SACONY CREEK HEADWATERS

– ACT 167 –

STORMWATER MANAGEMENT PLAN

April 2010

Lehigh Valley Planning Commission

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This is the text prepared by the Lehigh Valley Planning Commission (LVPC) staff on behalf of Lehigh County. It contains revisions, as necessary, based on comments received from the Sacony Creek Headwaters Watershed Plan Advisory Committee, the municipalities within the watershed, the LVPC, the general public, Lehigh County and the Department of Environmental Protection.

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April 2010

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CHAPTER 1. INTRODUCTION

The Pennsylvania Stormwater Management Act of 1978, Act 167, provides the framework for the improved management of the storm runoff impacts associated with the development of land by encouraging the sound planning management of storm runoff, coordinating the stormwater management efforts within each watershed, and encouraging the local administration and management of a coordinated stormwater 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 and changing regulatory requirements. Berks County adopted the original Sacony Creek Watershed Act 167 Stormwater Management Plan in 1997. The first update to the Plan was adopted by Berks County in 2008. This Plan provides revisions and clarifications as pertinent to municipalities in Lehigh County.

The goals of this plan are to create stormwater runoff rate control standards consistent with the other watersheds in Lehigh County. The difference between an 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 be to control the post-development peak rate of runoff to the pre-development peak rate for a given storm event, a watershed-level design would be focused on maintaining the peak rate of the entire watershed. The watershed-level design assumes that runoff volume will increase with development for the highest intensity events, and requires an analysis of how each site relates to the watershed in terms of the timing of the peak flow, the contribution of peak flows at various downstream locations, and the impact of the additional runoff volume generated by development. The plan is intended to "manage" the increase in runoff volume such that the peak rates throughout the watershed are not increased.

On a watershed-level, Act 167 stormwater management will provide a significant step forward in the sound management of the storm runoff impacts of new development. The storm runoff control strategy established by this plan provides for new development to occur, while ensuring that existing drainage problems are not aggravated and that new drainage problems are not created. To effectively implement this program, it is necessary to understand the following strengths and limitations:

- This plan is not an engineering design document, but it provides an engineering framework for individual site evaluation and design.

- Storm runoff criteria are based on controlling "design" storm events applied uniformly over the entire watershed. Natural storms, which may vary in duration, intensity, and total depth of rainfall throughout the watershed, may create runoff events which cannot be effectively controlled.

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

It is also important to understand that this plan is not a land use plan. Although some control techniques discussed in Chapter 6 deal with controlling runoff through creative land use practices, runoff controls developed in this plan are not based upon controlling the location, type, density, or rate of development in the watershed. The performance standards are based on the assumption that development will occur.

The most important aspect of this plan is that it establishes a process for decision-making. It defines the existing relationships between the various parts of a watershed in terms of the "timing" of peak flows from multiple sources, which provides for the development of the watershed-wide runoff control philosophy for controlling runoff impacts.

This plan uses a three-step process of runoff control which proceeds as follows:

1. Documentation of the existing state of stormwater runoff in the watershed. This includes the documentation of existing physical characteristics of the watershed (e.g. land use, soils, slopes, storm sewers, etc.), existing storm drainage problems, and the peak flow and timing relationships. The existing condition establishes the baseline against which all runoff control measures will be judged.

2. Preparation of the plan to control stormwater runoff from new development. The plan includes runoff control performance standards for new development *and* a process for site specific analysis and design. The performance standards do not dictate the control methods required, but rather indicate the necessary end product. The runoff control philosophy is intended to ensure that peak runoff rates through the watershed will not increase with development.

3. Development of priorities for implementation. This involves developing a prioritized list of actions aimed at improving the current state of stormwater runoff in the watershed, essentially preparing a strategy for dealing with the existing drainage problem areas within each municipality.

Additionally, the water quality criteria have been updated to better reflect the current standards used by the state in the National Pollutant Discharge Elimination System (NPDES) permit process, as well as to attempt to preserve the existing water balance between runoff, recharge, and evapotranspiration after development. To promote groundwater recharge, preserve water quality, and protect downstream channels from erosion, the Pennsylvania Department of Environmental Protection (DEP), through the NPDES permit process, requires that developments not increase the stormwater runoff volume discharged from the site associated with the 2-year rainfall event. However, throughout the DEP permitting process there has been no limit on how much of the post-development runoff could be directly recharged to groundwater via an underground infiltration facility. For a system designed to infiltrate the entire incremental 2-year runoff volume, this would cause approximately 95% of annual rainfall to be directly recharged. This is specifically problematic in carbonate bedrock areas but can be problematic in any geologic setting in terms of upsetting the natural water balance. In light of these factors, DEP's 2-year incremental runoff volume standard is proposed by this Plan, but with an upper limit placed on how much annual runoff may be directly recharged based on the water balance of an undeveloped site.

The LVPC has used two engineering consultants for the preparation of the Sacony Creek Headwaters Plan. Dr. David F. Kibler, P.E., is recently retired as a civil engineering professor from Virginia Tech. Dr. Kibler was formerly a professor of civil engineering at Pennsylvania State University. He has served as a consultant to the LVPC since the inception of Act 167 planning in the mid-1980s. Dr. Kibler was primarily involved in the hydrologic model development and calibration associated with the Sacony Creek Headwaters Plan. He provided further assistance regarding technical aspects of the model ordinance. Allen R. O'Dell, P.E., has served as a consultant to the LVPC since the early 1990s reviewing the engineering aspects of subdivision and land development plans versus the criteria contained in various Act 167 ordinances. For the Sacony Creek Headwaters Plan, Mr. O'Dell assisted with model ordinance development.

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 stormwater control sensitive to changing watershed characteristics.

The *Sacony Creek Headwaters - Act 167 - Stormwater Management Plan* has been prepared for Lehigh County by the Lehigh Valley Planning Commission (LVPC). The 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 that will be impacted by the Stormwater Management Plan, Act 167 requires that a Watershed Plan 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 stormwater management concepts evolving from the planning process. Each municipality in the study area plus the County Conservation District is 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 Sacony Creek Headwaters Watershed Plan Advisory Committee.

TABLE 1
SACONY CREEK HEADWATERS WATERSHED PLAN
ADVISORY COMMITTEE

Municipality/Organization	**Name**
Lehigh County	
Lehigh County	Jan Creedon
Lehigh County Conservation District	Rebecca Kennedy
Weisenberg Township	Tom Wehr
Berks County	
Berks County Planning Commission	Ashley Mazurek
Maxatawny Township	No representative designated
Other	
PA Department of Environmental Protection	Jennifer Kehler
PA Department of Transportation	Jeff Smallman
PA Fish & Boat Commission	Lee Creyer

CHAPTER 2. STUDY AREA CHARACTERISTICS AND HYDROLOGIC RESPONSE

A. General Characteristics

The Sacony Creek Headwaters Study Area is located in the western part of Lehigh County. The study area consists entirely of drainage areas which enter the channel within Lehigh County, all of which are tributary to the Mill Creek. The Mill Creek enters into the mainstem of the Sacony Creek below Kutztown, approximately five miles downstream of the Lehigh County border. Figure 1 shows the entire Sacony Creek tributary area, with the study area for this Plan noted as the shaded area. The Sacony Creek Headwaters has been separated into several different tributary areas. These tributary areas are shown in Figure 2, and the size of each drainage area (in square miles) is shown below in Table 2.

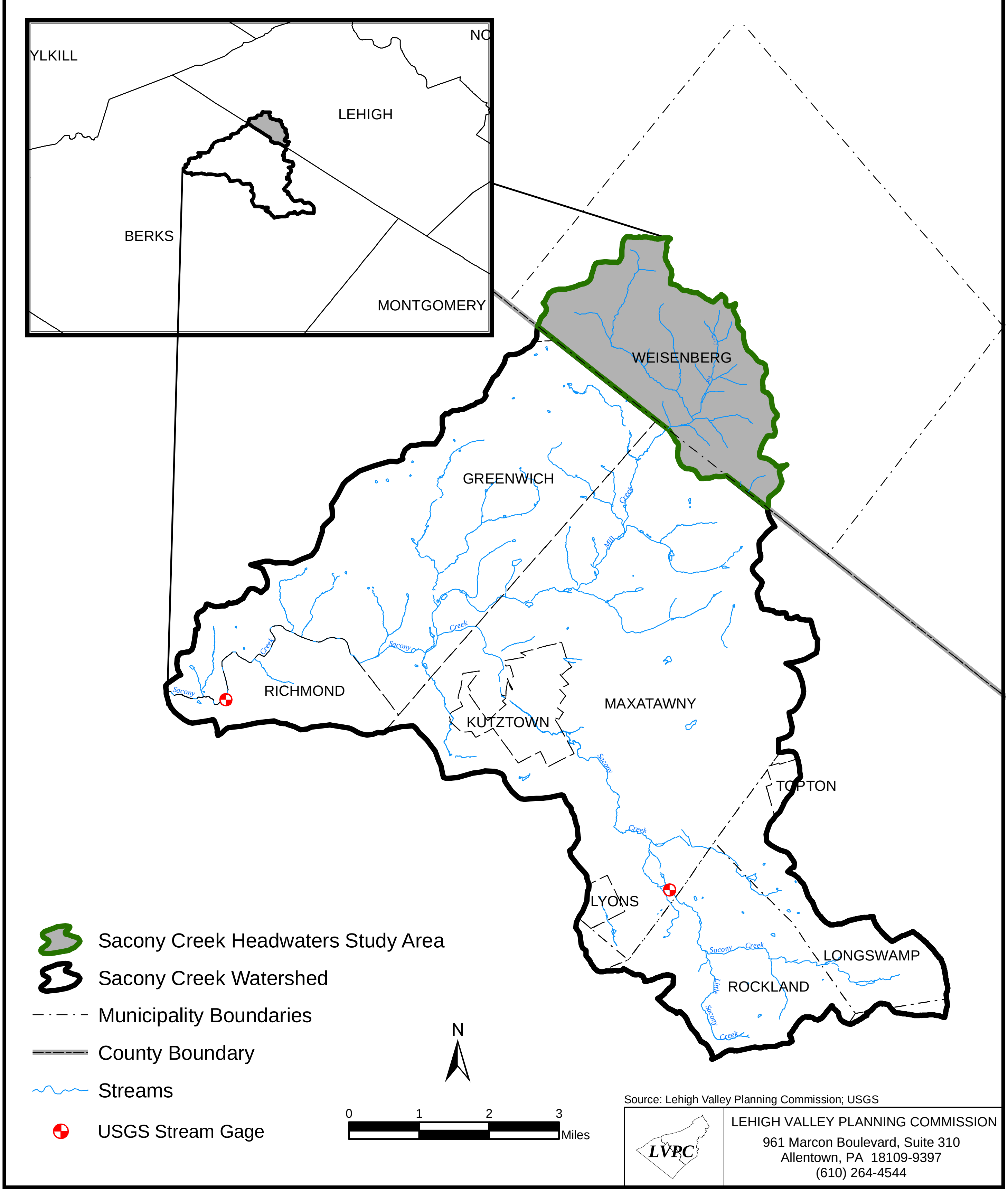
TABLE 2
SACONY CREEK HEADWATERS SQUARE MILEAGE

Subwatershed	Area (Square Miles)
Mill Creek Mainstem	5.55
Unnamed Tributary #1 to Mill Creek (subarea 17)	0.13
Unnamed Tributary #2 to Mill Creek (subarea 18)	0.18
Unnamed Tributary #3 to Mill Creek (subarea 19)	0.22
Unnamed Tributary #4 to Mill Creek (subarea 20)	0.32
Total Study Area	6.40

Within Lehigh County, the entire study area is underlain by shale with zones of conspicuous greywacke (sandstone). Geological documentation prepared by Berks County in 2008 is included in Appendix A of this Plan for reference. There are no areas of carbonate geology within the Sacony Creek Headwaters Study Area.

The predominant soils found in the Sacony Creek Headwaters in Lehigh County are classified as Hydrologic Soil Group C. Hydrologic Soil Groups (HSGs) 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 in the Sacony Creek Headwaters. Group B soils have moderate infiltration rates and consist mostly of moderately deep, well-drained soils. Group C soils have low infiltration rates and consist mostly of soils which impede the downward movement of water. Group D soils have very low infiltration rates, and therefore high runoff potential, and consist 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. Within the Sacony Creek Headwaters, the Berks-Weikert complex is the most common soil type. These soils are classified as HSG C and are found over glacial till or over material weathered from shale or sandstone. Other common soils in the study area include Bedington-

FIGURE 1
SACONY CREEK HEADWATERS STUDY AREA LOCATION MAP



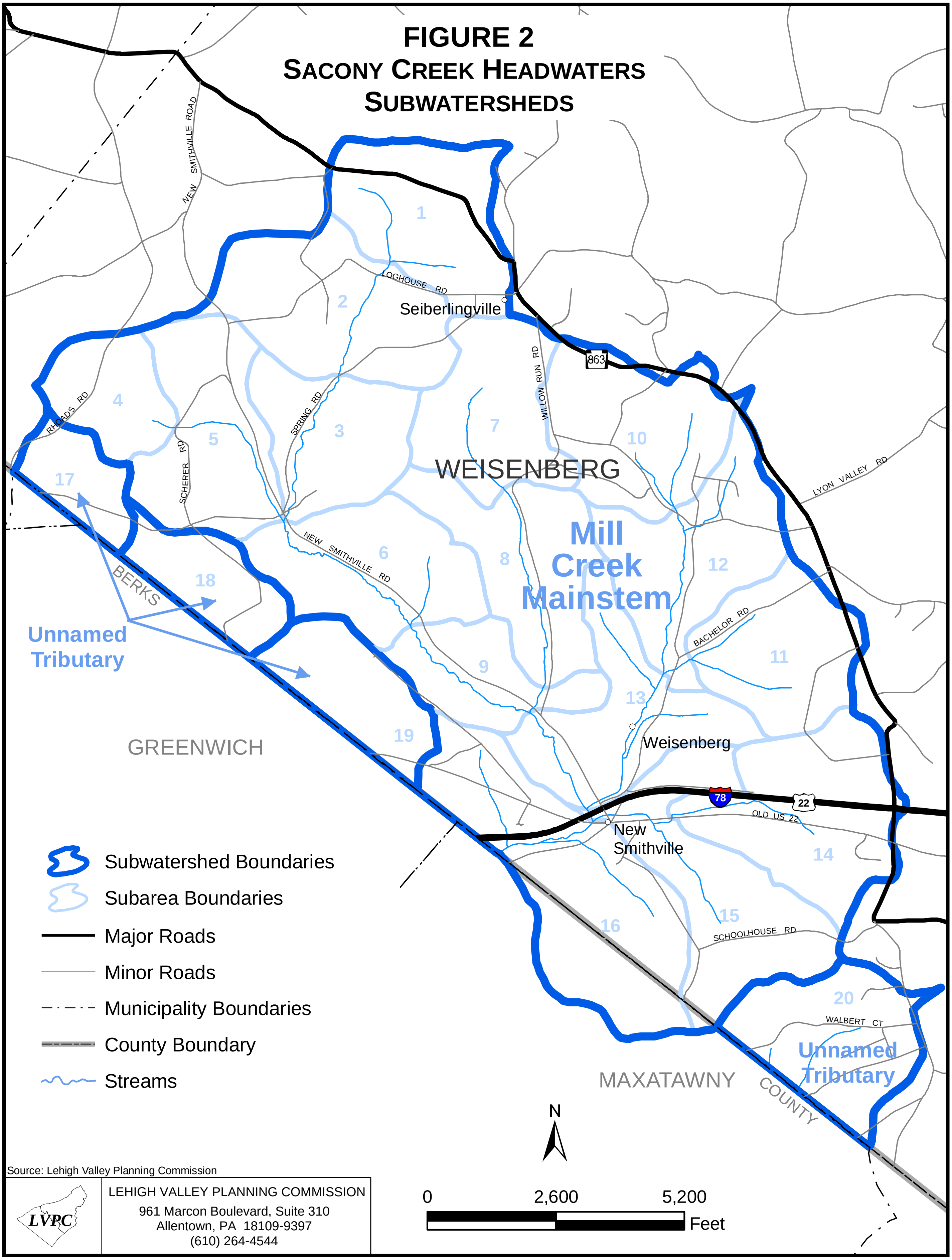


FIGURE 2
SACONY CREEK HEADWATERS SUBWATERSHEDS

Berks complex (HSG B), Comly silt loam (HSG C), and Holly silt loam (HSG D). Figure 3 is a map of the study area soils by HSG.

Land use within the watershed is generally agricultural, with scattered single-family residences throughout the watershed. There is some commercial/industrial development in the areas adjacent to Interstate 78 running through the watershed.

Mill Creek, the tributary of the Sacony Creek to which all area in Lehigh County is tributary, has been designated by DEP as Trout Stocking Fishes (TSF). TSF streams are designated as such for the protection of stocked trout from February 15 through July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.

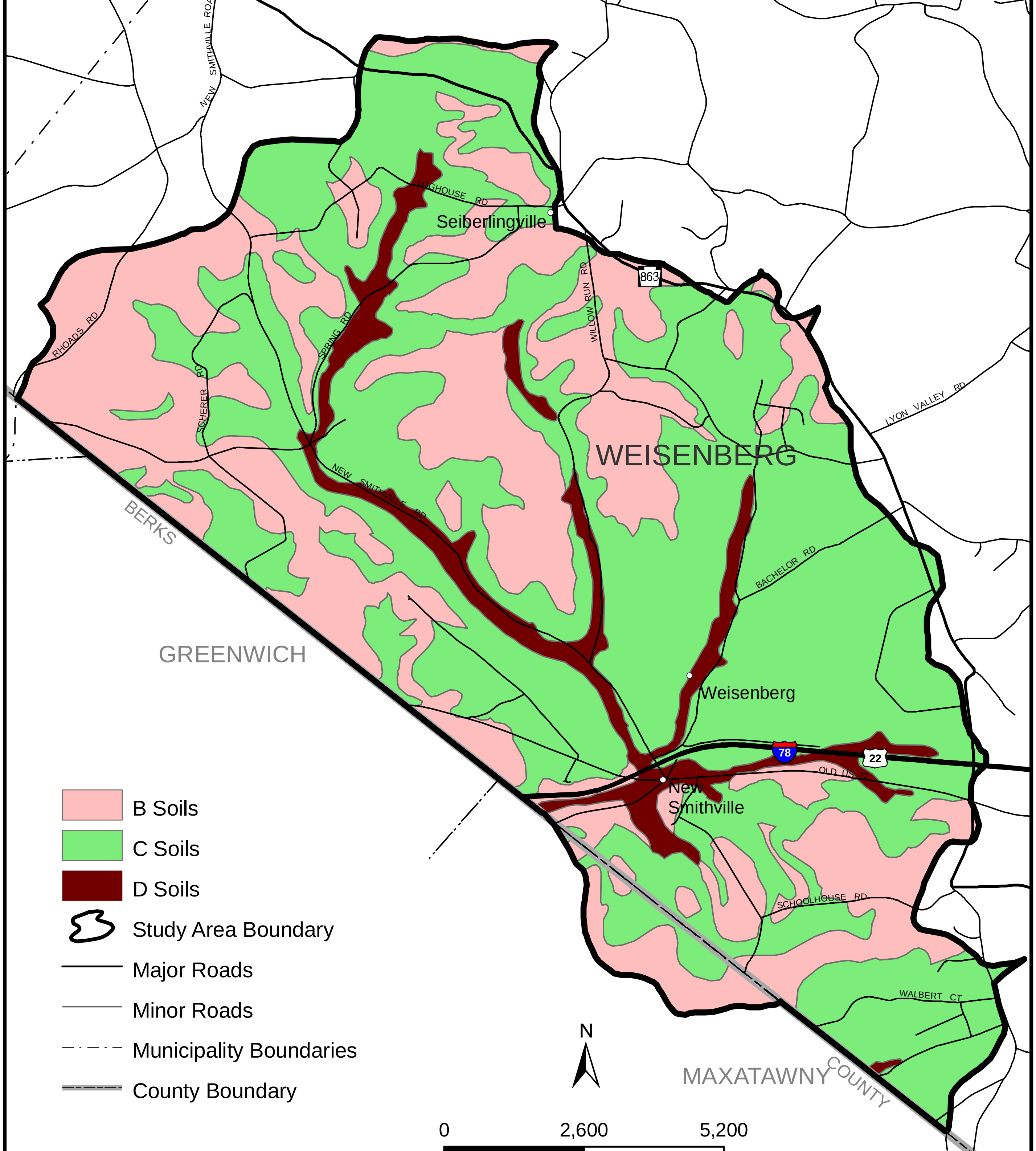
B. Hydrologic Response

There are no United States Geologic Survey (USGS) formal stream gages or miscellaneous measurement sites within the study area. However, there are two historic stream gages downstream in Berks County. One gage is near Virginville (approximately 8.8 miles downstream of the study area). This gage recorded annual peak flows from 1975 to 1985. The other gage is located above Bowers (which is located on the Sacony Creek mainstem above the confluence with Mill Creek). This gage recorded daily stream discharge from 1974 to 1977. The locations of these gages are noted in Figure 1.

Since the gages monitor areas that are not representative of our study area, the peak flow rates for our study area needed to be estimated. Several methods were available to accomplish this task. One such method is the PSU IV procedure for estimating flood peaks in ungaged watersheds developed by Penn State in 1981. This method provides a relatively simple means of estimating peak flows from general watershed characteristics and the watershed's location within Pennsylvania. Estimation of peak flows for a watershed using data from previously calibrated watersheds is also possible. Flow data from all previously modeled watersheds from Act 167 Plans in the Lehigh Valley was used to develop peak flow estimates. This correlation technique is based on the relative drainage areas of two watersheds and known peak flows from previous studies. A third source of peak flow data is from the 1997 Sacony Creek Act 167 Plan created by Berks County. The Berks County model was conveniently defined to calculate the peak flow on the Mill Creek at the Lehigh County border, so a direct comparison from these flows to the main Mill Creek tributary in Lehigh County is possible. Table 3 presents the data associated with Mill Creek, representing a 5.55[1] square mile area. A reference for each of the techniques applied is presented as part of the table.

[1] The 5.55 square mile area of the Mill Creek refers to the area that was used for calibration of the watershed model. There are four subareas totaling 0.85 square miles that drain over the county boundary before entering the creek in Berks County, and this was not included in the area used for the initial calibration.

FIGURE 3
SACONY CREEK HEADWATERS
HYDROLOGIC SOIL GROUPS



Source: Lehigh Valley Planning Commission; NRCS SSURGO Database

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**Hydrologic Soil Groups are classifications which indicate the relative runoff potential of soils based on infiltration rates for various soil types. On this map, the classifications range from Group B having a moderate infiltration rate and lower runoff potential to Group D, having a very low infiltration rate and high runoff potential.*

TABLE 3
PEAK FLOW ESTIMATES BY VARIOUS TECHNIQUES AT THE BOTTOM OF THE MILL CREEK MAINSTEM STUDY AREA

Method/Source	Peak Flow Estimates in cubic feet per second (cfs) for Return Period of:			
	2 Years	10 Years	25 Years	100 Years
PSU IV[a]	197	676	969	1,564
Correlation with[b]:				
Little Lehigh Creek	168	281	622	1,339
Jordan Creek	385	982	1,371	2,318
Coplay Creek	315	787	1,111	1,878
Martins Creek	318	727	965	1,589
Berks County Plan[c]	259	727	1,001	2,242
USGS Regression Model[d]	304	723	N/A	1,470

[a]*Field Manual of Procedure PSU IV for Estimating Design Flood Peaks on Ungaged Pennsylvania Watersheds,* Pennsylvania State University, April 1981. Details regarding the calculation of the PSU-IV flow values can be found in Plan Appendix B.
[b]Correlation based on the ratio of drainage areas between the listed watershed and the Mill Creek study area, raised to the 0.75 power, multiplied by the calibrated peak flow values of the listed watershed developed in previous Act 167 Plans.
[c]*Sacony Creek Watershed Act 167 Stormwater Management Plan Update*, Berks County Planning Commission, 2008
[d]Data from the USGS current regression model as outlined in document SIR-2008-5102.

As Table 3 shows, there is a good variance in the peak flows for a given return period, depending on the estimation method. For example, the 10-year peak flow estimates vary from a low of 281 cfs from the correlation with the Little Lehigh Creek Watershed to a high of 982 cfs from the correlation with the Jordan Creek Watershed. Of these possible targets, the most accurate is likely to be either PSU-IV or the data from the Berks County model. Flow correlation data becomes less reliable as watershed size decreases, and as the Mill Creek study area is only 5.55 square miles, these data points are somewhat suspect. Since the calibrated model peaks are largely a design reference for the development of stormwater improvements throughout the watershed (such as upgrading existing culverts and bridges to correct existing problem drainage areas), the slightly more conservative (in this respect) Berks County model data was selected as the goal for the Sacony Creek model calibration.

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was selected to create the hydrologic model for the watershed in the Sacony Creek Headwaters. HEC-HMS was selected for several reasons, including its ease of use, flexibility in modeling techniques, and cost (free). HEC-HMS is able to replicate the performance of the Penn State Runoff Model (PSRM) methodology fairly well, which the LVPC had used for the development of all Act 167 Plans prior to 2008.

Calibration of the hydrologic model involves the adjustment of certain parameters of the model to best reproduce actual conditions. In this case, the presumption is that the data from the original Sacony Creek model created by Berks County provides the best estimates of the actual conditions. Several sensitivity analyses were performed to determine how significantly the model parameters needed to be adjusted to meet the determined targets in the Sacony Creek Headwaters. The overland flow length and slope, Muskingum K (travel time), and percent impervious cover values were all tested separately, but these adjustments were not sufficient by themselves to calibrate the watershed. The Sacony Creek study area proved very difficult to calibrate with a 24-hour storm, as the study area is very small and composed of multiple stream channels that all combine in close proximity to one another. In the past, the LVPC has used storm durations shorter than 24 hours to calibrate hydrologic models for smaller watersheds, and the same approach was implemented in the Sacony Creek Headwaters. This ends up making a significant difference in the total flows in a model, since a shorter duration storm delivers smaller runoff volumes. These volumes are obviously smaller than those generated by a full 24-hour storm event, and can be used to reduce the impacts at high volume areas (e.g. confluences) in smaller watersheds. However, the watershed needs to be small enough so that the entire area contributes runoff to the bottom of the study area within the duration of the storm. Since the total study area time of concentration (the length of time it takes for the furthest upstream areas to contribute runoff to the bottom of the study area) is less than two hours, a 6-hour storm was able to be implemented as a calibration parameter. To generate the 6-hour storm, the most intense 6 hours of rainfall were taken from the 24-hour event. This equates to the center portion of the 24-hour event, from hour 9 to hour 15. The impervious cover was also used as a final calibration parameter. The impervious cover in the model is estimated based on general planning-level assumptions of impervious cover based on land use, as discussed later in the chapter. These values tend to be conservative, erring on the side of more impervious cover. However, in a watershed such as the Sacony Creek Headwaters, it is possible that this assumption is too conservative. Based on an analysis of 2007 aerial photography, the LVPC concluded that, in this case, the percent impervious could be reduced to 80% of the originally estimated values and still be representative of the existing land use. The third and last calibration adjustment involved increasing the channel travel time to compensate for flow in the floodplain. The channel travel time was increased by a factor of four, which is comparable to values used by the LVPC in certain past model calibrations. Since the study area can be considered nearly homogeneous (i.e. similar geography and topography), the travel time, percent impervious, and storm duration adjustments were applied to each tributary and subarea in the study area. Dr. David Kibler verified the acceptability of the calibration adjustments, as well as the results of the calibration in general.

Calibration for design storm events in the Mill Creek mainstem resulted in peak flow values by return period as presented in Table 4. The table shows a comparison of the calibrated peak flows versus the reported flows from the Berks County Act 167 Plan at the Lehigh County boundary. Table 4 shows that the calibration is closest to the 100-year event, which is the event most likely to be used in an engineering analysis of an existing problem area. The lower return periods are further above the targets, but these events are mainly used in determining the required runoff controls, for which the magnitude of the volume and rate increase from future development is much more crucial than the magnitude of the existing peak.

TABLE 4
CALIBRATED HEC-HMS MILL CREEK MAINSTEM VALUES VERSUS BERKS COUNTY ACT 167 PLAN VALUES*

Return Period	Peak Flow		HEC-HMS % Difference**
	HEC-HMS	BERKS CO.	
2	407	259	57
10	1,116	727	54
25	1,612	1,001	61
100	2,721	2,242	21

* Data is associated with the entire drainage area to the bottom of the Mill Creek mainstem study area.

** HEC-HMS percent difference calculated as the HEC-HMS peak flow minus the target divided by the same flow target.

The calibrated HEC-HMS data from the Mill Creek mainstem study area from Table 4 is also presented graphically in Figure 4. The plot of peak flow versus return period is called a “frequency curve” for the study area. The frequency curve is also shown for the Berks County Plan data.

The remainder of the study area within Lehigh County is divided into four drainage areas. These are areas that drain to small tributaries of the Mill Creek that flow across the Lehigh County border and enter into the mainstem in Berks County. Direct flow comparison with the Berks County Plan was not possible for these areas, and since calibration targets derived from correlation to gaged watersheds would be considered less reliable as watershed size decreases, these drainage areas were not individually calibrated. Since these drainage areas have the same basic characteristics of soil, slope, geology, and land use, it was decided that the largest drainage area, in this case the Mill Creek mainstem, would be calibrated, and the calibration adjustments would be applied to the remaining drainage areas. Therefore, the same calibration adjustments that were applied to the Mill Creek mainstem subareas were also applied to these drainage areas. A summary of the calibrated model flows from these four areas is included in Table 5.

FIGURE 4
MILL CREEK MAINSTEM FLOOD FREQUENCY AT LEHIGH COUNTY BOUNDARY FROM CALIBRATED HEC-HMS AND 1997 BERKS COUNTY PSRM MODEL

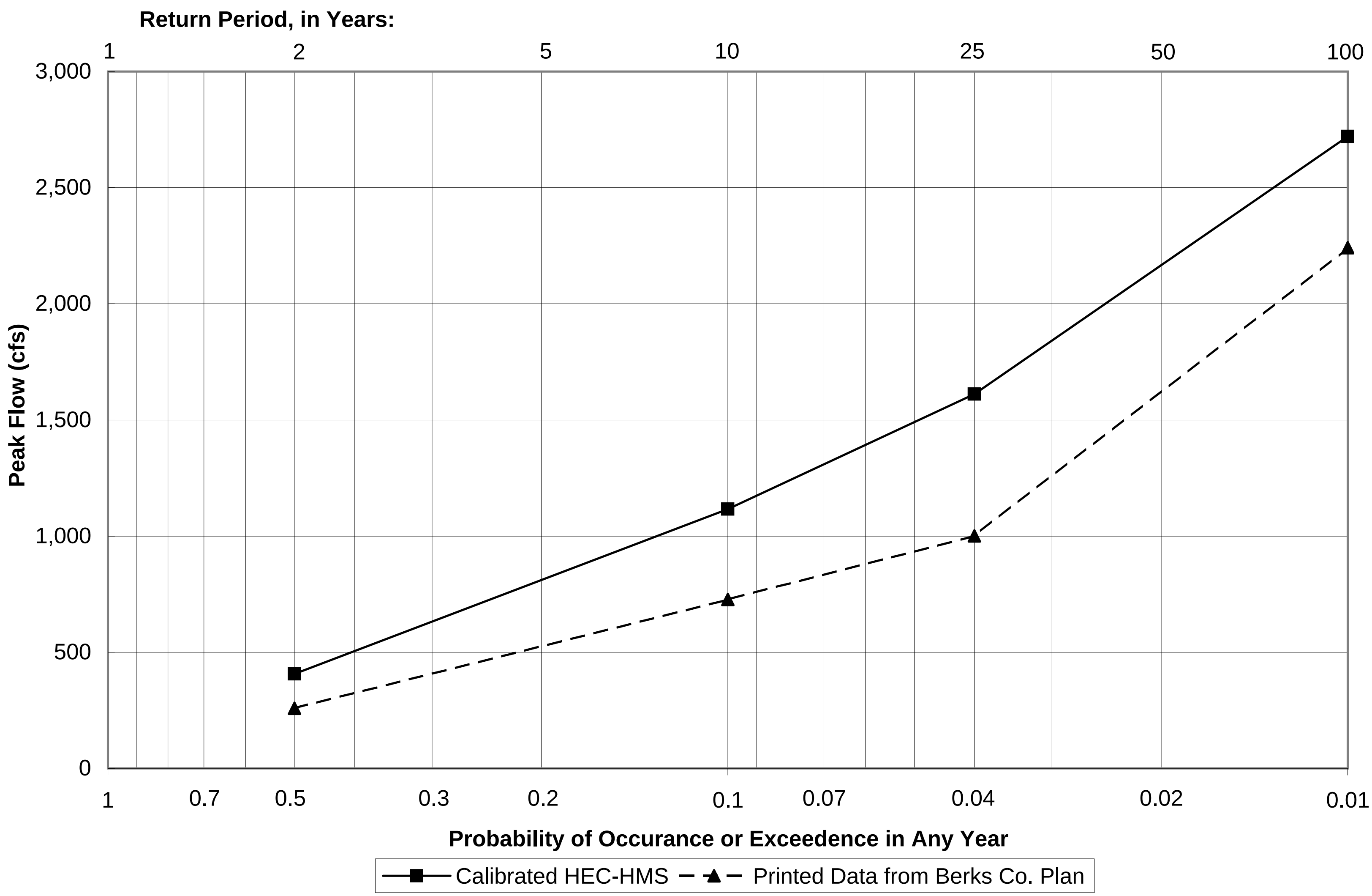

TABLE 5
CALIBRATED HEC-HMS PEAK FLOW VALUES FOR REMAINING DRAINAGE AREAS IN SACONY CREEK HEADWATERS
Peak Flow (cfs)

	Drainage Areas and Subareas (refer to Plate 1 following Appendix B):			
Return Period	**Unnamed Tributary #1 to Mill Creek Subarea 17**	**Unnamed Tributary #2 to Mill Creek Subarea 18**	**Unnamed Tributary #3 to Mill Creek Subarea 19**	**Unnamed Tributary #4 to Mill Creek Subarea 20**
2	5	27	21	53
10	25	98	85	168
25	47	166	148	272
100	115	352	330	543

CHAPTER 3. SACONY CREEK HEADWATERS LAND DEVELOPMENT AND RUNOFF IMPACTS

A. General Land Development Impacts of Storm Runoff

The necessity for the preparation of a stormwater 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 lots, roads, etc.). Impervious cover does not allow rainfall to infiltrate into the ground, but instead it predominantly becomes surface runoff. The exception to this would be when impervious areas drain to pervious areas which would allow for some infiltration. The percentage of impervious cover for a given development varies by the type of development, as shown in Table 6.

TABLE 6
"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	72
8. Commercial	85
9. Institutional	40
10. Large Impervious Areas	100
11. Water Bodies	100
12. Transportation Uses	30
13. Mining	0

*Total subarea percent impervious reduced to 80% of "typical" values for model calibration.

The above typical percent imperviousness figures have been developed from Technical Release 55 (TR-55) by the Natural Resources Conservation Service[2] (NRCS). The breakdown between the three residential densities is as follows: low density – less than or equal to two units per acre; medium density – between two and five units per acre; high density – greater than or equal to five units per acre.

[2] 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.

From Table 6, 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 is also clear that the cumulative impact of this type of development for a rural area could be severe without implementation of the proper runoff management controls.

An example of the impacts that increases in impervious cover have on a given watershed area are 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 by HEC-HMS. The watershed area used for this analysis represents a subarea size of 300 acres. The rainfall event used to produce the hydrographs was the NRCS 2-year design storm (24-hour duration, type II distribution, and a 3.0 inch rainfall depth).

From Figure 5, the peak runoff from the watershed area for 5% impervious cover is approximately 18 cfs (cubic feet per second). Further, each 5% increment in impervious cover produces an additional 8 to 11 cfs to the peak runoff such that 25% imperviousness produces a 56 cfs runoff peak. If the 5% impervious cover hydrograph represented the “existing” condition of a watershed area, then each 5% increment of impervious cover would increase the surface runoff by about 50% of the pre-development peak flow. In the Sacony Creek Headwaters, 65% (13 out of 20) of the watershed subareas have existing impervious cover of 5% or less, and 80% (16 out of 20) have existing impervious cover of 10% or less. It is clear that the runoff impacts of development 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 NRCS has researched the runoff response for 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 7 are the runoff curve numbers derived from NRCS which have been used in the Sacony Creek Headwaters planning process. Higher curve numbers reflect a greater potential for producing runoff.

FIGURE 5
IMPACT OF IMPERVIOUS COVER ON STORM RUNOFF

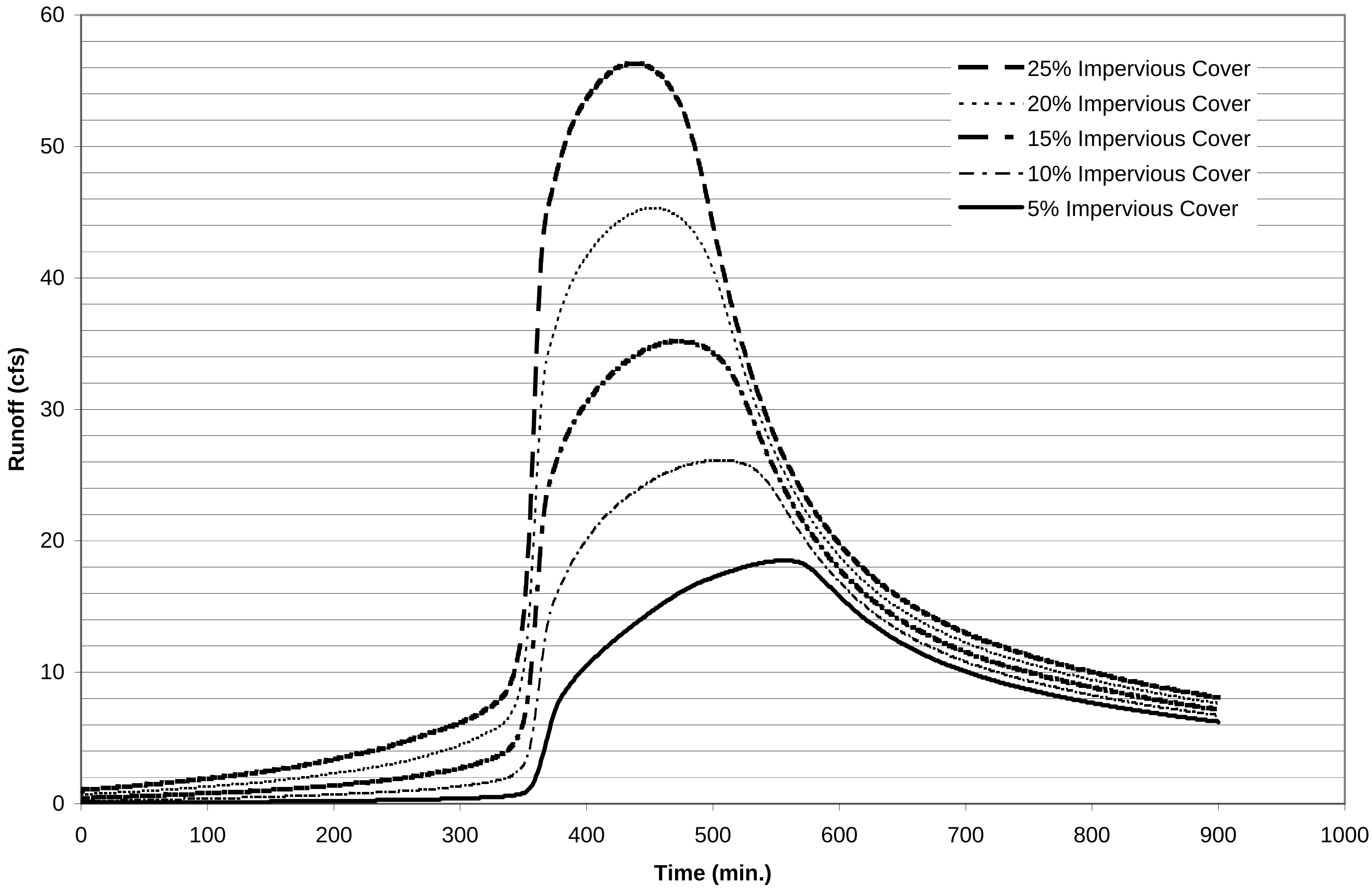

TABLE 7 RUNOFF CURVE NUMBERS BY LAND USE CATEGORY			
	Runoff Curve Number by Hydrologic Soil Group*		
Land Use	**B**	**C**	**D**
1. Woods	55	70	77
2. Open Space	61	74	80
3. Agriculture	76	83	86
4. Low Density Residential	68	79	84
5. Medium Density Residential	75	83	87
6. High Density Residential	85	90	92
7. Industrial	88	91	93
8. Commercial	92	94	95
9. Institutional	76	84	87
10. Large Impervious Areas	98	98	98
11. Water Bodies	100	100	100
12. Transportation Uses	72	81	85
13. Mining	0	0	0

*Curve numbers reflect impervious cover percentages from Table 6.

Note from Table 7 that, for Hydrologic Soil Group B, 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 6). However, agriculture, even though it has zero percent impervious cover, has a higher runoff curve number than the two lowest density residential land uses, which have 20% and 38% impervious cover, respectively. These differences primarily reflect variation in vegetative cover between land uses. Woods can have thick tree canopy and underbrush that intercept rainfall and produce little runoff, whereas open space represents grassy areas and agriculture can have periods with little vegetation after initial planting or in fallow seasons. Curve numbers for developed land uses such as medium density residential or industrial reflect differences in impervious cover.

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

One final factor that can affect the quantity of stormwater runoff in the Lehigh Valley is carbonate bedrock. However, this was not a factor in this Act 167 Plan, as there is no carbonate bedrock present in the Sacony Creek Headwaters.

The above described impacts of development on storm runoff – impervious cover modification and curve number modification – relate to the rate and volume of runoff generated from a land area. However, an additional potential impact of development is the manner in which the generated runoff is conveyed downstream. Part of a land development may involve the construction of a closed pipe system, channel, or both. Closed pipe systems typically convey water faster than natural systems, and therefore runoff is transported more rapidly downstream. In addition, closed systems do not provide the opportunity for infiltration that exists within natural channels. Existing channels may also be encroached upon by a development. This could take the form of fill to one or both sides of a channel, placement of structures within the channel, or any 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 the 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 the upstream flows in a safe and efficient manner.

B. Historical Sacony Creek Headwaters Land Development

During the past quarter-century, land development within the Sacony Creek Headwaters Study Area has predominately consisted of low density residential development. This residential development has been scattered throughout the study area, with notable clusters near Route 863. Commercial and industrial development is largely located along I-78. Table 8 provides a summary of historical land development within the Sacony Creek Headwaters Study Area by municipality and type of development. Data for the table was estimated by the LVPC based upon LVPC land use records, a study area field survey and aerial photograph analysis.

For the portions of the watershed within Lehigh County, LVPC land use records were used to estimate land development for the period from 1980 through 2002. Since only a portion of Weisenberg Township is in the study area, land development figures for the study area portion of the Township were estimated from the corresponding data for the entire municipality. Although land use data for Lehigh County is available for more recent years, the 2002 data was used because it provides the most meaningful comparison to the 1980 data. The land use data for both 1980 and 2002 was estimated using the LVPC's original land use database. For the years following 2002, land use data was estimated using a new LVPC database developed in 2005. Because the two databases classify and estimate land use differently, data from the two databases is not completely comparable. Therefore, an accurate comparison cannot be made between the 1980 land use data and the land use data for any year after 2002.

TABLE 8 SACONY CREEK HEADWATERS STUDY AREA HISTORICAL LAND DEVELOPMENT*					
County/Municipality	Acres Developed over Studied Period**				Average Number of Acres Developed per Year
	Residential	Commercial	Industrial	Total	
Lehigh County					
Weisenberg Twp.	297.7	21.3	59.2	378.2	17.2
Berks County					
Maxatawny Twp.	0.0	0.0	0.0	0.0	0.0

* Source: LVPC land use records, Sacony Creek Headwaters Study Area field survey and aerial photograph analysis.

** Land development estimates for Lehigh County were estimated for the period from 1980 through 2002. Land development estimates for Berks County were estimated for the period from 1980 through 2007.

Because the LVPC land use records only include data for municipalities within the Lehigh Valley, the LVPC employed a different method of measuring development to determine watershed land development outside of Lehigh County. For the portions of the watershed in Berks County, the LVPC used 1981 aerial photographs to estimate the land area that had been developed by the end of 1980. This data was then compared to current land use data gathered by the LVPC during a field survey of the study area performed during the summer of 2008. Comparing the development data from these two sources allowed the LVPC to estimate land development within the portions of the watershed outside of Lehigh County for the period from 1980 through 2007.

As shown in Table 8, approximately 380 acres were developed within the Lehigh County portion of the study area over the 22 year period from 1980 through 2002. No development occurred within the study area outside of Lehigh County during the 27 year period from 1980 through 2007.

Development in place as of August 2008 represents the “existing” situation for the preparation of the Sacony Creek Headwaters Stormwater Management Plan. The existing land use condition was generated using Lehigh County land use records and field surveys. A map of the existing land use is provided as Figure 6. Stormwater 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 future land use condition. Future land use condition assumptions used in the development of the watershed plan are discussed in the following section.

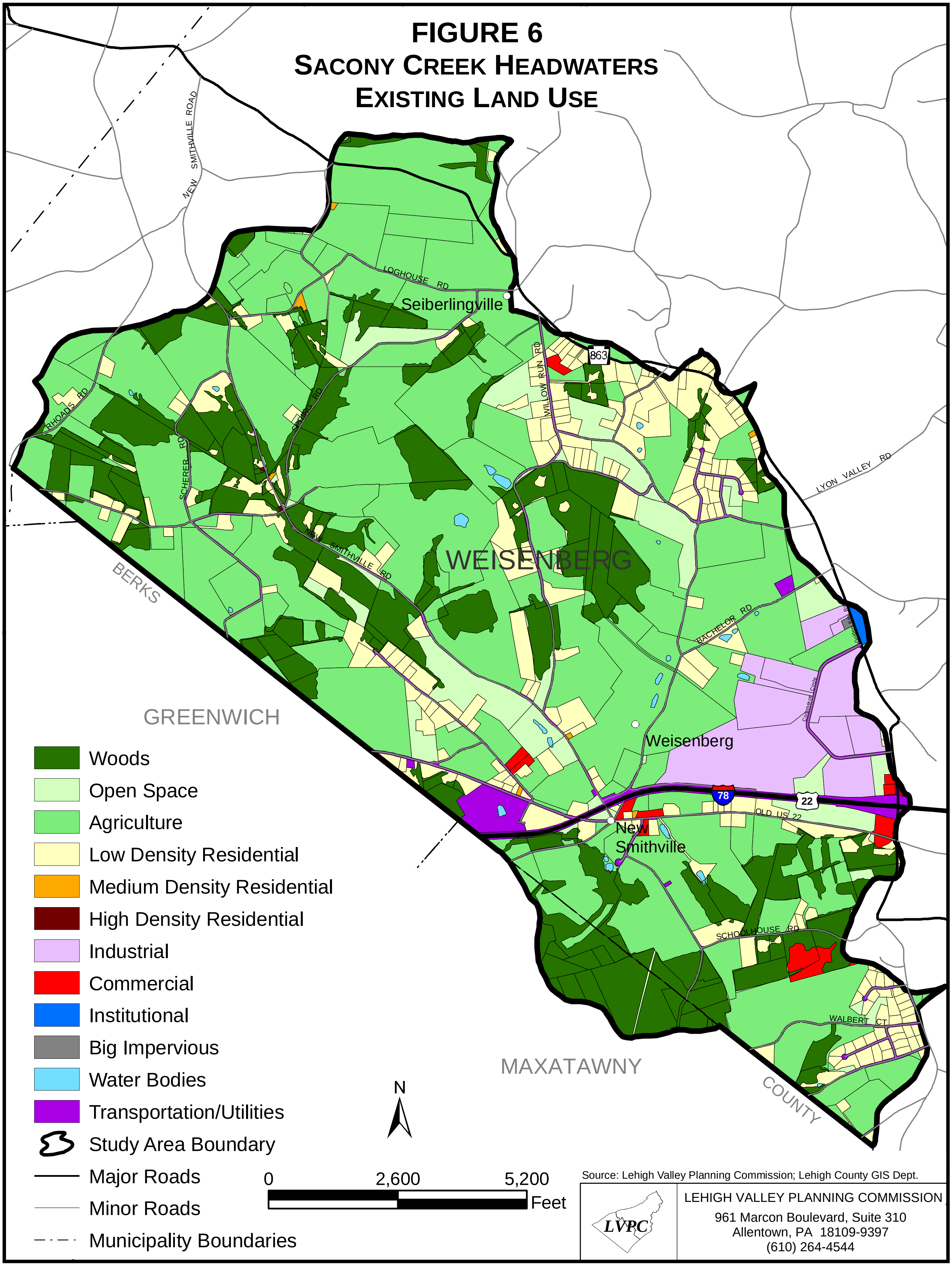
FIGURE 6
SACONY CREEK HEADWATERS
EXISTING LAND USE
NEW SMITHVILLE ROAD
LOGHOUSE RD
Seiberlingville
863
WILLOW RUN RD
RHOADS RD
SCHERER RD
NEW SMITHVILLE RD
WEISENBERG
LYON VALLEY RD
BACHELOR RD
BERKS
GREENWICH
Weisenberg
78
22
OLD US 22
New Smithville
SCHOOLHOUSE RD
WALBERT CT
MAXATAWNY
COUNTY
Woods
Open Space
Agriculture
Low Density Residential
Medium Density Residential
High Density Residential
Industrial
Commercial
Institutional
Big Impervious
Water Bodies
Transportation/Utilities
Study Area Boundary
Major Roads
Minor Roads
Municipality Boundaries
N
0
2,600
5,200
Feet
Source: Lehigh Valley Planning Commission; Lehigh County GIS Dept.
LVPC
LEHIGH VALLEY PLANNING COMMISSION
961 Marcon Boulevard, Suite 310
Allentown, PA 18109-9397
(610) 264-4544

C. Future Sacony Creek Headwaters Land 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 stormwater management would appear to dictate a design life consistent with full development of the watershed. Otherwise, the stormwater 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 (2008 to 2018). The second is a form of "ultimate" future land use based upon current zoning. Each of the scenarios is described below.

Land development projected over the period 2008 to 2018 based upon a continuation of historical development trends, and constrained by existing zoning and the availability of undeveloped land, is presented in Table 9. Using the historical trend assumption, approximately 170 acres of additional land development would occur within the Sacony Creek Headwaters Study Area by the year 2018.

TABLE 9
SACONY CREEK HEADWATERS STUDY AREA
PROJECTED LAND DEVELOPMENT 2008-2018*

County/ Municipality	Projected Land Development (acres)			
	Residential	Commercial	Industrial	Total
Lehigh County				
Weisenberg Twp.	135.0	10.0	27.0	172.0
Berks County				
Maxatawny Twp.	0.0	0.0	0.0	0.0
TOTAL	135.0	10.0	27.0	172.0

* Source: Projected based upon historical land development estimates from Table 8.

Table 9 may provide a very reasonable estimate of the study area's growth over the next decade. For stormwater runoff purposes, however, it is missing a critical element. That is, the table does not help identify where the projected growth may occur within a given municipality. As will be discussed in greater detail in subsequent chapters, the runoff control criteria will be developed for small individual watershed subareas of approximately 200 acres average size. Obviously, when considering watershed areas this small, the “where” question becomes important. An exaggerated example would be that the 135 acres of residential development projected for Weisenberg Township could occur in scattered fashion throughout residentially-zoned areas (i.e. scattered watershed subareas) or could be concentrated in one or two of the 200-acre subareas. The runoff control strategies devised to deal with these two situations could be very different.

The second future land use scenario is a full buildout scenario in which the entire watershed is developed according to current zoning regulations. Municipal zoning districts throughout the Sacony Creek Headwaters Study Area can be categorized as industrial, commercial, agricultural or low-density residential. 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 the low-density residential development was two or less units per acre.

The future condition land use map represents an “average ultimate” development scenario. It is an ultimate condition because all of the study area that is not protected by either agricultural zoning or an agricultural preservation easement is assumed to be developed. The future zoned condition land use map also represents 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 future land use map is provided as Figure 7.

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 stormwater runoff impacts associated with that development are to be controlled. 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 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. Thus, Figure 7 displays the future land use condition as used in the development of the runoff control strategy.

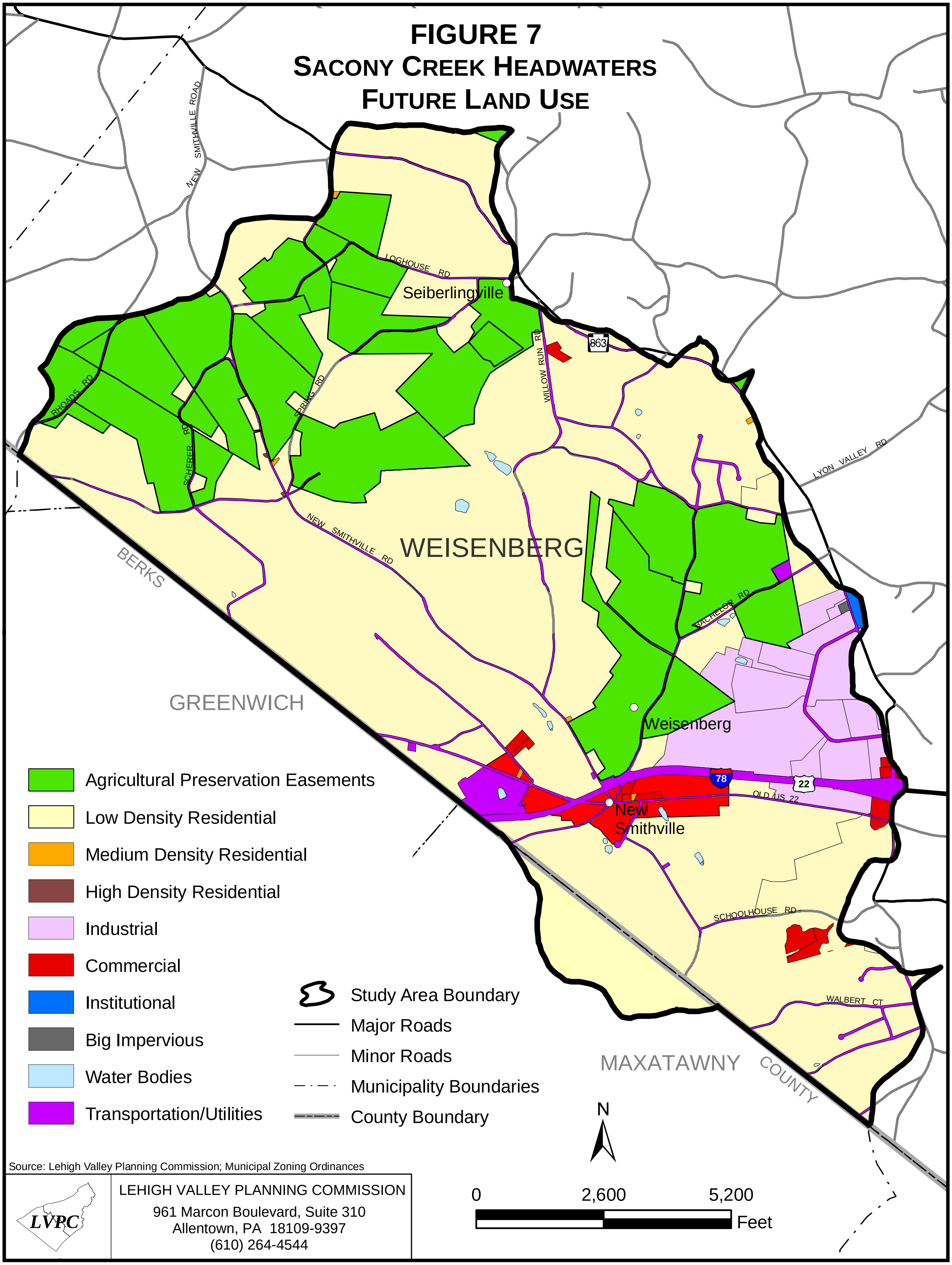

FIGURE 7
SACONY CREEK HEADWATERS
FUTURE LAND USE
NEW SMITHVILLE ROAD
LOGHOUSE RD
Seiberlingville
863
RHOADS RD
SPRING RD
SCHERER RD
WILLOW RUN RD
LYON VALLEY RD
NEW SMITHVILLE RD
WEISENBERG
BERKS
BACHELOR RD
GREENWICH
Weisenberg
78
22
OLD US 22
New Smithville
SCHOOLHOUSE RD
WALBERT CT
MAXATAWNY
COUNTY
Agricultural Preservation Easements
Low Density Residential
Medium Density Residential
High Density Residential
Industrial
Commercial
Institutional
Big Impervious
Water Bodies
Transportation/Utilities
Study Area Boundary
Major Roads
Minor Roads
Municipality Boundaries
County Boundary
N
0
2,600
5,200
Feet
Source: Lehigh Valley Planning Commission; Municipal Zoning Ordinances
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LEHIGH VALLEY PLANNING COMMISSION
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CHAPTER 4. SACONY CREEK HEADWATERS FLOODPLAIN INFORMATION

A. Floodplain Delineation

The Federal Emergency Management Agency (FEMA) has prepared a Lehigh County Flood Insurance Study and floodplain mapping for the county that include Weisenberg Township in the Sacony Creek Headwaters Study Area. The Lehigh County Flood Study is available for inspection at the Lehigh Valley Planning Commission office as well as Weisenberg Township and is not reproduced here. The publication date for the study and floodplain mapping is July 16, 2004.

The 100-year floodplains for the stream segments in Weisenberg Township have been determined only by approximate methods. Detailed hydraulic analyses were not performed and, therefore, base flood elevations have not been determined. As part of the original Sacony Creek Act 167 Plan from 1997, Berks County prepared a floodplain map that included the Sacony Creek Headwaters Study Area. The map is included in Appendix A of this Plan and is shown as Plate III-6. While the floodplains shown in Weisenberg Township on Plate III-6 were from the FEMA map dated October 15, 1985, FEMA did not re-study the stream segments with the July 2004 study and mapping. Therefore, the floodplain delineations remain the same for the Township. The portion of Maxatawny Township (Berks County) within the Sacony Creek Headwaters Study Area does not have a delineated 100-year floodplain.

FEMA'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 stormwater 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. Communities that require new developments to include in their design of stormwater management facilities appropriate Best Management Practices (BMPs) that will improve surface water quality can qualify for additional credits as well.

B. Existing and Future Floodplain Development

The Sacony Creek Headwaters Study Area is predominately rural. Currently within the study area floodplains, land use consists largely of agriculture, open space, woods and low density residential.

Development within the floodplains of the study area is taking place within the rules established by Pennsylvania Act 166 of 1978, the Floodplain Management Act. Act 166 requires municipalities to adopt ordinances to regulate the type and extent of development within floodplain areas. Weisenberg Township has enacted an ordinance consistent with Act 166. With enforcement of the ordinance, 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.

For the purposes of the Sacony Creek Headwaters Stormwater 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 2-year through 100-year return period events through implementation of the stormwater management criteria included in the Stormwater Management Plan for the Sacony Creek Headwaters.

- Damage potential for future floodplain development will be minimized by permitting only specific types of development that are damage resistant consistent with the Floodplain Management Act as implemented through the following: municipal floodplain regulation; 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 Stormwater Management Plan.

CHAPTER 5. SACONY CREEK HEADWATERS 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 Sacony Creek Headwaters was provided an opportunity to document the existing drainage problems within its borders. The municipalities reported that there are no known existing drainage problems of concern in the study area. The creation of the original Sacony Creek Plan by Berks County documented one problem area. This problem area was described as flooding along Mill Creek Road south of Interstate 78 and Old US Route 22. A location map showing this area is included in Appendix A, Plate III-7.

B. Significant Obstructions

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

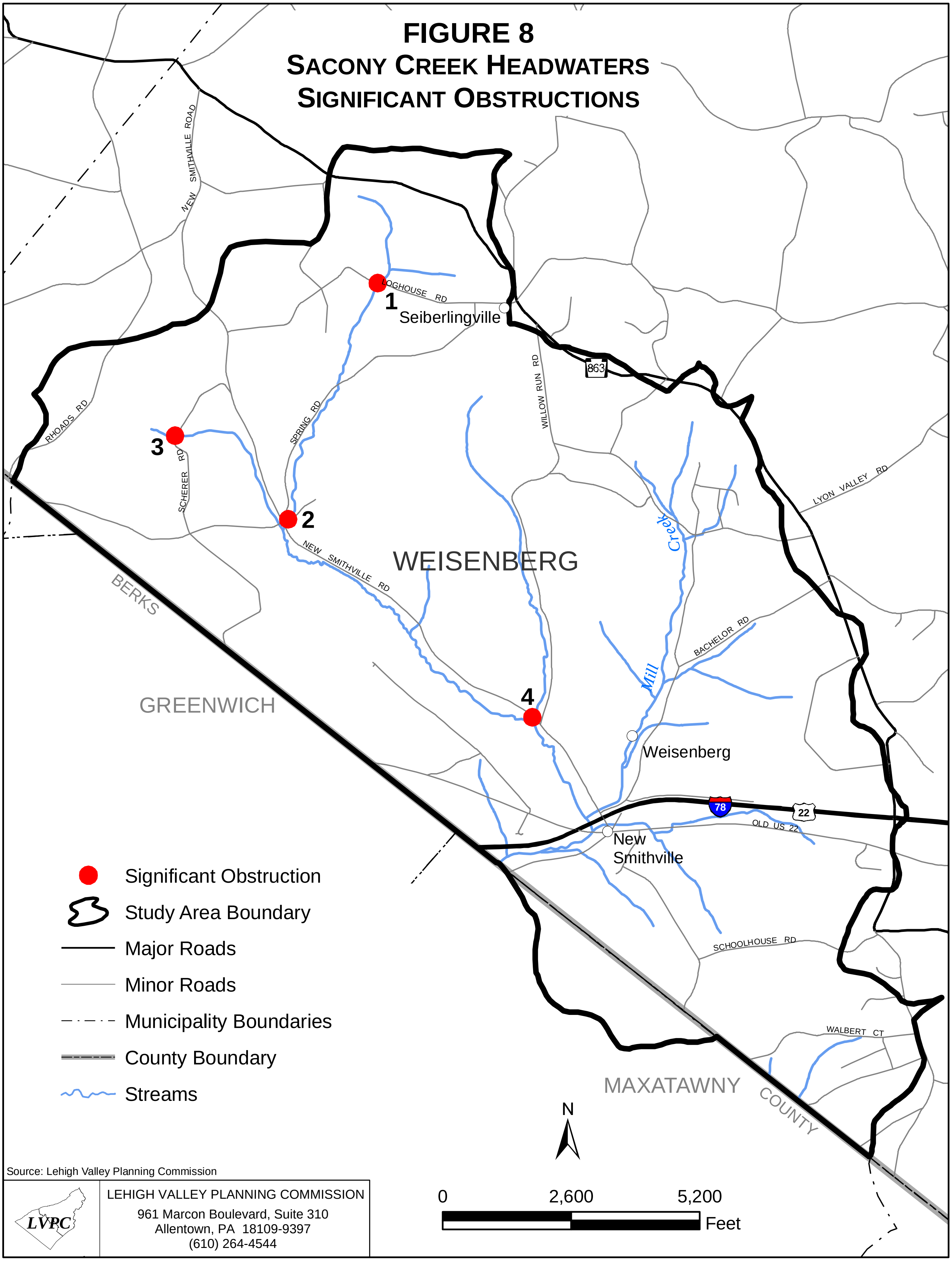
> "Any dike, bridge, culvert, wall, wingwall, fill, pier, wharf, embankment, abutment, or other structure located in, along, or across or projecting into any…channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow."

Using the above definition, 35 obstructions have been observed within the Sacony Creek Headwaters. Of these obstructions, 15 were located within the public right-of-way and were able to be measured in the field. The remaining obstructions were small driveway bridges, walking path bridges, etc. that were not able to be documented from the right-of-way and were included in the model as part of the travel time adjustment. For each of the measured obstructions, 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 Sacony Creek Headwaters Stormwater 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, four significant obstructions have been identified within the Sacony Creek Headwaters and are shown in Figure 8. A list of the significant obstructions is presented in Table 10 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

FIGURE 8
SACONY CREEK HEADWATERS SIGNIFICANT OBSTRUCTIONS



(where applicable) consistent with the calibrated HEC-HMS models for the watershed in the Sacony Creek Headwaters. 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 stormwater 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 that may affect the capacity for design flows.

The storm drainage problem areas identified by the municipalities through the Watershed Plan Advisory Committee process and presented in Figure 8 and Table 10 represent municipal responsibilities for remediation. There is no anticipated county involvement in the remediation process.

TABLE 10
SACONY CREEK HEADWATERS SIGNIFICANT OBSTRUCTIONS

Number	Obstruction	Municipality	Approximate Flow Capacity (cfs)
1	Loghouse Road	Weisenberg Twp.	70
2	Driveway	Weisenberg Twp.	50
3	Scherer Road	Weisenberg Twp.	25
4	New Smithville Road	Weisenberg Twp.	88

CHAPTER 6. STORMWATER RUNOFF CONTROL TECHNIQUES

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

The runoff control techniques presented in Sections A, B and C are "structural" stormwater management controls, meaning that they are physical facilities for runoff abatement. "Non-structural" controls, described in Section D, refer to land use management techniques geared towards minimizing storm runoff impacts through control of the type and extent of new development. The Sacony Creek Headwaters Stormwater 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 volume controls, rate controls, or water quality treatment controls. Volume controls are designed to allow a certain amount of the total 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 and other pervious cover 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. Water quality treatment controls are designed primarily to reduce the impact of high sediment, pollutant, and/or nutrient loads on receiving water bodies. In some cases, water quality controls can provide some peak rate attenuation, but it is unlikely that they would be able to act as the sole control for a site; other rate and/or volume controls would still be required.

Presented in Sections A, B, and C is a discussion of the various volume, rate and water quality treatment 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, and its advantages, 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 three sources: namely, (1) *New Jersey Stormwater Quantity/Quality Management Manual*, February 1981, prepared for the New Jersey Department of Environmental Protection by the

Delaware Valley Regional Planning Commission; (2) *Allegheny County Act 167 Pilot Stormwater 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, Inc.; (3) *Delaware River Sub-basin 2 and Lehigh River Sub-basin 5 (Fry's Run Study Area) - Act 167 - Stormwater Management Plan*, February 1999, prepared by the LVPC; and (4) *Pennsylvania Stormwater Best Practices Manual*, December 2006, by the Pennsylvania Department of Environmental Protection.

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 runoff control is based upon the substitution of porous or semi-pervious materials in place of conventional impervious surfaces. Other controls may be based on storing runoff for later use (irrigation, janitorial work, etc.). Also, there are controls that focus on restoring the natural infiltration capacity of soils that have been previously impacted by development. 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 generally not 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. Pervious Pavement

a.) Description

Pervious pavement consists of a permeable surface course underlain by a uniformly-graded stone bed which provides temporary storage for peak rate control and promotes infiltration. The surface course may consist of porous asphalt, porous concrete, or various porous structural pavers laid on uncompacted soil.

b.) Applicability

Pervious pavement systems can be used in areas such as parking lots, walkways, playgrounds, alleyways, plazas, tennis courts, and other similar uses.

c.) Advantages and Disadvantages

ADVANTAGES

- Does not require additional land space.
- Can reduce size, or possibly eliminate, other drainage facilities via volume control.
- Groundwater recharge.
- Improved preservation of roadside vegetation.
- Flexible measure to provide stormwater detention in both new and existing development.
- Safety improvements such as superior skid resistance during wet conditions, accelerated snow melting and a reduced risk of the formation of “black ice”, and enhanced visibility of pavement markings.
- Provides pavement drainage without the need for a crown slope, thus reducing costs and puddling.
- Less noisy than conventional pavements.
- Less costly over time than conventional pavements for most applications, due to lower maintenance costs.

DISADVANTAGES

- 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.
- Water that freezes within the pervious pavement takes longer to thaw and offsets infiltration.
- Motor oil drippings and gasoline may pollute groundwater.
- Costs more to install than traditional pavement.

- Locations limited by site slope, soil permeability, and underlying bedrock.

d.) Maintenance Requirements

Maintenance involves removing 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.

2. Infiltration Basin

a.) Description

An infiltration basin is a shallow impoundment that stores and infiltrates runoff over a level, uncompacted, (preferably undisturbed) area with relatively permeable soils.

b.) Applicability

This control may be used where the subsoil is sufficiently permeable to allow a reasonable rate of infiltration and where the water table and bedrock are sufficiently lower than the design depth of the facility. It is 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 reduce size, or possibly eliminate, other drainage facilities via volume control.
- Groundwater recharge.
- Runoff water quality is improved by the existing natural processes in the soil mantle.
- May help reduce local flood peaks.

DISADVANTAGES

- Locations limited by soil permeability and underlying bedrock.

- Vulnerable to clogging from sediment deposition.

d.) Maintenance Requirements

Catch basins and inlets (upgradient of infiltration basin) should be inspected and cleaned at least two times per year and after runoff events. The vegetation along the surface of the infiltration basin should be maintained in good condition, and any bare spots re-vegetated as soon as possible. Inspect the basin after runoff events and make sure that runoff drains down within 72 hours. Also inspect for accumulation of sediment, damage to outlet control structures, erosion control measures, signs of water contamination/spills, and slope stability in the berms. The original cross-section should be restored when necessary. Accumulated sediment should be removed as necessary.

3. Subsurface Infiltration Bed, Infiltration Trench, and Dry Well/Seepage Pit

a.) Description

Subsurface infiltration beds provide temporary storage and infiltration of stormwater runoff by placing storage media of varying types beneath the proposed surface grade.

An infiltration trench is a perforated pipe in a stone filled trench with a level bottom. An infiltration trench may be used as part of a larger storm sewer system, such as a relatively flat section of storm sewer, or it may serve as a portion of a stormwater system for a small area, such as a portion of a roof or a single catch basin.

A dry well, or seepage pit, is a variation on an infiltration system that is designed to temporarily store and infiltrate rooftop runoff.

b.) Applicability

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

c.) Advantages and Disadvantages

ADVANTAGES

- May help reduce local flood peaks.

- Groundwater recharge.

- Creates usable open space on-site.

- Usually unaffected by cold weather.

- Large subsurface infiltration beds could be capable of reducing peak and volume of runoff without additional rate controls.

- Infiltration trenches can combine the conveyance system with a storm-water management control by increasing travel time and infiltrating runoff.

DISADVANTAGES

- Locations limited by soil permeability and underlying bedrock.

- Vulnerable to clogging from sediment deposition.

- Maintenance is difficult if the facility becomes clogged.

d.) Maintenance Requirements

All catch basins and inlets should be inspected and cleaned at least 2 times per year. The overlying vegetation should be maintained in good condition, and any bare spots re-vegetated as soon as possible. Vehicular access on infiltration areas should be prohibited, and care should be taken to avoid excessive compaction by mowers. If access is needed, use of permeable, turf reinforcement should be considered.

4. Rain Garden or Bioretention

a.) Description

A rain garden (also called bioretention) is an excavated shallow surface depression planted with specially selected native vegetation to capture and treat runoff. Properly designed bioretention techniques mimic natural eco-systems through species diversity, density and distribution of vegetation, and the use of native species, resulting in a system that is resistant to insects, disease, pollution, and climatic stresses.

b.) Applicability

Rain gardens are extremely flexible and can be used in almost any location on any site. If soils are not sufficiently permeable to allow adequate drain-age, an underdrain can be used to control overflow.

c.) Advantages and Disadvantages

ADVANTAGES

- Can be more cost effective than traditional landscaping.

- Can balance nicely with other structural management systems, including porous asphalt parking lots, infiltration trenches, as well as non-structural stormwater controls.

- Plant root systems can increase infiltration of runoff.

- Groundwater recharge.

- Reduces stormwater temperature impacts.

- Filters pollutants through soil particles (which trap pollutants) and plant material (which takes up pollutants).

- Enhances site aesthetics.

DISADVANTAGES

- Generally small in surface area and depth, and are not practical to control runoff from events greater than the 2-year storm.

- May require manual watering in dry periods.

d.) Maintenance Requirements

While vegetation is being established, pruning and weeding may be required. Detritus may also need to be removed every year. Perennial plantings may be cut down at the end of the growing season. Mulch should be re-spread when erosion is evident and replenished as needed. Once every 2 to 3 years the entire area may require mulch replacement. They should be inspected at least 2 times a year for sediment buildup, erosion, vegetative conditions, etc. Trees and shrubs should be inspected twice per year to evaluate health. During periods of drought, bioretention areas may require watering.

5. Vegetated Roofs

a.) Description

A vegetated roof cover is a veneer of vegetation that is grown on and completely covers an otherwise conventional flat or pitched roof, endowing the roof with hydrologic characteristics that more closely match surface vegetation than the roof. The overall thickness of the veneer may range from 2 to 6 inches and may contain multiple layers, consisting of waterproofing, synthetic insulation, non-soil engineered growth media, fabrics, and synthetic components. Vegetated roof covers can be optimized to achieve water quantity and water quality benefits. Through the appropriate selection of materials, even thin vegetated covers can provide significant rainfall retention and detention functions. Since the purpose of most vegetated roofs is runoff mitigation, they are usually not irrigated. Plants should be selected which will create a vigorous, drought-tolerant ground cover.

b.) Applicability

Vegetated roofs can be installed on any flat roof, or a pitched roof with a slope of less than 30 degrees. The dead load bearing capacity of the roof must also be analyzed to assure that the structure can support the weight of a saturated vegetated roof.

c.) Advantages and Disadvantages

ADVANTAGES

- Does not require additional land space.
- Can mimic pre-development hydrological conditions, particularly for small storms.
- Enhances site aesthetics.
- Improves the efficiency of downstream infiltration facilities.

DISADVANTAGES

- Requires consideration of the building's structural capacity to support the facility.
- Provides no opportunity for groundwater recharge.
- Pitched roofs are less desirable and require additional measures against sliding.
- Could increase the risk of roof leaks if not properly installed.

d.) Maintenance Requirements

During the plant establishment period, periodic irrigation may be required, and three to four visits to conduct basic weeding, fertilization, and in-fill planting are recommended. Thereafter, only two annual visits for inspection and light weeding should be needed.

6. Landscape Restoration

a.) Description

Landscape restoration is the general term used for actively sustainable landscaping practices that are implemented outside of riparian (or other specially protected) buffer areas. Landscape restoration includes the restoration of forest (i.e. re-forestation) and/or meadow and the conversion of turf to meadow.

b.) Applicability

Landscape restoration can be used in any open area. Landscape restoration works to restore land to its original cover (or possibly more pervious cover if meadow is converted to forest), and to restore the infiltration capacity of the area. This control is most applicable for retrofitting projects.

c.) Advantages and Disadvantages

ADVANTAGES

- Meadow areas require little maintenance compared to conventional turf lawns.
- Meadow and forest areas require less long-term financial investment than conventional lawns, due to reduced or non-existent mowing and fertilizer costs.
- Groundwater recharge.

DISADVANTAGES

- Native grasses and flowers establish more slowly than weeds and turf grass, so establishing a meadow condition can be difficult and maintenance-intensive.
- Higher installation costs than conventional turf lawns.
- Can take several years before adequate cover is established.

d.) Maintenance Requirements

Forest restoration areas planted with a cover crop can be expected to require annual mowing and herbicide applicant to control invasives in the first 2-5 years, or until the tree canopy begins to form. Meadow areas should be carefully monitored for weed growth in the first few years. Afterwards, seasonal mowing or burning may be required.

7. Soil Amendment and Restoration

a.) Description

Soil amendment and restoration is the process of improving disturbed soils and low organic soils by restoring soil porosity and/or adding a soil amendment, such as compost, for the purpose of reestablishing the soil's long-term capacity for infiltration and pollutant removal.

b.) Applicability

This control can be used on any part of a construction site that will become compacted during the land development process due to material storage or heavy construction vehicle traffic.

c.) Advantages and Disadvantages

ADVANTAGES

- Decreases runoff volume over extensively graded or otherwise heavily trafficked areas of the site through restoration of the soil's porosity.

- Soil amendments increase the nutrient level of the soil, which benefits vegetative growth.

- Groundwater recharge.

DISADVANTAGES

- Long-term maintenance of amended soils is largely unknown. Compost-amended soils may need to be re-composted on a regular basis.

- Tilling is expensive.

- Wet soils are not suitable for tilling, as they are incapable of being broken up by the tines on the tilling equipment.

- Soil restoration is not suitable for sites with very steep slopes (30%+).

d.) Maintenance Requirements

The soil restoration process may need to be repeated over time, due to compaction by use and/or settling.

8. Runoff Capture and Re-use

a.) Description

Capture and re-use encompasses a wide variety of water storage techniques designed to “capture” precipitation or runoff, hold it for a period of time, and re-use the water. The facility may also be designed as a detention facility with a slow release over time.

b.) Applicability

Since cisterns, rain barrels, and storage media are not dependent on physiological conditions and their sizes can vary as necessary, they are applicable practically everywhere. Cisterns can be installed beneath paved areas or other structural facilities, within a building, or above the ground.

c.) Advantages and Disadvantages

ADVANTAGES

- Minimal space required for implementation, and minimal interference with traffic or people.
- Can be used in existing as well as newly developed areas.
- Potential for multiple uses of stored runoff.
- Keeps runoff on-site, which will affect local flood peaks in a manner similar to infiltration.

DISADVANTAGES

- Less effective in cold weather, since systems must be flushed to prevent damage resulting from freezing.
- To have an impact on runoff, cisterns must have available volume at the beginning of a storm event; full cisterns provide no attenuation.

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. Do not allow water to freeze in the storage devices.

9. Vegetated Swales, Vegetated Filter Strips, and Seepage Areas

a.) Description

These controls utilize grassed areas for managing stormwater runoff by using their natural capacity for reducing runoff velocities, enhancing infiltration, and filtering runoff contaminants.

A vegetated swale (or grassed waterway) is a broad, shallow, trapezoidal or parabolic channel, densely planted with a variety of trees, shrubs, and/or grasses. It is designed to attenuate and in some cases infiltrate runoff volume from adjacent impervious surfaces, allowing some pollutants to settle out in the process. Whenever possible, grasses native to the site should be selected for use to ensure acclimation.

Vegetated filter strips are grass buffer areas that sheet flows or surface runoff are directed across to reduce the flow velocity and cause the heavier particles to settle out of the water. This simultaneously enhances the infiltration of the runoff by passing it over the pervious grass filter. These strips of close growing grasses can be established at the perimeter of disturbed or impervious areas.

Seepage areas are small, grass-covered depressions that surface runoff is directed into to infiltrate the water and filter out particulate contaminants. Seepage areas are constructed 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 vehicle hydroplaning.

- Increased runoff travel time and groundwater recharge.

- Effective pre-treatment methods for other facilities, especially infiltration facilities which are vulnerable to sediments.

DISADVANTAGES

- Must be located on sufficiently permeable soils.

- 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.

- 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.

- Swales and filter strips can be prone to erosion, especially on steep slopes.

- Only effective when treating small areas.

d.) Maintenance Requirements

Vegetated swales require periodic inspections, especially after large storms, to evaluate whether erosion controls are needed, to remove accumulated debris, and to check the condition of the vegetation. Filter strips also require periodic inspection, 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 require similar maintenance to vegetated swales and filter strips. Mowing should be performed with low ground-pressure equipment and a high blade setting (4 to 6 inches), and only when the area is dry.

B. Rate Controls

The performance standard criteria presented in Chapter 8 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 the other watershed areas, and the anticipated increase in volume associated with development. The volume controls described in Section A will remove a portion of the increased volume of runoff and may also help to reduce the peak rate of runoff. However, it is primarily the rate controls 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" stormwater 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. These include dry detention and extended dry detention facilities. Wet impoundments, or wet ponds, 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 peaks, 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 ponds are applicable to any 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. A DEP dam permit may be required for a stormwater detention facility.

c.) Advantages and Disadvantages

ADVANTAGES

- Offers design flexibility for adapting to a variety of uses.
- Pond construction is relatively simple.

- May allow significant reduction in the size of downstream storm drainage structures.

- May enhance groundwater recharge to some extent.

- Reduces downstream litter and debris.

- Wet ponds (and, to a lesser extent, extended dry detention ponds) improve runoff quality through settling, filtration, uptake, chemical and biological decomposition, volatilization, and adsorption.

- Wet ponds can provide aesthetic and wildlife benefits.

DISADVANTAGES

- Due to the potential to discharge warm water, wet ponds and extended dry detention basins should be used with caution near temperature sensitive water bodies.

- Consumes land area that cannot be developed.

- Possible safety concerns.

- Site hydrology must be considered to determine if a wet pond can receive and retain enough flow from rain, runoff, and groundwater to ensure long-term viability. Modifications to the pond in Hydrologic Soil Group (HSG) A and B soils may be required.

- In carbonate bedrock areas, soil depth and type must be considered in the design to minimize the possibility of sinkhole occurrence.

- Detention basins with impervious lining do not provide groundwater recharge.

d.) Maintenance Requirements

To maintain the design efficiencies of a detention basin, maintenance of the structures and the impoundment areas are essential. Detention basins should be inspected at least four times per year and after major storms. Wet ponds should also be inspected after rapid ice breakup. Inspections should assess the vegetation, erosion, flow channelization, bank stability, inlet/outlet conditions, embankment, and sediment/debris accumulation. Pipe inlets and outlets should be inspected for accumulated sediment and debris. Sediment should be removed from the forebay (if applicable) before it occupies 50 percent of the forebay, typically every five to 10 years. The pond drain (if applicable) should also be inspected and tested four times per year. Measures to offset the production of fast-breeding insects should be taken as necessary.

2. Parking Lot and Roof Detention

a.) Description

Areas such as parking lots, rooftops, or other areas that are primarily intended for other uses can be designed to temporarily detain stormwater for peak rate mitigation. Generally, detention is achieved through the use of a flow control structure that allows runoff to temporarily pond. In most cases ponding depths are kept less than one foot. In rooftop detention, the control structures should be designed so that no water is ponded for small storms.

b.) Applicability

Portions of large, gently sloped parking lots that can be temporarily used for stormwater storage without significantly interfering with normal vehicle and pedestrian traffic are candidates for parking lot storage. New structures with flat rooftops are most applicable for rooftop storage, although retrofits are possible if specific design requirements are met. Areas such as recessed plazas and athletic fields can be used in a similar fashion.

c.) Advantages and Disadvantages

ADVANTAGES

- No additional land requirements.
- Can contribute to maintaining adequate capacity of downstream drainage facilities.
- Adaptable to both new and old facilities.
- Parking lot storage is generally easy to incorporate into parking lot design and construction.
- Water stored on rooftops has high potential for re-use.
- Rooftop storage does not cause any aesthetic or safety concerns and causes minimal interference with traffic and people.
- Low cost and low maintenance.

DISADVANTAGES

- Provides little volume control and negligible water quality benefits.

- Ponding areas are prone to icing in cold weather.

- Parking lot storage may be a public inconvenience.

- Rooftop storage costs to the owner may outweigh the benefits, since leaks can cause damage to buildings and their contents.

- Modifications to the building code may be required before rooftop storage can be used.

d.) Maintenance Requirements

Maintenance activities should include semiannual inspection and cleaning of flow control structures, clearing debris/sediment from detention areas (as necessary), and inspecting the waterproofing in rooftop storage areas.

3. Constructed Wetlands

a.) Description

Constructed wetlands are shallow marsh systems planted with emergent vegetation that are designed to treat stormwater runoff. While they are one of the best methods for pollutant removal, constructed wetlands can also mitigate peak rates and even reduce runoff volume to a certain degree. They also can provide considerable aesthetic and wildlife benefits.

b.) Applicability

Constructed wetlands are applicable in any marshy area, usually underlain by HSG C or D soils with a high water table, on sites that have sufficient hydrologic conditions to maintain a permanent pool in the pond.

c.) Advantages and Disadvantages

ADVANTAGES

- Improve runoff quality through settling, filtration, uptake, chemical and biological decomposition, volatilization, and adsorption.

- Effective at removing many common stormwater pollutants including suspended solids, heavy metals, total phosphorus, total nitrogen, toxic organics, and petroleum products.

- Capable of providing some peak rate control above the permanent pool elevation.

DISADVANTAGES

- Application limited by site hydrology.

- Consumes large amounts of land area that cannot be developed.

d.) Maintenance Requirements

During the first growing season, vegetation should be inspected every two to three weeks. Constructed wetlands should be inspected several times per year and after major storms and rapid ice melt to assess vegetation cover, erosion, flow channelization, bank stability, inlet/outlet conditions, and sediment/debris accumulation. Sediment should be removed from the forebay (if applicable) before it occupies 50 percent of the forebay, typically every three to seven years.

C. Water Quality Treatment Controls

New development in a watershed can introduce large amounts of new sediments, excessive levels of nutrients (such as nitrogen and phosphorus), and other pollutants into the receiving waters. To prevent these contaminants from impacting the watershed, certain measures should be taken to mitigate the potential impact of development on the water quality in the watershed. These controls are designed primarily to reduce the pollutant load from the site by natural, physical, and/or biological processes. These controls do not provide significant peak rate or volume control.

1. Constructed Filter

a.) Description

Filters are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other filter media that reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. The runoff passes through the filter media and is collected in an under-drain and returned to the conveyance system, receiving waters, or infiltrated into the soil mantle.

b.) Applicability

Filters are applicable in urbanized areas having high pollutant loads and are especially applicable where there is limited area for construction of other water quality BMPs. Filters may be used as a pretreatment method for runoff before it reaches other facilities, especially infiltration systems. Filters may be used in Hot Spot areas for water quality treatment, and spill containment capabilities may be incorporated into a filter.

c.) Advantages and Disadvantages

ADVANTAGES

- Effective pre-treatment to reduce sediment and pollutant loads on other facilities.
- Flexibility of design to meet varying degrees of water quality standards.
- Sand filters can be used to "throttle" unacceptably high infiltration rates.
- If effluent is allowed to infiltrate into the soil mantle, the filter can reduce some runoff volume and increase groundwater recharge.

DISADVANTAGES

- Maintenance can be expensive if the filter media becomes clogged.
- Poor performance in cold weather.

d.) Maintenance Requirements

The filter should be inspected at least four times per year for evidence of standing water and any film or discoloration of surface filter material. Trash and debris should be removed as necessary. Also, scraping the silt with rakes, tilling or aerating the filter area, and/or replacing the filter medium may be required.

2. Water Quality Inlets & Hydrodynamic Devices

a.) Description

Water quality inlets are stormwater inlets that have been fitted with a proprietary product (or the proprietary product replaces the catch basin itself) designed to remove water quality contaminants. They are designed to receive large sediment, suspended solids, oil and grease, and other pollutant loads.

Hydrodynamic devices are on-line structures that separate sediment and pollutants from the flow stream via physical methods. These methods include baffle plate design, vortex design, tube settler design, inclined plate settler design or a combination of these. Ideally, the flow through device should remove litter, oil, sediment, heavy metals, dissolved solids and nutrients.

b.) Applicability

These controls can be used at any existing or proposed inlet where contributing runoff may contain significant levels of sediment and debris: parking lots, gas stations, golf courses, streets, driveways, industrial or commercial facilities, etc.

c.) Advantages and Disadvantages

ADVANTAGES

- Effective pre-treatment to reduce sediment and pollutant loads on other facilities.
- No additional land requirements.

DISADVANTAGES

- Potentially adversely impacted by cold weather.
- Requires rigorous maintenance to be effective.

d.) Maintenance Requirements

Maintenance is crucial for pollutant removal effectiveness. The more frequent a water quality insert is cleaned, the more effective it will be. Follow the manufacturer's guidelines for maintenance, also taking into account expected pollutant load and site conditions. Inlets should be inspected weekly during construction. Post construction, they should be emptied when over half full of sediment (and trash) and cleaned at least twice a year. They should also be inspected after large runoff events.

3. Riparian Buffer Restoration

a.) Description

A riparian buffer is a permanent area of trees and shrubs located adjacent to streams, lakes, ponds, and wetlands. Riparian forests are the most beneficial type of buffer for they provide ecological and water quality benefits. Restoration of this ecologically sensitive habitat is a responsive action to past activities that may have eliminated any vegetation.

b.) Applicability

Riparian buffer restoration is applicable for sites traversed by, or adjacent to, a stream with a degraded or previously developed riparian buffer.

c.) Advantages and Disadvantages

ADVANTAGES

- Restores the natural pollutant and nutrient removal capacity of the stream bank.

- Enhances site aesthetics.

- Improves biodiversity.

DISADVANTAGES

- Consumes large amounts of land that cannot be developed.

- Considerable financial cost.

- Establishment of the vegetation can take upwards of five years.

d.) Maintenance Requirements

Riparian buffers require diligent maintenance efforts, with inspections at least four times per year, particularly in the first three to five years while vegetation is being established. Buffers need to be regularly watered, mulched, and weeded. Weeds and other invasive species may be controlled with herbicides (only in the first two to three years), mowing (or other mechanical methods), or weed mats. Plants should be inspected for any damage from deer grazing. If tree shelters are employed to protect vegetation, they should be inspected regularly and repaired as needed.

4. Floodplain Restoration

a.) Description

Floodplain restoration aims to mimic the pre-settlement (pre-1600's) conditions of the interaction of groundwater, stream base flow, and root systems in a stream bed. The interaction among the stream's base flow, groundwater, permeable floodplain soils, and riparian root zones provides multiple benefits, including the filtering of sediments and nutrients through retention of frequent high flows onto the floodplain, removal of nitrates from groundwater, reduction of peak flow rates, groundwater recharge/infiltration, and increase of storage and reduction of flood elevation during higher flows.

b.) Applicability

Floodplain restoration can be performed on any location where stream networks have little interaction among the groundwater, stream base flow, and the root systems. This can be done on-site as part of the on-site stormwater management plan, or on projects that do not have a stream on or adjacent to the site, floodplain restoration may be implemented downstream in the watershed.

c.) Advantages and Disadvantages

ADVANTAGES

- Restores pre-settlement stream hydrology.
- Enhances the sediment and nutrient load attenuation capabilities of the stream bank.
- Impacts flood control on the watershed level.

DISADVANTAGES

- Consumes large amounts of land that cannot be developed.
- Considerable financial cost.
- May not be suitable near existing wetlands and mature forests.

d.) Maintenance Requirements

Floodplain areas should be inspected regularly to monitor the vegetative cover. Weeds and other invasive species should be controlled with herbicides (only within the first two to three years), mowing (or other mechanical methods), or weed mats.

D. Nonstructural Stormwater Management Techniques

Nonstructural stormwater management techniques refer to land use management techniques geared toward minimizing storm runoff impacts through control of the type, location, layout, 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, or through creative site planning. These alternative provisions in a zoning ordinance and SALDO can minimize impervious surfaces for a given zoning district. These zoning ordinance and SALDO provisions would aim to move development away from areas that are desirable to preserve, and towards areas that are suitable for development (such as near existing urban and suburban areas, etc.). This can be done either on a per parcel basis, or on a municipality-wide basis. Areas that are desirable for preservation can include any areas that the municipality sees fit to protect, but usually include mature woodlands, wetlands, existing natural drainage systems, riparian areas, and other areas that are important for natural runoff control. Other non-structural controls involve minimizing the impacts of a land development on areas that will be pervious post-development or passing flow from impervious areas over pervious areas to allow it to be partially filtered and possibly infiltrated.

Presented here is a discussion of the various nonstructural practices and controls available for implementation on a development site (or region). The discussion includes a physical description of the control, its advantages and disadvantages, and maintenance requirements (if any). The practices that do not have disadvantages noted can be assumed to be hindered by existing zoning ordinances and SALDOs that limit the extent that the control can be implemented in certain areas. This does not include those controls that only seek to preserve existing features, in which the only disadvantage is a possible loss of profitability from the reduced development area.

1. Protect Sensitive/Special Value Resources

   a.) Description

   To minimize stormwater impacts, land development should avoid affecting and encroaching upon areas with important natural stormwater functional values (floodplains, wetlands, riparian areas, drainageways, others), and with stormwater impact sensitivities (steep slopes, adjoining properties, others) wherever practicable. This avoidance should occur site-by-site and on an area wide basis. Development should not occur in areas where sensitive and/or special value resources exist so that their valuable natural functions are not lost, thereby doubling or tripling stormwater impacts. Sensitive resources also include those resources of special value (such as designated habitat of threatened and endangered species that are known to exist and have been identified through the Pennsylvania Natural Diversity Inventory or PNDI).

   b.) Advantages

   - Reduces the pollutant load by preventing existing hydrologic features from being converted to impervious, which would increase the impact of the impervious several times over.
   - Reduces the pollutant load by minimizing maintained landscape areas (lawns, etc.).
   - Preserves site aesthetics and wildlife habitat.
   - Preserves the site's ability to reduce runoff through evapotranspiration.

c.) Maintenance Requirements

Typically, the designated open space may be conveyed to the municipality, although most municipalities prefer not to receive these open space portions, including all of the maintenance and other legal responsibilities associated with open space ownership. If the open space will not be received by the municipality, a homeowner's association is the ideal party to own the open space.

2. Protect/Conserve/Enhance Riparian Areas

a.) Description

This control serves to protect the existing natural vegetative buffers protecting streams. The Executive Council of the Chesapeake Bay Program defines a riparian forest buffer as "an area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water and which is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering and converting sediments, nutrients, and other chemicals, and to supply food, cover, and thermal protection to fish and other wildlife." Also, it is important to note that riparian buffer areas are not the same as floodplains. While most riparian buffers are within the floodplain, there can be areas where riparian buffers extend beyond the floodplain (such as banks with steep slopes, etc.).

b.) Advantages

- Vegetation provides water quality filtering for sediments, nutrients, and other pollutants.
- Increases the bank stability of the stream.
- Improves groundwater recharge.
- Preserves the existing peak rate and volume control of the wooded area.
- Controls the temperature of the stream shaded by the existing tree canopy.
- Preserves site aesthetics and wildlife habitat.

c.) Maintenance Requirements

Since the purpose of this control is to preserve existing wooded areas, post-development maintenance requirements are not significant.

3. Protect/Utilize Natural Flow Pathways

a.) Description

Most sites have identifiable drainage features such as swales, depressions, watercourses, ephemeral streams, etc. which serve to effectively manage any stormwater that is generated on the site. By identifying, protecting, and utilizing these features a development can minimize its stormwater impacts. Instead of ignoring or replacing natural drainage features with engineered systems that rapidly convey runoff downstream, designers can use these features to reduce or eliminate the need for structural drainage systems.

b.) Advantages

- Natural drainage features can be used as a guide for site design and layout.
- Using natural swales and depressions can decrease the cost associated with engineered controls.
- Preserves the site's ability to reduce runoff through evapotranspiration.
- Can improve water quality through filtration, infiltration, sedimentation, and thermal mitigation.
- Preserves site aesthetics and wildlife habitat.

c.) Maintenance Requirements

Natural drainage features should be protected from upstream increases in peak and volume so as to reduce the risk of channel erosion. Periodic inspections and maintenance actions (if necessary) are important. Inspections should assess erosion, bank stability, sediment/debris accumulation, and vegetative conditions including the presence of invasive species. Problems should be corrected in a timely manner. Protected drainage features should be placed in an easement or other legal measure to protect against future damage and/or neglect.

4. Clustering Development

a.) Description

Clustering is the practice of decreasing lot size while keeping density constant. Development should be concentrated in areas that will allow for the preservation of natural features in other areas of the site. Clustering is beneficial to stormwater management, since it decreases the disturbed area associated with development, and also increases the amount of open space that is preserved. Clustering proposals will require cooperation with the municipality, since clustering techniques are likely to go against the minimum lot size provisions in most municipal ordinances.

b.) Advantages

- Reduces the area impacted by development.

- Preserves the site's ability to reduce runoff through evapotranspiration.

- Preserves site aesthetics and wildlife habitat.

- Reduces total impervious cover by limiting street lengths and reducing the size of other impervious areas (driveways, sidewalks, etc.).

c.) Maintenance Requirements

Ownership of the open space should be established in the same fashion as in the Protect Sensitive/Special Value Resources control.

5. Concentrate Uses Area Wide Through Smart Growth Practices

a.) Description

This control involves using practices that direct growth to areas or groups of parcels in the municipality that are most desirable and away from areas or groups of parcels that are undesirable. This can be thought of as "Super Clustering;" rather than clustering on individual parcels, which will preserve open space in a piecemeal manner across the municipality, using practices such as transfer of development rights, urban growth boundaries, effective agricultural zoning, purchase of development rights, etc. allows for preservation of large amounts of connected, desirable open space across the municipality. "Desirability" is defined in terms of environmental, historical and archaeological, scenic and aesthetic, "sense of place," and quality of life sensitivities and values.

b.) Advantages

- Preserves the natural infiltrative and hydrologic properties of the soil and vegetation on a potentially watershed-impacting level.

- Reduces total impervious cover in the watershed by limiting development to certain areas.

c.) Maintenance Requirements

Ownership of the open space should be established in the same fashion as in the Protect Sensitive/Special Value Resources control.

6. Minimize Total Disturbed Area – Grading

a.) Description

This control involves reducing site grading, removal of existing vegetation (clearing and grubbing), and total soil disturbance. This eliminates the need for reestablishment of a new maintained landscape for the site and lot-by-lot. This can be accomplished by modifying the proposed road system and other relevant infrastructure as well as the building location and elevations to better fit the existing topography. The requirements of grading for roadway alignment (curvature) and roadway slope (grade) frequently increase site disturbance throughout a land development site and on individual lots. In some cases, if the minimum standards for road slope and alignment make it difficult or impossible to implement this control, developers may wish to work with the municipality to possibly deviate from the ordinance standards, without sacrificing public safety standards (regarding sight distance, winter icing, etc.).

b.) Advantages

- Reduces the area impacted by development.
- Preserves the site's ability to reduce runoff through evapotranspiration.
- Reduces the cost of development by minimizing the amount of earthwork required.
- Preserves site aesthetics and wildlife habitat.

c.) Maintenance Requirements

Since this control only involves better site planning techniques, there is no maintenance associated with it. However, if large amounts of open space are to be created as part of the development, ownership of the open space should be established in the same fashion as in the Protect Sensitive/Special Value Resources control.

7. Minimize Soil Compaction in Disturbed Areas

a.) Description

Minimizing soil compaction is the practice of protecting and minimizing damage to soil quality caused by land development. Healthy, native soil will provide significant benefits, including effectively cycling nutrients, minimizing runoff and erosion, maximizing water-holding capacity, reducing storm runoff surges, absorbing and filtering excess nutrients, sediments, and pollutants to protect surface and groundwater, providing a healthy root environment and creating habitat for microbes, plants, and animals, and reducing the resources needed to care for turf and landscape plantings. Compacted soils can never be returned to a perfectly native state (although techniques described in Section A.7: Soil Amendment and Restoration will restore some of the original infiltrative capacity), so it is desirable to protect areas that will be pervious post-development from vehicular traffic, material stockpiling, and other methods of compaction during the land development process.

b.) Advantages

- Preserves the natural infiltrative capacity of the soils on-site.
- Preserves the natural ability of the soils on-site to filter nutrients and pollutants.
- Reduces the need for pesticides and fertilizers to maintain lawns post-development.

c.) Maintenance Requirements

Sites that have minimized soil compaction properly during the development process should require considerably less maintenance than sites that have not. Landscape vegetation will likely be healthier, have a higher survival rate, require less irrigation and fertilizer, and even look better. Some maintenance activities such as frequent lawn mowing can cause considerable soil compaction after construction and should be avoided whenever possible. Planting low-maintenance native vegetation is the best way to avoid damage due to maintenance.

8. Re-vegetate and Re-forest Disturbed Areas with Native Species

a.) Description

This control involves selecting vegetation (i.e., native species) that does not require significant chemical maintenance by fertilizers, herbicides, and pesticides on sites that require landscaping and re-vegetation. This is based on the assumption that native species have the greatest tolerance and resistance to pests and require less fertilization and chemical application than non-native species.

b.) Advantages

- Reduces costs associated with pesticides and fertilizers for vegetated areas.

- Reduction in use of pesticides and fertilizers improves water quality.

c.) Maintenance Requirements

Re-vegetated areas need to be monitored in the first three to five years while vegetation is being established. Woodland areas planted with a proper cover crop can be expected to require annual mowing to control invasives. Application of a carefully selected herbicide around the protective tree shelters/tubes may be necessary, reinforced by selective cutting/manual removal, if necessary. Meadow areas may require a seasonal mowing.

9. Reduce Street and Parking Imperviousness

a.) Description

This control involves reducing impervious street areas, usually by minimizing street widths and lengths, and by minimizing imperviousness associated with parking areas. Street impervious reduction can also be achieved by other methods, such as using pervious pavement (see Section A.1) for parking lanes, or including a landscaped island in the middle of cul-de-sacs. Parking impervious reduction can be accomplished by reducing parking ratios and including pervious overflow parking areas or by having a more efficient parking lot layout (with one-way aisles and angled stalls).

b.) Advantages

- Decreases post-development runoff volume and increases amount of pervious area available for infiltration.

- Improves water quality by decreasing the pollutant load associated with impervious areas.

- Decreases the concentration and energy of stormwater.

c.) Maintenance Requirements

There are no maintenance requirements associated with reducing street and parking imperviousness.

10. Disconnection of Impervious Areas from Storm Sewers

a.) Description

Disconnection of impervious area involves minimizing stormwater volume by directing runoff from roof leaders and impervious roads and driveways to vegetated areas to infiltrate. Impervious areas are directed over a grassed area to an infiltration basin or other volume or water quality control facility. Curb cuts can be used to convey runoff from road and driveway areas if curbs cannot be eliminated from the design.

b.) Advantages

- Increases runoff travel time.
- Promotes infiltration of the roof areas.
- Improves water quality by allowing runoff to be filtered on-site, rather than allowing pollutants to concentrate in a storm sewer.

c.) Maintenance Requirements

There are no maintenance requirements for disconnected impervious areas directly, but downstream controls treating the roof runoff must be maintained for this control to be effective.

11. Streetsweeping

a.) Description

Streetsweeping involves the use of one of several modes of sweeping equipment (such as mechanical, regenerative air, or vacuum filter sweepers) on a programmed basis to remove larger debris material and smaller particulate pollutants, preventing this material from clogging the stormwater management system and washing into receiving waterways.

b.) Advantages and Disadvantages

ADVANTAGES

- Can significantly reduce pollutant loads from highly trafficked roads and parking lots.

DISADVANTAGES

- Winter road conditions can interrupt the sweeping schedule.
- Provides no control for pollutants generated during a rainfall event.
- Modern streetsweeping equipment comes at a cost.

c.) Maintenance Requirements

Other than potential vehicle maintenance to the equipment, there are no maintenance requirements for this control.

CHAPTER 7. REVIEW OF STORMWATER COLLECTION SYSTEMS AND THEIR IMPACTS

A. Existing Stormwater Collection Systems and Their Impacts

As part of an Act 167 plan, existing stormwater collection and conveyance systems throughout the study area are to be documented through correspondence with the municipalities and field surveys. Information on existing storm sewer systems can be important for the hydrologic model, as some systems may be extensive enough to act as the main drainage course for a subarea. These systems would then need to be measured (or have their geometry and dimensions estimated) and input into the model. There were no existing storm sewer systems documented in the study area during the creation of the original Sacony Creek Plan prepared by Berks County. The relevant section from the Berks County Plan is included in Appendix A for reference.

B. Future Stormwater Collection Systems

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 problems and the public support for an improvement. In this manner, projects are constructed as money becomes available in the capital maintenance budget. The effect of this 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 Sacony Creek Headwaters Stormwater Management Plan can impact this situation in two 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, 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.

Even without the development of a comprehensive remedial strategy, the Stormwater 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.

Except as facilities may be provided through development activities, there are no known future stormwater collection and control systems to be provided within the Sacony Creek Headwaters study area within the next ten years.

C. Existing and Proposed Flood Control Projects

There are no existing or proposed flood control projects located within the study area based on Plan data prepared by Berks County. The relevant section from the Berks County Plan is included in Appendix A for reference.

CHAPTER 8. WATERSHED-LEVEL RUNOFF CONTROL PHILOSOPHY AND PERFORMANCE STANDARDS FOR THE CONTROL OF STORMWATER RUNOFF FROM NEW DEVELOPMENT

Earlier chapters identified the impacts of new development on stormwater runoff. This chapter will identify the performance standards or goals which need to be met for the watersheds to minimize the adverse stormwater impacts of new development. The method used to determine the performance standards was two-fold. A statistical analysis of annual rainfall and the existing water balance was used to determine criteria for water quality and maximum direct groundwater recharge. Additionally, a detailed hydrologic model was developed to "stress" the watershed under various design conditions to evaluate peak rate control options. The specific computer model used was HEC-HMS because it provides acceptable hydraulic and hydrologic accuracy, can utilize multiple computational methodologies, produces total runoff hydrographs rather than individual peaks, and is compatible with current LVPC computer hardware and operating systems.

A. Existing Water Balance Preservation Philosophy

1. Determining the Water Quality Volume

The Water Quality Volume is intended as the volume of runoff that is required to be captured and treated to mitigate the water quality impacts of development activities. The strategy to meet this objective is outlined below including the historical aspects of water quality volume consideration.

In previous Act 167 Plans prepared by the LVPC, we have used two different methods to calculate the water quality volume (WQv): the incremental 2-year runoff volume, based on the 24-hour, 2-year return period storm, and a rational method-based formula using the post-development coefficient and a rainfall depth of 1.25 inches. The greater of these two volumes was used; however, it was capped at a maximum volume equal to 1.25 inches of runoff over the entire site. The 1.25 inches represents the rainfall depth associated with 90% of the annual rainfall in the Lehigh Valley. Stated otherwise, if all rainfall up to and including a 1.25 inch storm plus the first 1.25 inches of larger storms is counted, it represents 90% of all annual rainfall. As documented in the *Little Lehigh Creek Water Quality Update, May 2004* and the *"Global" Water Quality Update, April 2006,* this water quality volume was intended as the maximum volume that required capture and treatment to remove water quality contaminants. DEP uses a standard that requires the entire incremental 2-year runoff volume to be controlled such that the volume leaving the site does not increase with development for the 2-year storm. From a rainfall capture perspective, a 2-year, 24-hour storm of 3.0 inches represents about 99% of annual rainfall. This is a rather strict water quality volume control. One reason for its strictness is that it is not simply intended as a volume that needs to be treated to remove contaminants. It is apparently based on a concern that increased runoff volume with development, even if managed through a release rate approach, still may cause increases in flooding downstream. It is also in part based on the concern for erosion of downstream channels. Bankfull conditions for natural channels are typically based on about a 2-year return period. Therefore, this return period is key to defining erosion for receiving channels. If 2-year runoff volumes do not increase and release rates ensure peak flow rates don't increase with development, downstream channels would presumably be protected from erosion. Previous LVPC model Act 167 ordinances have used a 30% 2-year release rate as a channel protection standard. From an annual water balance perspective, the difference between a water quality volume based on a 3.0 inch rainfall versus a 1.25 inch rainfall is only about 9% (99% - 90%). However, from a Best Management Practice (BMP) volume perspective, a 3.0 inch rainfall standard would produce about twice the needed volume as a 1.25 inch rainfall standard. At first, this would seem to create higher runoff control costs for a developer. This would be true if the only requirements for runoff control were for water quality purposes. However, the basic Act 167 ordinance requires runoff control for the 2-year through 100-year return period runoff events. This means that the more strict (i.e. 3.0 inch event) requirement for water quality purposes may not have any bearing on the control cost to a developer that needs to manage runoff up through the 100-year return period (i.e. 7.5 inch event). In fact, a design example created by the LVPC found no appreciable difference in the amount of stormwater management storage volume required for the 100-year control whether 1.25 inches or 3.0 inches was used for determining the water quality volume. Since one of our goals with updating the water quality standards is to achieve greater consistency with DEP standards, and since this will not add any significant cost to the developer, this Plan includes the 2-year incremental runoff volume as the WQv. Further, 25 Pa. Code Chapter 96.3 requires that Water Quality Standards shall be achieved in surface waters 99% of the time, and capturing and treating the increase in runoff associated with the 2-year, 24-hour rainfall event is consistent with these requirements.

There are multiple methods to calculate the 2-year incremental volume, all of which produce slightly different results. There are two ways to use the soil-cover-complex method (discussed in more detail below in Section C.2.b) to calculate the WQv. The first is the correct application of the method: to calculate runoff from pervious and impervious areas separately. The other method is to use a single area-weighted runoff curve number (CN) based on land cover. These two implementations of the same method produce significantly different results: nearly 50% for lower values of CN (65-70). The only places the two values converge are at CN values of 61 and 98: 0% and 100% impervious, respectively. DEP will only accept the "split" approach, so there is not a compelling reason to allow the less conservative weighted CN approach for calculating the WQv. The other method would be to use a Rational Method with a 3.0 inch rainfall depth applied to pre- and post-development conditions. At larger values of CN, this volume ends up being much less than the split CN volume. However, at lower values of CN (<80), the Rational volume is more than 80% of the TR-55 volumes, and that difference goes to zero as impervious cover goes to zero. In this Plan and Ordinance, both a curve number methodology and the Rational Method are available to designers, so both methods of water quality volume calculation are allowed. If using the CN method, calculating pervious and impervious area separately is required to implement the method correctly to calculate the WQv and BMP tributary area volumes.

2. Determining the Existing Water Balance

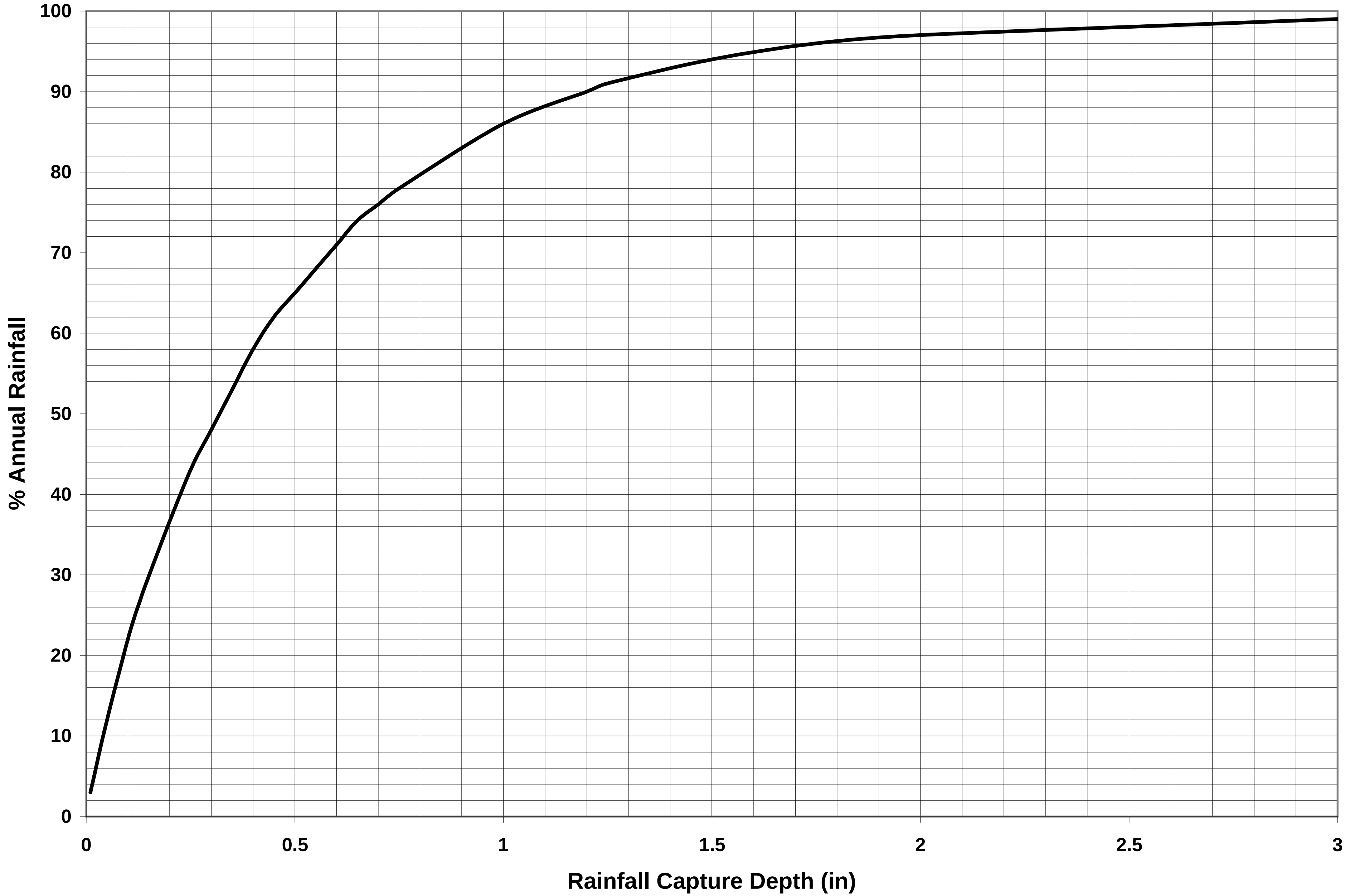
As stated above, control of the water quality volume will require a development plan to severely restrict the runoff leaving the site for storms up to and including the 2-year return period event. On an annual water balance basis, the 3.0 inch rainfall depth for the 2-year event represents a rainfall capture of more than 99% of annual rainfall based on LVPC analysis of rainfall records from Allentown, Pennsylvania. The end result of the standard is to very significantly reduce runoff on an annual basis. Post-development runoff then must either be recharged or returned to the atmosphere through evapotranspiration. If ordinances don't place limits on recharge, virtually the entire annual rainfall could result in direct recharge to groundwater. This is specifically problematic in carbonate bedrock areas, but can be problematic in any geologic setting in terms of upsetting the natural water balance.

A key to preventing situations where groundwater recharge would be greatly increased due to development, possibly with detrimental side effects, is to attempt to quantify the eventual fate of rainfall in the pre-development condition, be it runoff, recharge, or evapotranspiration. Pre-development or natural or existing water balance can be inferred from various sources, including the *Technical Best Management Practice Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain By Carbonate Bedrock within the Little Lehigh Creek Watershed*, LVPC 2002, as well as data prepared by the LVPC for the Monocacy and Jordan creeks based on stream gage analyses. Consistently through these sources, groundwater recharge is about 30% of annual rainfall while runoff ranges from approximately 10-20%. Based on this data, we can make the following generalization about the fate of rainfall in the "natural" condition:

Runoff – 10% of annual rainfall
Recharge – 30% of annual rainfall
ET – 60% of annual rainfall

As stated above, over 99% of all annual rainfall is included if you capture the 3.0 inches of rainfall associated with a 2-year, 24-hour storm. Figure 9 shows the non-linear relationship between rainfall capture depth and percent annual rainfall. This graph is based on capturing all the rainfall in storms up to and including the listed depth plus the listed depth of larger storms. From the graph, a 0.1 inch capture depth translates into 22% of annual rainfall. A 0.5 inch capture depth includes 65% of annual rainfall. A 3.0 inch capture depth (2-year storm) is slightly greater than 99% of annual rainfall. The key idea from the chart is that very small rainfall capture volumes will have a very large influence on annual water balance.

FIGURE 9
PERCENT ANNUAL RAINFALL VERSUS RAINFALL CAPTURE DEPTH



The most critical aspect for determining post-development water balance is the fate of runoff produced by impervious surfaces as passed through various BMPs. Impervious surfaces produce a well understood "transform" of rainfall to runoff such that most rainfall will become runoff. The change from pervious cover to impervious cover with development can dramatically alter peak runoff rate and runoff volume. BMPs can be employed to manage rate and volume impacts, but the annual water balance implications of those choices may not be considered. There is very little available data on BMP water balance. However, we can begin with some very simple rules to classify BMPs by the predominant fate of runoff. BMPs that primarily provide an opportunity for evapotranspiration (ET) through a vegetative layer are ET BMPs. BMPs that initially direct runoff to an underground infiltration surface are direct recharge (D-RE) BMPs. BMPs that mainly pass runoff volume through such that the volume leaves the BMP as runoff are runoff (RO) BMPs. BMPs can then be classified as evapotranspiration (ET), direct recharge (D-RE), or runoff (RO) BMPs on the basis of the predominant fate of runoff.

Again, we have a relatively clear understanding of the rainfall/runoff response of impervious areas. Pervious areas are also important for annual water balance purposes, but our level of understanding is not as clear. In the pre-development condition, pervious areas probably have an annual water balance representative of the stream gage data presented above, where 60% of annual rainfall becomes ET, 30% becomes recharge, and 10% becomes runoff. However, in the post-development condition soil compaction by heavy equipment probably changes the annual water balance even for proposed pervious areas (i.e. lawns). For purposes of this Plan, the following assessment has been made of pervious areas pre- and post-development. If the natural landscape produces ET, RE and RO in portions of 60%, 30% and 10% of the annual water balance, this translates from Figure 9 into a capture volume of 1.25 inches of annual rainfall since at this point 90% is captured and 10% is runoff. In the post-development case, with the assumption that compacted soil areas would be covered with at least a few inches of topsoil and seeded with grass, the grass and topsoil combination should at least be able to capture the first 0.5 inches of precipitation, thereby producing a 70% rainfall capture with 30% left as runoff. In this simple illustration, runoff would triple from pre- to post-development conditions for these pervious areas on an annual water balance basis. This will be the operating rule for this Plan for water balance purposes. Note that we're not making any judgment how this reflects design storm events of 2- through 100-year return period. These are more severe events than the storms of 3.0 inches or less that are important for annual water balance.

The first step in BMP deployment for a site can be based on what areas don't need BMP controls to meet annual water balance objectives. To preserve the existing water balance, part of the site could be allowed to bypass the BMPs to attempt to maintain existing runoff levels. Additionally, moving toward the goal of having 10% of annual rainfall leave the site as runoff, a significant portion of the site as lawn area can bypass the BMPs. Simply stated, if the whole site was lawn post-development and if lawn was considered equal to pre-development meadow, no BMPs would be needed and 100% of the site could be “bypass” flow to meet pre-development runoff volume. Owing to soil compaction on the site with development and our operating rule regarding water balance characteristics, it is conservatively estimated that only one-third of the site could be discharged as lawn bypassing BMPs. It would still be possible to control the WQv without needing to retain the entire site runoff volume, so this bypass standard should not conflict with the water quality volume requirements of the ordinance.

For an assessment of the fate of runoff directed to BMPs, we need operating rules for how each type of BMP translates runoff received into ET, RE and/or RO. Two of the rules are quite simple. For RO BMPs, all water directed to them will be assumed to be eventually released as runoff. For D-RE BMPs, all water directed to them will be assumed to be released as recharge. ET BMPs are different. Water directed to ET BMPs clearly will have some fraction of the water become evapotranspiration. Some fraction of the water directed to them is also intended to be recharged. Again, our operating rule is the simplest we can make. ET BMPs are assumed to distribute water directed to them in a way that mimics the natural landscape. That is, the natural landscape produces 60% ET, 30% RE and 10% RO. The 10% RO is, in effect, not captured by the natural landscape and runs off. The captured rainfall is split two-thirds to ET and one-third to RE. Therefore, all runoff that is intended to be captured by an ET BMP will be assumed to be distributed as 2/3 ET and 1/3 RE. With this in mind, impervious areas of a site directed to ET BMPs should closely reproduce a natural water balance. Runoff volume released from a site is restricted by the incremental 2-year return period water quality volume standard such that only about 10% of proposed impervious could be directed solely to RO BMPs. Since almost all runoff directed to D-RE BMPs becomes recharge, only about one-third of proposed impervious (owing to some ET off pavement) could be discharged to D-RE BMPs to preserve annual water balance.

Referring back to the proposed water quality volume, the change in 2-year runoff volume with development may not leave the site as runoff and must therefore be directed to some combination of ET and/or D-RE BMPs. Since the water quality volume will mostly reflect the creation of impervious surfaces, this means that most proposed impervious cover will need to be directed to ET and/or D-RE BMPs. For a 2-year return period storm, the runoff produced from impervious surfaces is about 90% of rainfall based on curve number or rational method approaches. If we use this for water balance purposes also and we ignore runoff because it’s less than 10% of annual rainfall, the range of ET and RE we get from impervious areas directed to ET and/or D-RE BMPs is about 70% ET/30% RE if using exclusively ET BMPs, to 10% ET/90% RE if using exclusively D-RE BMPs. Again, ET BMPs mimic natural conditions and D-RE BMPs create higher than natural recharge. It seems clear some restriction of the use of D-RE BMPs is appropriate to maintain annual water balance near natural conditions. The challenge is to use an appropriate standard that takes advantage of the most sound technical justification possible and properly manages the uncertainties involved in the process toward a reasonable design goal.

The best data we seem to have is: natural recharge is about 30% of annual rainfall, the understanding that BMPs that employ an underground infiltration surface will recharge almost all runoff directed to them, and the rainfall to runoff response for impervious areas is much better understood than for pervious areas. We further know that any pervious areas directed to D-RE BMPs will increase annual water balance recharge above that of the impervious areas being recharged. With the water quality volume standard as the 2-year change in runoff volume, we also believe that capturing that volume with ET BMPs exclusively will about match natural RE, and any use of D-RE BMPs will increase RE above the natural conditions. The standard proposed in this Plan is that direct recharge of runoff from impervious areas by employing D-RE BMPs shall be limited to 30% of the site's annual rainfall. This translates into a maximum of one third of the site as impervious being directed to D-RE BMPs when designed to capture the full 2-year event. Any sites with less than 33% impervious cover proposed would be exempt from this water balance standard. D-RE BMPs designed to capture less than the full 2-year event can direct more site impervious to these BMPs. Figure 10 shows the design curves for implementing this standard from a rainfall capture perspective for capture volumes of 0.0 to 3.0 inches. Since the BMP design storage is a function of percent annual rainfall and the RO fraction, we can create a curve to solve for the maximum storage volume allowable for a given percent impervious and percent D-RE. However, this assumes that runoff will first flow into a D-RE BMP and then flow into an ET BMP downstream when the storage volume is exceeded. Of course, this is not always the case. Sites may be designed to drain to an ET BMP first and overflow downstream into a D-RE facility. Based on the design storage volume of the ET BMP, we can calculate the amount of D-RE that occurs from the overflow into the downstream D-RE BMP. These curves, along with instructions for their application, are included in Appendix C of the ordinance.

Given this data, the proposed water quality standards are as follows:

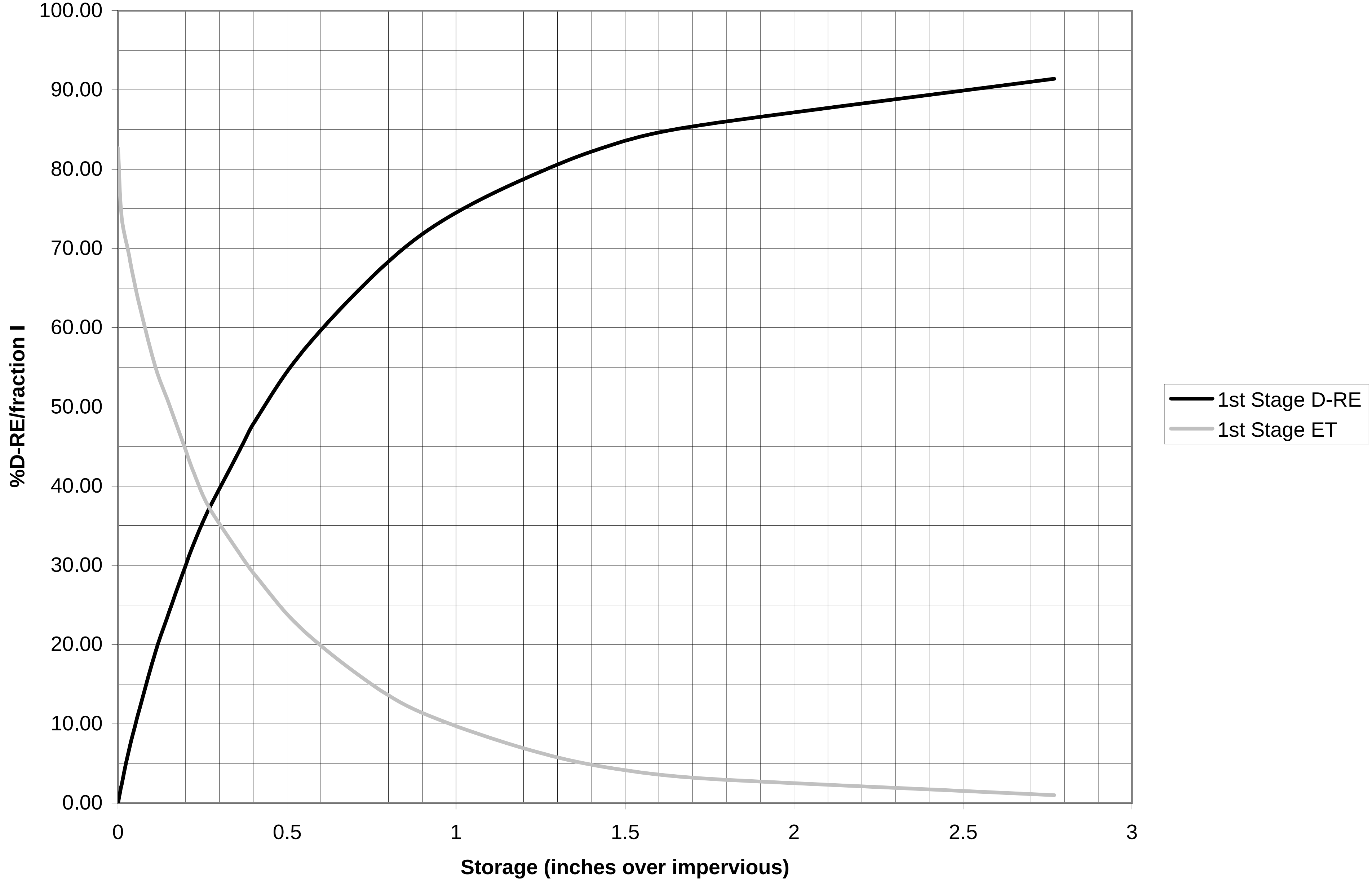
a.) The entire water quality volume shall be captured and treated by either D-RE or ET BMPs.

b.) Lawn area up to a maximum of 33% of the entire site area may be allowed to bypass water quality BMPs. As much proposed impervious area as practical shall be directed to water quality BMPs.

c.) Existing impervious area that is not proposed to be treated by D-RE BMPs should be excluded from all water balance calculations.

d.) A maximum of 30% of the total annual rainfall for a site may be directly recharged to groundwater using direct recharge (D-RE) BMPs for runoff from impervious areas.

FIGURE 10
PERCENT DIRECT RECHARGE (D-RE) PER FRACTION IMPERVIOUS VERSUS STORAGE



i.) For development sites with greater than 33% proposed impervious cover:

(1) If all impervious cover is directed to ET BMPs to capture the full 2-year event, the D-RE standard is met.

(2) Up to 33% of the site as impervious cover may be directed to D-RE BMPs designed to capture the full 2-year event. All remaining impervious cover shall be directed to ET BMPs designed to capture the remainder of the WQv.

(3) For ET and/or D-RE BMPs designed for runoff from impervious areas designed to capture less than the full 2-year event, Appendix C shall be used to assure that the maximum D-RE standard is met.

ii.) For development sites with less than 33% proposed impervious cover, all proposed impervious and the entire WQv may be directed to D-RE BMPs.

iii.) The maximum 30% D-RE standard applies on an overall site basis, rather than in each individual drainage direction.

B. Watershed-Level Runoff Control Philosophy

1. Watersheds Modeled Using HEC-HMS

Within the Sacony Creek Headwaters, there are five drainage areas which were modeled using HEC-HMS. The five drainage areas are the Mill Creek mainstem and four unnamed tributaries to the Mill Creek. The following text refers to the process and the data used in modeling the five drainage areas. Sections B and C describe the theory behind the modeling approach, as well as the methods and standards used to verify it.

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 the post-development peak runoff rates to pre-development level 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 volume generated by development of the site. The proposed watershed-level runoff control philosophy is based on the assumption that runoff volumes will increase somewhat with development. This will be partially mitigated by the proposed water quality standards, which would eliminate the potential increase in runoff volume associated with the 2-year event with development. However, larger events would still create additional runoff volume post-development. The watershed-level philosophy, rather than necessarily attempting to reduce post-development volume across *all* return periods, seeks to "manage" the increase in volume such that peak rates of runoff throughout a watershed are not increased for any storm event. Note that although Act 167 would permit standards to be created to reduce overall peak flows with development; the standards of this Plan are created to maintain existing peak flows.

The basic goal of both the at-site and watershed-level philosophies is the same — no increase in the peak rate of runoff. However, the end products can be very different as illustrated in the following simplified example.

Presented in Figure 11 is a typical at-site runoff control strategy for dealing with the increase in peak rate of runoff with development. The "Existing Condition" curve represents the pre-development runoff hydrograph. The "Developed Condition" hydrograph portrays three important changes in the site runoff response with development: a higher peak rate, a shorter time until the peak occurs, and an increase in total runoff volume. The "Controlled Developed Condition" hydrograph is based on limiting the post-development runoff peak to the pre-development level through the use of detention facilities. The impact of "squashing" the post-development runoff to the pre-development peak is that the peak rate occurs over a much longer period of time. The instantaneous pre-development peak has become an extended peak (approximately two hours long in this example) under the Controlled Developed Condition.

At-site, the maintenance of the pre-development peak rate of runoff is an effective management approach. However, the potential detrimental impact of the approach is illustrated in Figures 12 and 13. Figure 12 represents the existing hydrograph at the point of confluence of Watershed A and Watershed B. The timing relationship of the watersheds is such that Watershed A peaks more quickly (at time t_{PA}), while Watershed B peaks more slowly (at time t_{PB}). Watershed A is an area of significant development pressure and all new development proposals are met with the at-site runoff control philosophy as depicted in Figure 11. The eventual end product of Watershed A development under the "Controlled" Runoff Condition is an extended peak rate of runoff as shown in Figure 13. The extended Watershed A peak occurs long enough so that it coincides with the peak of Watershed B. Since the total hydrograph at the confluence is the sum of A and B, the total hydrograph peak must increase under these conditions to the "Controlled" Total Hydrograph. The conclusion from the above example is that simply controlling peak rates of runoff at-site does not guarantee an effective watershed-level control because of the increase in total runoff volume.

FIGURE 11
TYPICAL "AT-SITE" RUNOFF CONTROL PHILOSOPHY

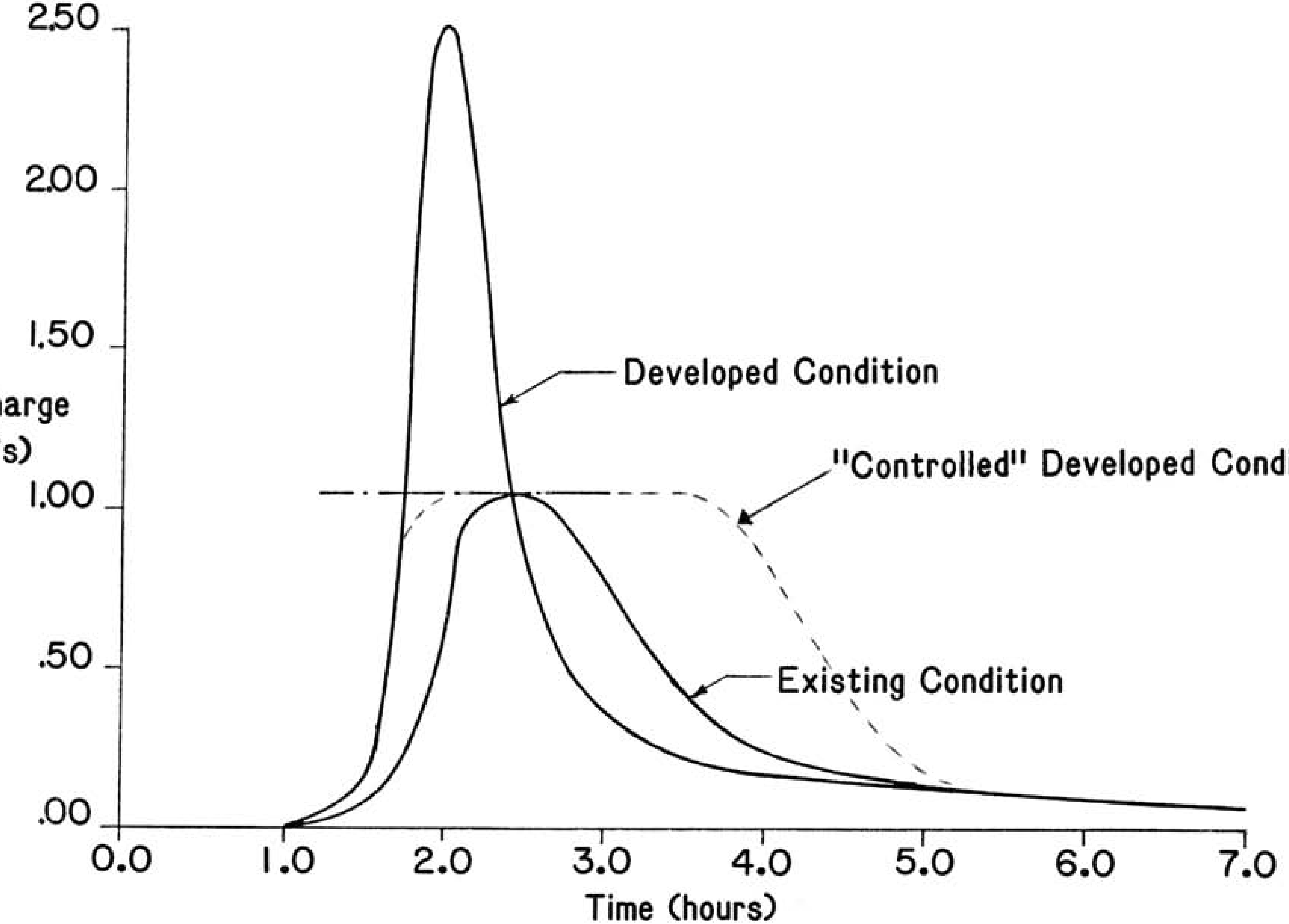


FIGURE 12
EXISTING RUNOFF CONDITION

Pre-Development

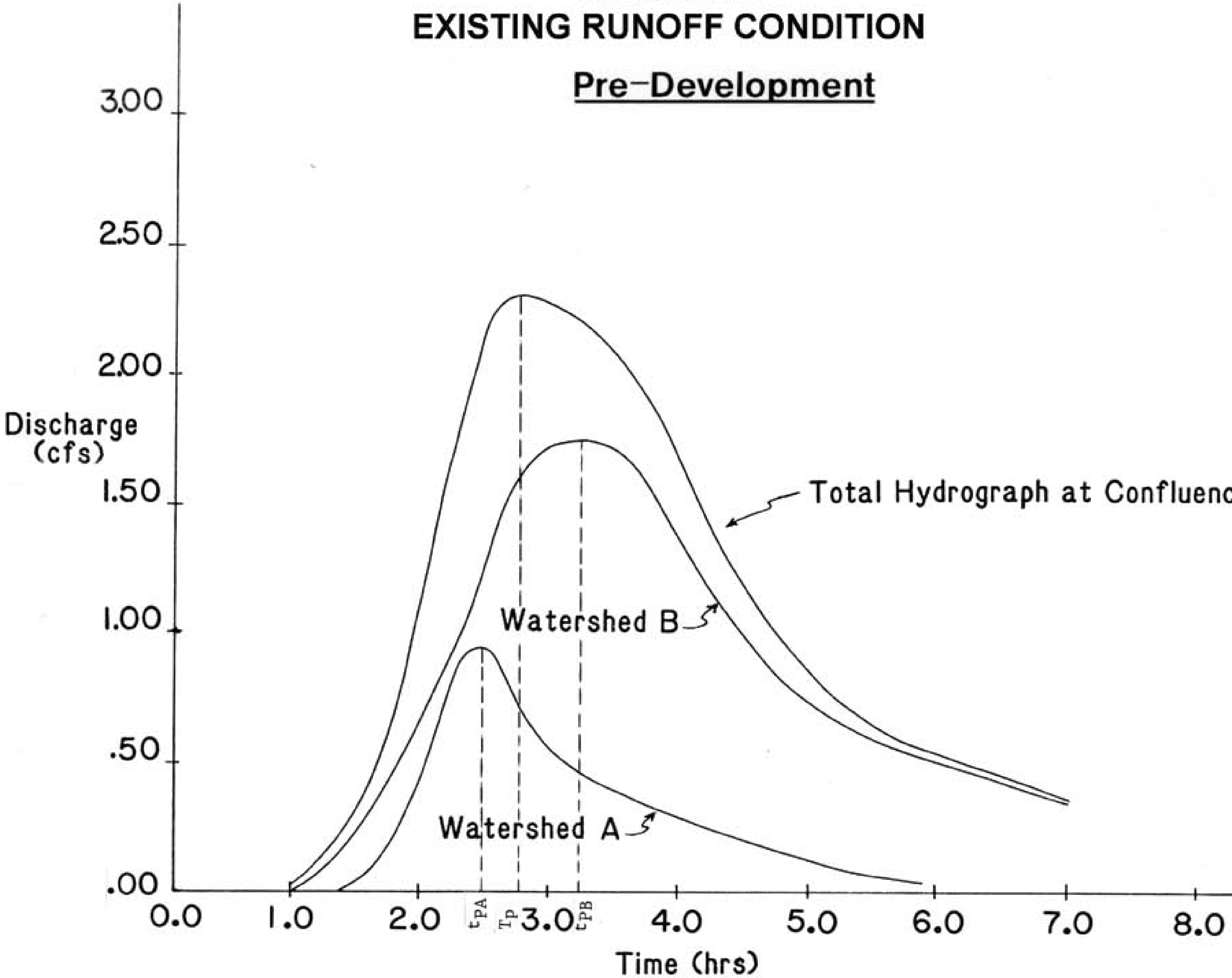
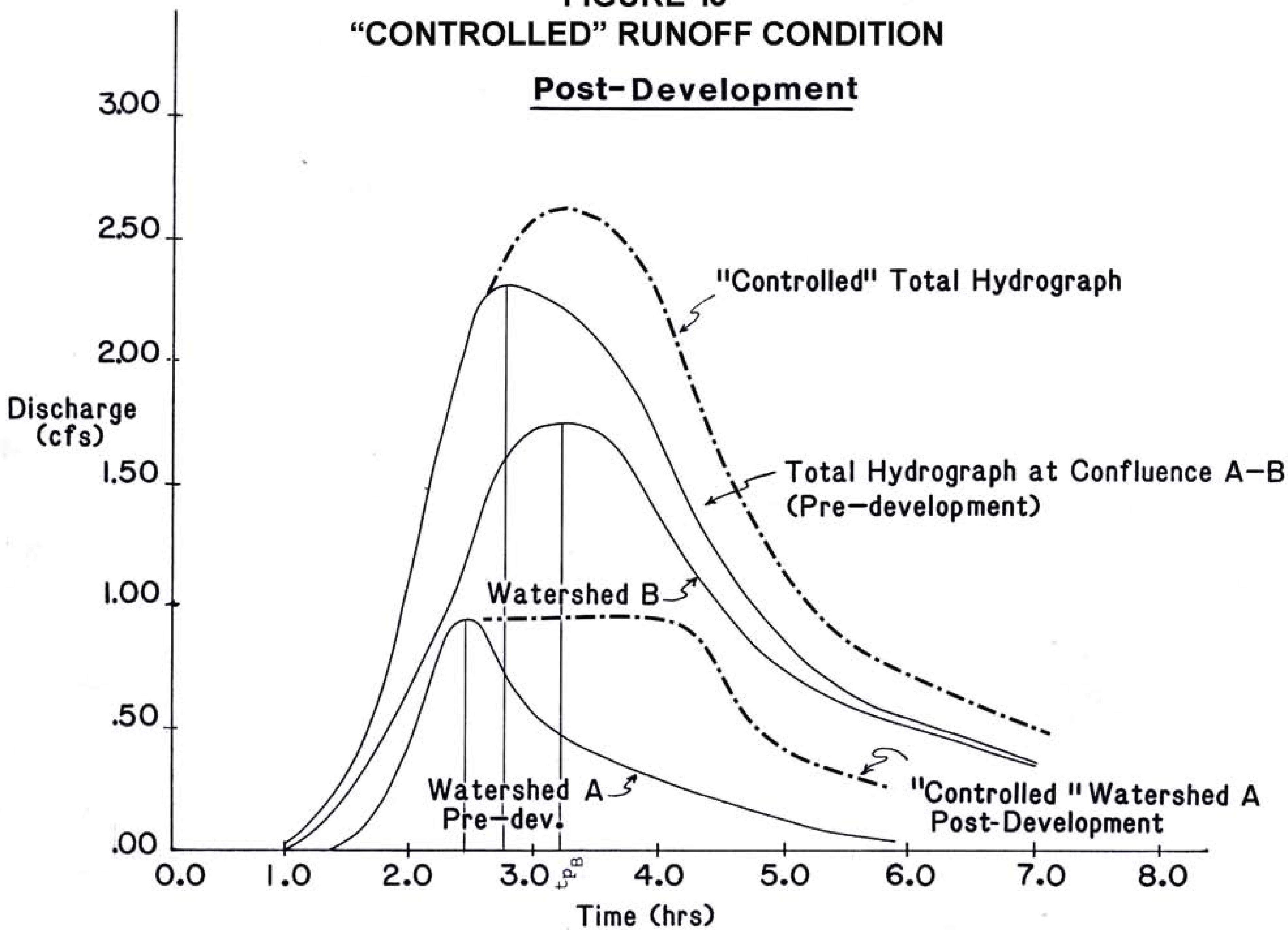


FIGURE 13
"CONTROLLED" RUNOFF CONDITION

Post-Development



a.) Release Rate Concept

The previous example indicated that 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 from development. The critical runoff control criteria for a given site or watershed area is not necessarily its own pre-development peak rate or runoff, but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest. The concept is best explained through the use of a few simplified charts.

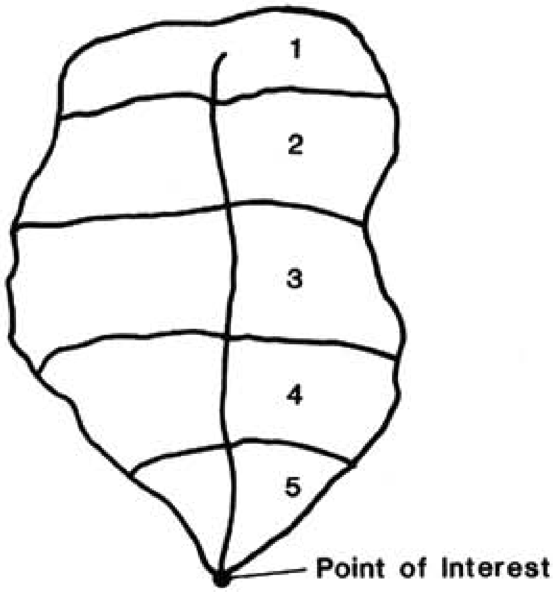
Figure 14 indicates how the individual runoff contributions from a number of sites or watersheds create the total hydrograph to a particular point. Areas 1 through 5 each have a particular runoff response to a given rainfall event (i.e. each will generate a characteristic hydrograph). Note that the configuration of the watershed is such that all areas will contribute runoff to the point of interest at the downstream end of area 5. However, the five areas do not contribute at the same time. 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. Therefore, the contribution of each area to the hydrograph at the point of interest 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 14.

The release rate concept is perhaps best described by looking at how area 4 contributes to the hydrograph at the point of interest. Figure 15 shows the total hydrograph from Figure 14 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 15 are the possible outcomes of development occurring in area 4.

Specifically, the possible area 4 hydrograph assuming development occurs with no stormwater 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 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

FIGURE 14
"POINT OF INTEREST" HYDROGRAPH ANALYSIS EXAMPLE

Watershed Configuration



Hydrograph Components at Point of Interest

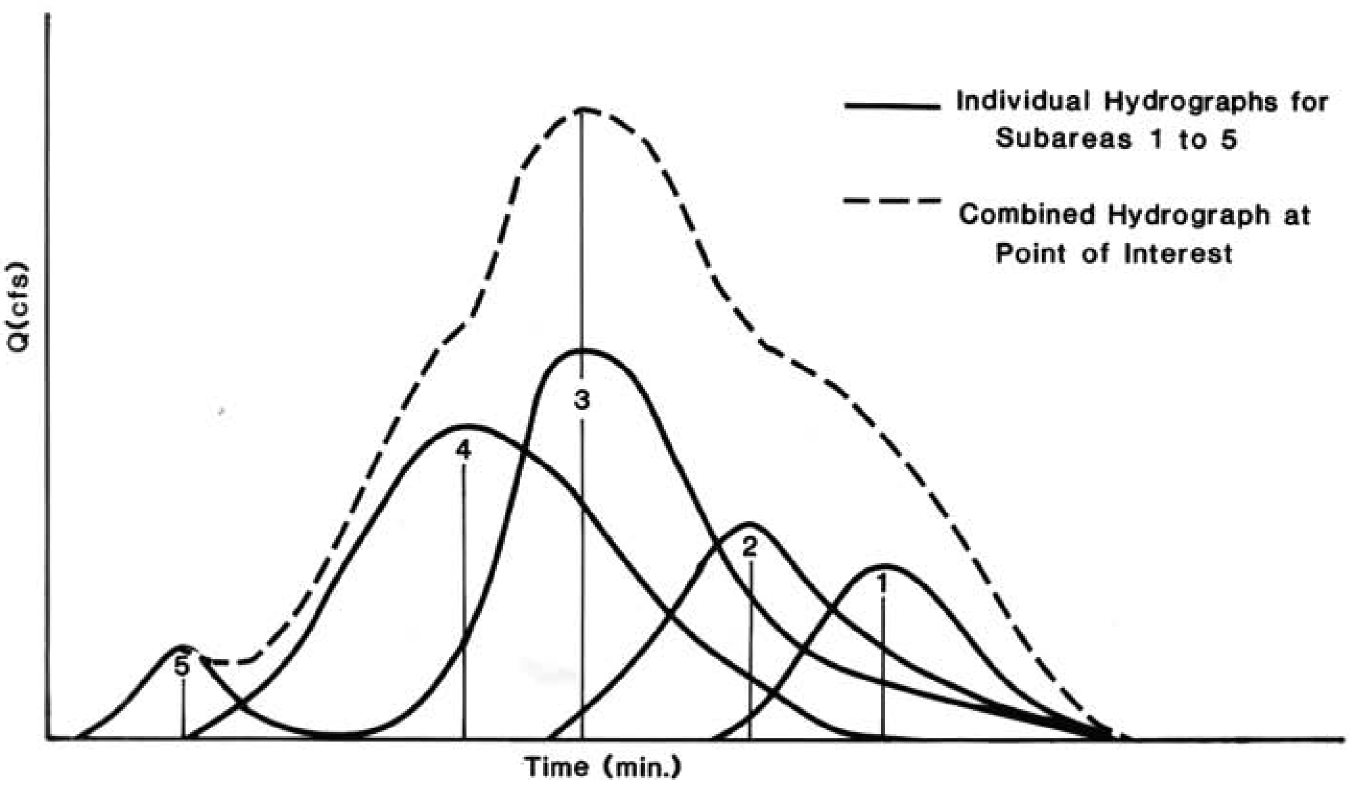
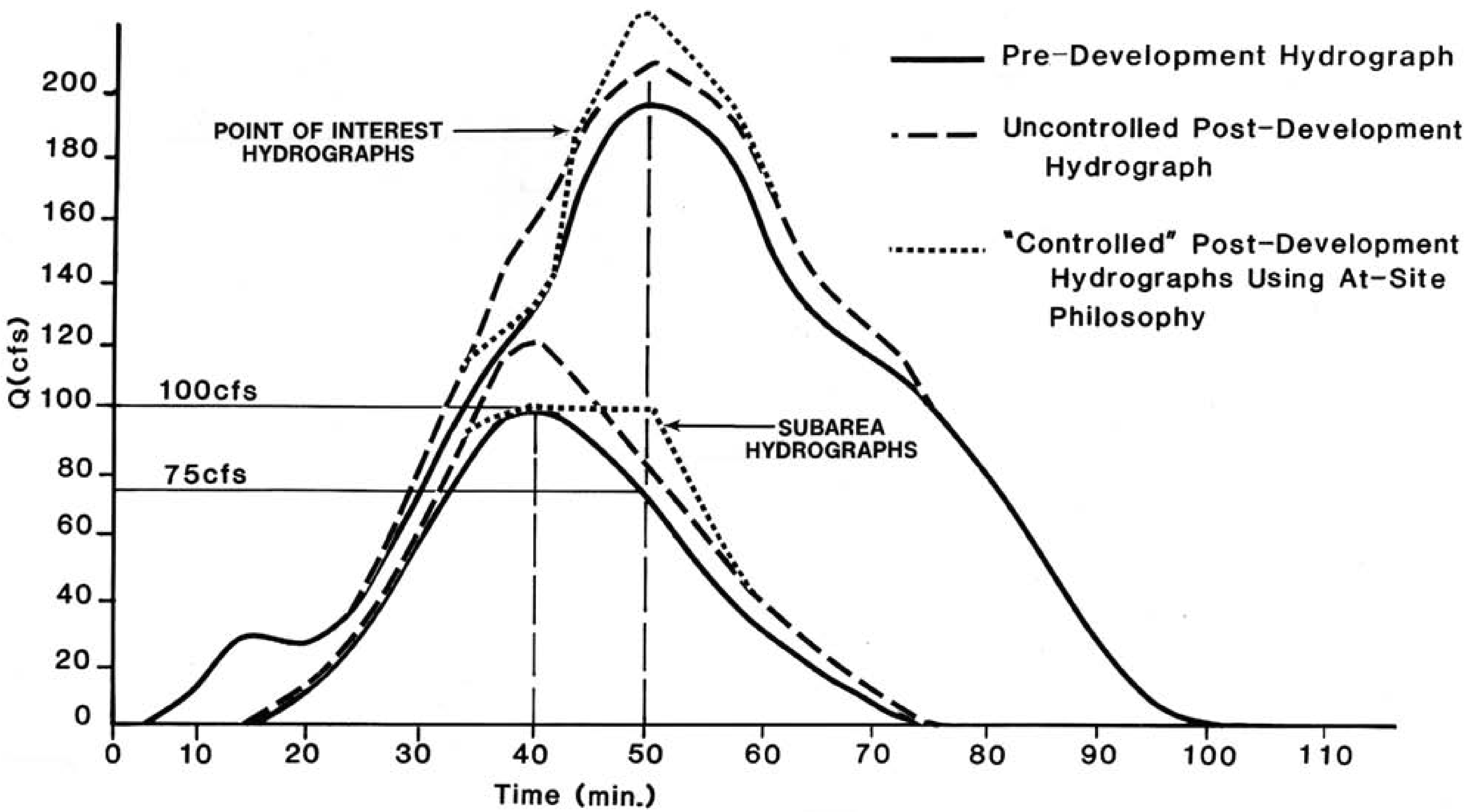


FIGURE 15
HYDROGRAPH ANALYSIS FOR EXAMPLE SUBAREA 4



75% of the 100 cfs peak flow from area 4. This is the basis for the release rate concept.

Conventional at-site detention philosophy would control post-development peak runoff flows to 100% of pre-development level. 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 the pre-development levels as illustrated in Figure 16. 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 14 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 in the following section.

b.) Runoff Control Strategy Categorization

The five drainage areas of the previous example, beginning with Figure 14, each contribute to the runoff at the point of interest in a different manner as outlined below:

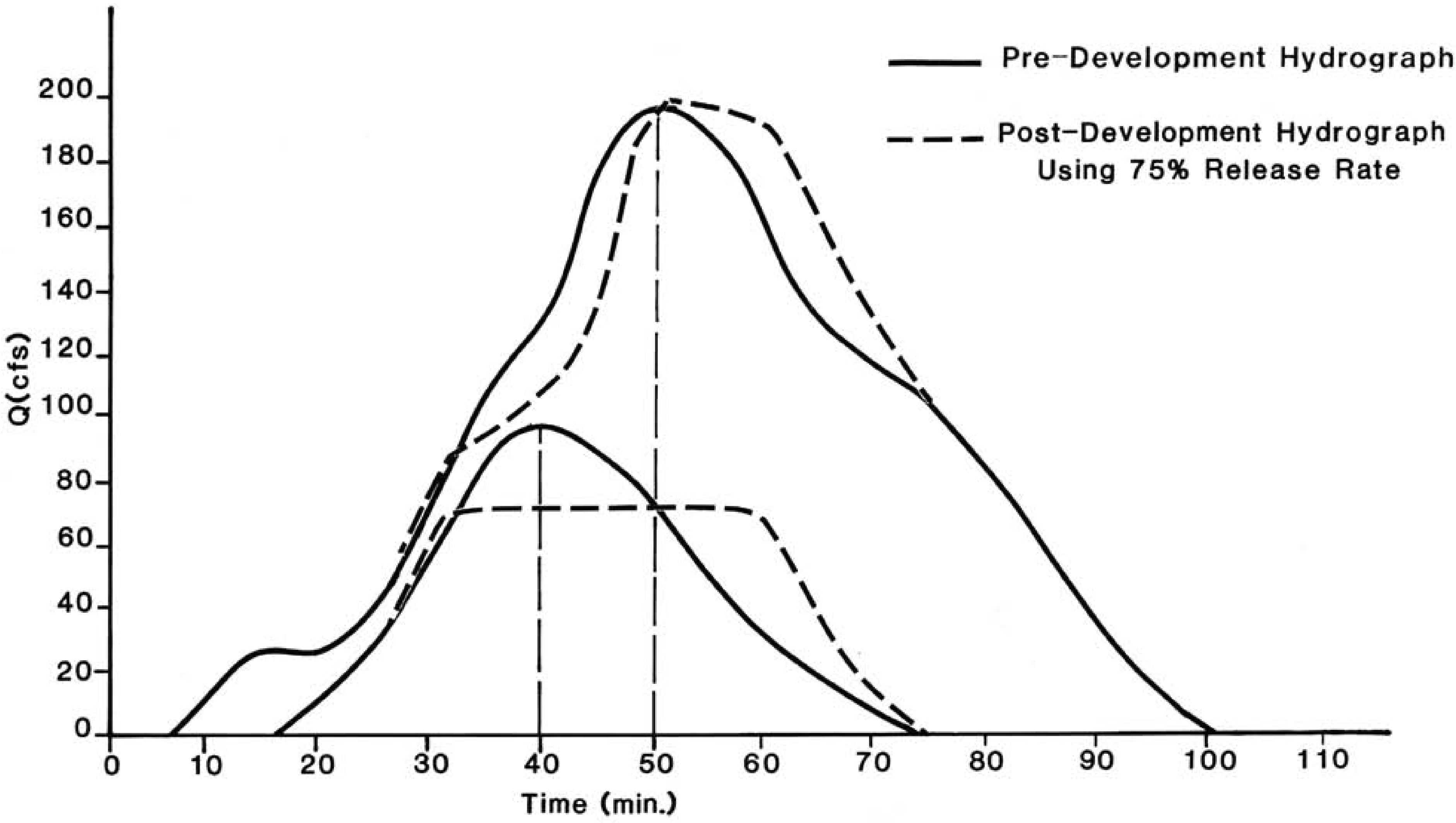
Area 1: Due to its very long travel time, area 1 peaks later than the point of interest peak and does not contribute any runoff to the point of interest peak.

Area 2: Due to its long travel time, area 2 peaks later than the point of interest peak but does contribute to the point of interest peak.

Area 3: Area 3 peaks at exactly the same time as 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.

Area 4: Area 4 peaks prior to the point of interest peak and contributes runoff to the point of interest peak.

FIGURE 16
RELEASE RATE RUNOFF CONTROL FOR EXAMPLE SUBAREA 4



Area 5: Due to its proximity to the point of interest, area 5 peaks very early (before the point of interest peak) and does not contribute runoff to the point of interest peak.

Each of the above situations presents a different stormwater runoff analysis problem. In fact, each of the five areas define the five different runoff categories which need to be examined in the preparation of a watershed-level runoff control plan. The five categories, or cases, are described in the sections below.

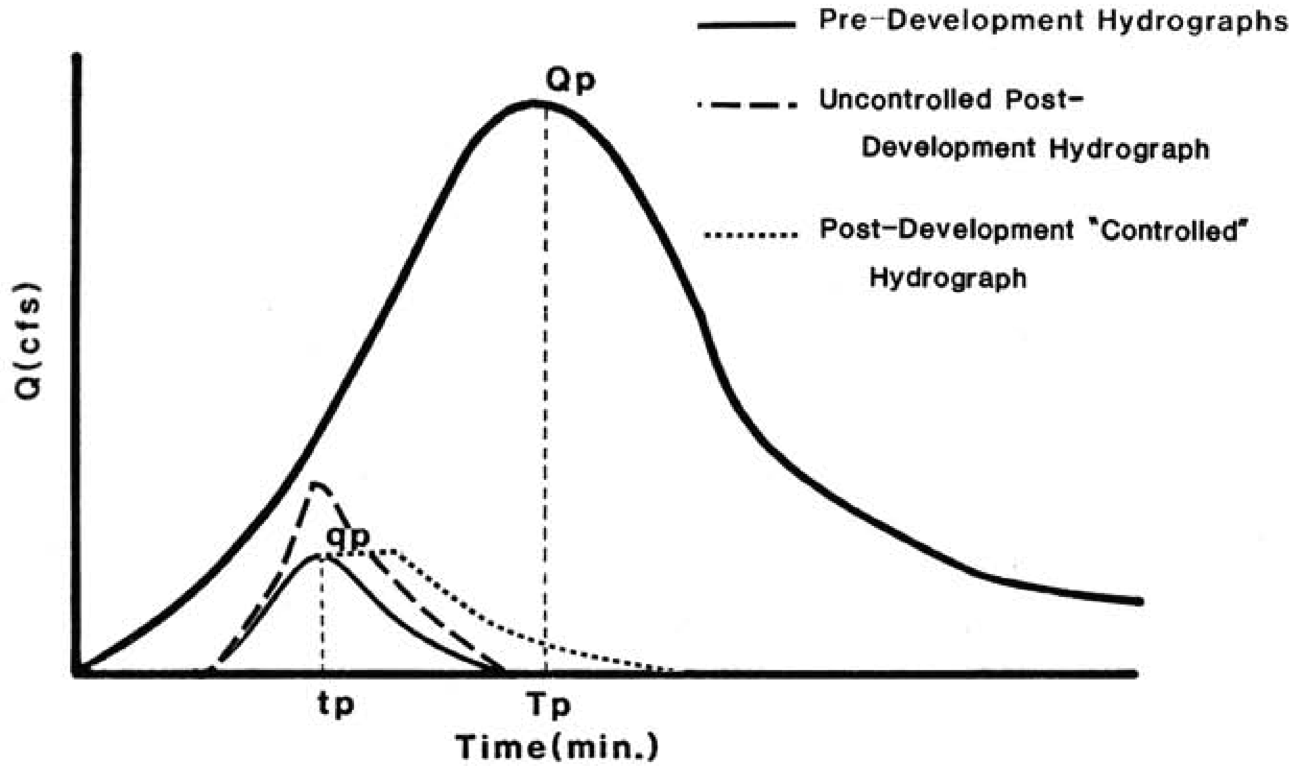
(i) Case I (Equivalent to Area 5) – Figure 17 portrays the Case I example of a drainage area which peaks prior to the point of interest peak and does not contribute to the peak flow of interest. From Figure 17, q_p and t_p are the peak flow and time to peak, respectively, of the individual drainage area, and Q_p and T_p are the peak flow and time to peak of the hydrograph at the point of interest. In addition, the value of the individual drainage area hydrograph at any point in time is specified as q @ t, where t is the time in question (e.g. q @ 0, q @ t_p, Q @ T_p = 0). Therefore, notationally, Case I is described as follows:

$$t_p < T_p \text{ and } q \ @ \ T_p = 0$$

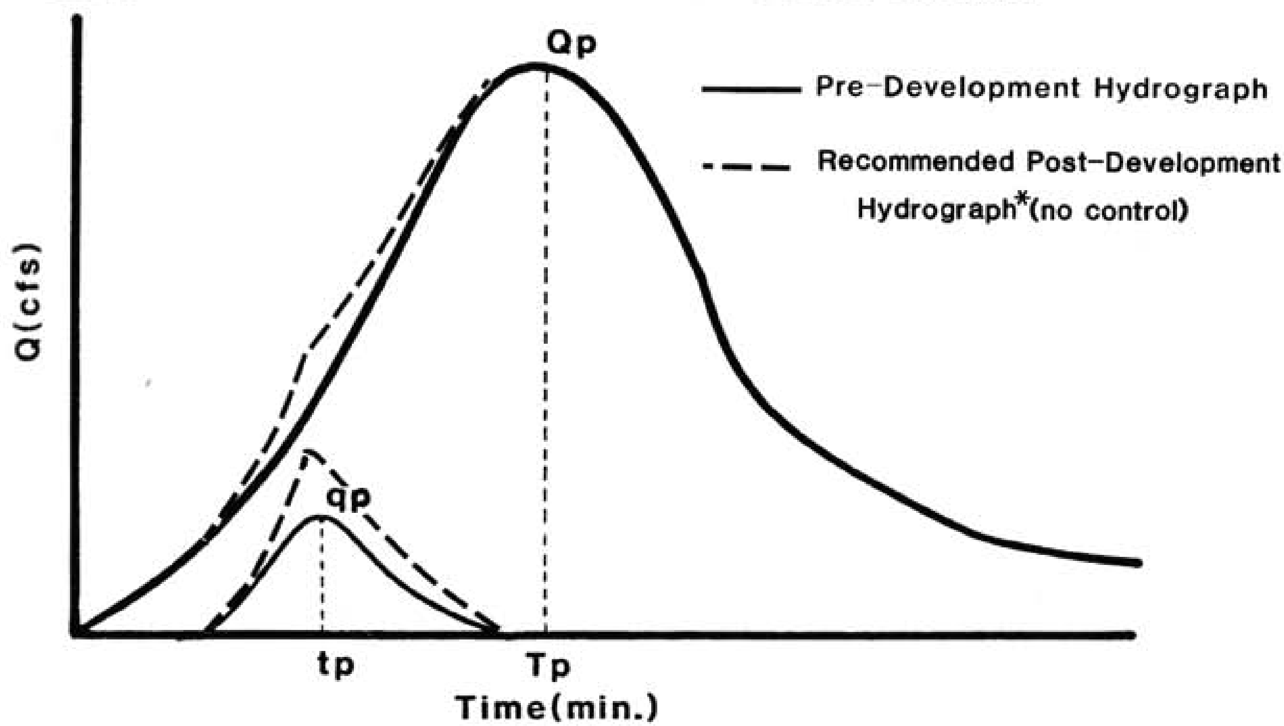
Application of the basic release rate concept to Case I would dictate a release rate of 0% corresponding to the contribution of the drainage area to the point of interest peak. Taken literally, a 0% release rate would mean that no runoff would be allowed to leave the site post-development. Obviously, this would not be a workable control, and in fact, not a necessary one. The reason is that a release rate does not have to be associated with a detention facility geared to pass a certain percentage of the pre-development peak flows. The release rate applicable to Case I is that, whatever the storm runoff control philosophy used, the contribution of the individual drainage area to the point of interest peak should be zero. The most appropriate control in this instance is no control as shown in Figure 17. Any form of detention may extend the peak flow such that the drainage area begins to contribute to the point of interest peak. Simply allowing the drainage hydrograph to peak higher and recede in an uncontrolled fashion results in a more effective approach at the point of interest. Note that the impact of the no control approach for the subarea on the point of interest hydrograph is limited to the rising portion of the hydrograph and not the peak. Therefore, the Case I runoff control philosophy would be no control at all, provided that the unrestricted runoff can be safely transported to the stream channel from each development site.

FIGURE 17
CASE I ANALYSIS CATEGORY AND RUNOFF CONTROL STRATEGY

CASE I: $t_p < T_p$ and subarea does not contribute to subwatershed peak



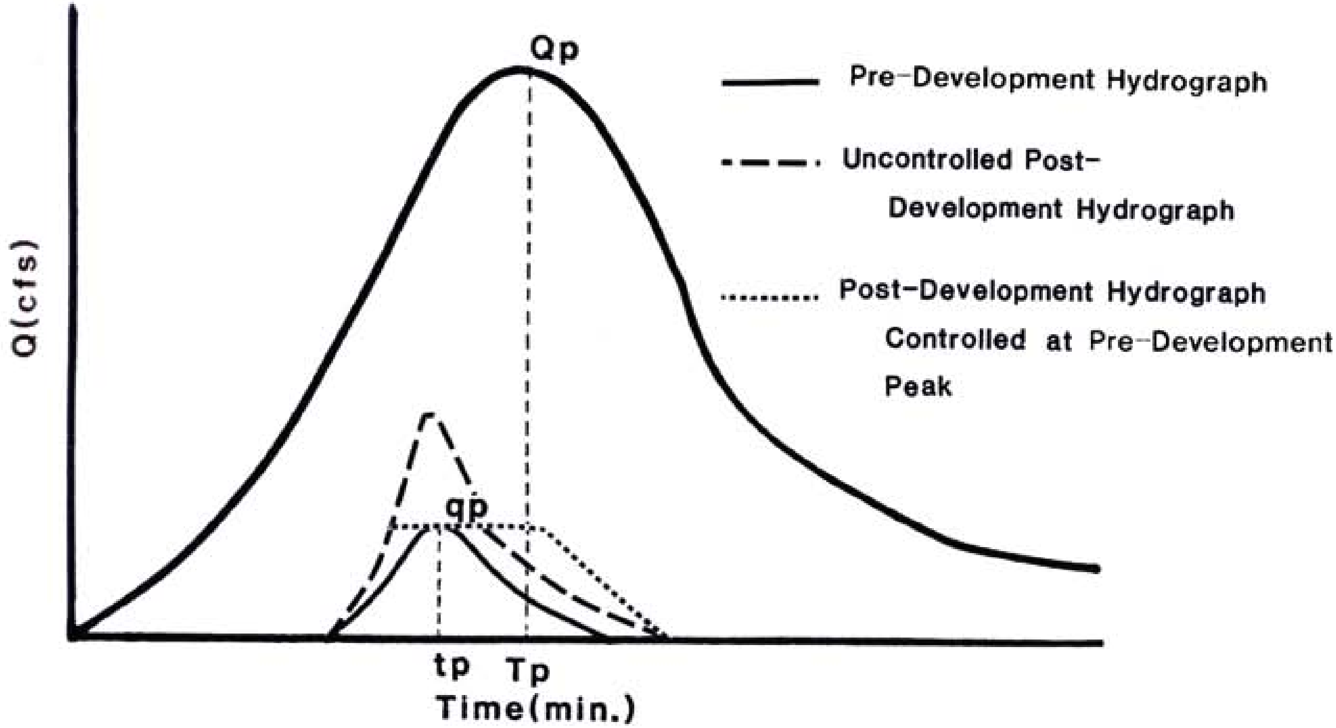
Recommended Watershed-Level Runoff Control Strategy



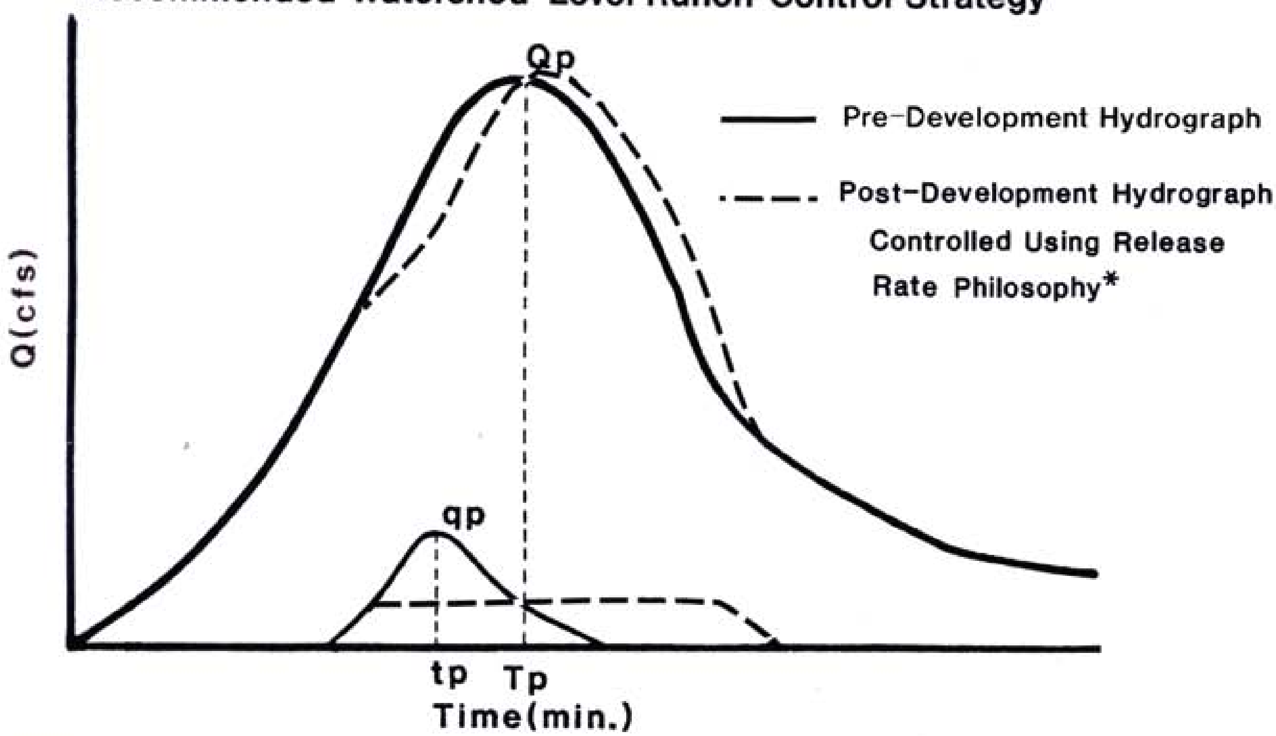
*Contingent upon ability of localized drainage network to safely convey higher peak runoff.

FIGURE 18
CASE II ANALYSIS CATEGORY AND RUNOFF CONTROL STRATEGY

CASE II: $t_p < T_p$ <u>and</u> subarea does contribute to subwatershed peak



Recommended Watershed-Level Runoff Control Strategy



*For watershed areas which fall into Case II and have very low Release Rates the Case I option would be employed. See text for additional details.

(ii) Case II (Equivalent to Area 4) – Figure 18 portrays the Case II example of an area which peaks prior to the peak at the point of interest and does contribute to the peak. Notationally, this is:

$$t_p < T_p \text{ and } q \text{ @ } T_p > 0$$

The calculated release rate for this situation could fall anywhere within the range of 1% to 99%, depending upon the difference between t_p and T_p for various drainage areas which contribute to the point of interest. A 99% release rate area represents essentially the conventional (Case III) detention philosophy of controlling to the pre-development peak rate. The 1% release rate area is essentially a Case I area where, rather than attempting to detain the runoff from new development to 1% of pre-development, a no control approach would be adopted. However, within the range of 1% to 99% the appropriate control strategy is not always clear as will be discussed in Section B.1.d.

(iii) Case III (Equivalent to Area 3) – The Case III situation is presented in Figure 19. Case III represents the simplest control strategy where the release rate is 100% since the time to peak of the drainage area equals the time to peak of the point of interest. For Case III areas, detention should be provided to ensure that post-development peak runoff does not exceed pre-development levels.

(iv) Case IV (Equivalent to Area 2) – Figure 20 displays the Case IV situation where the individual drainage area peaks later than the point of interest peak, and the individual drainage area contributes to the point of interest peak. Notationally, this is:

$$t_p > T_p \text{ and } q \text{ @ } T_p > 0$$

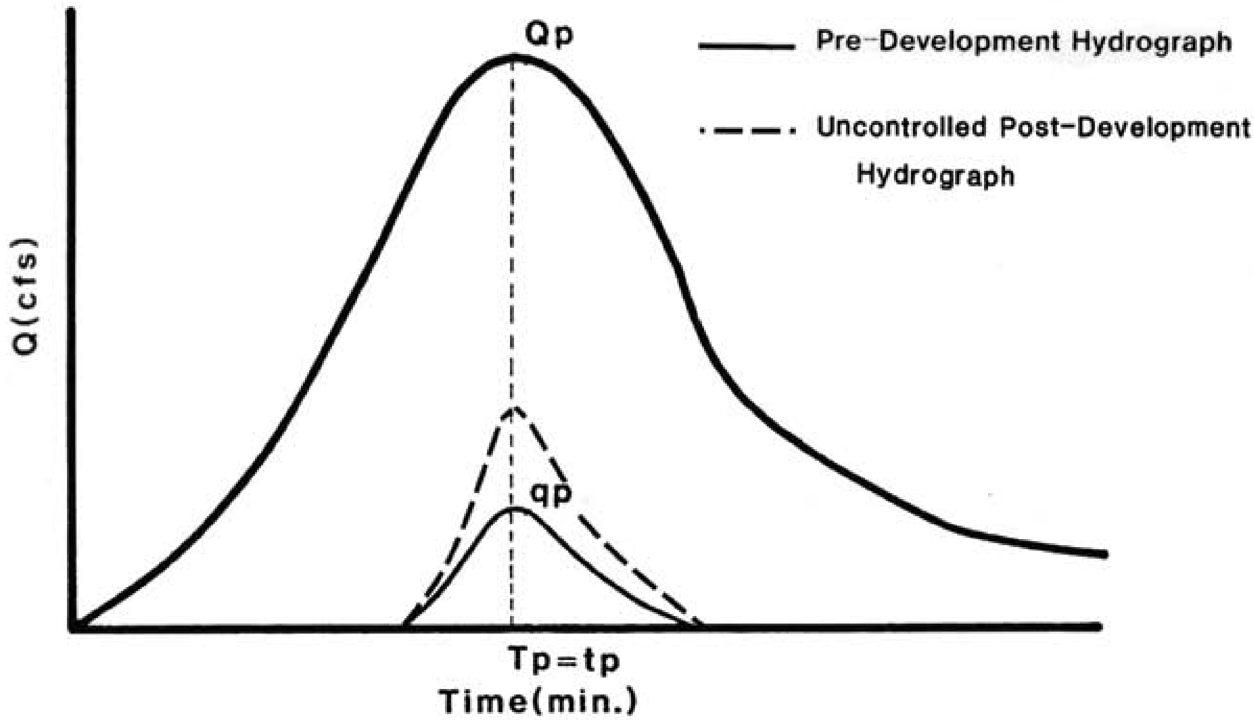
Case IV does not fit the conventional release rate concept because of the relationship between the times to peak. However, as depicted on Figure 20, uncontrolled post-development runoff could increase the point of interest peak because of the tendency of new development to raise the peak of the drainage 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.

(v) Case V (Equivalent to Area 1) – The Case V situation is shown in Figure 21 where the individual drainage area time to peak occurs much later than the point of interest peak and the drainage area does not contribute to the point of interest peak. In other words:

FIGURE 19
CASE III ANALYSIS CATEGORY AND RUNOFF CONTROL STRATEGY

CASE III: $t_p = T_p$



Recommended Watershed-Level Runoff Control Strategy

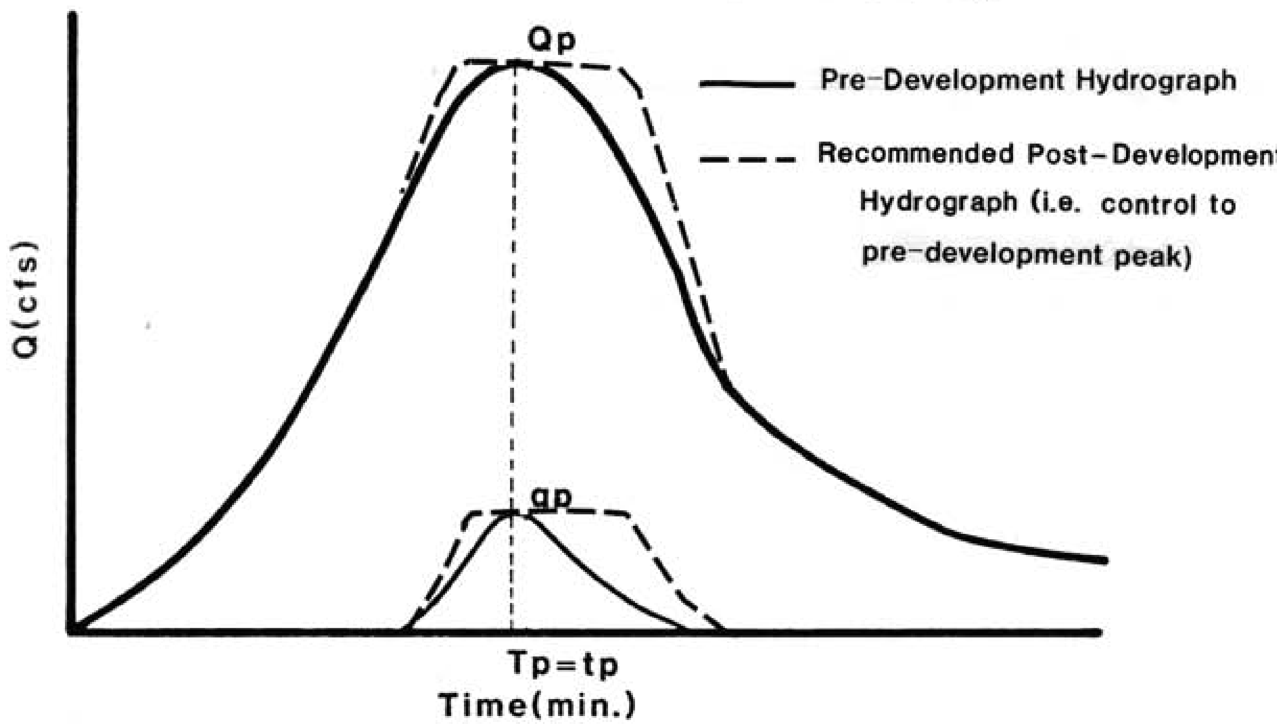
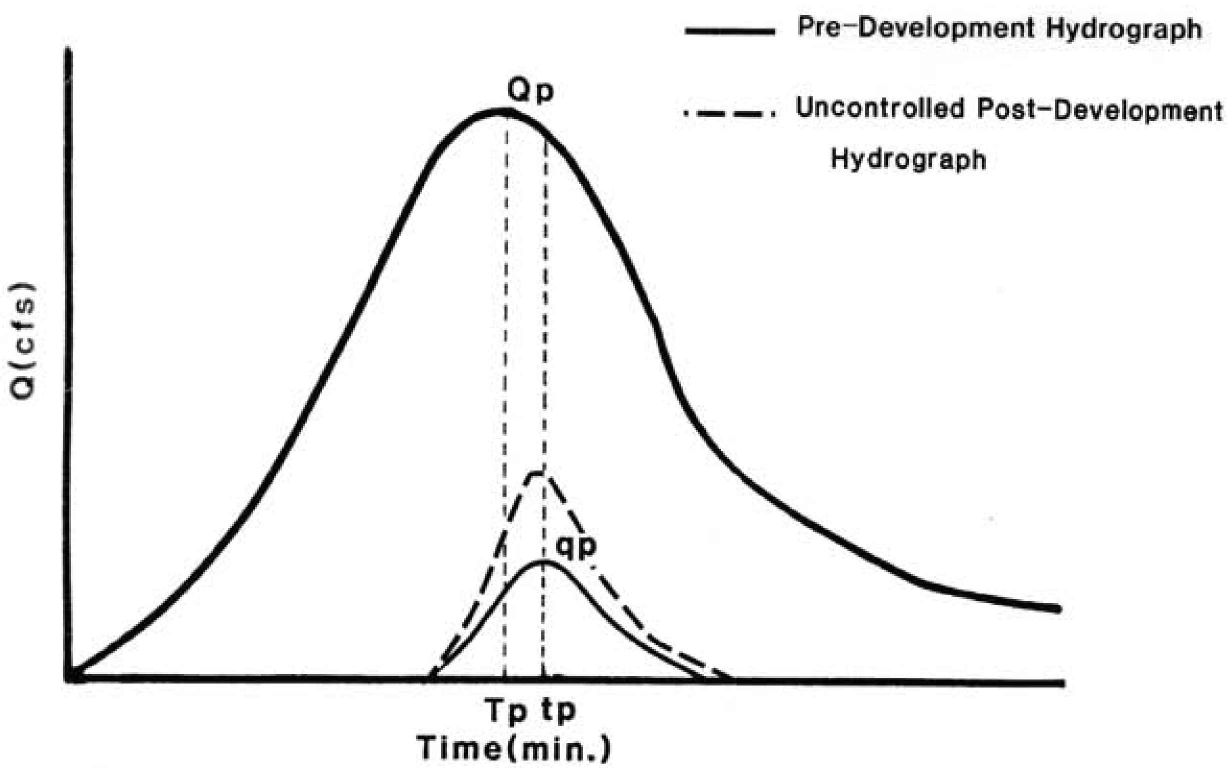


FIGURE 20
CASE IV ANALYSIS CATEGORY AND RUNOFF CONTROL STRATEGY

CASE IV: $t_p > T_p$ <u>and</u> subarea does contribute to subwatershed peak



Recommended Watershed-Level Runoff Control Strategy

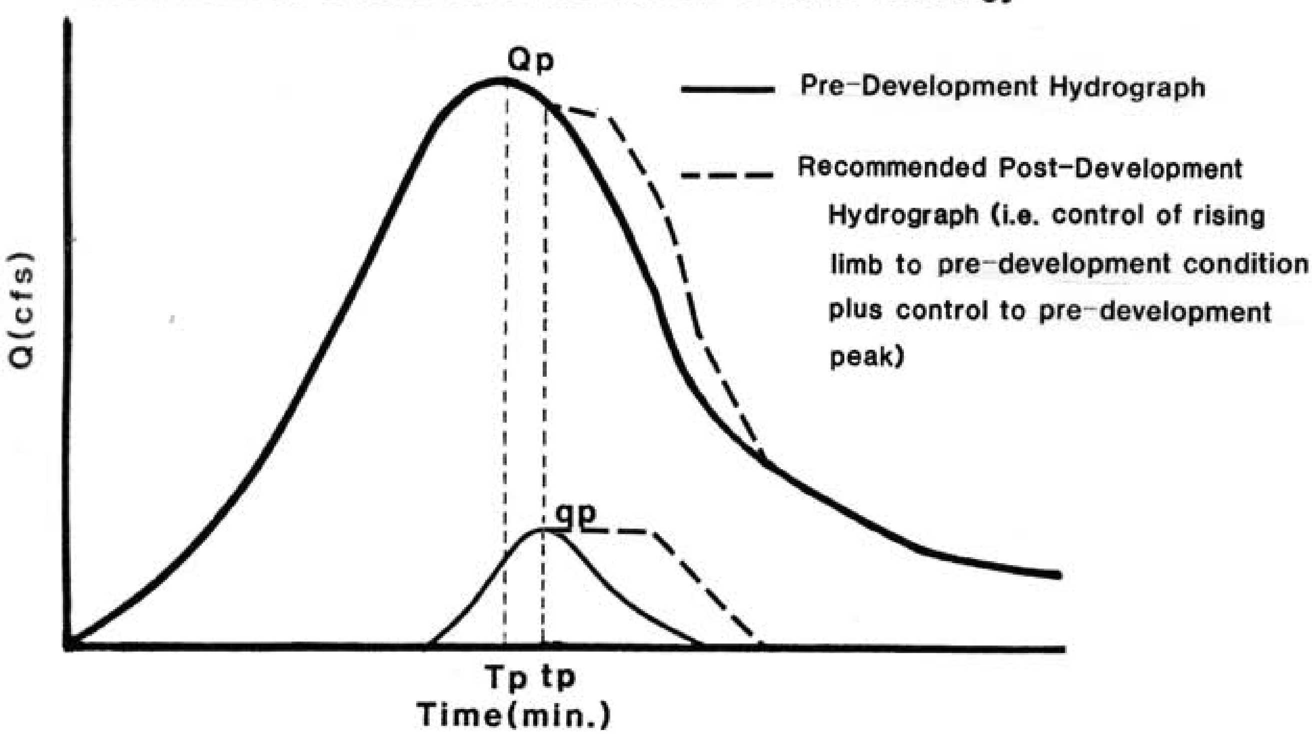
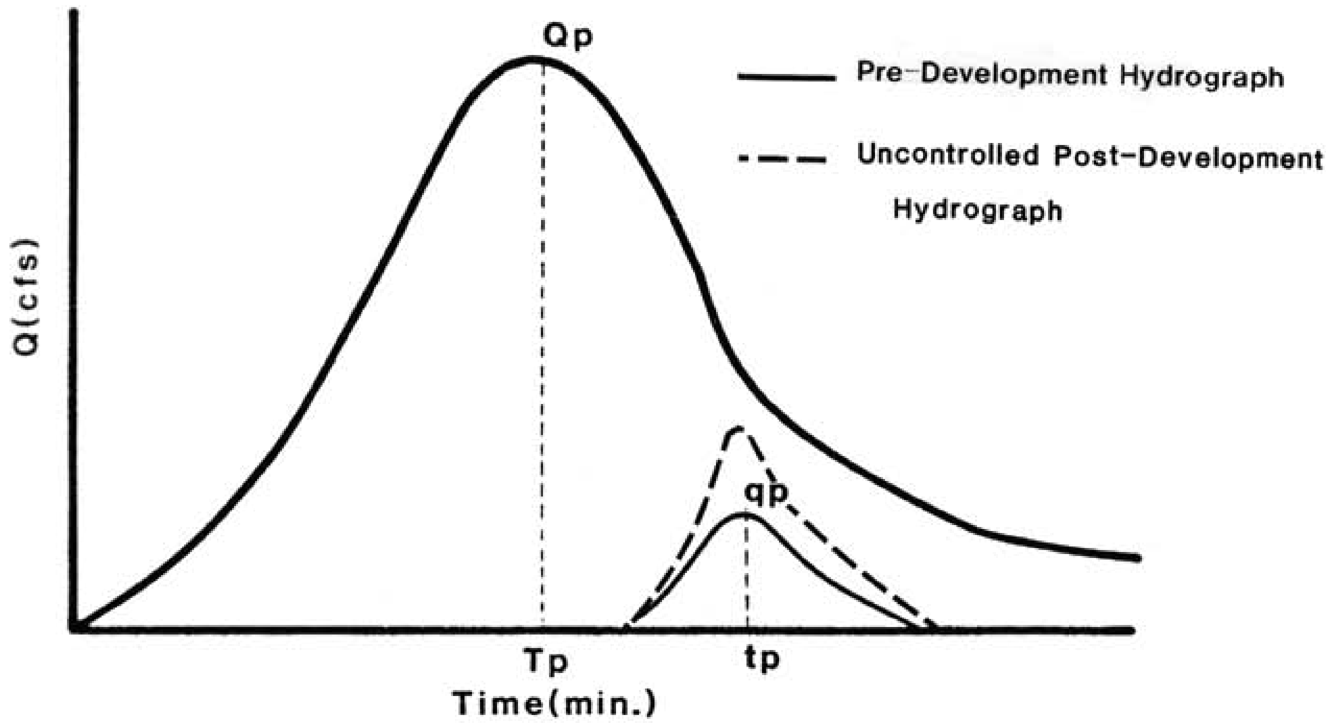
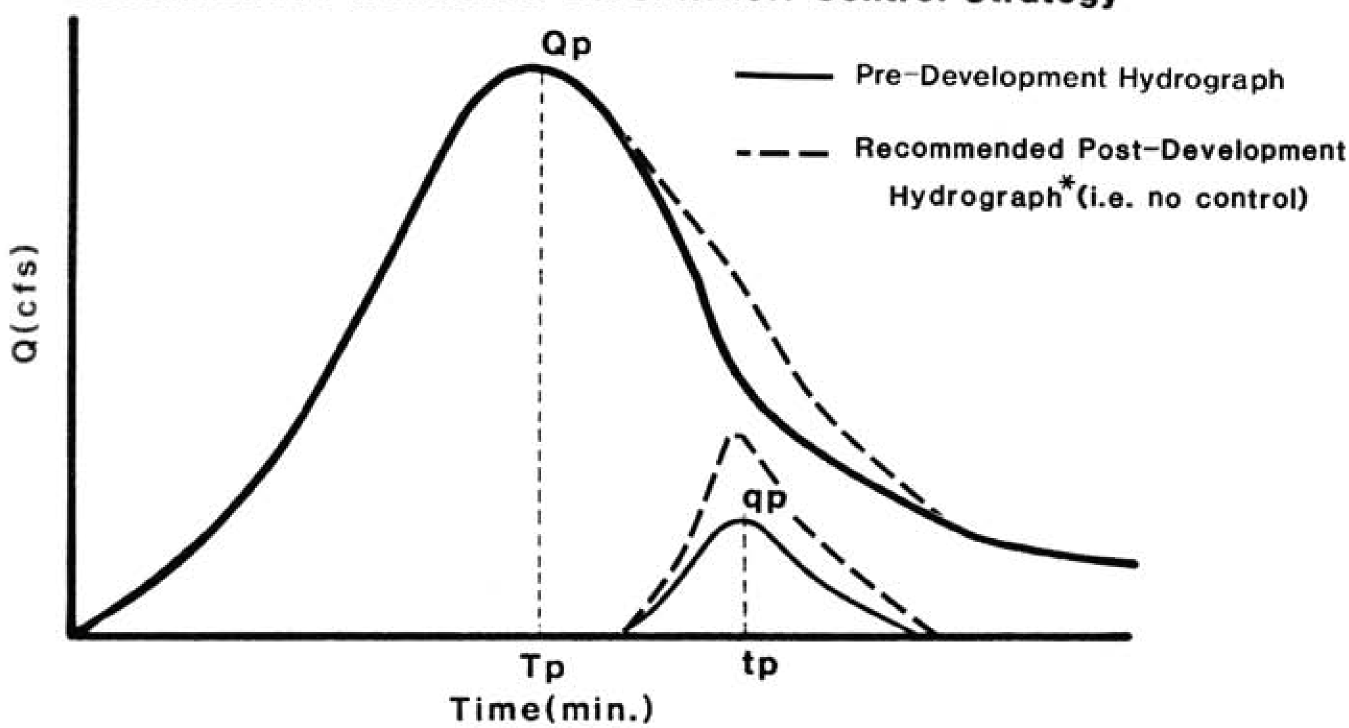


FIGURE 21
CASE V ANALYSIS CATEGORY AND RUNOFF CONTROL STRATEGY

CASE V: $t_p > T_p$ and subarea does not contribute to subwatershed peak



Recommended Watershed-Level Runoff Control Strategy



*Contingent upon ability of localized drainage network to safely convey higher peak runoff.

$t_p > T_p$ and q @ $T_p = 0$

The runoff control strategy adopted for Case V areas is very nearly inconsequential at the point of interest. Neither uncontrolled post-development runoff nor extended-detention-achieved peaks would have the effect of increasing the point of interest peak flow. However, the analysis performed at Area 5 would need to be also performed at Areas 1 through 4 as will be described below. For this reason a 100% release rate is required for Area 1.

c.) Point of Interest Selection

The five runoff control strategies, Cases I through V, developed above were determined based on a single point of interest at the downstream end of area 5. This was done simply for ease of illustration. In actuality, a point of interest could occur at any location in the watershed, such as the downstream end of area 1, 2, 3, or 4. Given that the relationships between the point of interest hydrograph and a single drainage area hydrograph (as defined by Cases I through V) are determined by travel time between the drainage and the point of interest, selection of the point of interest has a bearing on the runoff control category applicable to each drainage area. Further, the selection of multiple points of interest could mean that each drainage area would fit into multiple control categories. Therefore, selection of the points of interest is a critical element in the development of the watershed-level runoff control strategy. The following items are considered in the selection of the points of interest:

(i) Significant obstructions (4) – identified from comparisons of estimated capacity and 10-year return period peak flow.

(ii) All subarea boundaries (20) – identified by breakdown of the subwatersheds for modeling purposes.

(iii) Municipal boundaries.

The overall goals of Act 167 are to prevent the aggravation of existing drainage problems and to prevent the formation of new problems through the coordination of stormwater runoff decisions throughout the watershed. Therefore, at minimum, existing storm drainage problem areas must be used as points of interest for hydrograph analysis. However, no documented problem areas exist within the study area.

Prevention of any new storm drainage problems is by far the more difficult Act 167 goal. Ensuring that no new problems are created requires that either (1) peak runoff values are not increased at any point in the watershed, or (2) peak flow values are only increased to the point that the existing drainage system can safely convey the increased flows. Option 2 would require knowledge of the capacity of the drainage system at every point in the watershed, which is not available in this case. For modeling purposes, the average capacities of the major drainage elements have been determined using simplified methods. Actual capacities may differ significantly depending upon the accuracy of the assumptions used in the simplified approach. In addition, even calibration of the runoff models does not guarantee accurate runoff values at every point in the watershed. The conclusion is that even though it may be possible to increase peak flow in values at various points in the watershed without creating new drainage problems, the ability to accurately define those areas and identify the allowable increase in peak flow does not exist within the Act 167 planning effort. Therefore, a conservative engineering approach and practicality dictate using the philosophy of maintaining existing peak flow rates.

With the control philosophy decided, it is still necessary to determine at what points in the watershed the philosophy will be applied. Strict adherence to the philosophy would mean using the most detailed level of watershed breakdown available as the control points. Justification for use of significant obstructions as control points would be that ponding currently occurs at these locations, indicating a lack of adequate conveyance capacity under existing conditions. Increased peak flows at these points would aggravate the current ponding conditions and possibly create a hazard to property or safety.

Municipal boundaries as possible control points have their justification in the goals of Act 167 itself, namely to coordinate the runoff control efforts of all the municipalities in the watershed. Municipal coordination could mean, at minimum, that the stormwater management decisions made for a development in one municipality do not have an adverse impact on any other downstream municipality. Therefore, using municipal boundaries as points of interest could ensure the minimum acceptable coordination consistent with Act 167.

Each of the individual control point categories (existing drainage problem areas, significant obstructions, and municipal boundaries) are valid control points for formulation of a runoff management plan. Since using the 20 subarea boundaries effectively incorporates all the other control strategies, the 20 subarea boundaries have been used as the critical drainage points for runoff analysis. Therefore, the runoff from a particular subarea has been analyzed at every other downstream subarea and the appropriate control philosophy devised based on not increasing the peak flow at any of the downstream subarea boundaries.

Devising a runoff control strategy based upon 20 critical points means that each subarea in the watershed will fit into multiple control strategy categories (Cases I through V). The control strategy selected for a particular subarea is based on the most critical category applicable to the subarea. One impact of this is that there are no subareas for which the Case V situation is most critical, since evaluation of upland-most subareas at their own downstream points yields a 100% release rate. Further, only in very isolated instances would a Case IV situation be most critical. Therefore, the control strategy developed is based essentially on runoff control categories I through III.

d.) Return Periods to be Controlled

The performance criteria developed as part of this Plan will be used to control the 2-, 10-, 25-, and 100-year return period events. These four events represent a full range of design frequency events. The 2-year storm event is included because, on a percentage basis, the increase in runoff volume between pre- and post-development conditions is greater for the 2-year event than for any of the other return periods analyzed. This is true because the depth of rainfall is least for the 2-year event, and the pervious areas (lawns, etc.) do not significantly contribute to peak flows or runoff volume. As total rainfall depth increases with return period, pervious areas become saturated and nearly all rainfall becomes runoff – resembling the response of impervious areas. Therefore, the change in imperviousness with development is more difficult to control from a runoff perspective for the more frequent (e.g. 2-year) storms. However, the proposed water quality standards will maintain the existing runoff volume in the watershed, meaning that post-development peak rates from new development only need be controlled to the existing peak flows on-site. The 100-year event was included because many existing municipal ordinances already require analysis of the 100-year storm. Finally the 10- and 25-year storms were included to ensure control of intermediate frequency storm events between the 2- and 100-year extremes.

The preceding sections described the theory behind release rate determination. Section C outlines the actual procedure used to implement the theory. Steps to determine the most appropriate control strategy for each subarea in each subwatershed are as follows:

(i) Run the HEC-HMS model for the "existing" land use condition in each subwatershed for the 2-, 10-, 25- and 100-year storms.

(ii) Beginning with the uppermost subarea, develop each subarea to future land use and assign the highest release rate that does not create a peak flow of greater than 105% of pre-development, if possible. Test the release rate chosen by running HEC-HMS for the 10-year storm, only with the WQv removed from the discharged volume of each subarea to account for the water quality standards. Continue downstream until each subarea has a release rate.

Consistent with the analysis conducted per parts (i) and (ii) above, all subareas in the Sacony Creek Headwaters were able to be grouped into three control categories. Seventeen of the subareas have been designated as 100% Release Rate areas, and can be effectively controlled by detaining the post-development peak rate to pre-development levels for the 10-, 25-, and 100-year storm events. Two of the subareas have been designated as 50% Release Rate areas, and post-development flows must be constrained to 50% of the existing flows for the 10-, 25-, and 100-year rainfall events. The final subarea has been designated as a 70% Release Rate area, and post-development flows must be constrained to 70% of the existing flows for the 10-, 25-, and 100-year rainfall events.

As discussed earlier, the percentage increase in runoff from development for the 2-year return period storm is the most difficult to control. In previous Act 167 Plans developed by LVPC, a 30% release rate was applied to all areas not designated as no detention areas. This was done for reasons of rate control, as well as water quality and streambed erosion protection. However, with the proposed water quality standards in the Sacony Creek Headwaters, the 2-year runoff volume will not increase post-development. Since the release rate concept is based on the assumption that volume will increase post-development, the 2-year event will only need to control runoff to pre-development levels throughout the watershed. Additionally, since the increase in the 2-year volume is being retained post-development, this will also have an impact on the post-development runoff volume of the higher return periods as well. As noted above, when the release rates were tested with the 10-year storm, the WQv (which is equal to the increase in the 2-year runoff volume) was removed from the outflow hydrograph using retention basins in the watershed model.

C. Performance Standards

1. Description of Performance Standard Districts

The main goal of the Act 167 Plan effort was to determine what levels of runoff control are needed throughout the watershed. With the increased focus on water quality and specification of a water quality volume, as well as the location of the study area (i.e. the study area terminus is based on the county boundary, as opposed to the terminus being based on the confluence of the watershed with the Lehigh or Delaware rivers), no detention areas were deemed to be inappropriate for the Sacony Creek Headwaters. All of the factors described in Section B of this chapter have been incorporated into a control strategy for successfully dealing with the runoff impacts of new development. The runoff control district for the Sacony Creek Headwaters is described below:

a.) Release Rate Districts – The anticipated post-development runoff from these areas can be controlled across the range of return periods from 10- through 100-years by meeting a defined Release Rate in each drainage district, and by retaining the increase in the 2-year runoff volume on-site. The Release

Rate is expressed as the percentage of the pre-development peak runoff rate that may be discharged post-development for each return period.

A map of the Sacony Creek Headwaters Study Area drainage districts is included as Plate 1, located inside the back cover of the Plan.

2. Performance Standard Implementation Provisions

The performance standards specified above represent one-half of the stormwater runoff control strategy for the Sacony Creek Headwaters. 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, 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, any earth disturbance or other activities that involve alteration or development of land in a manner that may affect stormwater runoff onto an adjacent property, diversion or piping of any natural or man-made stream channel, and the installation of any storm sewer system. The latter two items have been included because they may have the impact of significantly modifying 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 creates 10,000 square feet or less of additional impervious cover would not be required to meet the quantity standards of the Plan. The 10,000 square foot criterion is based on the amount of impervious cover which would generate 2 cfs or less additional peak runoff for a five-minute duration storm for a 100-year return period rainfall event. This waiver only applies to land developments, subdivisions and creation of impervious cover or buildings. Also, as stated above, this waiver only applies to the rate control criteria, and not the water quality criteria discussed in Section A of this chapter.

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 volume control standard must be met for the 2-year and the applicable release rates must be met for the 10-, 25-, 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 Sacony Creek Headwaters Study Area. 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 associated with NRCS.

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.) “No Harm” Option

The control philosophy as described above incorporating Release Rate districts and capacity improvements is based on the goal of maintaining (as nearly as possible) existing peak flow values and water balance throughout the study area, or otherwise ensuring that any increase in peak runoff would not adversely impact persons or property. However, in certain instances, 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 rate 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 rate 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. Therefore, a developer may be able to prove “no harm” even though peak flows would increase by using a different control strategy than that which is 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. However, in certain instances, 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 bottom of the study area, as applicable, since the Plan criteria have been developed consistent with that objective. Conceivably, 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 upon downstream peak flow versus capacity analysis shall be governed by the following factors:

(1) 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).

(2) 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.

(3) Any downstream capacity improvements proposed by the developer as part of a "no harm" justification would be designed using the capacity criteria specified in the ordinance. Peak flow contributions to the proposed improvements shall be calculated as the larger of: (1) assuming the local watershed is in the existing condition, or (2) assuming that the local watershed is developed per current zoning and using the specified runoff controls.

The examples of possible bases to pursue "no harm" justifications as presented above are for illustration purposes only, 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. Therefore, the burden 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. "No Harm" justifications may not be applied to the water quality aspects of the control strategy. As a final step, the municipality will consult with DEP to assure that the proposal meets the State Water Quality requirements as defined in the model municipal ordinance in Chapter 9.

d.) 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.

However, there are 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 the 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 a large tributary area, the payback time frame would be very uncertain. Third, 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 aside, it may be feasible to implement regional detention alternatives within the Sacony Creek Headwaters. The most likely alternatives would involve relatively small tributary areas representing several development sites. For the purposes of this Plan, any regional detention 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 discussions. Development sites for which regional detention facilities are proposed must be designed, considering both on-site and regional controls, to meet all applicable performance standards of the model municipal ordinance included in Chapter 9. There are no specific recommendations for locations of regional detention facilities incorporated in this Plan.

CHAPTER 9. MUNICIPAL ORDINANCE TO IMPLEMENT THE SACONY CREEK HEADWATERS STORMWATER 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 Sacony Creek Headwaters Stormwater 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 *Sacony Creek Headwaters Act 167 Stormwater Management Ordinance* will not completely replace the existing storm drainage ordinance provisions currently in effect in the Sacony Creek Headwaters municipalities. This is because not all of the municipalities in the Sacony Creek Headwaters are completely within the watershed. For those portions of a municipality outside the Sacony Creek Headwaters, the existing ordinance provisions would still apply.

Municipalities must adopt or amend, and shall implement such ordinances and regulations, as are necessary to manage stormwater in a manner consistent with the applicable watershed stormwater plan and the provisions of Act 167. These regulations must also be consistent with state water quality requirements (i.e., the Clean Streams Law).

The Act 167 Ordinance provides an exemption from the drainage plan preparation provisions for certain regulated activities which create less than 10,000 square feet of new impervious cover.

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, Stormwater Management Requirements, Drainage Plan Requirements, Inspections, Fees and Expenses, Maintenance Responsibilities, and Enforcement.

The Ordinance Appendices, to be made part of the municipal ordinances, should provide maps of the Sacony Creek Headwaters and stormwater management districts 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 this version of the Ordinance.

Although the actual stormwater 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 Sacony Creek Headwaters 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. It is noted that 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 includes all five of the “findings” included with the Plan version of the provision.

The Ordinance contains references to the National Pollutant Discharge Elimination System (NPDES) stormwater permit program. Each construction site (where applicable) must meet the NPDES requirements and obtain a proper NPDES permit from the County Conservation District or DEP, as applicable.

Presented as the remainder of this chapter is the *Sacony Creek Headwaters Act 167 Stormwater Management Ordinance*.

SACONY CREEK HEADWATERS ACT 167 STORMWATER MANAGEMENT ORDINANCE

ARTICLE 1
GENERAL PROVISIONS

SECTION 101. SHORT TITLE

The Ordinance shall be known and may be cited as the "Sacony Creek Headwaters Act 167 Stormwater Management Ordinance."

SECTION 102. STATEMENT OF FINDINGS

The governing body of the municipality finds that:

A. Inadequate management of accelerated runoff of stormwater resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, changes the natural hydrologic patterns, destroys aquatic habitat, elevates aquatic pollutant concentrations and loadings, overtaxes the carrying capacity of streams and storm sewers, greatly increases the cost of public facilities to carry and control stormwater, undermines floodplain management and flood control efforts in downstream communities, reduces groundwater recharge, and threatens public health and safety.

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

C. Stormwater can be an important resource by providing groundwater recharge for water supplies and baseflow of streams, which also protects and maintains surface water quality.

D. Public education on the control of pollution from stormwater is an essential component in successfully addressing stormwater.

E. Federal and State regulations require certain municipalities to implement a program for stormwater controls. These municipalities are required to obtain a permit for stormwater discharges from their separate storm sewer systems under the National Pollutant Discharge Elimination System (NPDES).

F. Non-stormwater discharges to municipal separate storm sewer systems can contribute to pollution of waters of the Commonwealth by the municipality.

SECTION 103. PURPOSE

The purpose of this Ordinance is to promote the public health, safety, and welfare within the Sacony Creek Headwaters by minimizing the damages and maximizing the benefits described in Section 102 of this Ordinance by provisions designed to:

A. Manage stormwater runoff impacts at their source by regulating activities which cause stormwater problems.

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

C. Encourage infiltration of stormwater, where appropriate, to maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to otherwise protect water resources.

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

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

F. Provide for proper maintenance of all permanent stormwater management BMPs that are implemented in the municipality.

G. Provide review procedures and performance standards for stormwater planning, design, and management.

H. Manage stormwater impacts close to the runoff source which requires a minimum of structures and relies on natural processes.

I. Meet legal water quality requirements under State law, including regulations at 25 Pa. Code Chapter 93.4a to protect and maintain "existing uses" and maintain the level of water quality to support those uses in all streams, and to protect and maintain water quality in "special protection" streams.

J. Prevent scour and erosion of streambanks and streambeds.

K. Provide standards to meet the NPDES permit requirements.

SECTION 104. 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 "Stormwater Management Act", Act 247, the Pennsylvania Municipalities Planning Code of July 31, 1968, P.L. 805; 53 P.S. §10101, as reenacted and amended, and the [appropriate municipal code].

SECTION 105. APPLICABILITY

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

All activities that may affect stormwater runoff, including land development and earth disturbance activity, are subject to regulation by this Ordinance. Regulated activities include:

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 or channel.

F. Installation of stormwater systems or appurtenances thereto.

G. Regulated Earth Disturbance Activities.

H. Other than that included in 105.A through G, any Earth Disturbance Activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff onto adjacent property.

SECTION 106. EXEMPTIONS

A. Impervious Cover – Any proposed Regulated Activity, except those defined in Section 105.E through 105.H, which would create 10,000 square feet or less of additional impervious cover is exempt from the Drainage Plan preparation provisions of this Ordinance. If a site has previously received an exemption and is proposing additional development such that the total impervious cover on the site exceeds 10,000 square feet, the total impervious cover on the site proposed since the original ordinance date must meet the provisions of this Ordinance.

1. The date of the municipal Ordinance adoption of the original Sacony Creek Headwaters Act 167 Stormwater Management Ordinance [Watershed Plan Date]† shall be the starting point from which to consider tracts as "parent tracts" in which future subdivisions and respective impervious area computations shall be cumulatively considered.

2. For development taking place in stages, the entire development plan must be used in determining conformance with these criteria.

3. Additional impervious cover shall include, but not be limited to, additional indoor living spaces, decks, patios, garages, driveways, storage sheds and similar structures, and roof, parking, or driveway areas, and any new streets and sidewalks constructed as part of or for the proposed Regulated Activity.

4. Any additional areas proposed initially to be gravel, crushed stone, porous pavement, etc., shall be assumed to be impervious for the purposes of comparison to the exemption criteria. Any existing gravel, crushed stone, or hard-packed soil areas on a site shall be considered as pervious cover for the purpose of exemption evaluation.

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, except as cited in Section 106.D, provided that the approved Drainage Plan included design of stormwater facilities to control runoff from the site currently proposed for Regulated Activities 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 this Ordinance, preparation of a new Drainage Plan, subject to the provisions of this Ordinance, shall be required. Significant revisions would include a change in control methods or techniques, relocation or redesign of control measures, or changes necessary because soil or other conditions are not as stated on the original Drainage Plan.

C. Activities associated with 105.H shall be exempt from the Drainage Plan preparation requirements of the Ordinance unless the municipality determines that the activity could create a new or relocated concentrated drainage discharge. Agricultural plowing and tilling as may be covered by Section 105.H are exempt from the Drainage Plan provisions of this ordinance.

†Note: This is the original Act 167 Plan for the Sacony Creek Headwaters such that the adoption date of this ordinance sets the regulatory date.

D. These exemptions shall not relieve the applicant from implementing such measures as are necessary to protect health, safety and property, and to meet State Water Quality Requirements. These measures include adequate and safe conveyance of stormwater on the site and as it leaves the site. These exemptions do not relieve the applicant from the responsibility to secure permits or approvals for activities regulated by any other applicable code, rule, act, or ordinance.

E. No exemptions shall be provided for Regulated Activities as defined in Sections 105.E through 105.G.

F. Agricultural activity is exempt from the rate control and Drainage Plan preparation requirements of this Ordinance provided the activities are performed according to the requirements of 25 Pa. Code 102.

G. Forest management and timber operations are exempt from the rate control and Drainage Plan preparation requirements of this Ordinance provided the activities are performed according to the requirements of 25 Pa. Code 102.

H. The municipality may deny or revoke any exemption pursuant to this Section at any time for any project that the municipality believes may pose a threat to public health, safety, property or the environment.

SECTION 107. 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 108. 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 109. 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 110. DUTY OF PERSONS ENGAGED IN THE DEVELOPMENT OF LAND

Notwithstanding any provisions of this Ordinance, including exemption and waiver provisions, any landowner and any person engaged in the alteration or development of land which may affect stormwater 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, direction, and quality of resulting stormwater runoff in a manner which otherwise adequately protects health and property from possible injury.

ARTICLE 2
DEFINITIONS

For the purposes of this Ordinance, certain terms and words used herein shall be interpreted as follows:

A. Words used in the present tense include the future tense; the singular number includes the plural, and the plural number includes the singular; words of masculine gender include feminine gender; and words of feminine gender include masculine gender.

B. The word "includes" or "including" shall not limit the term to the specific example but is intended to extend its meaning to all other instances of like kind and character.

C. The words "shall" and "must" are mandatory; the words "may" and "should" are permissive.

Accelerated Erosion – The removal of the surface of the land through the combined action of human activities and natural processes, at a rate greater than would occur because of the natural processes alone.

Best Management Practice (BMP) – Activities, facilities, measures or procedures used to manage stormwater quantity and quality impacts from the Regulated Activities listed in Section 105, to meet State Water Quality Requirements, to promote groundwater recharge and to otherwise meet the purposes of this Ordinance.

Best Management Practice Operations and Maintenance Plan – Documentation, included as part of a Drainage Plan, detailing the proposed BMPs, how they will be operated and maintained and who will be responsible.

Bioretention – Densely vegetated, depressed features that store stormwater and filter it through vegetation, mulch, planting soil, etc. Ultimately stormwater is evapotranspirated, infiltrated, or discharged. Optimal bioretention areas mimic natural forest ecosystems in terms of species diversity, density, distribution, use of native plants, etc.

Capture/Reuse – Stormwater management techniques such as cisterns and rain barrels which direct runoff into storage devices, surface or subsurface, for later reuse, such as for irrigation of gardens and other planted areas.

Cistern – An underground reservoir or tank for storing rainwater.

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

Concentrated Drainage Discharge – Stormwater runoff leaving a property via a point source.

Conservation District – The [county name] County Conservation District.

Constructed Wetlands – Constructed wetlands are similar to wet ponds (see below) and consist of a basin which provides for necessary stormwater storage as well as a permanent pool or water level, planted with wetland vegetation. To be successful, constructed wetlands must have adequate natural hydrology (both runoff inputs as well as soils and water table which allow for maintenance of a permanent pool of water). In these cases, the permanent pool must be designed carefully, usually with shallow edge benches, so that water levels are appropriate to support carefully selected wetland vegetation.

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.

Design Storm – The depth and time distribution of precipitation from a storm event measured in probability of occurrence (e.g., 100-yr. storm) and duration (e.g. 24-hour) and used in computing stormwater management control systems.

Detention Basin – A basin designed to retard stormwater 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 (Site) – The specific tract of land for which a Regulated Activity is proposed.

Diffused Drainage – See Sheet Flow.

Direct Recharge (D-RE) BMP – A BMP which directs runoff to an underground infiltration surface. Examples include infiltration trenches, seepage beds, and drywells such that nearly all runoff becomes recharge to groundwater.

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

Drainage Plan – The documentation of the proposed stormwater quantity and quality management controls to be used for a given development site, including a BMP Operations and Maintenance Plan, the contents of which are established in Section 403.

Earth Disturbance Activity – A construction or other human activity which disturbs the surface of the land, including, but not limited to, clearing and grubbing, grading, excavations, embankments, land development, agricultural plowing or tilling, timber harvesting activities, road maintenance activities, mineral extraction, and the moving, depositing, stockpiling, or storing of soil, rock or earth materials.

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

Evapotranspiration (ET) BMP – A BMP which provides opportunity for runoff evaporation and transpiration by vegetation. Examples include bioretention and surface infiltration basins.

Existing Uses – Those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards. (25 Pa. Code Chapter 93.1)

Fill – Man-made deposits of natural soils or rock products and waste materials.

Filter Strips – See Vegetated Buffers.

Freeboard – The incremental depth in a stormwater 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.

Hardship Waiver Request – A written request for a waiver alleging that the provisions of this Ordinance inflict unnecessary hardship upon the applicant. A Hardship Waiver does not apply to and is not available from the water quality provisions of this Ordinance and should not be granted.

Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS) – The computer-based hydrologic modeling technique developed by the U.S. Army Corps of Engineers and adapted to the Sacony Creek Headwaters for the Act 167 Plan. The model was "calibrated" to reflect actual flow values by adjusting key model input parameters.

Hot Spot Land Uses – A land use or activity that generates higher concentrations of hydrocarbons, trace metals or other toxic substances than typically found in stormwater runoff. These land uses are listed in Appendix F.

Hydrologic Soil Group (HSG) – Soils are classified into four HSG's (A, B, C and D) to indicate the minimum infiltration rates, which are obtained for bare soil after prolonged wetting. The Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of the development site may be identified from a soil survey report that can be obtained from local NRCS offices or conservation district offices. Soils become less permeable as the HSG varies from A to D.

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

Infiltration Practice - A practice designed to allow runoff an opportunity to infiltrate into the ground, e.g. French drain, seepage pit, seepage trench, or bioretention area.

Land Development – Any of the following activities:

(1) The improvement of one lot or two or more contiguous lots, tracts or parcels of land for any purpose involving (i) a group of two or more residential or nonresidential buildings, whether proposed initially or cumulatively, or a single nonresidential building on a lot or lots regardless of the number of occupants of tenure; or (ii) 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.
(2) A subdivision of land.
(3) Development in accordance with Section 503 (1.1) of the Pennsylvania Municipalities Planning Code.

Low Impact Development – A development approach that promotes practices that will minimize post-development runoff rates and volumes thereby minimizing needs for artificial conveyance and storage facilities. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces and protecting natural depression storage.

"Local" Runoff Conveyance Facilities – Any natural channel or man-made 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 Sacony Creek Headwaters 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.

Maryland Stormwater Design Manual – A stormwater design manual written by the Maryland Department of the Environment and the Center for Watershed Protection. As of January 2004, the Manual can be obtained through the following web site: www.mde.state.md.us.

Minimum Disturbance/Minimum Maintenance Practices (MD/MM) – Site design practices in which careful limits are placed on site clearance prior to development allowing for maximum retention of existing vegetation (woodlands and other), minimum disturbance and compaction of existing soil mantle and minimum site application of chemicals post-development. Typically, MD/

MM includes disturbance setback criteria from buildings as well as related site improvements such as walkways, driveways, roadways, and any other improvements. These criteria may vary by community context as well as by type of development being proposed. Additionally, MD/MM shall include provisions (e.g., deed restrictions, conservation easements) to protect these areas from future disturbance and from application of fertilizers, pesticides, and herbicides.

Municipality – [municipal name], [county name] County, Pennsylvania.

NPDES – National Pollutant Discharge Elimination System.

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

Oil/Water Separator – A structural mechanism designed to remove free oil and grease (and possibly solids) from stormwater runoff.

Outfall – "Point source" as described in 40 CFR § 122.2 at the point where the municipality's storm sewer system discharges to surface waters of the Commonwealth.

Owner – One with an interest in and often dominion over a property.

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

Person – An individual, partnership, public or private association or corporation, firm, trust, estate, municipality, governmental unit, public utility or any other legal entity whatsoever which is recognized by law as the subject of rights and duties.

Point Source – Any discernible, confined and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel or conduit from which stormwater is or may be discharged, as defined in State regulations at 25 Pa. Code § 92.1.

Pretreatment – Measures implemented for Hot Spot Land Uses designed to reduce the concentration of hydrocarbons, trace metals, and other toxic substances to levels typically found in stormwater runoff.

Public Water Supplier – A person who owns or operates a Public Water System.

Public Water System – A system which provides water to the public for human consumption which has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. (See 25 Pa. Code Chapter 109)

Rational Method – A method of 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 method formula for peak rate calculation 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. The Rational method formula for runoff volume calculation is as follows: V = cPA/12 where “c” and “A” are as noted above, “P” is the total depth of precipitation for the design event in inches, and “V” is the total runoff volume in acre-feet.

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

Regulated Activities – All activities that may affect stormwater runoff, including land development and earth disturbance activity, that are subject to regulation by this Ordinance.

Regulated Earth Disturbance Activities – Activity involving earth disturbance, other than agricultural plowing and tilling, subject to regulation under 25 Pa. Code 92, 25 Pa. Code 102, or the Clean Streams Law.

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.

Road Maintenance – Earth disturbance activities within the existing road cross-section such as grading and repairing existing unpaved road surfaces, cutting road banks, cleaning or clearing drainage ditches and other similar activities.

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

Sediment Traps/Catch Basin Sumps – Chambers which provide storage below the outlet in a storm inlet to collect sediment, debris and associated pollutants, typically requiring periodic clean out.

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.

Separate Storm Sewer System – A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains) primarily used for collecting and conveying stormwater runoff.

Sheet Flow – Stormwater runoff flowing in a thin layer over the ground surface.

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.

Spill Prevention and Response Program – A program that identifies procedures for preventing and, as needed, cleaning up potential spills and makes such procedures known and the necessary equipment available to appropriate personnel.

State Water Quality Requirements – As defined under State regulations – protection of designated and existing uses (See 25 Pa. Code Chapters 93 and 96) – including:

A. Each stream segment in Pennsylvania has a "designated use," such as "cold water fishes" or "potable water supply," which is listed in Chapter 93. These uses must be protected and maintained, under State regulations.
B. "Existing uses" are those attained as of November 1975, regardless whether they have been designated in Chapter 93. Regulated Earth Disturbance Activities must be designed to protect and maintain existing uses and maintain the level of water quality necessary to protect those uses in all streams, and to protect and maintain water quality in special protection streams.
C. Water quality involves the chemical, biological and physical characteristics of surface water bodies. After Regulated Earth Disturbance Activities are complete, these characteristics can be impacted by addition of pollutants such as sediment, and changes in habitat through increased flow volumes and/or rates as a result of changes in land surface area from those activities. Therefore, permanent discharges to surface waters must be managed to protect the stream bank, streambed and structural integrity of the waterway, to prevent these impacts.

Storage Indication Method – A method of routing or moving an inflow hydrograph through a reservoir or detention structure. The method solves the mass conservation equation to determine an outflow hydrograph as it leaves the storage facility.

Storm Drainage Problem Areas – Areas which lack adequate stormwater 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.

Stormwater – The surface runoff generated by precipitation reaching the ground surface.

Stormwater Filters – Any number of structural mechanisms such as multi-chamber catch basins, sand/peat filters, sand filters, and so forth which are installed to intercept stormwater flow and remove pollutants prior to discharge. Typically, these systems require periodic maintenance and clean out.

Stormwater Management Plan - The plan for managing stormwater runoff adopted by [county name] County for the Sacony Creek Headwaters as required by the Act of October 4, 1978, P.L. 864, (Act 167), as amended, and known as the "Stormwater 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 Stormwater 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, partition by the court for distribution to heirs or devisees, transfer of ownership or building or lot development: provided, however, that the subdivision by lease of land for agricultural purposes into parcels of more than ten acres, not involving and new street or easement of access or any residential dwelling, shall be exempted.

Surface Waters of the Commonwealth – Any and all rivers, streams, creeks, rivulets, impoundments, ditches, watercourses, storm sewers, lakes, dammed water, wetlands, ponds, springs and all other bodies or channels of conveyance of surface water, or parts thereof, whether natural or artificial, within or on the boundaries of this Commonwealth.

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

Trash/Debris Collectors – Racks, screens or other similar devices installed in a storm drainage system to capture coarse pollutants (trash, leaves, etc.).

Vegetated Buffers – Gently sloping areas that convey stormwater as sheet flow over a broad, densely vegetated earthen area, possibly coupled with the use of level spreading devices. As water quality BMPs, vegetated buffers serve to filter pollutants from runoff and promote infiltration. Vegetated buffers should be situated on minimally disturbed soils, have low-flow velocities and extended residence times. Vegetated buffers may be, but are not restricted to, use in riparian (streamside) conditions.

Vegetated Roofs – Vegetated systems installed on roofs that generally consist of a waterproof layer, a root-barrier, drainage layer (optional), growth media, and suitable vegetation. Vegetated roofs store and eventually evapotranspirate the collected rooftop rainfall; overflows may be provided for larger storms.

Vegetated Swales – Vegetated earthen channels designed to convey and possibly treat stormwater. As water quality BMPs, these are broad, shallow, densely vegetated, earthen channels designed to treat stormwater through infiltration, evapotranspiration, and sedimentation. Swales should be gently sloping with low flow velocities to prevent erosion. Check dams may be added to enhance performance.

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

Water Quality Inserts – Any number of commercially available devices that are inserted into storm inlets to capture sediment, oil, grease, metals, trash, debris, etc.

Water Quality Volume (WQv) – The increase in volume on a development site associated with a 2-year, 24-hour storm event.

Watershed – The entire region or area drained by a river or other body of water, whether natural or artificial.

Wet Detention Ponds – Basins that provide for necessary stormwater storage as well as a permanent pool of water. To be successful, wet ponds must have adequate natural hydrology (both runoff inputs as well as soils and water table which allow for maintenance of a permanent pool of water) and must be able to support a healthy aquatic community so as to avoid creation of mosquito and other health and nuisance problems.

ARTICLE 3
STORMWATER MANAGEMENT REQUIREMENTS

SECTION 301. GENERAL REQUIREMENTS

A. All Regulated Activities in the municipality shall be subject to the stormwater management requirements of this Ordinance.

B. Storm drainage systems shall be designed to preserve natural watercourses except as modified by stormwater detention facilities, recharge facilities, water quality facilities, pipe systems or open channels consistent with this Ordinance.

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

D. 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 obtain the written approval of the affected property owner(s). 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.

E. 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 308 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 stormwater 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.

F. Post construction BMPs shall be designed, installed, operated and maintained to meet the requirements of the Clean Streams Law and implementing regulations, including the established practices in 25 Pa. Code Chapter 102 and the specifications of this Ordinance as to prevent accelerated erosion in watercourse channels and at all points of discharge.

G. No Earth Disturbance Activities associated with any Regulated Activities shall commence until approval by the municipality of a plan which demonstrates compliance with the requirements of this Ordinance.

H. Techniques described in Appendix E (Low Impact Development) of this Ordinance are encouraged because they reduce the costs of complying with the requirements of this Ordinance and the State Water Quality Requirements.

SECTION 302. PERMIT REQUIREMENTS BY OTHER GOVERNMENT ENTITIES

A. Other regulations contain independent permit requirements that apply to certain Regulated and Earth Disturbance Activities eligible for authorization by the Municipality in accordance with the permitting requirements in this Ordinance. Permit requirements pursuant to those other regulations must be met prior to commencement, and during the conduct, of such Regulated and Earth Disturbance Activities, as applicable:

1. All Regulated and Earth Disturbance Activities subject to permit requirements by DEP under regulations at 25 Pa. Code Chapter 102.

2. Work within natural drainageways subject to permit by DEP under 25 Pa. Code Chapter 102 and Chapter 105.

3. Any stormwater management facility that would be located in or adjacent to surface waters of the Commonwealth, including wetlands, subject to permit by DEP under 25 Pa. Code Chapter 105.

4. Culverts, bridges, storm sewers or any other facilities which must pass or convey flows from the tributary area and any facility which may constitute a dam subject to permit by DEP under 25 Pa. Code Chapter 105.

5. Projects that involve use of PennDOT right-of-way, or that involve new discharges onto or toward PennDOT right-of-way, are subject to the requirements, including the permitting requirements, of Title 67, Chapter 441 of the Pennsylvania Code.

SECTION 303. EROSION AND SEDIMENT CONTROL DURING REGULATED EARTH DISTURBANCE ACTIVITIES

A. No Regulated Earth Disturbance Activities within the municipality shall commence until approval by the municipality of an Erosion and Sediment Control Plan for construction activities. Written approval by DEP or a delegated County Conservation District shall satisfy this requirement.

B. A written Erosion and Sediment Control Plan is required by DEP regulations for any Earth Disturbance Activity of 5,000 square feet or more under Pa. Code § 102.4(b).

C. A DEP NPDES Stormwater Discharges Associated with Construction Activities Permit is required for Regulated Earth Disturbance Activities of one acre or greater under Pa. Code Chapter 92.

D. Evidence of any necessary permit(s) for Regulated Earth Disturbance Activities from the appropriate DEP regional office or County Conservation District must be provided to the municipality before the commencement of an Earth Disturbance Activity.

E. A copy of the Erosion and Sediment Control Plan and any permit, as required by DEP regulations, shall be available at the project site at all times.

SECTION 304. POST CONSTRUCTION WATER QUALITY CRITERIA

A. No Regulated Earth Disturbance Activities within the municipality shall commence until approval by the municipality of a Drainage Plan which demonstrates compliance with this Ordinance.

B. The Water Quality Volume (WQv) shall be captured and treated with evapotranspiration and/or direct recharge BMPs. The WQv shall be calculated as the difference in runoff volume from pre-development to post-development for the 24-hour, 2-year return period storm. This may be calculated using either the Soil-Cover-Complex Method or Rational Method using the 2-year rainfall depth as noted in Section 308.H. The effect of closed depressions on the site shall be considered in this calculation. The WQv shall be captured and treated in a manner consistent with the standards outlined in Section 305 of the Ordinance.

C. The WQv shall be calculated for each post-development drainage direction on a site for sizing BMPs. Site areas having no impervious cover and no proposed disturbance during development may be excluded from the WQv calculations and do not require treatment.

D. Sites where applicants intend to use infiltration BMPs must meet the following criteria:

- Depth to bedrock below the invert of the BMP greater than or equal to 2 feet.
- Depth to seasonal high water table below the invert of the BMP greater than or equal to 2 feet; except for infiltration of residential roof runoff where the seasonal high water table must be below the invert of the BMP.
- Soil permeability (as measured using the standards listed in Appendix C of the Pennsylvania Stormwater Best Practices Manual) greater than or equal to 0.1 inches/hour and less than or equal to 10 inches per hour.
- Setback distances or buffers as follows:
  – 100 feet from water supply wells, or 50 feet in residential development.
  – 10 feet downgradient or 100 feet upgradient from building foundations.
- 50 feet from septic system drainfields.

E. Site areas proposed for infiltration shall be protected from disturbance and compaction except as necessary for construction of infiltration BMPs.

F. If infiltration of the entire WQv is not proposed, the remainder of the WQv shall be treated by acceptable BMPs for each discharge location. Acceptable BMPs are listed in Appendix F.

G. Stormwater runoff from Hot Spot land uses shall be pretreated. Suggested methods of pretreatment are listed in Appendix F.

H. The use of infiltration BMPs is prohibited on Hot Spot land use areas unless the applicant can demonstrate that existing and proposed site conditions, including any proposed runoff pretreatment, create conditions suitable for runoff infiltration under this Ordinance.

I. Applicants shall request, in writing, Public Water Suppliers to provide the Zone I Wellhead Protection radius, as calculated by the method outlined in the Pennsylvania Department of Environmental Protection Wellhead Protection regulations, for any public water supply well within 400 feet of the site. In addition to the setback distances specified in Section 304.D, infiltration is prohibited in the Zone I radius as defined and substantiated by the Public Water Supplier in writing. If the applicant does not receive a response from the Public Water Supplier, the Zone I radius is assumed to be 100 feet.

J. The municipality may, after consultation with DEP, approve alternative methods for meeting the State Water Quality Requirements other than those in this Ordinance, provided that they meet the minimum requirements of, and do not conflict with, State law including but not limited to the Clean Streams Law.

SECTION 305. EXISTING WATER BALANCE PRESERVATION STANDARDS

A. The entire WQv as calculated in Section 304.B of this Ordinance shall be captured and treated by either direct recharge (D-RE) or evapotranspiration (ET) BMPs.

B. Lawn area up to a maximum of 33% of the entire site area may be allowed to bypass water quality BMPs. As much proposed impervious area as practical shall be directed to water quality BMPs.

C. Existing impervious area that is not proposed to be treated by D-RE BMPs should be excluded from all water balance calculations.

D. A maximum of 30% of the total annual rainfall for a site may be directly recharged to groundwater using direct recharge (D-RE) BMPs, for runoff from impervious areas.

1. For development sites with greater than 33% proposed impervious cover:

a. If all impervious cover is directed to ET BMPs to capture the entire 2-year, 24-hour event, the D-RE standard is met.

b. Up to 33% of the site as impervious cover may be directed to D-RE BMPs designed to capture the entire 2-year, 24-hour event. All remaining impervious cover shall be directed to ET BMPs designed to capture the remainder of the WQv.

c. For ET and/or D-RE BMPs designed for runoff from impervious areas designed to capture less than the entire 2-year, 24-hour event, Appendix C shall be used to assure that the maximum D-RE standard is met.

2. For development sites with less than 33% proposed impervious cover, all proposed impervious and the entire WQv may be directed to D-RE BMPs.

3. The maximum 30% D-RE standard applies on an overall site basis, rather than in each drainage direction.

SECTION 306. STORMWATER MANAGEMENT DISTRICTS

A. Mapping of Stormwater Management Districts - To implement the provisions of the Sacony Creek Headwaters Stormwater Management Plan, the municipality is hereby divided into Stormwater Management Districts consistent with the Sacony Creek Headwaters Release Rate Map presented in the Plan. The boundaries of the Stormwater 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 Stormwater Management Districts – The 10-, 25-, 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 307. STORMWATER MANAGEMENT DISTRICT IMPLEMENTATION PROVISIONS

A. Applicants shall provide a comparative pre- and post construction stormwater management hydrograph analysis for each direction of discharge and for the site overall to demonstrate compliance with the provisions of this Ordinance.

B. Any stormwater management controls required by this Ordinance and subject to release rate criteria shall meet the applicable release rate criteria for each of the 10-, 25- and 100-year return period runoff events consistent with the calculation methodology specified in Section 308.

C. The exact location of the Stormwater 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.

D. 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.

2. Natural or man-made channels, swales, culverts, bridges, storm sewers, or any other facilities which must convey flows from the tributary area must be able to convey the increased 25-year return period runoff.

E. 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.

F. For a proposed development site located within two or more release rate 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.

G. For sites straddling major watershed divides (e.g. Sacony and Maiden or Jordan), runoff volumes shall be managed to prevent diversion of runoff between watersheds, as practicable.

H. Within a release rate category area, for a proposed development site which has 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 307.D and the minimum orifice criteria.

I. 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 307.D and the detention criteria in Section 308. In addition to the criteria in section 307.D, on-site conveyance systems designed to carry runoff to a detention basin must be able to transport the basin’s 100-year tributary flow either in-system, in-gutter, or overland.

J. 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 areas 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.

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

L. Development proposals which, through groundwater recharge or other means, do not increase either the rate or volume of runoff discharged from the site compared to predevelopment are not subject to the release rate provisions of this Ordinance.

M. “No Harm” Water Quantity Option - For any proposed development site, the developer has the option of using a less restrictive runoff control 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 this Ordinance. Special circumstances are defined as any hydrologic or hydraulic aspects of the development itself not accommodated by the runoff control standards of this Ordinance. 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 Delaware or Lehigh River. Proof of “no harm” must be shown using the capacity criteria specified in Section 307.D. 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. 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).

2. 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”.

3. Any downstream capacity improvements proposed by the developer as part of a “no harm” justification would be designed using the capacity criteria specified in Section 307.D. Peak flow contributions to the proposed improvements shall be calculated as the larger of: (1) assuming the local watershed is in the existing condition, or (2) assuming that the local watershed is developed per current zoning and using the specified runoff controls.

Any “no harm” justifications shall be submitted by the developer as part of the Drainage Plan submission per Article 4. Developers submitting “no harm” justifications must still meet all of the water quality requirements in Section 304. The municipality will process all eligible “no harm” requests in accordance with Section 304.J.

SECTION 308. CALCULATION METHODOLOGY

A. Stormwater 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 or other methodology demonstrated to be more appropriate. For basins designed using the Rational Method technique, the design hydrograph for routing shall be either the Universal Rational Hydrograph or another Rational hydrograph that closely approximates the volume of the Universal Rational hydrograph.

C. BMPs designed to store or infiltrate runoff and discharge to surface runoff or pipe flow shall be routed using the storage indication method.

D. BMPs designed to store or infiltrate runoff and discharge to surface runoff or pipe flow shall provide storage volume for the full WQv below the lowest outlet invert.

E. Wet Detention Ponds designed to have a permanent pool for the WQv shall assume that the permanent pool volume below the primary outlet is full at the beginning of design event routing for the purposes of evaluating peak outflows.

F. All above-ground stormwater detention facilities shall provide a minimum 0.5 feet of freeboard above the maximum pool elevation associated with the 2- through 100-year runoff events, or an additional ten percent of the 100-year storage volume as freeboard volume, whichever is greater. All below-ground stormwater detention and infiltration facilities shall have an additional ten percent of the 100-year storage volume available within the storage medium, as well as a minimum of 0.5 feet of freeboard. The freeboard shall be measured from the maximum pool elevation to the invert of the emergency spillway for above-ground facilities, and from the maximum pool elevation to the lowest overflow elevation for below-ground facilities. The 2- through 100-year storm events shall be controlled by the primary outlet structure. An emergency spillway for each above-ground 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 off-site areas tributary to the basin as developed, as applicable. Exceptions to the freeboard requirements are as follows:

1. Bioretention BMPs with a ponded depth less than or equal to 0.5 feet are exempt from the freeboard requirements.

2. Small detention basins, with a ponded depth less than or equal to 1.5 feet or having a depth to the top of the berm less than or equal to 2.5 feet, may provide twenty percent additional storage volume measured from the maximum ponded depth to the invert of the emergency spillway in lieu of the above requirements. The depth of the emergency spillway must be sufficient to pass either two times the 100-year peak or the 100-year peak with 0.2’ of freeboard to the top of berm, whichever is greater.

3. Small infiltration basins, with a ponded depth less than or equal to 1.5 feet or having a depth to the top of the berm less than or equal to 2.5 feet, may provide twenty percent additional storage volume measured from the maximum ponded depth to the top of the berm in lieu of the above requirements. In this case, an emergency spillway is only necessary if runoff in excess of the basin volume would cause harm to downstream owners. If a spillway is necessary, it must be sufficiently sized to pass the 100-year peak inflow.

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.

G. The minimum circular orifice diameter for controlling discharge rates from detention facilities shall be three (3) inches. Designs where a lesser size orifice would be required to fully meet release rates shall be acceptable with a 3-inch orifice provided that as much of the site runoff as practical is directed to the detention facilities. The minimum 3 inch diameter does not apply to the control of the WQv.

H. Runoff 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 may be taken from NOAA Atlas 14, Volume 2 Version 2.1, 2004 or the PennDOT Intensity - Duration - Frequency Field Manual ("PDT-IDF") (May 1986) for Region 4. The following values are taken from the PDT-IDF Field Manual:

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.

I. Runoff calculations using the Rational Method shall use rainfall intensities consistent with appropriate times of concentration and return periods and NOAA Atlas 14, Volume 2 Version 2.1, 2004 or the Intensity-Duration-Frequency Curves as presented in Appendix C.

J. Runoff Curve Numbers (CN's) to be used in the Soil-Cover-Complex method shall be based upon the table presented in Appendix C.

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

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

1. Sheet Flow (overland flow) calculations shall use either the NRCS average velocity chart (Figure 3-1, 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 sheet 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.

2. 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.

3. 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.

4. 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.

M. If using the Rational Method, 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. If using the Rational Method, 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.

N. When conditions exist such that a proposed detention facility may experience a tailwater effect, the basin shall be analyzed without any tailwater effect for all storm events for comparison against the required Release Rates. An additional routing of the 100-year storm with the full tailwater effect shall be performed to check that the basin has sufficient storage to contain the 100-year tributary flow with a tailwater.

O. 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 or other appropriate standard engineering 'n' value resources. Pipe capacities shall be determined by methods acceptable to the municipality.

P. 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 stormwater management facilities according to this Ordinance may differ from the 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 Regulated Earth Disturbance Activity, the owner, subdivider, developer or his agent shall submit a Drainage Plan and receive municipal approval of the Plan.

SECTION 402. EXEMPTIONS

Exemptions from the Drainage Plan Requirements are as specified in Section 106.

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 stormwater controls.

3. The name and address of the project site, the name and address of the owner of the property and the name of the individual or firm preparing the Drainage Plan.

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 features including flood hazard boundaries, 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. The locations of all existing and proposed utilities, sanitary sewers and water lines within 50 feet of property lines of the project site.

6. An overlay showing soil types and boundaries based on the county soil survey, as applicable, latest edition. Any hydric soils present on the site should be identified as such.

7. An overlay showing geologic types, boundaries and any special geologic features present on the site.

8. Proposed changes to land surface and vegetative cover.

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

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

11. Stormwater Management District boundaries applicable to the site.

12. Clear identification of the location and nature of permanent stormwater BMPs.

13. An adequate access easement around all stormwater BMPs that would provide municipal ingress to and egress from a public right-of-way.

14. 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.

15. The location of all public water supply wells within 400 feet of the project and all private water supply wells within 100 feet of the project.

C. Stormwater Management Controls and BMPs

1. All stormwater management controls and BMPs shall 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 shall 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 BMPs shall be shown.

3. All site testing data used to determine the feasibility of infiltration on a site.

4. All details and specifications for the construction of the stormwater management controls and BMPs.

D. The BMP Operations and Maintenance Plan, as required in Article 7, describing how each permanent stormwater BMP will be operated and maintained and the identity of the person(s) responsible for operations and maintenance. A statement must be included, signed by the landowner, acknowledging that the stormwater BMPs are fixtures that cannot be altered or removed without approval by the municipality.

SECTION 404. PLAN SUBMISSION

A. For Regulated Activities specified in Sections 105.A. and 105.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. Two (2) copies to the Lehigh Valley Planning Commission (LVPC), except for Drainage Plans involving less than 10,000 square feet of additional impervious cover.

4. Drainage Plans involving more than 10,000 square feet of additional impervious cover shall be submitted by the developer (possibly through the municipality) to the LVPC as part of the Preliminary Plan submission. The LVPC will conduct an advisory review of the Drainage Plan for consistency with the Sacony Creek Headwaters Stormwater Management Plan. The LVPC will not review details of the Erosion and Sedimentation Plan or the BMP Operations and Maintenance Plan.

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

b. 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 Stormwater Management Plan.

B. For Regulated Activities specified in Sections 105.C. and 105.D., the Drainage Plan shall be submitted by the developer to the municipal building permit officer as part of the building permit application.

C. For Regulated Activities specified in Sections 105.E., 105.F. and 105.G.:

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), Chapter 106 (Flood Plain Management) of DEP's Rules and Regulations and the NPDES regulations.

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

D. Earthmoving for all Regulated Activities under Section 105 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 municipality shall review the Drainage Plan, including the BMP Operations and Maintenance Plan, for consistency with this Ordinance. The municipality shall also review the Drainage Plan against any additional storm drainage provisions contained in the municipal subdivision and land development or zoning ordinance, as applicable.

B. The municipality shall notify the applicant in writing whether the Drainage Plan, including the BMP Operations and Maintenance Plan, is approved, consistent with timeframes as established by the current Pennsylvania Municipalities Planning Code.

C. The municipality shall not approve any subdivision or land development (Regulated Activities 105.A. and 105.B.) or building permit application (Regulated Activities 105.C. and 105.D.) if the Drainage Plan has been found to be inconsistent with this Ordinance.

D. The municipality may require an "As-Built Survey" of all stormwater BMPs and an explanation of any discrepancies with the Drainage Plan.

SECTION 406. MODIFICATION OF PLANS

A modification to a 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 municipality) 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 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 accept a waiver request provided that the Municipality determines that in each case the request satisfies all of the following findings:

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 Stormwater 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 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;

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; and

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

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

A. For Regulated Activities described in Section 105.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 105.C., D., E., F. and G., the Zoning Hearing Board shall hear requests for and decide on hardship waiver requests on behalf of the municipality.

C. The municipality will process all eligible waiver requests in accordance with the provisions of Section 304.J.

ARTICLE 5
INSPECTIONS

SECTION 501. SCHEDULE OF INSPECTIONS

A. DEP or its designees (e.g. County Conservation District) normally ensure compliance with any permits issued, including those for stormwater management. In addition to DEP compliance programs, the municipality or its designee may inspect all phases of the construction, operations, maintenance and any other implementation of stormwater BMPs.

B. During any stage of the Regulated Earth Disturbance Activities, if the municipality or its designee determines that any BMPs are not being implemented in accordance with permit conditions or this Ordinance, the municipality may suspend or revoke any existing permits issued by the municipality or other approvals issued by the municipality until the deficiencies are corrected.

ARTICLE 6
FEES AND EXPENSES

SECTION 601. GENERAL

The municipality may charge a reasonable fee for review of the Drainage Plan, including the BMP Operations and Maintenance Plan, to defray review costs incurred by the municipality. The applicant shall pay all such fees.

SECTION 602. EXPENSES COVERED BY FEES

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

A. The review of the Drainage Plan, including the BMP Operations and Maintenance Plan, by the municipality.

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 monitor and 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
STORMWATER BMP OPERATIONS AND MAINTENANCE PLAN REQUIREMENTS

SECTION 701. GENERAL REQUIREMENTS

A. No Regulated Earth Disturbance Activities within the municipality shall commence until approval by the municipality of the BMP Operations and Maintenance Plan which describes how the permanent (e.g. post construction) stormwater BMPs will be properly operated and maintained.

SECTION 702. RESPONSIBILITIES FOR OPERATIONS AND MAINTENANCE OF BMPS

A. The BMP Operations and Maintenance Plan for the project site shall establish responsibilities for the continuing operation and maintenance of all permanent stormwater BMPs, as follows:

1. If a Plan includes structures or lots which are to be separately owned and in which streets, sewers and other public improvements are to be dedicated to the municipality, stormwater BMPs may also be dedicated to and maintained by the municipality.

2. If a Plan includes operations and maintenance by a single owner or if sewers and other public improvements are to be privately owned and maintained, then the operation and maintenance of stormwater BMPs shall be the responsibility of the owner or private management entity.

B. The municipality shall make the final determination on the continuing operations and maintenance responsibilities. The municipality reserves the right to accept or reject the operations and maintenance responsibility for any or all of the stormwater BMPs.

SECTION 703. ADHERENCE TO APPROVED BMP OPERATIONS AND MAINTENANCE PLAN

It shall be unlawful to alter or remove any permanent stormwater BMP required by an approved BMP Operations and Maintenance Plan or to allow the property to remain in a condition which does not conform to an approved BMP Operations and Maintenance Plan unless an exception is granted in writing by the municipality.

SECTION 704. OPERATIONS AND MAINTENANCE AGREEMENT FOR PRIVATELY OWNED STORMWATER BMPS

A. The property owner shall sign an operations and maintenance agreement with the municipality covering all stormwater BMPs that are to be privately owned. The agreement shall be substantially the same as the agreement in Appendix D of this Ordinance.

B. Other items may be included in the agreement where determined by the municipality to be reasonable or necessary to guarantee the satisfactory operation and maintenance of all permanent stormwater BMPs. The agreement shall be subject to the review and approval of the municipality.

SECTION 705. STORMWATER MANAGEMENT EASEMENTS

Stormwater management easements shall be provided by the property owner if necessary for access for inspections and maintenance or for preservation of stormwater conveyance, infiltration, detention areas and other BMPs by persons other than the property owner. The purpose of the easement shall be specified in any agreement under Section 704.

SECTION 706. RECORDING OF APPROVED BMP OPERATIONS AND MAINTENANCE PLAN AND RELATED AGREEMENTS

A. The owner of any land upon which permanent BMPs will be placed, constructed or implemented, as described in the BMP Operations and Maintenance Plan, shall record the following documents in the county Office of the Recorder of Deeds, as applicable, within 90 days of approval of the BMP Operations and Maintenance Plan by the municipality:

1. The Operations and Maintenance Plan or a summary thereof.

2. Operations and Maintenance Agreements under Section 704.

3. Easements under Section 705.

B. The municipality may suspend or revoke any approvals granted for the project site upon discovery of the failure of the owner to comply with this Section.

SECTION 707. MUNICIPAL STORMWATER BMP OPERATIONS AND MAINTENANCE FUND

A. Persons installing stormwater BMPs shall be required to pay a specified amount to the Municipal Stormwater BMP Operations and Maintenance Fund to help defray costs of operations and maintenance activities. The amount may be determined as follows:

1. If the BMP is to be privately owned and maintained, the amount shall cover the cost of periodic inspections by the municipality in perpetuity, as determined by the municipality.

2. If the BMP is to be owned and maintained by the municipality, the amount shall cover the estimated costs for operation and maintenance in perpetuity, as determined by the municipality.

3. The amount shall then be converted to present worth of the annual series values.

B. If a BMP is proposed that also serves as a recreation facility (e.g. ball field, lake), the municipality may adjust the amount due accordingly.

ARTICLE 8
PROHIBITIONS

SECTION 801. PROHIBITED DISCHARGES

A. No person in the municipality shall allow or cause to allow stormwater discharges into the municipality's separate storm sewer system which are not composed entirely of stormwater except as provided in subsection B below or as allowed under a State or Federal permit.

B. The following discharges are authorized unless they are determined to be significant contributors to pollution to the waters of this Commonwealth.

1. Discharges from fire fighting activities.
2. Potable water sources including dechlorinated water line and fire hydrant flushings.
3. Irrigation drainage.
4. Routine external building washdown which does not use detergents or other compounds.
5. Air conditioning condensate.
6. Water from individual residential car washing.
7. Springs.
8. Water from crawl space pumps.
9. Uncontaminated water from foundation or footing drains.
10. Flows from riparian habitats and wetlands.
11. Lawn watering.
12. Pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spill material has been removed) and where detergents are not used.
13. Dechlorinated swimming pool discharges.
14. Uncontaminated groundwater.

C. In the event that the municipality determines that any of the discharges identified in Section 801.B. significantly contribute to pollution of waters of the Commonwealth or is so notified by DEP, the municipality will notify the responsible person to cease the discharge.

D. Upon notice provided by the municipality under Section 801.C., the discharger will have a reasonable time, as determined by the municipality, to cease the discharge consistent with the degree of pollution caused by the discharge.

E. Nothing in this Section shall affect a discharger's responsibilities under State law.

SECTION 802. PROHIBITED CONNECTIONS

A. The following connections are prohibited, except as provided in Section 801.B. above:

1. Any drain or conveyance, whether on the surface or subsurface, which allows any non-stormwater discharge including sewage, process wastewater and wash water to enter the separate storm sewer system and any connections to the storm drain system from indoor drains and sinks.

2. Any drain or conveyance connected from a commercial or industrial land use to the separate storm sewer system which has not been documented in plans, maps or equivalent records and approved by the municipality.

SECTION 803. ROOF DRAINS

A. Roof drains shall discharge to infiltration areas or vegetative BMPs to the maximum extent practicable.

ARTICLE 9
RIGHT OF ENTRY, NOTIFICATION AND ENFORCEMENT

SECTION 901. RIGHT OF ENTRY

A. Upon presentation of proper credentials and with the consent of the land owner, duly authorized representatives of the municipality may enter at reasonable times upon any property within the municipality to inspect the implementation, condition or operation and maintenance of the stormwater BMPs or to investigate or ascertain the condition of the subject property in regard to any aspect regulated by this Ordinance.

B. In the event that the land owner refuses admission to the property, duly authorized representatives of the municipality may seek an administrative search warrant issued by a district justice to gain access to the property.

SECTION 902. NOTIFICATION

A. Whenever the municipality finds that a person has violated a prohibition or failed to meet a requirement of this Ordinance, the municipality may order compliance by written notice to the responsible person. Such notice may require without limitation:

1. The name of the owner of record and any other person against whom the municipality intends to take action.

2. The location of the property in violation.

3. The performance of monitoring, analyses and reporting.

4. The elimination of prohibited connections or discharges.

5. Cessation of any violating discharges, practices or operations.

6. The abatement or remediation of stormwater pollution or contamination hazards and the restoration of any affected property.

7. Payment of a fine to cover administrative and remediation costs.

8. The implementation of stormwater BMPs.

9. Operation and maintenance of stormwater BMPs.

B. Such notification shall set forth the nature of the violation(s) and establish a time limit for correction of the violation(s). Said notice may further advise that should the violator fail to take the required action within the established deadline, the work will be done by the municipality or designee and the expense thereof, together with all related lien and enforcement fees, charges and expenses, shall be charged to the violator.

C. Failure to comply within the time specified shall also subject such person to the penalty provisions of this Ordinance. All such penalties shall be deemed cumulative and shall not prevent the municipality from pursuing any and all other remedies available in law or equity.

SECTION 903. PUBLIC NUISANCE

A. The violation of any provision of this Ordinance is hereby deemed a Public Nuisance.

B. Each day that an offense continues shall constitute a separate violation.

SECTION 904. SUSPENSION AND REVOCATION OF PERMITS AND APPROVALS

A. Any building, land development or other permit or approval issued by the municipality may be suspended or revoked by the municipality for:

1. Non-compliance with or failure to implement any provision of the permit.

2. A violation of any provision of this Ordinance.

3. The creation of any condition or the commission of any act during construction or development which constitutes or creates a hazard or nuisance, pollution or which endangers the life or property of others.

B. A suspended permit or approval shall be reinstated by the municipality when:

1. The municipality or designee has inspected and approved the corrections to the stormwater BMPs or the elimination of the hazard or nuisance.

2. The municipality is satisfied that the violation of the ordinance, law or rule and regulation has been corrected.

3. Payment of all municipal fees, costs and expenses related to or arising from the violation has been made.

C. A permit or approval which has been revoked by the municipality cannot be reinstated. The applicant may apply for a new permit under the procedures outlined in this Ordinance.

SECTION 905. PENALTIES

A. Any person, partnership or corporation who or which has violated the provisions of this Ordinance shall, upon being found liable therefore in a civil enforcement proceeding commenced by the municipality, pay a judgment of not more than Five Hundred ($500.00) Dollars plus all court costs, including reasonable attorney's fees incurred by the municipality as a result thereof. No judgment shall commence or be imposed, levied or payable until the date of the determination of a violation by the district justice. If the defendant neither pays nor timely appeals the judgment, the municipality may enforce the judgment pursuant to a separate violation, unless the district justice, determining that there has been a violation, further determines that there was a good faith basis for the person, partnership, or corporation violating this Chapter to have believed that there was no such violation, in which event there shall be deemed to have been only one such violation until the fifth (5^{th}) day following the date of the determination of a violation by the district justice and thereafter each day that a violation continues shall constitute a separate violation.

B. The court of common pleas, upon petition, may grant an order of stay upon cause shown, tolling the per diem judgment pending a final adjudication of the violation and judgment.

C. Nothing contained in this Section shall be construed or interpreted to grant to any person or entity other than the municipality the right to commence any action for enforcement pursuant to this Section.

D. District justices shall have initial jurisdiction in proceedings brought under this Section.

E. In addition, the municipality, through its solicitor, may institute injunctive, mandamus or any other appropriate action or proceeding at law or in equity for the enforcement of this Ordinance. Any court of competent jurisdiction shall have the right to issue restraining orders, temporary or permanent injunctions, mandamus or other appropriate forms of remedy or relief.

SECTION 906. APPEALS

Any person aggrieved by any action of the municipality or its designee relevant to the provisions of this Ordinance may appeal using the appeal procedures established in the Pennsylvania Municipalities Planning Code.

APPENDIX A

(Not Included in Plan Copy of Ordinance)

A-1 Map of Sacony Creek Headwaters

A-2 Municipal Map of Stormwater 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

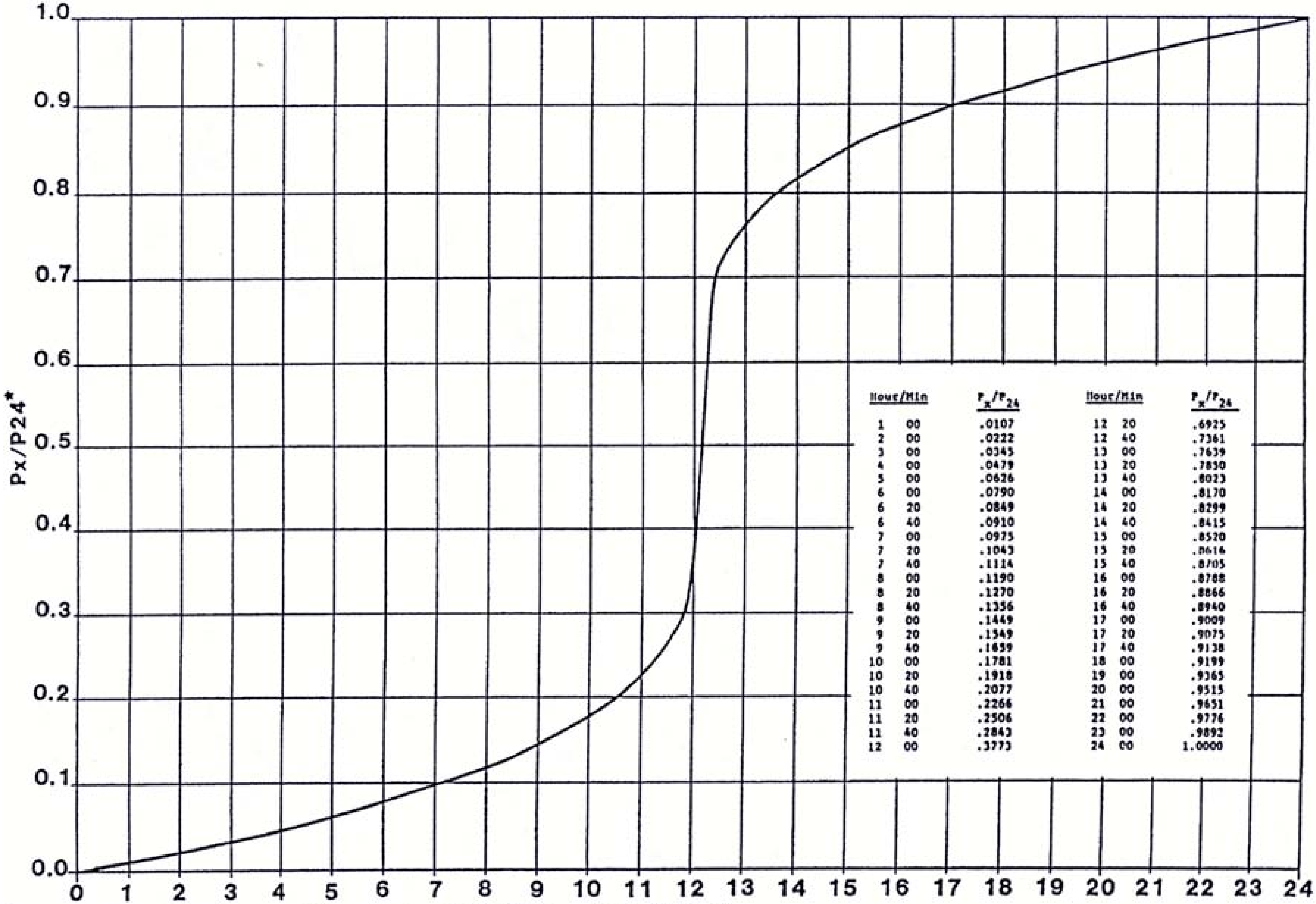
C-4 Runoff Coefficients for the Rational Method

C-5 Manning 'n' Values

C-6 Percent D-RE per Fraction Impervious versus Storage Curve

C-7 Percent D-RE per Fraction Impervious versus Storage Curve Usage Instructions

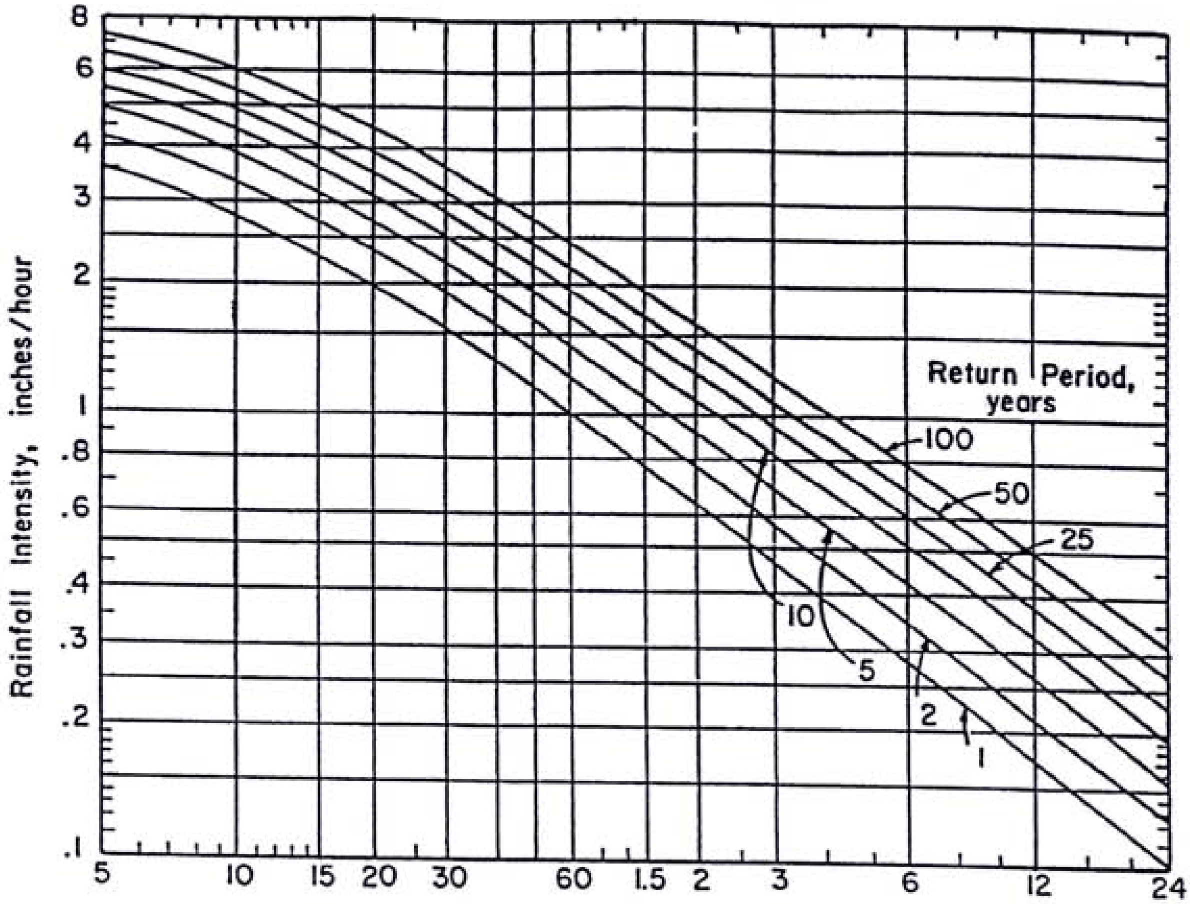
NRCS TYPE II RAINFALL DISTRIBUTION

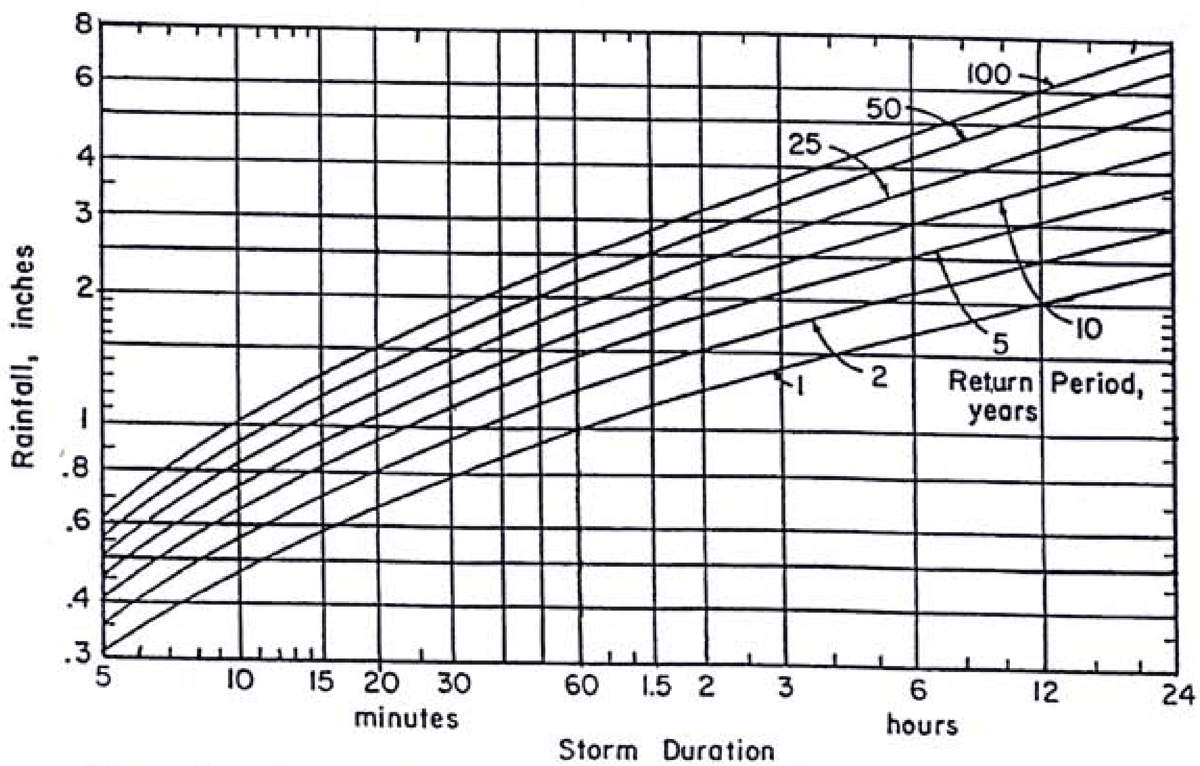


Hour/Min	P_x/P_{24}	Hour/Min	P_x/P_{24}
1 00	.0107	12 20	.6925
2 00	.0222	12 40	.7361
3 00	.0345	13 00	.7639
4 00	.0479	13 20	.7850
5 00	.0626	13 40	.8023
6 00	.0790	14 00	.8170
6 20	.0849	14 20	.8299
6 40	.0910	14 40	.8415
7 00	.0975	15 00	.8520
7 20	.1043	15 20	.8616
7 40	.1114	15 40	.8705
8 00	.1190	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:					
$\frac{1}{8}$ acre or less (townhouses)	65	77	85	90	92
$\frac{1}{4}$ acre	38	61	75	83	87
$\frac{1}{3}$ acre	30	57	72	81	86
$\frac{1}{2}$ 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**

LAND USE	*A*			*B*			C			D		
	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	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97
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.											

*Coefficients for all land uses except parking and other impervious cover are based on the Rossmiller Equation for translating NRCS curve numbers into Rational Method 'c' values. The source for the parking and other impervious cover coefficients is RAWLS, W.J., S.L. WONG and R.H. McCUEN, 1981. Comparison of urban flood frequency procedures. Preliminary draft report prepared for the Soil Conservation Service, Beltsville, MD.

**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.

MANNING 'n' VALUES BY TYPICAL REACH DESCRIPTION

Reach Description	Manning 'n'
Natural stream, clean, straight, no rifts or pools	0.030
Natural stream, clean, winding, some pools and shoals	0.040
Natural stream, winding, pools, shoals, stony with some weeds	0.050
Natural stream, sluggish with deep pools and weeds	0.070
Natural stream or swale, very weedy or with timber under brush	0.100
Concrete pipe, culvert or channel	0.012
Corrugated metal pipe	0.012-0.027*

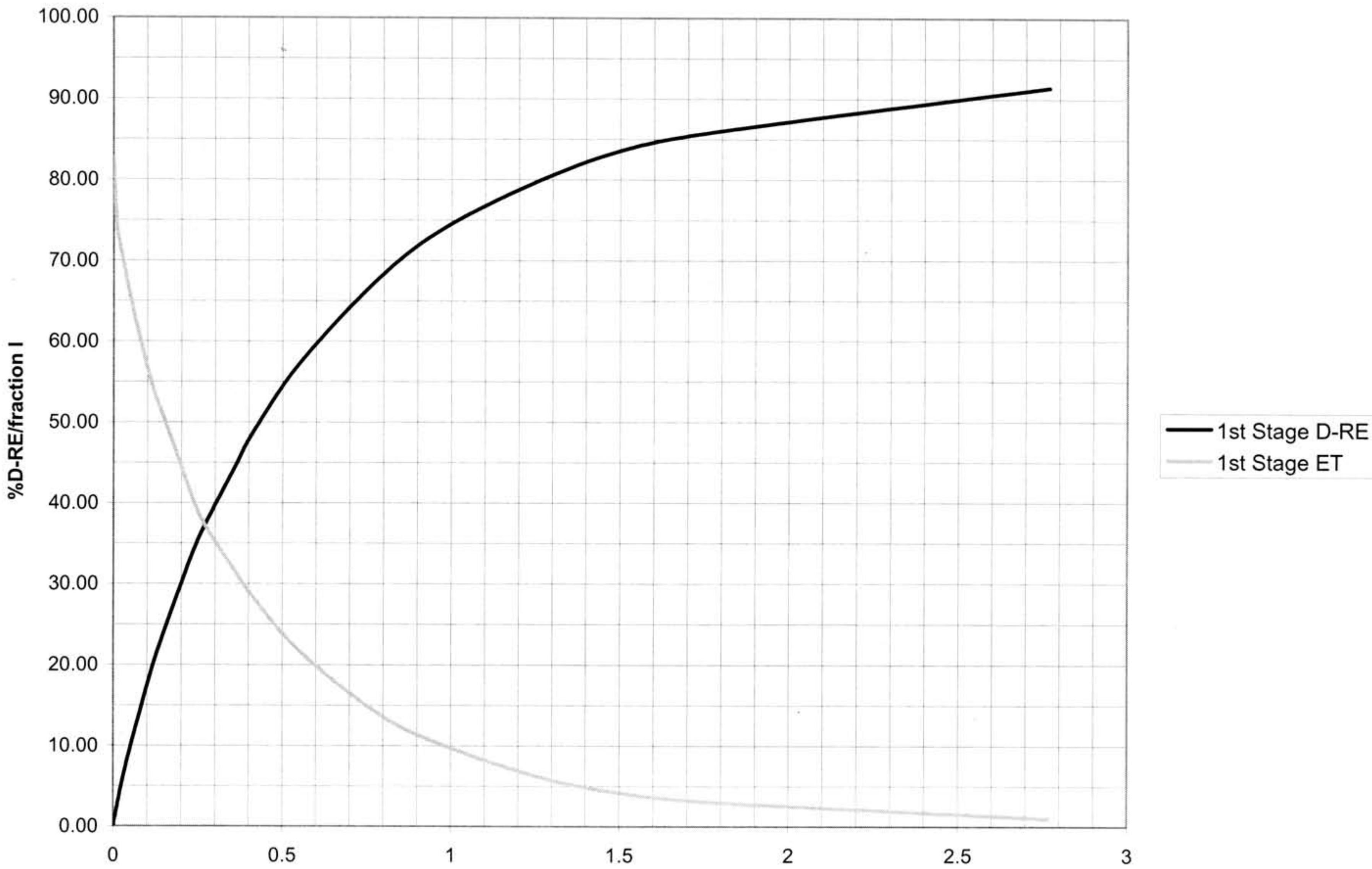
*Depending upon type and diameter.

ROUGHNESS COEFFICIENTS (MANNING 'n') FOR SHEET FLOW

Surface Description	Manning 'n'[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.050
Cultivated soils:	
Residue cover <= 20%	0.060
Residue cover > 20%	0.170
Grass:	
Short grass prairie	0.150
Dense grasses[2]	0.240
Bermuda grass	0.410
Range (natural)	0.130
Woods:[3]	
Light underbrush	0.400
Dense underbrush	0.800

[1]The 'n' values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass and native grass mixtures.
[3]When selecting 'n', consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

% Direct Recharge (D-RE) per Fraction Impervious vs. Storage



Note: See section C-7 for instruction on how to use the chart

PERCENT D-RE PER FRACTION IMPERVIOUS VERSUS STORAGE CURVE USAGE INSTRUCTIONS

The "1st Stage D-RE" curve is based on impervious areas being diverted first to a D-RE BMP designed to capture less than the 2-year event, with the remaining 2-year runoff overflowing into an ET BMP. The "1st stage ET" curve is based on reversing the above. The curves may be used for the whole site, or for pieces of a site to achieve successful designs as follows:

A. If used for whole site designs, the "fraction I" used is the proposed impervious as a fraction of the entire site. As an example, for a 60% impervious site with all impervious directed to a first stage D-RE BMP, use 30% D-RE with 0.60 fraction I to yield 50% D-RE/fraction I and translate into 0.42 inches of storage over impervious areas. The total first stage D-RE maximum BMP storage is 0.42 inches of depth times the surface area of the impervious cover. Similarly, if a first stage ET BMP followed by a second stage D-RE BMP was used, the minimum ET storage is 0.15 inches over the impervious cover.

B. If used for pieces of the site smaller than the whole site, the fraction I used is the impervious cover of the part of the site in question as a fraction of the area of the same piece. Each piece may be designed for 30% D-RE if desired, but individual pieces may exceed 30% D-RE provided all BMPs on site are providing less than 30% D-RE in aggregate. In this case, the BMP storage for each piece is used in the chart with the fraction I using the whole site area to determine the contribution of each piece to the 30% D-RE allowable. As an example, still using the 60% impervious site, a piece of the site uses a D-RE BMP first. The piece is half of the total area of the site and is 80% impervious. The BMP is designed for 0.6 inches of runoff from the impervious surfaces. Using 0.6 inches of storage and a fraction I of 0.80, the piece is designed for (%D-RE/Fraction I = 60) 48% D-RE. The impervious cover in this piece has fraction I of 0.4 of the overall site acreage and, therefore, using 0.6 inches of storage and a fraction I of 0.4 yields a D-RE/ fraction I of 60% using the graph which solves to a D-RE of 24%. This means that this piece uses 24% of the allowable 30% D-RE. The remaining piece(s) will need to be designed for 6% or less D-RE. The remaining piece in this example has a fraction I of the overall site of 0.2. Using 6% D-RE and a fraction I of 0.2 yields a D-RE/fraction I of 30%. Entering the graph at that value, the maximum storage for the piece in a first stage D-RE BMP is 0.2 inches over the impervious portion of its tributary area.

C. If more than two stages of ET and D-RE BMPs are used to control the WQv, the design considerations are as follows:

   1. If the design has a first stage ET BMP draining to additional stage ET BMPs and subsequent D-RE BMP, add the storage volumes of the ET BMPs and use this volume as the first stage ET storage volume.
   2. Similarly, if two or more D-RE BMPs are used first followed by an ET BMP, add the storage volumes of the D-RE BMPs and use this volume as the first stage D-RE storage volume.

3. In designs with more than two ET or D-RE BMPs used in series to control the WQv and rules C.1 and C.2 don’t apply, the chart shall be applied conservatively to assure the D-RE standard is not violated. For example, with proposed use of a first stage D-RE BMP, second stage ET BMP, and third stage D-RE BMP, all storage provided shall be assumed to be D-RE for use in the chart. Essentially, any ET BMP applied beyond the first stage will be ignored for purposes of determining compliance with the D-RE standard.

APPENDIX D

STORMWATER BEST MANAGEMENT PRACTICES OPERATIONS AND MAINTENANCE AGREEMENT

THIS AGREEMENT, made and entered into this ____________ day of _________, 200__, by and between _______________________________________, (hereinafter the "Landowner"), and _ _________________________________, _____________________________ County, Pennsylvania, (hereinafter "municipality");

WITNESSETH

WHEREAS, the Landowner is the owner of certain real property as recorded by deed in the land records of ________________ County, Pennsylvania, Deed Book ___________ at Page ______, (hereinafter "Property").

WHEREAS, the Landowner is proceeding to build and develop the Property; and

WHEREAS, the stormwater management BMP Operations and Maintenance Plan approved by the municipality (hereinafter referred to as the "Plan") for the property identified herein, which is attached hereto as Appendix A and made part hereof, as approved by the municipality, provides for management of stormwater within the confines of the Property through the use of Best Management Practices (BMP's); and

WHEREAS, the municipality, and the Landowner, his successors and assigns, agree that the health, safety, and welfare of the residents of the municipality and the protection and maintenance of water quality require that on-site stormwater Best Management Practices be constructed and maintained on the Property; and

WHEREAS, for the purposes of this agreement, the following definitions shall apply:

- BMP – "Best Management Practice;" activities, facilities, designs, measures or procedures used to manage stormwater impacts from land development, to protect and maintain water quality and groundwater recharge and to otherwise meet the purposes of the Municipal Stormwater Management Ordinance, including but not limited to infiltration trenches, seepage pits, filter strips, bioretention, wet ponds, permeable paving, rain gardens, grassed swales, vegetated buffers, sand filters and detention basins.
- Infiltration Trench – A BMP surface structure designed, constructed, and maintained for the purpose of providing infiltration or recharge of stormwater into the soil and/or groundwater aquifer,
- Seepage Pit – An underground BMP structure designed, constructed, and maintained for the purpose of providing infiltration or recharge of stormwater into the soil and/or groundwater aquifer,
- Rain Garden – A BMP overlain with appropriate mulch and suitable vegetation designed, constructed, and maintained for the purpose of providing infiltration or recharge of stormwater into the soil and/or underground aquifer; and

WHEREAS, the municipality requires, through the implementation of the Plan, that stormwater management BMPs as required by said Plan and the Municipal Stormwater Management Ordinance be constructed and adequately operated and maintained by the Landowner, his successors and assigns; and

NOW, THEREFORE, in consideration of the foregoing promises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The BMPs shall be constructed by the Landowner in accordance with the plans and specifications identified in the Plan.
2. The Landowner shall operate and maintain the BMP(s) as shown on the Plan in good working order acceptable to the municipality and in accordance with the specific maintenance requirements noted on the Plan.
3. The Landowner hereby grants permission to the municipality, its authorized agents and employees, to enter upon the property, at reasonable times and upon presentation of proper identification, to inspect the BMP(s) whenever it deems necessary. Whenever possible, the municipality shall notify the Landowner prior to entering the property.
4. In the event the Landowner fails to operate and maintain the BMP(s) as shown on the Plan in good working order acceptable to the municipality, the municipality or its representatives may enter upon the Property and take whatever action is deemed necessary to maintain said BMP(s). This provision shall not be construed to allow the municipality to erect any permanent structure on the land of the Landowner. It is expressly understood and agreed that the municipality is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the municipality.
5. In the event the municipality, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the municipality for all expenses (direct and indirect) incurred within 10 days of receipt of invoice from the municipality and if not timely paid, a municipal lien shall be placed upon the premises for 110% of the invoice amount, plus statutorily allowed fees, expenses and costs.
6. The intent and purpose of this Agreement is to ensure the proper maintenance of the on-site BMP(s) by the Landowner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability of any party for damage alleged to result from or be caused by stormwater runoff.
7. The Landowner, its executors, administrators, assigns, and other successors in interests, hereby release and hold harmless the municipality's employees and designated representatives from all damages, accidents, casualties, occurrences or claims which might arise or be asserted against said employees and representatives from the construction, presence, existence, or maintenance of the BMP(s) by the Landowner or municipality. In the event that a claim is asserted against the municipality, its designated representatives or employees, the municipality shall promptly notify the Landowner and the Landowner shall defend, at his own expense, any suit based on the claim. If any judgment or claims against the municipality's employees or designated representatives shall be allowed, the Landowner shall pay all costs and expenses regarding said judgment or claim.

8. The municipality shall inspect the BMP(s) as necessary to ensure their continued functioning. The municipality may accept third party inspection certification as evidence of proper BMP functioning.

This Agreement shall be recorded at the Office of the Recorder of Deeds of ______________ County, Pennsylvania, and shall constitute a covenant running with the Property and/or equitable servitude, and shall be binding on the Landowner, his administrators, executors, assigns, heirs and any other successors in interests, in perpetuity.

ATTEST:

WITNESS the following signatures and seals:

(SEAL) For the municipality:

____

(SEAL) For the Landowner:

____

ATTEST:

_______________________________ (City, Borough, Township)

County of _____________________________, Pennsylvania

I, ____, a Notary Public in and for the County and

State aforesaid, whose commission expires on the __________ day of __________________,

200_, do hereby certify that ____ whose

name(s) is/are signed to the foregoing Agreement bearing date of the ___________ day of

___________________, 200_, has acknowledged the same before me in my said County and

State.

GIVEN UNDER MY HAND THIS _____________ day of ___________, 200_.

__________________________________ ______________________________________

NOTARY PUBLIC (SEAL)

APPENDIX E

LOW IMPACT DEVELOPMENT PRACTICES

ALTERNATIVE APPROACH FOR MANAGING STORMWATER RUNOFF

Natural hydrologic conditions may be altered radically by poorly planned development practices, such as introducing unneeded impervious surfaces, destroying existing drainage swales, constructing unnecessary storm sewers, and changing local topography. A traditional drainage approach of development has been to remove runoff from a site as quickly as possible and capture it in a detention basin. This approach may lead ultimately to the degradation of water quality as well as expenditure of additional resources for detaining and managing concentrated runoff at some downstream location.

The recommended alternative approach is to promote practices that will minimize post-development runoff rates and volumes, which will minimize needs for artificial conveyance and storage facilities. To simulate pre-development hydrologic conditions, forced infiltration is often necessary to offset the loss of infiltration by creation of impervious surfaces. The ability of the ground to infiltrate depends upon the soil types and its conditions.

Preserving natural hydrologic conditions requires careful alternative site design considerations. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, and protecting natural depression storage. A well-designed site will contain a mix of all those features. The following describes various techniques to achieve the alternative approach:

- Preserving Natural Drainage Features. Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in land development. In fact, commonly held drainage philosophy encourages just the opposite pattern — streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. As a result, runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration. Developments designed to fit site topography also minimize the amount of grading on site.

- Protecting Natural Depression Storage Areas. Depression storage areas have no surface outlet, or drain very slowly following a storm event. They can be commonly seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining, thereby obliterating their ability to reduce surface runoff volumes and trap pollutants. The volume and release rate characteristics of depressions should be protected in the design of the development site. The depressions can be protected by simply avoiding the depression or by incorporating its storage as additional capacity in required detention facilities.

- Avoiding Introduction of Impervious Areas. Careful site planning should consider reducing impervious coverage to the maximum extent possible. Building footprints, sidewalks, driveways and other features producing impervious surfaces should be evaluated to minimize impacts on runoff.

- Reducing the Hydraulic Connectivity of Impervious Surfaces. Impervious surfaces are significantly less of a problem if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are routing of roof runoff over lawns and reducing the use of storm sewers. Site grading should promote increasing travel time of stormwater runoff, and should help reduce concentration of runoff to a single point in the development.

- Routing Roof Runoff Over Lawns. Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. By routing roof drains and crowning the driveway to run off to the lawn, the lawn is essentially used as a filter strip.

- Reducing the Use of Storm Sewers. By reducing use of storm sewers for draining streets, parking lots, and back yards, the potential for accelerating runoff from the development can be greatly reduced. The practice requires greater use of swales and may not be practical for some development sites, especially if there are concerns for areas that do not drain in a "reasonable" time. The practice requires educating local citizens and public works officials, who expect runoff to disappear shortly after a rainfall event.

- Reducing Street Widths. Street widths can be reduced by either eliminating on-street parking or by reducing roadway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets which ultimately could lower maintenance.

- Limiting Sidewalks to One Side of the Street. A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk could be replaced with bicycle/recreational trails that follow back-of-lot lines. Where appropriate, backyard trails should be constructed using pervious materials.

- Using Permeable Paving Materials. These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low use surfaces such as driveways, overflow parking lots, and emergency access roads.

- Reducing Building Setbacks. Reducing building setbacks reduces driveway and entry walks and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

- Constructing Cluster Developments. Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development. Cluster development clusters the construction activity onto less-sensitive areas without substantially affecting the gross density of development.

APPENDIX F

LIST OF ACCEPTABLE BMPs

Best Management Practice	Design Reference Number[B]
Bioretention[A]	4, 5, 11, 16
Capture/Reuse	4, 14
Constructed Wetlands	4, 5, 8, 10, 16
Dry Extended Detention Ponds	4, 5, 8, 12, 18
Minimum Disturbance/ Minimum Maintenance Practices	1, 9
Significant Reduction of Existing Impervious Cover	N/A
Stormwater Filters[A] (Sand, Peat, Compost, etc.)	4, 5, 10, 16
Vegetated Buffers/Filter Strips	2, 3, 5, 11, 16, 17
Vegetated Roofs	4, 13
Vegetated Swales[A]	2, 3, 5, 11, 16, 17
Water Quality Inlets[C]	4, 7, 15, 16, 19
Wet Detention Ponds	4, 5, 6, 8

[A] This BMP could be designed with or without an infiltration component. If infiltration is proposed, the site and BMP will be subject to the testing and other infiltration requirements in this Ordinance.
[B] See table below.
[C] Water Quality Inlets include such BMPs as Oil/Water Separators, Sediment Traps/Catch Basin Sumps, and Trash/Debris Collectors in Catch Basins.

Number	Design Reference Title
1	"Conservation Design For Stormwater Management – A Design Approach to Reduce Stormwater Impacts From Land Development and Achieve Multiple Objectives Related to Land Use", Delaware Department of Natural Resources and Environmental Control, The Environmental Management Center of the Brandywine Conservancy, September 1997
2	"A Current Assessment of Urban Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone", Schueler, T. R., Kumble, P. and Heraty, M., Metropolitan Washington Council of Governments, 1992.
3	"Design of Roadside Channels with Flexible Linings", Federal Highway Administration, Chen, Y. H. and Cotton, G. K., Hydraulic Engineering Circular 15, FHWA-IP-87-7, McLean Virginia, 1988.

LIST OF ACCEPTABLE BMPs

Number	Design Reference Title
4	"Draft Stormwater Best Management Practices Manual", Pennsylvania Department of Environmental Protection, January 2005.
5	"Evaluation and Management of Highway Runoff Water Quality", Federal Highway Administration, FHWA-PD-96-032, Washington, D.C., 1996.
6	"Evaporation Maps of the United States", U.S. Weather Bureau (now NOAA/National Weather Service) Technical Paper 37, Published by Department of Commerce, Washington D.C., 1959.
7	"Georgia Stormwater Manual", AMEC Earth and Environmental, Center for Watershed Protection, Debo and Associates, Jordan Jones and Goulding, Atlanta Regional Commission, Atlanta, Georgia, 2001.
8	"Hydraulic Design of Highway Culverts", Federal Highway Administration, FHWA HDS 5, Washington, D.C., 1985 (revised May 2005).
9	"Low Impact Development Design Strategies *An Integrated Design Approach*, Prince Georges County, Maryland Department of Environmental Resources, June 1999.
10	"Maryland Stormwater Design Manual", Maryland Department of the Environment, Baltimore, Maryland, 2000.
11	"Pennsylvania Handbook of Best Management Practices for Developing Areas", Pennsylvania Department of Environmental Protection, 1998.
12	"Recommended Procedures for Act 167 Drainage Plan Design", LVPC, Revised 1997.
13	"Roof Gardens History, Design, and Construction", Osmundson, Theodore. New York: W.W. Norton & Company, 1999.
14	"The Texas Manual on Rainwater Harvesting", Texas Water Development Board, Austin, Texas, Third Edition, 2005.
15	"VDOT Manual of Practice for Stormwater Management", Virginia Transportation Research Council, Charlottesville, Virginia, 2004.
16	"Virginia Stormwater Management Handbook", Virginia Department of Conservation and Recreation, Richmond, Virginia, 1999.
17	"Water Resources Engineering", Mays, L. W., John Wiley & Sons, Inc., 2005.
18	"Urban Hydrology for Small Watersheds", Technical Report 55, US Department of Agriculture, Natural Resources Conservation Service, 1986.
19	US EPA, Region 1 New England web site (as of August 2005) http://www.epa.gov/NE/assistance/ceitts/stormwater/techs/html.

LIST OF ACCEPTABLE BMPs

PRE-TREATMENT METHODS FOR "HOT SPOT" LAND USES

Hot Spot Land Use	Pre-treatment Method(s)
Vehicle Maintenance and Repair Facilities including Auto Parts Stores	-Water Quality Inlets -Use of Drip Pans and/or Dry Sweep Material Under Vehicles/Equipment -Use of Absorbent Devices to Reduce Liquid Releases -Spill Prevention and Response Program
Vehicle Fueling Stations	-Water Quality Inlets -Spill Prevention and Response Program
Storage Areas for Public Works	-Water Quality Inlets -Use of Drip Pans and/or Dry Sweep Material Under Vehicles/Equipment -Use of Absorbent Devices to Reduce Liquid Releases -Spill Prevention and Response Program -Diversion of Stormwater away from Potential Contamination Areas
Outdoor Storage of Liquids	-Spill Prevention and Response Program
Commercial Nursery Operations	-Vegetated Swales/Filter Strips -Constructed Wetlands -Stormwater Collection and Reuse
Salvage Yards and Recycling Facilities*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Fleet Storage Yards and Vehicle Cleaning Facilities*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Facilities that Store or Generate Regulated Substances*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Marinas*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Certain Industrial Uses (listed under NPDES)*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit

*Regulated under the NPDES Stormwater Program

Design references for the pre-treatment methods, as necessary, are listed below. If the applicant can demonstrate to the satisfaction of the municipality that the proposed land use is not a Hot Spot, then the pre-treatment requirement would not apply.

LIST OF ACCEPTABLE BMPs

Pre-treatment Method	Design Reference[A]
Constructed Wetlands	4, 5, 8, 10, 16
Diversion of Stormwater Away from Potential Contamination Areas	4, 11
Stormwater Collection and Reuse (especially for irrigation)	4, 14
Stormwater Filters (Sand, Peat, Compost, etc.)	4, 5, 10, 16
Vegetated Swales	2, 3, 5, 11, 16, 17
Water Quality Inlets	4, 7, 15, 16, 19

[A]These numbers refer to the Design Reference Title Chart beginning on page F-1.

CHAPTER 10. PRIORITIES FOR IMPLEMENTATION OF THE PLAN

The Sacony Creek Headwaters Stormwater Management Plan preparation process is complete with the Lehigh 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 stormwater management criteria. Sacony Creek Headwaters municipalities would have six months from DEP approval within which to adopt the necessary municipal 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 and development of a local program to coordinate with DEP regarding permit reviews for stream encroachments, diversions, etc. 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 County, the Plan is submitted to DEP for approval. The DEP review process involves determination that all of the activities specified in the approved work program 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 stormwater plans for the basin in which the watershed is located, and is consistent with the policies 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

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. Additionally, the approved *Sacony Creek Headwaters Act 167 Stormwater Management Plan* will be posted on the LVPC website.

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 development for the Sacony Creek Headwaters. Activities of this type may modify the conveyance characteristics of the study area and have an 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 Stormwater Management Plan is the adoption of the necessary ordinance provisions by the Sacony Creek Headwaters municipalities. Provided as part of the Plan is the *Sacony Creek Headwaters Act 167 Stormwater Management Ordinance*, which is a single purpose stormwater 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 Sacony Creek Headwaters to the single purpose ordinance from the other ordinances.

However, it is not required that a municipality adopts 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.

CHAPTER 11. PLAN REVIEW, ADOPTION, AND UPDATING PROCEDURES

A. Plan Review and Adoption

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

1. Watershed Plan Advisory Committee Review – This body has been formed to assist in the development of the Sacony Creek Headwaters Plan. Municipal members of the Committee have provided input data to the process in the form of storm drainage problem area documentation which resulted in the documentation of zero existing problem areas. The Committee met on three (3) 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 Plan Advisory Committee review would be a revised draft Plan for municipal and County consideration.

2. 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 *Sacony Creek Headwaters Act 167 Stormwater Management Ordinance*, which would implement the Plan through municipal adoption. The output of the municipal review would be a letter directed to Lehigh County outlining the municipal suggestions, if any, for revising the draft Plan (or Ordinance) prior to adoption by the County.

3. County Review and Adoption – Upon completion of the review by the Watershed Plan Advisory Committee and each municipality, the draft Plan will be submitted to the Lehigh County Commissioners for their consideration.

The County review of the draft Plan will include a detailed review by the County Commissioners and an opportunity for public input through the holding of a public hearing. A public hearing 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 hearing, 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 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 Sacony Creek Headwaters 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 Stormwater 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 the Adequacy of Plan – The Watershed Plan Advisory Committee will be convened periodically to review the Stormwater 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 as monitored by the LVPC.

   (b) Information regarding additional storm drainage problem areas as provided by the municipal representatives to the Watershed Plan 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 Sacony Creek Headwaters Stormwater Management Plan. Lehigh County will review the recommendations of the Watershed Plan Advisory Committee and determine if the revisions are to be made. A revised Plan would be subject to the same rules of adoption as the Plan preparation.

PLAN APPENDIX A —

Excerpts from Act 167 Plans Prepared by Berks County

Insert C:\Act 167 Plans\Sacony Creek Headwaters\ Excerpts from Berks County Plans\ AppendixA.pdf

PLAN APPENDIX B —

Mill Creek PSU-IV Calculation Process

Appendix B. Mill Creek PSU-IV Calculation Process

Step 1: Determine base flood peak flows
Calculate area in square miles

$A = 2.458$

Determine watershed centroid
Determine Flood Frequency Region using the centroid and Plate 1

Region = Region 2

Determine y_{hat} using either the equation or chart on Figure 1.1

Wooded area = 21.3%

$y_{hat} = 2.510$

Determine S_y (std dev of log of annual streamflow) using the centroid and Plate 2

$S_y = 0.283$

Determine G (skew of log of annual streamflow) using the centroid and Plate 3

$G = 0.35$

Determine K_y (Pearson coefficient) for each return period from table 1.2

$K_{y,2} = -0.580$
$K_{y,10} = 1.313$
$K_{y,25} = 1.865$
$K_{y,100} = 2.600$

Determine Y (log base 10 of the flood peak) by return period based on figure 1.2 or equation 1.1

$Y_2 = 2.29$
$Y_{10} = 2.83$
$Y_{25} = 2.99$
$Y_{100} = 3.19$

Determine Q from the relationship $Q = 10^Y$

$Q_2 = 197$
$Q_{10} = 676$
$Q_{25} = 969$
$Q_{100} = 1{,}564$

Step 2: Flood peak adjustments for watershed urbanization
This step was not performed in this watershed due to minimal impact from urbanization.

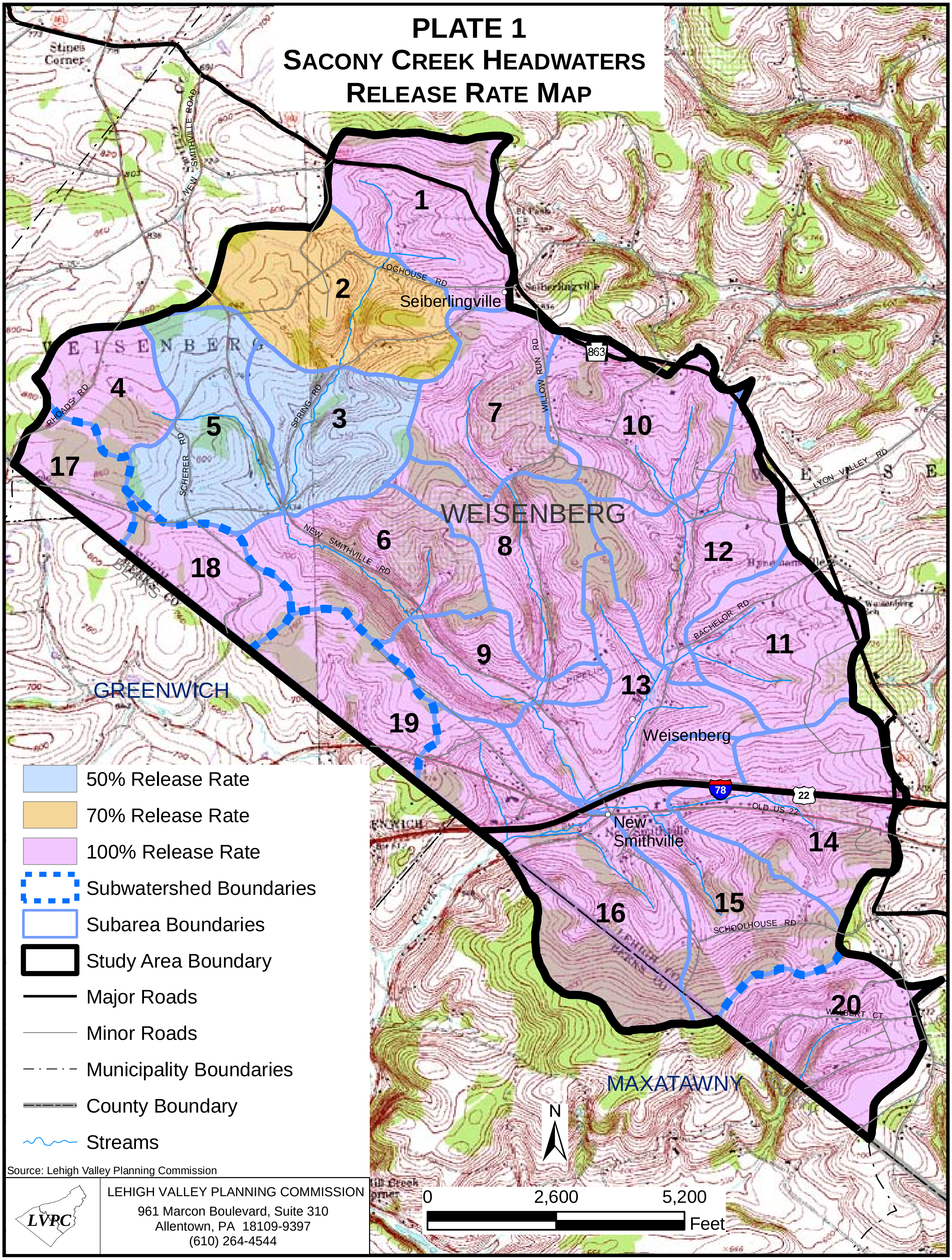
Step 3: Flood peak reduction by reservoir, lake, or swamp storage
This step was not performed due to negligible available storage.

Step 4: Flood peak reduction by carbonate rocks
This step was not performed due to lack of carbonate bedrock in the watershed.

Step 5: Flood peak adjustment for drainage basins less than 1.5 square miles
This step was not performed due to the sufficient size of the drainage area.

Step 6: Confidence Limits and Safety Factors
This step was not performed.

PLATE 1
SACONY CREEK HEADWATERS RELEASE RATE MAP



Source: Lehigh Valley Planning Commission

LVPC
LEHIGH VALLEY PLANNING COMMISSION
961 Marcon Boulevard, Suite 310
Allentown, PA 18109-9397
(610) 264-4544

CERTIFICATION STATEMENTS

A. Engineer Information

Geoffrey A. Reese
Engineer Name

Lehigh Valley Planning Commission
Company

961 Marcon Boulevard, Suite 310	Allentown
Street Address	City

Pennsylvania	18109	(610) 264-4544	gar@lvpc.org
State	Zip Code	Telephone	Email Address

B. Certification

I, Geoffrey A. Reese attest under penalty of law:

(i) that I am a Registered Professional Engineer in the Commonwealth of Pennsylvania, with expertise in civil or environmental engineering, and am employed by the Lehigh Valley Planning Commission;

(ii) that this Act 167 Plan for Lehigh County hereby referred to as the PLAN, has been prepared in accordance with sound engineering practice and is intended to meet the technical requirements in all applicable federal, state and local laws and regulations, including, but not limited to the federal Clean Water Act, Pennsylvania Clean Streams Law, Pennsylvania Stormwater Management Act and Title 25 of the Pennsylvania Code; and

that the information submitted is, to the best of my knowledge and belief, true, accurate and complete.

I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment or both for knowing violations pursuant to Section 309(c)(4) of the Clean Water Act and 18 Pa. C.S.§§4903-4904.

Geoffrey A Reese	PE038651E
Signature	Pennsylvania PE Number
Assistant Director	9/22/10
Title	Date

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
GEOFFREY A. REESE
ENGINEER
NO. 38651-E

A. **Solicitor Information**

Catharine M. Roseberry, Esquire
Solicitor Name

County of Lehigh
Company

17 South 7th Street	Allentown
Street Address	**City**

PA	18101	610-782-3180	
State	**Zip Code**	**Telephone**	**Email Address**

B. **Certification**

I, Catharine M. Roseberry, Esquire
Name

Lehigh County Department of Law
Name of Company/Firm

hereby certify:

(i) that I am the duly appointed Senior Counsel for Lehigh County for which this Act 167 Stormwater Management Plan (PLAN) has been prepared; and

(ii) that I personally have reviewed this PLAN; and

(iii) that this PLAN for Lehigh County
County Name

Has, to the best of my knowledge and belief, been approved in accordance with all applicable federal, state and local laws, regulations and standards, including, but not limited to the federal Clean Water Act, Pennsylvania Clean Streams Law and Pennsylvania Stormwater Management Act.

	8.30.10
Signature	Date