal review would be the draft *Little Lehigh Creek Watershed - Act 167 - Storm Water Management Ordinance* which would implement the Plan through municipal adoption. The output of the municipal review would be a letter directed to the counties outlining the municipal suggestions, if any, for revising the draft Plan (or Ordinance) prior to adoption by the County.

4. County Review and Adoption — Upon completion of the review by the Watershed Advisory Committee, Legal Advisory Committee and each municipality, the draft Plan will be submitted to both the Lehigh and Berks County Boards of Commissioners for their consideration. The formal agreement between Lehigh and Berks Counties for the preparation of the watershed Plan specifies that the draft Plan will simply be submitted to Berks County by Lehigh County accompanied, if requested, by a presentation of the draft Plan to the Board of Commissioners. Any subsequent action by Berks County toward adoption of the draft Plan would be the responsibility of Berks County and would follow the procedures outlined below for Lehigh County.

The Lehigh County review of the draft Plan will include a detailed review by the County Board of Commissioners and an opportunity for public input through the holding of public hearings. Public hearings on the draft Plan must be held with a minimum two-week notice period with copies of the draft Plan available for inspection by the general public. Any modifications to the draft Plan would be made by the County based upon input from the public hearings, comments received from the municipalities in the study area or their own review. Adoption of the draft Plan by Lehigh County would be by resolution and require an affirmative vote of the majority of members of the County Board of Commissioners.

The adopted Plan would be submitted by the county to DEP for their consideration for approval. Accompanying the adopted Plan to DEP would be the review comments of the municipalities.

B. Procedure for Updating the Plan

Act 167 specifies that the county must review and, if necessary, revise the adopted and approved study area plan every five years, at minimum. Any proposed revisions to the Plan would require municipal and public review prior to county adoption consistent with the procedures outlined above. An important aspect of the Plan is a procedure to monitor the implementation of the Plan and initiate review and revisions in a timely manner. The process to be used for the Little Lehigh Creek Watershed Storm Water Management Plan will be as outlined below.

1. Monitoring of the Plan Implementation — The Lehigh Valley Planning Commission will be responsible for monitoring the implementation of the Plan by maintaining a record of all development activities within the study area. Development activities are defined as those activities regulated by the Storm Water Management Plan as described in Chapter 9 and included in the recommended municipal ordinance. Specifically, the LVPC will monitor the following data records:

   (a) All subdivision and land developments subject to review per the Plan which have been approved within the study area.

   (b) All building permits subject to review per the Plan which have been approved within the study area.

   (c) All DEP permits issued under Chapter 105 (Dams and Waterway Management) and Chapter 106 (Floodplain Management) including location and design capacity (if applicable).

2. Review of Adequacy of Plan — The Watershed Advisory Committee will be convened periodically to review the Storm Water Management Plan and determine if the Plan is adequate for minimizing the runoff impacts of new development. At minimum, the information to be reviewed by the Committee will be as follows:

   (a) Development activity data as monitored by the LVPC.

   (b) Information regarding additional storm drainage problem areas as provided by the municipal representatives to the Watershed Advisory Committee.

(c) Zoning amendments within the study area.

(d) Information associated with any regional detention alternatives implemented within the study area.

(e) Adequacy of the administrative aspects of regulated activity review.

The Committee will review the above data and make recommendations to the County as to the need for revision to the Little Lehigh Creek Watershed Storm Water Management Plan. Lehigh County will review the recommendations of the Watershed Advisory Committee and determine if revisions are to be made. A revised Plan would be subject to the same rules of adoption as the original Plan preparation. Should the County determine that no revisions to the Plan are required for a period of five consecutive years, the County will adopt resolutions stating that the Plan has been reviewed and been found satisfactory to meet the requirements of Act 167 and forward the resolution to DEP.

APPENDIX A

(Not Included in Plan Copy of Ordinance)

A-1 **Map of Little Lehigh Creek Watershed**

A-2 **Municipal Map of Storm Water Management Districts**

APPENDIX B

(Not Included in Plan Copy Text)

B-1 **Map of Storm Drainage Problem Areas**

B-2 **Description of Storm Drainage Problem Areas**

APPENDIX C

C-1 NRCS Type II 24-Hour Rainfall Distribution (Graphic & Tabular)

C-2 Intensity-Duration-Frequency Curves

C-3 Runoff Curve Numbers and Percent Imperviousness Values

C-4 Runoff Coefficients for the Rational Method

C-5 Manning ‘n’ Values

C-6 Permissible Velocities for Channels

PERMISSIBLE VELOCITIES FOR SELECTED CHANNELS

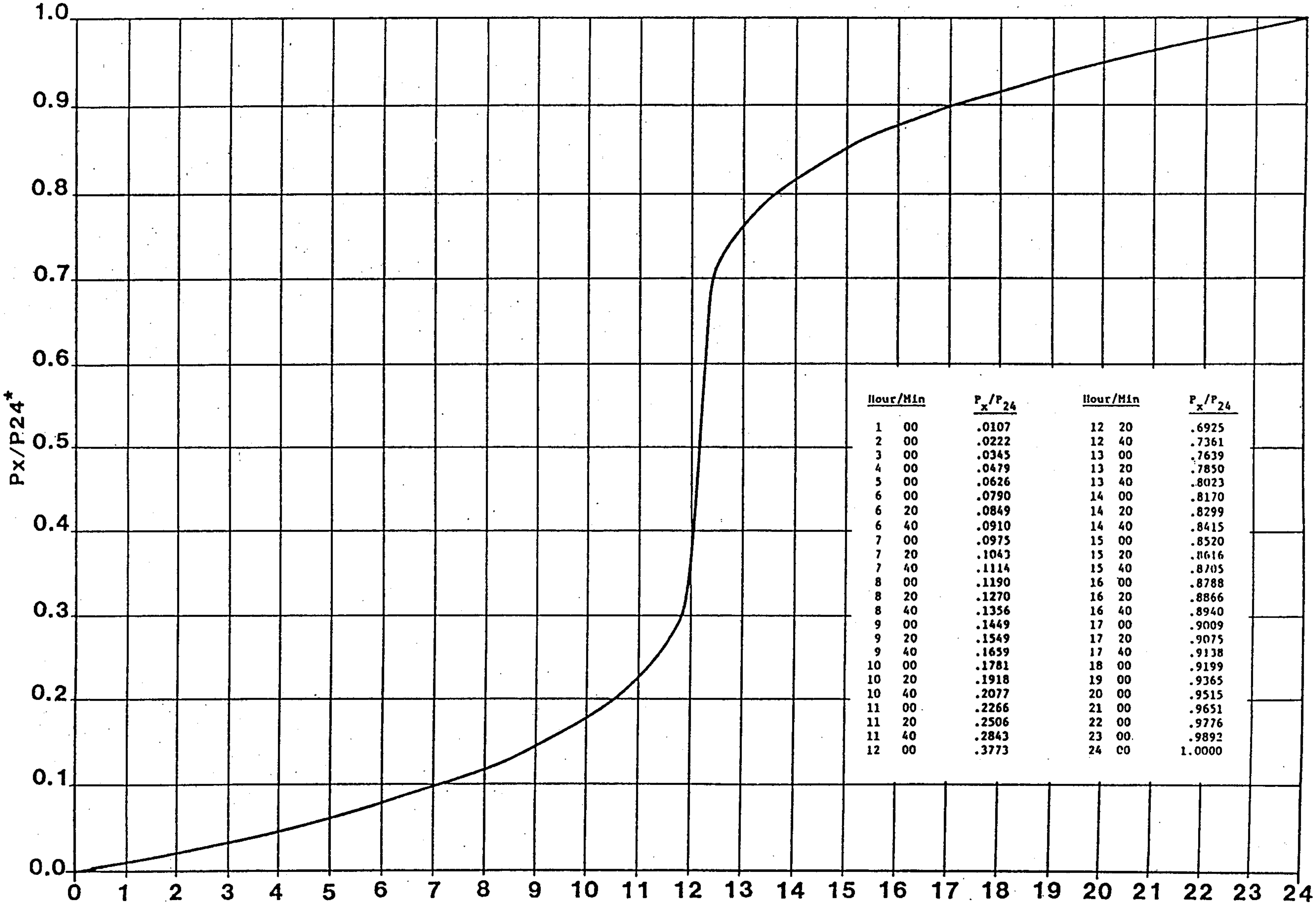
CHANNEL LINING	PERMISSIBLE CHANNEL VELOCITY (FEET PER SECOND)		
Vegetation[1]			
Grass Mixture	4.0	-	5.0
Kentucky Bluegrass	5.0	-	7.0
Kentucky 31 Tall Fescue	3.0	-	6.0
Red Clover or Red Fescue	2.5	-	3.5
Red Top	2.5	-	3.5
Red Canarygrass	3.0	-	4.0
Sericea Lespedeza	2.5	-	3.5
Sudan Grass	2.5	-	3.5
Weeping Lovegrass	2.5	-	3.5
Bare Earth, Easily Eroded[2]			
Fine Sand	1.5		
Sand Loam	1.75		
Silt Loam or Alluvial Silts, Loose	2.0		
Firm Loam	2.50		
Bare Earth, Erosion Resistant[2]			
Fine Gravel	2.5		
Stiff Clay or Alluvial Silts, Firm	3.75		
Loam to Cobbles (Graded)	3.75		
Silt to Cobbles (Graded or Course Gravel)	4.0		
Cobbles and Stones or Shales and Hardpans	6.0		
Rock Lined			
6" Rip Rap	9.0		
9" Rip Rap	11.5		
12" Rip Rap	13.0		

[1] Maximum permissible velocities dependent on soil erodibility and slope.

[2] Maximum permissible velocities in bare earth channels - for straight channels where slopes <0.02 ft./ft.

Source: Department of Environmental Protection, *Erosion and Sediment Pollution Control Program Manual*, April 1990.

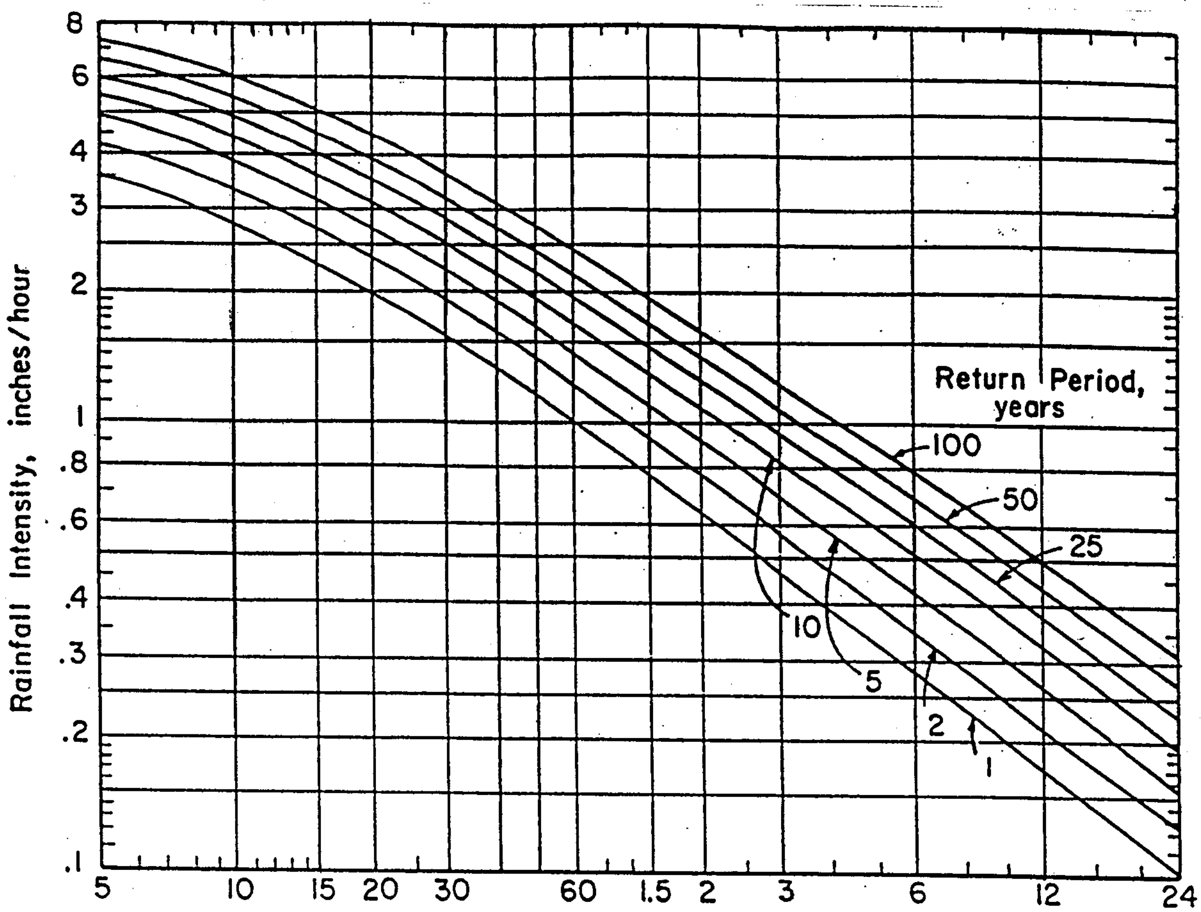
NRCS TYPE II RAINFALL DISTRIBUTION

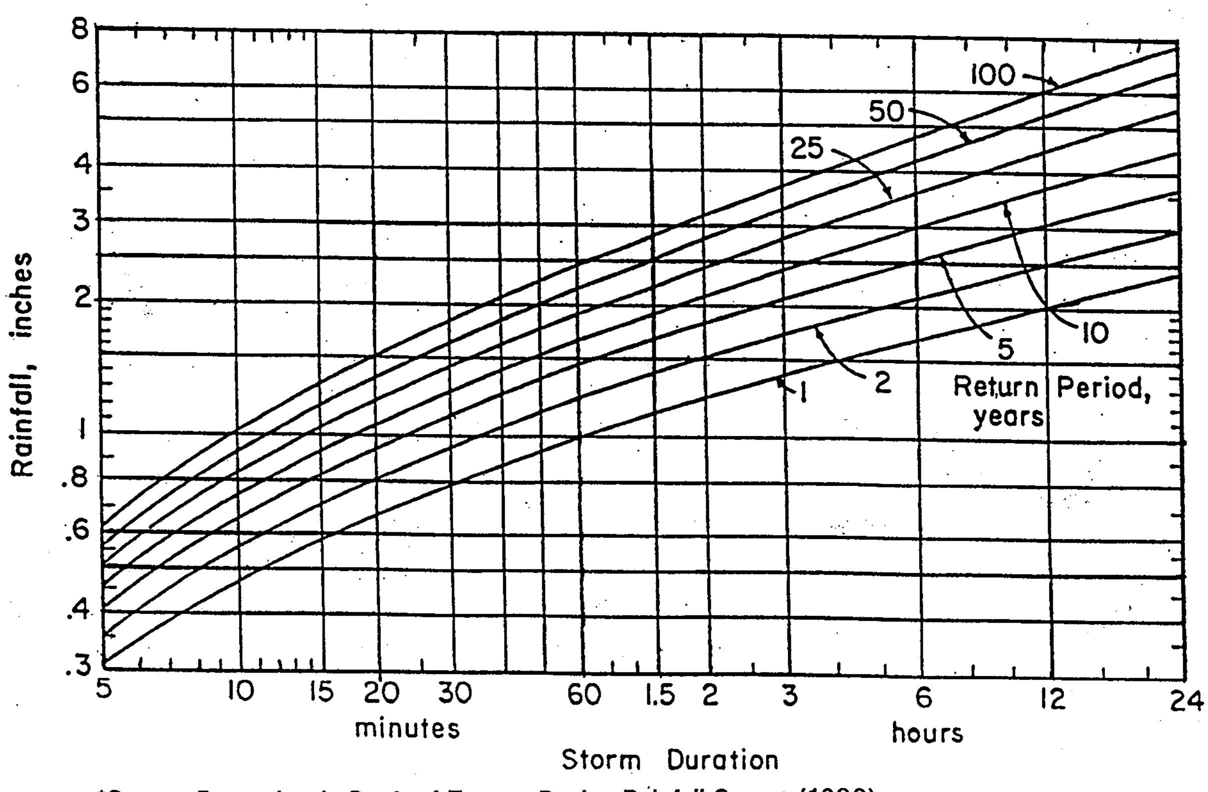


Hour/Min	P_x/P_{24}	Hour/Min	P_x/P_{24}
1 00	.0107	12 20	.6925
2 00	.0222	12 40	.7361
3 00	.0345	13 00	.7639
4 00	.0479	13 20	.7850
5 00	.0626	13 40	.8023
6 00	.0790	14 00	.8170
6 20	.0849	14 20	.8299
6 40	.0910	14 40	.8415
7 00	.0975	15 00	.8520
7 20	.1043	15 20	.8616
7 40	.1114	15 40	.8705
8 00	.1190	16 00	.8788
8 20	.1270	16 20	.8866
8 40	.1356	16 40	.8940
9 00	.1449	17 00	.9009
9 20	.1549	17 20	.9075
9 40	.1659	17 40	.9138
10 00	.1781	18 00	.9199
10 20	.1918	19 00	.9365
10 40	.2077	20 00	.9515
11 00	.2266	21 00	.9651
11 20	.2506	22 00	.9776
11 40	.2843	23 00	.9892
12 00	.3773	24 00	1.0000

*Px/P24 equals cumulative percentage rainfall as a fraction of the total 24 hour rainfall.

INTENSITY–DURATION–FREQUENCY CURVES*





*Source: Pennsylvania Dept. of Transp. Design Rainfall Curves (1986).

RUNOFF CURVE NUMBERS AND PERCENT IMPERVIOUSNESS VALUES*

Cover Description		Curve numbers for hydrologic soil group**			
Land Use/Cover Type	Average percent impervious area	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Good condition (grass cover greater than 75%) . .		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way) .		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Urban districts:					
Commercial and business . . .	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
⅛ acre or less (townhouses)	65	77	85	90	92
¼ acre	38	61	75	83	87
⅓ acre	30	57	72	81	86
½ acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Woods		30	55	70	77
Agriculture		Refer to Table 2-2b in source document (TR55) by crop type and treatment.			

*Source: Natural Resources Conservation Service Technical Release No. 55, Second Edition, June 1986.

**Hydrologic Soil Group based on the County Soil Survey latest edition.

RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD*

HYDROLOGIC SOIL GROUP AND SLOPE RANGE**

	A			B			C			D		
LAND USE	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Cultivated[A]	[a]0.18 [b]0.23	0.23 0.29	0.28 0.34	0.24 0.30	0.29 0.36	0.33 0.40	0.30 0.36	0.34 0.41	0.38 0.45	0.33 0.39	0.37 0.44	0.41 0.48
Pasture[B]	0.09 0.12	0.13 0.17	0.17 0.23	0.19 0.24	0.24 0.30	0.29 0.36	0.27 0.33	0.31 0.38	0.36 0.43	0.31 0.37	0.35 0.42	0.39 0.46
Meadow, Lawn[C]	0.05 0.07	0.08 0.12	0.12 0.17	0.15 0.19	0.20 0.25	0.24 0.30	0.23 0.28	0.28 0.34	0.32 0.39	0.28 0.33	0.32 0.39	0.36 0.43
Forest, Woods	0.03 0.04	0.05 0.08	0.08 0.12	0.11 0.15	0.16 0.21	0.20 0.26	0.20 0.25	0.25 0.31	0.29 0.36	0.25 0.31	0.30 0.37	0.34 0.41
Gravel	0.24 0.30	0.29 0.36	0.33 0.40	0.32 0.38	0.36 0.43	0.40 0.47	0.35 0.42	0.39 0.46	0.43 0.50	0.37 0.44	0.41 0.48	0.44 0.51
Parking, Other Impervious	0.72 0.84	0.76 0.88	0.80 0.92	0.72 0.84	0.76 0.88	0.80 0.92	0.72 0.84	0.76 0.88	0.80 0.92	0.72 0.84	0.76 0.88	0.80 0.92
Residential, Commercial, Industrial And Other "Developed"	Runoff coefficients should be calculated based upon weighted average of impervious area coefficients and pervious area coefficients from above based upon soil type, slope and the particular development proposal.											

*Based on Rossmiller Equation for translating NRCS curve numbers into Rational Method 'c' values.
**Hydrologic Soil Group based on the county soil survey latest edition.

a—Runoff coefficients for storm recurrence intervals less than 25 years.
b—Runoff coefficients for storm recurrence intervals of 25 years or more.

[A]Represents average of cultivated land with and without conservation treatment from TR-55, January 1975. These values are consistent with several categories of cultivated lands from TR-55, June 1986.
[B]Represents grasslands in fair condition with 50% to 75% grass cover.
[C]Represents grasslands in good condition with greater than 75% grass cover.

APPENDIX D

D-1 to D-6 Calibrated WATERSHED Peak Flow Values

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK
Little Lehigh Creek										
1	20.1 (cfs)	20.1	41.6 (cfs)	41.6	157.8 (cfs)	157.8	253.2 (cfs)	253.2	504.4 (cfs)	504.4
2	26.3	43.6	58.4	96.7	226.9	378.6	364.7	608.4	730.9	1210.4
3	26.4	26.4	51.1	51.1	158.6	158.6	250.7	250.7	488.1	488.1
4	39.8	101.5	71.0	202.9	192.6	684.6	295.3	1071.2	551.5	2036.5
5	30.8	30.8	47.9	47.9	140.1	140.1	217.8	217.8	405.7	405.7
6	52.8	52.8	81.6	81.6	194.6	194.6	304.8	304.8	692.9	692.9
7	8.8	90.3	16.6	144.2	48.2	356.6	73.8	554.9	133.2	1128.8
8	38.3	117.7	81.7	206.6	254.8	571.3	405.7	884.7	801.6	1738.8
9	45.8	213.8	74.7	423.9	185.4	1361.7	275.4	2087.5	509.2	3811.4
10	61.6	232.2	107.9	477.3	266.0	1482.3	395.1	2225.6	728.1	3938.5
11	31.1	251.0	54.5	518.5	149.7	1572.0	229.5	2341.3	439.1	4073.5
Toad Creek										
12	32.5	32.5	54.9	54.9	122.2	122.2	176.1	176.1	314.5	314.5
13	87.0	114.5	126.6	171.2	250.6	346.7	338.4	475.8	541.0	782.5
14	44.4	44.4	65.3	65.3	131.4	131.4	181.7	181.7	302.5	302.5
15	17.8	175.6	24.4	258.3	44.4	509.4	58.2	690.4	88.2	1113.2
16	48.9	212.3	75.9	316.8	166.5	623.4	235.9	844.5	405.3	1384.2
17	39.9	39.9	65.1	65.1	160.8	160.8	235.8	235.8	427.1	427.1
18	4.5	241.5	9.8	367.5	31.7	790.0	50.2	1104.5	98.1	1875.1
19	100.0	227.0	160.6	370.6	384.4	886.4	562.4	1272.5	1007.9	2125.6
20	28.9	28.9	54.9	54.9	175.8	175.8	277.1	277.1	537.1	537.1
21	14.7	261.8	33.1	448.3	109.9	1113.6	175.1	1597.0	345.3	2639.7
22	7.2	260.1	15.4	445.2	48.6	1102.7	77.1	1578.7	147.6	2604.9
Little Lehigh Creek										
23	3.5	469.5	7.1	930.7	21.2	2476.0	33.1	3534.3	61.4	5882.1
24	14.0	472.1	29.4	930.5	91.2	2464.8	143.2	3519.0	275.6	5841.5
25	56.2	56.2	87.7	87.7	197.8	197.8	283.3	283.3	495.1	495.1
26	35.8	505.0	62.4	983.2	167.9	2561.6	256.2	3644.7	486.0	6005.5
27	22.3	510.6	36.1	991.7	86.7	2572.4	127.2	3656.7	228.7	6010.8
Schaefer Run										
28	31.0	31.0	48.2	48.2	108.0	108.0	158.2	158.2	286.8	286.8
29	23.6	22.0	38.4	38.4	91.5	91.5	135.0	135.0	228.4	228.4
30	50.5	98.1	84.7	160.8	217.1	360.0	327.9	518.9	585.6	862.4
31	20.6	20.6	35.4	35.4	88.0	88.0	127.1	127.1	220.1	220.1
32	23.0	141.1	39.6	229.2	98.9	515.4	142.9	740.0	238.5	1237.2
33	15.4	15.4	26.8	26.8	70.1	70.1	106.1	106.1	186.9	186.9
34	21.3	171.6	39.7	288.0	115.1	664.8	176.5	943.0	326.8	1569.8
35	21.6	21.6	36.5	36.5	91.5	91.5	139.8	139.8	265.6	265.6
36	16.9	206.7	30.4	349.3	80.7	807.3	122.8	1149.2	222.9	1917.8
37	19.5	19.5	34.8	34.8	89.6	89.6	134.5	134.5	239.8	239.8
38	16.7	235.8	33.4	404.4	98.9	955.2	154.4	1371.0	295.7	2281.9
39	3.7	235.3	7.7	403.8	23.3	955.4	36.5	1365.9	69.8	2279.5
40	24.6	24.6	42.9	42.9	109.2	109.2	162.1	162.1	293.1	293.1
41	67.2	87.0	115.0	150.1	295.8	394.3	445.2	595.5	837.8	1100.2

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**
Schaefer Run, cont.										
42	8.7 (cfs)	94.0	16.9 (cfs)	164.9	48.5 (cfs)	441.0	74.6 (cfs)	666.7	141.3 (cfs)	1229.0
43	7.1	331.8	14.7	573.7	45.0	1393.9	70.5	2023.4	134.5	3449.8
44	27.7	27.7	51.3	51.3	138.9	138.9	210.0	210.0	389.8	389.8
45	67.1	373.7	100.1	650.2	200.4	1578.1	276.7	2281.5	457.7	3867.2
46	133.2	393.3	185.6	673.6	345.2	1599.8	458.7	2296.5	710.8	3851.1
47	15.2	404.9	30.5	696.5	89.0	1665.1	137.6	2387.2	261.3	4004.1
48	11.6	404.5	22.0	699.3	68.0	1674.7	104.7	2394.9	205.9	3992.4
49	18.1	18.1	31.3	31.3	79.8	79.8	119.2	119.2	213.2	213.2
50	22.0	39.3	39.7	69.2	106.6	181.7	161.1	273.5	298.6	501.0
51	56.6	73.5	84.4	114.8	166.3	263.2	225.5	371.8	366.0	658.2
52	6.0	77.9	9.6	121.3	23.1	277.6	34.0	391.8	61.9	682.5
53	12.4	448.3	20.6	770.0	50.6	1811.8	75.5	2566.2	139.3	4231.8
54	23.0	457.2	38.7	779.7	97.8	1817.7	146.9	2562.2	273.2	4216.8
55	25.7	25.7	39.9	39.9	88.3	88.3	125.9	125.9	218.9	218.9
56	16.4	468.4	25.9	795.4	61.7	1838.6	90.4	2581.4	163.2	4222.4
57	17.2	469.7	28.9	793.8	75.3	1824.5	113.7	2557.8	212.7	4170.1
58	35.9	35.9	61.0	61.0	158.4	158.4	238.8	238.8	443.5	443.5
59	71.2	100.4	119.4	169.6	293.1	428.6	437.9	645.2	795.9	1160.5
60	24.1	123.7	40.5	207.7	103.5	528.9	157.5	785.1	297.2	1410.5
61	23.9	131.2	42.5	233.8	116.7	612.1	179.3	914.4	343.2	1603.5
62	12.8	12.8	21.7	21.7	57.0	57.0	86.6	86.6	159.1	159.1
63	28.7	40.8	53.4	73.5	146.5	192.6	224.5	286.3	406.2	505.2
64	2.2	171.8	4.2	300.4	10.9	753.1	15.5	1093.9	24.9	1867.2
65	16.5	184.7	32.1	325.8	93.4	820.5	144.6	1194.0	276.5	2030.3
66	28.9	5.6	48.7	11.3	124.4	46.2	188.4	69.4	353.8	95.4
67	4.6	190.3	8.0	333.3	24.3	852.9	36.5	1254.2	66.3	2120.1
68	8.3	197.3	15.7	345.7	43.1	878.2	66.1	1285.9	126.9	2159.1
69	37.9	37.9	58.0	58.0	127.6	127.6	181.7	181.7	316.4	316.4
70	34.4	218.3	56.9	388.4	124.3	970.4	179.1	1403.4	314.9	2324.5
71	73.9	73.9	103.1	103.1	188.0	188.0	242.9	242.9	361.4	361.4
72	59.3	235.7	86.4	410.6	165.2	1011.5	218.9	1455.2	336.3	2396.1
73	20.5	20.5	38.2	38.2	104.3	104.3	158.6	158.6	285.7	285.7
74	35.1	252.5	53.4	434.7	115.9	1050.5	163.8	1503.6	280.5	2447.8
75	13.1	263.8	26.8	453.1	82.2	1083.5	128.6	1538.0	246.6	2489.7
76	232.6	232.6	342.7	342.7	673.1	673.1	904.7	904.7	1427.2	1427.2
77	175.1	400.0	251.1	578.1	482.1	1099.7	639.0	1455.0	979.5	2229.8
78	84.7	429.6	120.9	603.1	232.8	1107.1	309.0	1450.6	476.7	2205.1
79	25.0	409.8	36.4	571.6	69.1	1032.2	92.4	1348.1	146.1	2040.2
80	40.7	640.8	62.6	906.7	133.9	1708.2	187.6	2269.2	317.6	3510.5
81	73.8	654.0	110.1	923.1	222.0	1746.8	301.9	2323.7	483.8	3605.2
82	158.7	668.7	218.6	948.3	390.6	1797.4	500.9	2385.8	762.3	3698.0
83	12.2	12.2	26.5	26.5	85.6	85.6	135.9	135.9	265.7	265.7
84	20.2	891.8	29.0	1347.1	56.3	3064.5	76.6	4264.9	124.5	6809.1
85	27.5	890.6	47.1	1351.3	123.4	3061.3	188.0	4257.2	355.6	6787.4
Little Lehigh Creek										
86	11.5	1263.7	16.9	2164.2	34.4	5079.1	47.3	7120.2	77.8	11576.6

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK
Little Lehigh Creek, cont.										
87	100.8	1275.1	150.2	2186.2	315.0	5128.1	434.7	7180.4	714.0	11649.5
88	62.7	62.7	97.6	97.6	222.8	222.8	319.2	319.2	557.5	557.5
89	18.6	18.6	27.7	27.7	57.5	57.5	80.2	80.2	135.8	135.8
90	34.7	98.7	49.4	146.9	91.3	312.0	120.3	437.1	183.9	744.7
91	34.1	106.8	52.1	160.1	112.5	351.2	158.1	499.9	268.6	866.9
92	12.9	1305.2	19.4	2241.4	41.6	5243.9	58.4	7330.0	99.4	11860.6
93	11.8	1306.9	20.8	2242.7	54.6	5242.7	83.4	7324.0	159.3	11840.3
94	32.9	32.9	54.8	54.8	137.1	137.1	205.4	205.4	381.3	381.3
95	6.8	36.9	14.4	64.0	46.3	172.3	73.2	266.2	142.5	507.7
96	13.5	1328.0	22.8	2276.7	55.3	5299.5	81.7	7389.4	149.4	11919.2
97	22.9	22.9	34.3	34.3	68.1	68.1	92.5	92.5	149.3	149.3
98	20.0	1333.7	32.0	2284.6	75.6	5309.2	110.3	7402.6	197.8	11931.7
99	44.6	44.6	63.7	63.7	123.6	123.6	166.4	166.4	266.5	266.5
100	9.0	1336.1	17.2	2287.4	48.6	5311.0	75.9	7399.3	148.7	11917.6
101	2.9	1335.8	4.5	2286.8	10.9	5309.2	15.7	7395.8	27.6	11910.3
102	87.9	1337.2	128.9	2288.4	261.0	5304.4	355.6	7382.0	576.2	11873.1
103	43.0	43.0	63.0	63.0	126.4	126.4	171.2	171.2	276.1	276.1
104	43.8	43.8	65.4	65.4	140.6	140.6	195.4	195.4	327.0	327.0
105	18.8	1344.0	31.5	2298.4	81.7	5316.4	123.0	7392.8	229.9	11879.5
106	3.0	1343.0	6.3	2295.9	20.0	5308.3	31.5	7379.4	61.5	11852.4
107	15.8	1342.2	25.2	2294.3	56.5	5302.5	80.5	7369.8	141.2	11832.9
Swabia Creek										
108	99.5	99.5	172.7	172.7	489.6	489.6	738.3	738.3	1402.1	1402.1
109	78.0	75.6	144.6	137.2	368.7	343.4	555.8	514.8	1043.3	972.0
110	15.0	189.8	26.8	333.7	61.8	881.2	88.4	1352.5	148.5	2533.5
111	26.1	199.9	46.8	353.1	109.2	948.3	159.9	1439.5	292.7	2696.0
112	27.1	210.8	44.4	379.8	104.2	1016.8	150.5	1544.2	268.9	2780.6
113	22.7	22.7	36.1	36.1	87.3	87.3	122.3	122.3	212.7	212.7
114	21.9	21.9	35.7	35.7	91.3	91.3	129.1	129.1	230.9	230.9
115	26.4	67.3	54.8	116.9	190.7	349.8	293.9	518.4	554.0	947.9
116	9.7	9.7	18.4	18.4	50.8	50.8	75.2	75.2	132.9	132.9
117	11.3	86.4	20.2	152.7	52.8	450.4	79.1	645.0	141.1	1172.8
118	16.1	304.3	27.2	530.4	71.5	1482.6	108.2	2237.8	200.9	4015.1
119	16.0	16.0	28.3	28.3	81.3	81.3	128.1	128.1	251.5	251.5
120	51.5	296.4	81.5	552.4	194.0	1588.7	284.4	2376.5	517.9	4239.6
121	28.0	294.3	46.2	557.7	115.1	1620.8	171.7	2413.5	316.1	4272.2
122	13.8	13.8	29.4	29.4	91.4	91.4	143.2	143.2	274.4	274.4
123	39.2	206.4	64.8	583.8	163.7	1638.8	247.6	2401.2	464.0	4156.5
124	53.8	309.3	77.5	588.2	147.4	1642.2	195.9	2395.0	305.1	4116.8
125	100.6	318.6	143.8	605.8	270.8	1667.9	357.3	2426.2	549.0	4150.6
126	37.0	37.0	68.1	68.1	205.0	205.0	308.1	308.1	586.9	586.9
127	58.3	93.6	80.8	143.1	155.3	337.5	205.5	475.1	328.1	827.5
128	45.7	337.0	64.3	652.2	125.1	1763.8	169.1	2542.9	265.6	4311.1
129	30.0	338.7	45.5	657.9	95.3	1772.5	131.7	2551.5	218.2	4306.0
130	50.7	50.7	84.6	84.6	203.7	203.7	292.9	292.9	529.6	529.6
131	53.1	92.8	78.1	142.1	158.5	301.9	220.5	418.7	370.9	739.1

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**
Swabis Creek , cont.										
132	111.5	437.4	160.6	718.9	317.9	1877.1	426.8	2672.8	682.1	4449.8
133	43.7	432.1	67.0	727.0	147.8	1871.0	210.4	2649.9	364.7	4381.5
Little Lehigh Creek										
134	1.8	1450.5	6.1	2473.2	18.3	5642.7	28.2	7816.6	49.7	12476.2
135	2.6	1450.3	6.8	2472.4	19.8	5640.8	29.3	7815.3	49.7	12474.2
136	27.5	27.5	45.7	45.7	106.2	106.2	153.7	153.7	276.8	276.8
137	31.7	55.5	51.5	90.5	126.1	213.8	181.2	297.6	321.2	530.9
138	88.1	133.4	128.5	200.3	256.4	412.2	346.5	531.7	557.3	862.2
139	32.8	1463.6	53.9	2489.7	135.3	5665.9	201.5	7844.9	372.8	12511.1
140	32.1	1460.3	47.7	2482.9	123.5	5649.7	176.9	7819.6	307.0	12462.9
141	23.6	1461.2	39.7	2483.0	94.0	5646.7	136.4	7808.6	243.7	12437.1
Leibert Creek										
142	15.6	15.6	25.3	25.3	65.7	65.7	97.3	97.3	173.9	173.9
143	50.3	59.6	84.8	97.4	193.0	213.8	276.7	295.3	489.7	519.7
144	16.3	65.3	29.3	112.6	80.3	274.6	126.6	407.2	245.7	732.3
145	15.1	15.1	26.5	26.5	78.2	78.2	122.4	122.4	234.4	234.4
146	5.7	20.4	13.5	39.8	36.5	113.7	57.3	177.9	111.3	335.1
147	52.1	109.6	89.8	202.7	206.0	509.3	297.8	760.6	529.5	1368.1
148	17.9	116.6	34.8	225.0	115.9	572.0	177.6	836.7	342.5	1476.3
149	25.6	130.4	40.2	242.5	91.9	622.8	130.7	913.7	227.0	1612.8
150	35.6	157.2	54.7	265.7	120.2	683.7	167.1	1002.3	280.9	1759.5
151	48.1	187.9	68.5	300.9	133.1	720.4	176.5	1050.0	274.6	1833.8
152	200.0	199.6	288.5	287.0	567.8	561.3	755.1	744.7	1177.4	1156.8
153	81.2	435.1	116.2	635.8	222.2	1192.9	293.8	1517.2	451.7	2325.1
154	41.1	431.0	60.2	626.9	126.0	1197.3	171.8	1554.4	278.6	2433.1
Little Lehigh Creek										
155	2.2	1498.7	6.7	2536.3	20.5	5725.0	32.3	7900.4	62.1	12552.9
156	10.2	1496.9	17.0	2532.3	39.5	5714.1	57.2	7886.0	102.4	12524.9
157	16.7	16.7	24.4	24.4	56.6	56.6	79.5	79.5	137.2	137.2
158	71.4	1495.8	105.8	2527.9	240.7	5701.1	336.8	7863.5	577.5	12481.0
159	100.0	100.0	144.0	144.0	293.9	293.9	392.4	392.4	621.7	621.7
160	74.9	142.7	113.1	204.1	249.8	427.7	343.3	577.3	567.2	941.0
161	151.6	151.6	207.4	207.4	384.5	384.5	496.6	496.6	744.7	744.7
162	179.2	414.3	254.1	575.7	482.1	1021.4	633.4	1289.2	963.9	1901.0
163	9.4	1503.0	20.8	2538.1	84.6	5711.0	131.4	7871.3	258.2	12480.1
164	10.2	1501.6	16.0	2534.9	41.7	5701.8	59.7	7857.9	106.3	12455.0
165	16.6	16.6	25.9	25.9	62.0	62.0	89.3	89.3	159.1	159.1
166	54.8	1503.3	85.0	2536.0	200.9	5700.2	285.5	7853.8	498.0	12443.9
167	1.2	1503.2	3.2	2535.6	14.9	5699.7	23.2	7851.7	44.8	12440.1
168	74.2	1502.6	106.9	2533.5	216.2	5691.0	290.6	7838.0	460.3	12412.3
169	102.8	1502.6	148.2	2532.3	301.7	5685.0	406.7	7825.2	647.2	12385.5
170	61.8	1500.6	88.1	2527.4	180.6	5671.1	248.4	7803.2	403.0	12345.7
171	46.6	1498.8	66.2	2523.0	133.9	5657.8	178.7	7783.2	285.3	12308.9
Cedar Creek										
172	64.0	64.0	93.1	93.1	184.5	184.5	252.3	252.3	413.8	413.8
173	33.1	33.1	49.4	49.4	99.5	99.5	137.1	137.1	227.1	227.1

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**	**SUBAREA PEAK**	**TOTAL PEAK**
Cedar Creek, cont.										
174	66.6	153.4	102.0	222.3	202.0	420.5	274.6	569.3	445.9	886.0
175	30.0	30.0	44.3	44.3	97.3	97.3	136.0	136.0	230.3	230.3
176	253.2	369.1	372.0	533.1	733.0	998.9	984.6	1301.4	1560.5	1972.5
177	51.4	375.8	77.5	540.7	175.9	1017.1	244.7	1316.1	410.6	2010.4
178	23.9	375.6	38.8	570.9	103.2	1037.1	149.6	1367.4	268.6	2131.5
179	112.1	112.1	163.7	163.7	322.6	322.4	431.1	430.8	673.1	672.5
180	15.6	438.8	22.2	659.7	51.2	1161.2	70.4	1526.4	114.6	2369.7
181	139.4	139.4	203.2	203.2	402.8	402.8	541.1	541.1	854.5	854.5
182	73.9	183.6	112.1	266.7	243.2	527.3	339.1	711.4	568.0	1141.7
183	137.3	137.3	184.3	184.3	319.2	319.2	417.1	417.1	612.9	612.9
184	16.4	104.0	25.6	143.2	54.2	252.4	76.1	322.6	132.1	473.7
185	3.8	270.2	6.2	381.9	14.8	723.4	21.2	963.7	36.1	1510.0
186	92.6	92.6	140.2	140.2	291.1	291.1	400.9	400.9	659.2	659.2
187	66.2	367.6	98.1	535.1	204.5	1059.9	286.6	1436.2	488.3	2291.3
188	133.4	133.4	182.4	182.4	347.7	347.7	460.2	460.2	720.3	720.3
189	158.1	421.6	224.7	608.5	429.1	1260.7	568.6	1713.0	882.7	2779.4
190	117.4	508.7	162.7	619.5	292.5	1290.8	376.1	1756.7	564.7	2803.5
191	75.4	510.6	108.0	628.8	210.7	1315.5	279.8	1798.9	433.5	2869.8
192	12.6	895.8	17.4	1277.0	35.4	2304.5	46.7	3142.1	74.5	5058.2
193	70.3	10.5	101.0	15.3	202.3	47.8	271.3	115.7	427.8	324.4
194	114.6	118.6	157.7	162.6	292.6	299.8	377.5	386.4	576.8	586.3
195	48.1	48.1	66.0	66.0	113.6	113.6	145.1	145.1	209.8	209.8
196	14.7	178.3	19.4	243.4	34.0	428.9	42.2	552.7	60.0	8369.2
197	74.9	74.8	104.9	104.8	197.1	196.7	257.9	257.2	392.8	391.3
198	31.5	276.8	44.1	378.9	94.5	656.5	129.7	854.1	215.0	1306.6
199	163.6	907.4	222.6	1259.2	428.3	2442.2	560.9	3303.2	881.6	5241.4
200	36.0	897.5	51.0	1245.8	98.7	2436.6	130.8	3293.0	202.2	5215.3
201	49.4	899.8	68.8	1246.7	127.9	2446.0	167.0	3290.5	256.2	5205.5
202	68.9	894.2	96.7	1244.1	179.2	2447.9	233.3	3290.2	349.7	5202.1
203	57.1	57.1	81.5	81.5	159.1	159.1	211.3	211.3	328.7	328.7
204	97.1	891.5	10.3	1247.6	254.5	2463.6	334.0	3307.6	525.6	5219.1
205	21.0	21.0	29.4	29.4	56.2	56.2	74.7	74.7	120.6	120.6
206	9.2	888.1	14.1	1244.9	34.5	2462.8	49.6	3303.2	86.9	5207.3
207	12.4	884.8	17.5	1241.1	36.2	2457.1	48.5	3297.5	79.0	5198.0
Little Lehigh Creek										
208	12.7	1545.7	18.9	2588.5	42.2	5753.7	58.8	7895.1	98.5	12443.2
209	336.1	1542.7	456.7	2579.5	819.9	5724.5	1071.7	7851.4	1623.6	12364.5
Trout Creek										
210	24.1	24.1	36.9	36.9	87.5	87.5	123.0	123.0	211.7	211.7
211	52.2	75.9	76.4	111.2	170.2	249.7	232.4	343.0	381.0	569.4
212	10.2	10.2	16.0	16.0	77.1	77.1	119.3	119.3	230.1	230.1
213	122.6	184.0	172.4	249.4	352.6	446.5	472.9	630.1	754.1	1086.6
214	79.5	250.4	116.3	341.9	283.4	682.9	394.2	876.0	664.3	1498.4
215	70.4	306.1	100.0	418.6	197.6	780.6	262.6	1003.0	407.4	1627.4
216	10.7	315.9	17.5	435.4	56.7	831.3	83.4	1072.8	152.7	1760.4
217	196.8	475.9	285.2	668.6	581.9	1133.8	782.7	1451.2	1240.4	2261.9
218	87.2	87.2	127.3	127.3	259.8	259.8	349.9	349.9	552.9	552.9

CALIBRATED *WATERSHED* PEAK FLOW VALUES FOR THE LITTLE LEHIGH CREEK WATERSHED

	1 YEAR		2 YEAR		10 YEAR		25 YEAR		100 YEAR	
SUBAREA NO.	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK	SUBAREA PEAK	TOTAL PEAK
Trout Creek, cont.										
219	223.1	271.0	314.7	378.2	584.5	705.2	762.5	919.3	1142.4	1351.1
220	66.4	704.4	89.5	971.8	165.5	1712.8	215.0	2105.6	332.2	3071.0
221	73.0	718.4	103.3	988.9	194.4	1759.2	354.6	2175.7	386.4	3168.9
222	68.6	704.3	92.6	968.5	175.3	1750.5	228.1	2190.2	353.9	3209.0
223	39.7	705.5	52.1	972.0	97.2	1753.7	127.7	2198.0	196.9	3219.9
Little Lehigh Creek										
224	6.5	1558.8	9.4	2596.9	20.9	5748.8	28.1	7877.3	44.2	12393.2
225	114.1	1551.7	156.6	2593.1	280.9	5737.4	365.5	7859.2	553.2	12360.8
226	132.8	1554.8	188.8	2594.7	367.5	5738.7	487.3	7859.5	753.2	12359.8

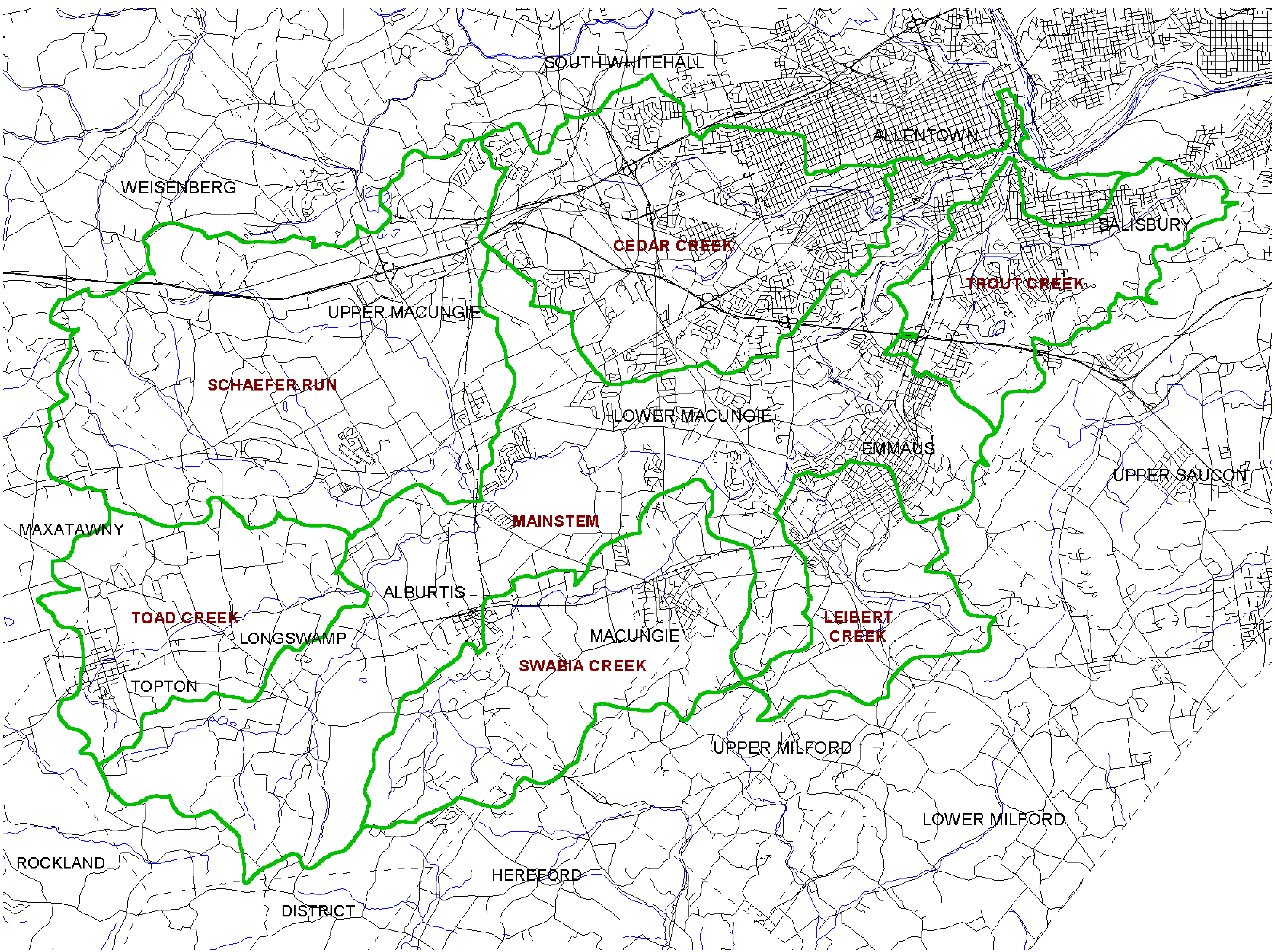


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**Figure 2
Little Lehigh Creek
Watershed Map**

Legend:
- Basin Boundary
- Municipality Boundary
- Railroads
- Streets
- Streams
- Intermittent Drainage

N W E S

1 0 1
Miles

Figure 3
Little Lehigh Creek
Geology Map

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PLANNING COMMISSION

Figure 6
Little Lehigh Creek
Flood Area Mapping
by Stream Segment

Figure 7
Little Lehigh Creek
Problem Area Map

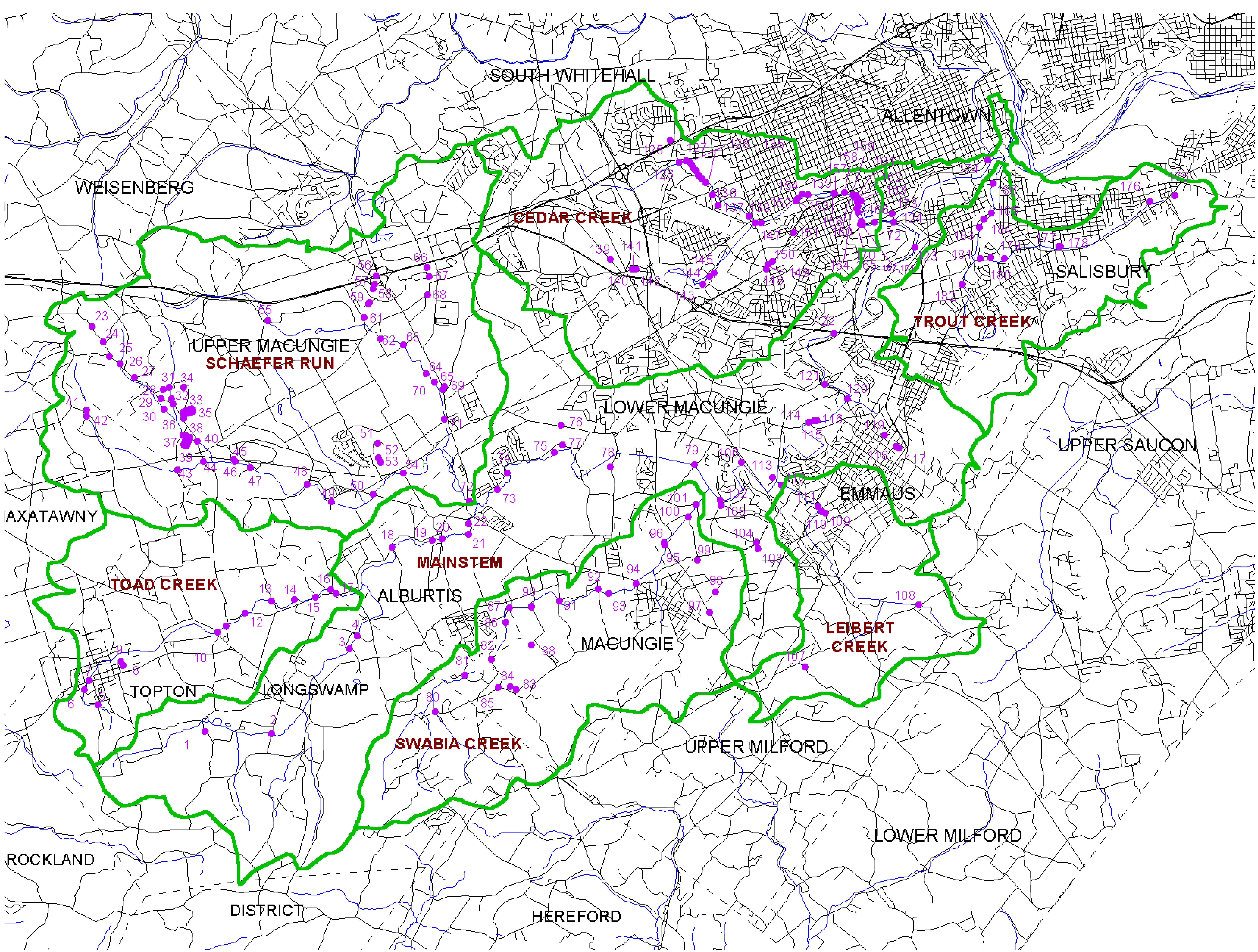

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Figure 8
Little Lehigh Creek
Significant Obstructions

Legend
- Significant Obstruction Location
- 00 Significant Obstruction Number Keyed to Table 13
- Watershed Boundaries

N W E S

1 0 1

Miles