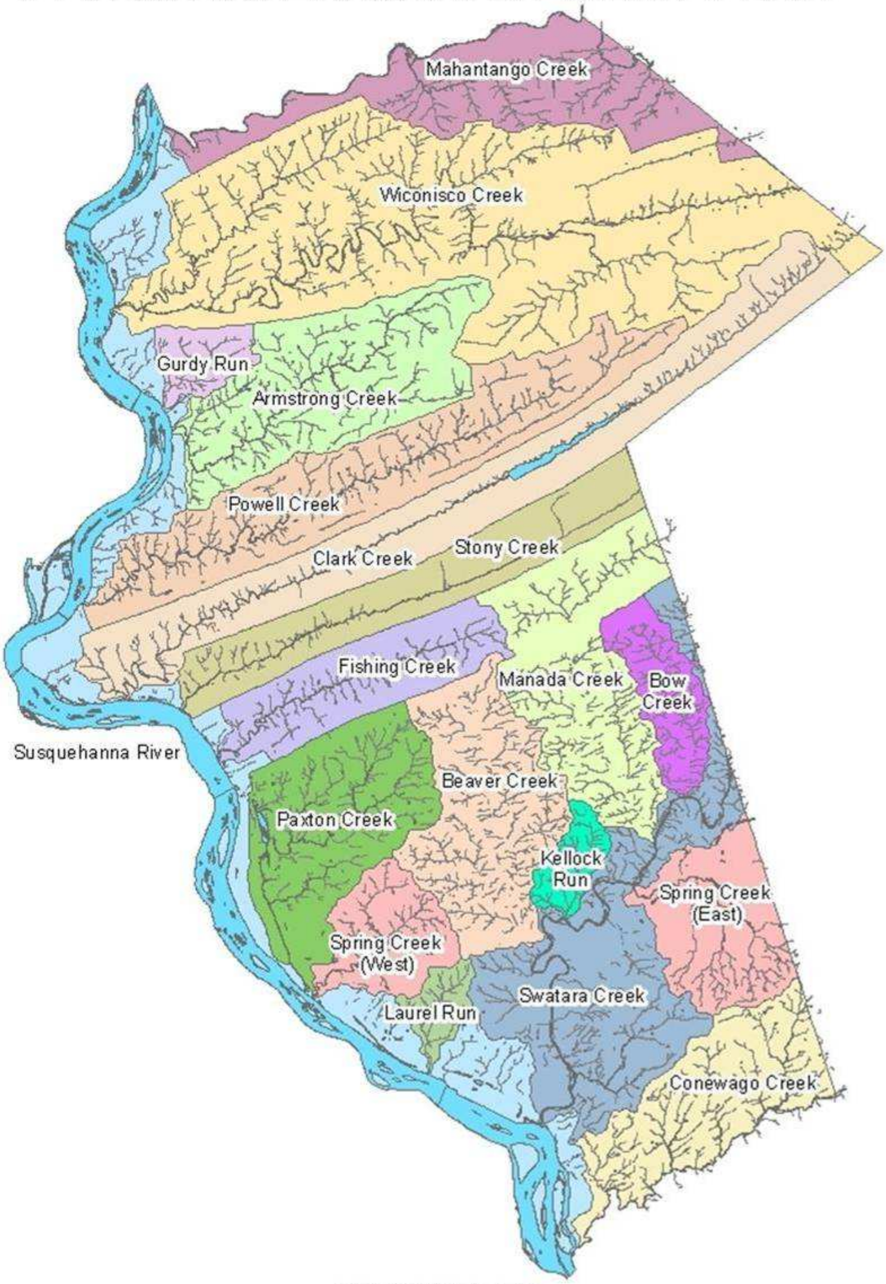
DAUPHIN COUNTY
-ACT 167-
STORMWATER MANAGEMENT PLAN



PREPARED BY:
DAUPHIN COUNTY CONSERVATION DISTRICT
IN CONJUNCTION WITH:
HERBERT, ROWLAND, & GRUBIC, INC.
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DAUPHIN COUNTY COMMISSIONERS

JEFFREY T. HASTE
DOMINIC DIFRANCESCO II
GEORGE P. HARTWICK III

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

BARRY NEWMAN
NANCY CISAR
JEN KEHLER

DAUPHIN COUNTY WATERSHED PLAN ADVISORY COMMITTEE

NORTHERN PLANNING REGION

JERRY STRAUB	BERRYSBURG BOROUGH
FREDERICK RENN	ELIZABETHVILLE BOROUGH
LARRY SHADE	GRATZ BOROUGH
BONNIE LIDLE	HALIFAX BOROUGH
NORMA SHEARER	HALIFAX TOWNSHIP
RUSSELL MILLER	JACKSON TOWNSHIP
ED FISHER	JEFFERSON TOWNSHIP
CLAUDIA MOFFEI	LYKENS BOROUGH
ALBERT MORGAN	LYKENS TOWNSHIP
PAUL REITZ	MIFFLIN TOWNSHIP
JAMES BULLOCK	MILLERSBURG BOROUGH
JOSEPH REED	PILLOW BOROUGH
MARJORIE ALESKY	REED TOWNSHIP
THOMAS SHAFFER	UPPER PAXTON TOWNSHIP
JAMES WILBERT, SR.	WASHINGTON TOWNSHIP
ED FISHER	WAYNE TOWNSHIP
DAVID PERNIOLA	WICONISCO TOWNSHIP
DONALD SCHWALM	WILLIAMS TOWNSHIP
DANE WILLIARD	WILLIAMSTOWN BOROUGH

CENTRAL PLANNING REGION

JOSEPH LINK	CITY OF HARRISBURG
STEPHEN BOMGARDNER	DAUPHIN BOROUGH
JAROMIR KOVARIK	EAST HANOVER TOWNSHIP
ED FISHER	MIDDLE PAXTON TOWNSHIP
SERRELL ULRICH	MIDDLE PAXTON TOWNSHIP
WILLIAM HAWK	LOWER PAXTON TOWNSHIP
JOHN NINOSKY, SR.	PAXTANG BOROUGH
KEVIN RAMPER	PENBROOK BOROUGH
RONALD KOPPENHAVER	RUSH TOWNSHIP
ROBERT CASSEL	SOUTH HANOVER TOWNSHIP
JACQUELYN PATTON	SUSQUEHANNA TOWNSHIP
LARRY HARTMAN	WEST HANOVER TOWNSHIP

SOUTHERN PLANNING REGION

NORM MILLER	CONEWAGO TOWNSHIP
THOMAS CLARK	DERRY TOWNSHIP
KENT BACHMANN	HERCO/CONEWAGO TOWNSHIP
D. ROBERT BRADY	HIGHSPIRE BOROUGH
MICHAEL O'KEEFE	HUMMELSTOWN BOROUGH
STEVE LETAVIC	LONDONDERRY TOWNSHIP
RONALD PAUL	LOWER SWATARA TOWNSHIP
EDWARD KAZLAUSKAS	MIDDLETOWN BOROUGH
JEFF REITZ	ROYALTON BOROUGH
JOSHUA HANES	STEELTON BOROUGH/HRG
PAUL CORNELL	SWATARA TOWNSHIP
THOMAS EMBICH	SWATARA CREEK WATERSHED ASSOCIATION
JAMES SYMBORSKI	TRI-COUNTY PLANNING COMMISSION

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INTRODUCTION

In compliance with Act 167, the Pennsylvania Stormwater Management Act, the Dauphin County Conservation District (DCCD) has produced this document for all watersheds of Dauphin County. This Stormwater Management Plan (Plan) serves as a framework and information source to assist all municipalities within Dauphin County in planning for and managing the increased runoff associated with development and future population growth.

The intent of the Plan is to provide stormwater management standards that address the adverse impacts of increased runoff from development. The goals are to maintain and not exacerbate peak flows throughout the watersheds; retain the natural hydrology of the watersheds as near to pre-development conditions as possible, including groundwater recharge and stream flow patterns; reduce the adverse impacts of runoff on water quality, stream morphology, and aquatic habitat; and minimize the potential for increased flood hazards and damage.

Early stormwater management strategies were primarily designed to collect stormwater runoff and remove it from a site as quickly as possible, typically through a series of pipes that emptied into the nearest stream. The underlying philosophy of this approach was to "collect and remove". This approach had numerous shortcomings. It ignored water quality, did not emphasize infiltration for groundwater recharge, and did not consider the adverse impacts of increased volumes and peak rates of stormwater on channel morphology, aquatic habitat, and flood frequency. Current stormwater management philosophy, including Act 167 planning, recognizes that stormwater is a natural resource and should be managed as such. This new approach seeks to manage stormwater runoff so the adverse impacts listed above are considered and addressed appropriately. The goal is to retain, to the maximum extent practical, the existing hydrology of the individual watersheds including groundwater recharge, water quality and stream flow patterns.

This Plan contains several features that are different from previous Act 167 plans in Dauphin County. These features are incorporated into the Plan for several reasons:

1. Pennsylvania Department of Environmental Protection's (PADEP) approach to Act 167 planning has changed from an individual watershed by watershed planning effort to County–Wide watershed planning. This approach provides increased cost effectiveness by completing one (1) plan for a given county rather than several plans. For example, as many as twelve (12) plans may have been needed in Dauphin County under an individual watershed by watershed approach.

2. The Plan incorporates all existing Dauphin County Act 167 watershed plans into this one (1) Plan. Because Act 167 requires consideration of plan updates every five (5) years, this approach will put the entire County on the same five (5) year review schedule.

3. Detailed hydrologic modeling, the foundation of previous plans, is conducted only in key watersheds determined to merit such an effort. New watersheds included in this Plan that have detailed hydrologic modeling are: Burd Run, Laurel Run and Spring Creek (East). The hydrologic modeling is performed to coordinate the timing of peak discharges from sub-watersheds within the overall watershed. The concept is to prevent the "overlap" of sub-watersheds peak discharges downstream. These "overlaps" were prevented to ensure that no increase peak discharges or associated stream flow elevations rose to levels which may increase nuisance flooding or cause channel degradation.

4. This Plan incorporates the stormwater volume management guidance found in the Pennsylvania Stormwater Best Management Practices (BMP) Manual. This is a fundamental change from previous plans that based water quality and groundwater recharge requirements on the 90 percent storm, which meant that the volume of 90% of all annual rainfall events would be treated by BMPs. This change will ensure that the Plan, local ordinances based on the Model Ordinance, and the National Pollutant Discharge Elimination System (NPDES) post-construction stormwater management standards are uniform and consistent. Ideally, this consistency will result in less confusion and variation on the part of designers and regulators, and will provide a more efficient stormwater management plan review process for new development in all municipalities.

5. This Plan incorporates ordinance language to address existing Total Maximum Daily Loads (TMDLs) requirements where they exist for streams in Dauphin County. TMDLs are established along impaired waterways in accordance with Section 303(d) of the Federal Clean Water Act (CWA), and are determined using hydrologic and hydraulic computer models.

In order for the Act 167 planning process to be successful and effective, the cooperation and coordination of the individual municipalities involved is essential. Since this Act 167 stormwater management planning effort affects all municipalities in Dauphin County, it is important for each municipality to be involved in the planning process. Act 167 provides access to the planning process for the municipalities by establishing Watershed Plan Advisory Committees (WPACs) within each planning region. The committees are comprised of representatives from the municipalities, as well as other concerned organizations or citizens.

By coordinating with the local governments and managing stormwater in consideration of overall watershed hydrology, this Plan helps to prevent stormwater management problems and improve water quality within and beyond municipal boundaries. By implementing new ordinances or revising existing local municipal ordinances and regulations to comply with the standards set forth within this Plan, the negative impacts of increased stormwater runoff will be identified, addressed, minimized or eliminated. Further, a central coordinated effort involving all municipalities within Dauphin County will ensure that the criteria and standards established by the Plan will be implemented uniformly throughout each watershed and municipality. Uniform and watershed wide implementation of this Plan are critical to its success.

PLANNING APPROACH AND PLANNING REGIONS

Planning Approach

Stormwater Management Standards

It is important to note that this County-Wide Plan features a new, revised stormwater management strategy that is consistent with the PA BMP Manual. Although this strategy still employs detailed hydrologic modeling to determine release rate percentages to control larger storm events for selected watersheds, it does not require the need for detailed modeling in all watersheds contained within Dauphin County. In previous Dauphin County Act 167 watershed plans, release rates were determined for only the 2-year, 10-year, and 25-year rainfall events. The revised stormwater management concepts in the PA BMP Manual acknowledge the importance of addressing less frequent storms. The reduction in total runoff volume for the 2-year storm event required by the PA BMP Manual will effectively manage smaller storms and may provide some peak flow reductions for larger events. This management strategy, coupled with the application of a 100 percent release rate for un-modeled areas is anticipated to provide overall, effective management throughout Dauphin County. Release rates that were developed for modeled watersheds in previous plans, will continue to be in effect for the respective watersheds under this Plan. The standard for un-modeled watershed areas will be that post-construction peak discharge rates be less than or equal to pre-construction levels for 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year storms events. This represents a 100 percent release rate.

Incorporation of Existing Plans

This Plan incorporates all prior Act 167 watershed-wide plans previously completed in Dauphin County and addresses stormwater management planning in all the remaining lands of Dauphin County.

Previously completed Dauphin County Act 167 plans covered a total of 13 significant County watersheds. Five (5) Act 167 watershed plans were completed prior to the development of this county-wide Plan. The watershed plans included: Mid-Dauphin Basins, Wiconisco Creek, Spring Creek (West), Paxton Creek, and Multi-Creek Watersheds. These watershed plans have been incorporated in and are part of this county-wide Plan.

Act 167 requires the review and update of each plan every five (5) years, and by incorporating all of the existing Dauphin County Act 167 watershed-wide plans into this Plan, the update schedule is synchronized. Table 1 lists existing watershed-wide plans, watersheds covered, and plan date.

Table 1: Previously Completed Act 167 Plans in Dauphin County

PLAN NAME	WATERSHEDS	PLAN DATE
Mid-Dauphin Basins	Fishing Creek, Stony Creek, Clark Creek, Powell Creek, Armstrong Creek, and Gurdy Run	June 2003
Wiconisco Creek Watershed	Wiconisco Creek	July 2005
Spring Creek Watershed	Spring Creek (West)	August 2005
Paxton Creek Watershed	Paxton Creek	September 2005
Multi-Creek Watersheds	Beaver Creek, Manada Creek, Bow Creek and Kellock Run	December 2005

Existing Dauphin County Act 167 Plans

Mid-Dauphin Basins

The Mid-Dauphin Basin Act 167 Plan covers six (6) major watersheds covering a total of 174-square miles. These watersheds include: Armstrong Creek, Clark Creek, Fishing Creek, Powell Creek, Stony Creek, and Gurdy Run. A total of 12 municipalities had all or part of their jurisdictions in these watersheds. They included: Dauphin and Halifax Boroughs, and East Hanover, Halifax, Jackson, Jefferson, Middle Paxton, Reed, Rush, Susquehanna, Wayne, and West Hanover Townships.

Land use in these watersheds is mostly rural with a significant amount of agriculture and mountain area. All six (6) watersheds were modeled using the Penn State Runoff Model (PSRM) to simulate both existing and potential future stormwater runoff. Both present and future land use scenarios were modeled for the 2-year, 10-year, and 25-year storm events. The maximum standards and criteria established in the plan were developed to meet stated plan objectives. These standards and criteria were based on the requirements of Act 167, the hydrologic model of existing and future land use conditions, and the perceived abilities of the municipalities and developers to implement the criteria. The plan also contains standards addressing water quality, groundwater recharge and channel protection. Other elements included in the plan are a description of the watersheds, an analysis of existing municipal regulations related to stormwater management, a discussion of watershed level stormwater management planning, economic impacts of management criteria, a listing of current stormwater management techniques, additional recommended municipal stormwater management actions, and a listing of plan update procedures. A model municipal stormwater management ordinance was also included in the plan.

No additional hydrologic analyses have been conducted on the Mid Dauphin Basins as part of this Plan, and release rates for the 2-year, 10-year, and 25-year storms shall remain in effect.

Wiconisco Creek Watershed

The Wiconisco Creek Act 167 Plan addressed stormwater management in the 116-square mile Wiconisco Creek watershed. There are 18 municipalities that are entirely or partially within the watershed. They are: Berrysburg, Elizabethville, Gratz, Lykens, Tower City (Schuylkill County), Millersburg, and Williamstown Boroughs and Jackson, Jefferson, Lykens, Mifflin, Porter (Schuylkill County), Rush, Tremont (Schuylkill County), Upper Paxton, Washington, Wiconisco, and Williams Townships.

Outside of the Boroughs, the watershed is largely rural with significant areas of agriculture and forest. The entire Wiconisco Creek Watershed was modeled using the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) developed by the U.S. Army Corps of Engineers. The model was used to establish runoff release rates within the designated subwatershed areas for 2-year, 10-year, and 25-year storm events. The plan also contains standards addressing water quality, groundwater recharge and channel protection. In addition to the aforesaid technical analysis and standards section, other plan elements included a description of the watershed, identification and analysis of stormwater problem areas and obstructions, a discussion of watershed level stormwater management planning, an analysis of existing municipal regulations related to stormwater management, economic impacts of management criteria, additional recommended municipal stormwater management actions, and a listing of plan implementation and update procedures. A model municipal stormwater management ordinance was also included in the plan.

No additional hydrologic analyses have been conducted on the Wiconisco Creek as part of this Plan, and release rates for the 2-year, 10-year, and 25-year storms shall remain in effect.

Spring Creek (West) Watershed

The Spring Creek (West) Act 167 Plan addresses stormwater management in the 11.6-square miles Spring Creek watershed. Six (6) municipalities are partially located within the watershed. These municipalities include: the City of Harrisburg, Lower Paxton, Swatara, and Susquehanna Townships, and Paxtang and Penbrook Boroughs.

The Spring Creek (West) watershed has a widely varied mix of urban and suburban land uses. The entire Spring Creek (West) watershed was modeled using the HEC-HMS establishing standards for runoff release rates within the designated subwatershed areas for 2-year, 10-year, and 25-year storm events. As was the case in prior plans, this plan also contains standards addressing water quality, groundwater recharge and channel protection. Other plan elements were similar to those contained in the Wiconisco Plan.

No additional hydrologic analyses have been conducted on the Spring Creek (West) watershed as part of this Plan, and release rates for the 2-year, 10-year, and 25-year storms shall remain in effect.

Paxton Creek Watershed

The Paxton Creek Act 167 Plan addresses stormwater management in the 27-square mile Paxton Creek watershed. Four (4) municipalities are located within the watershed. These municipalities included: the City of Harrisburg, Lower Paxton and Susquehanna Townships, and Penbrook Borough.

Located in southwestern Dauphin County, the Paxton Creek watershed features a mix of low, medium, and high density (Harrisburg City) residential development with some significant areas of commercial and office development. The entire watershed was modeled using HEC-HMS to establish standards for runoff release rates within the designated subwatershed areas for 2-year, 10-year, and 25-year storm events. As was the case in prior plans, this plan also contains standards addressing water quality, groundwater recharge and channel protection. Other plan elements were similar to those contained in the Spring Creek (West) Plan.

No additional hydrologic analyses have been conducted on the Paxton Creek watershed as part of this Plan, and release rates for the 2-year, 10-year, and 25-year storms shall remain in effect.

Multi-Creek Watersheds

The Multi-Creek Watersheds Act 167 Plan encompasses four (4) major watersheds, all of which discharge into the Swatara Creek. These watersheds are Beaver, Bow, and Manada Creeks and Kellock Run. Portions of five (5) municipalities are located within the boundaries of the above referenced watersheds. These municipalities include: East Hanover, Lower Paxton, Swatara, South Hanover, and West Hanover Townships.

The plan covers a total of 73.2-square miles, all but 2.3-square miles located in Dauphin County. All four (4) watersheds were modeled using HEC-HMS to establish standards for runoff release rates within the designated subwatershed areas for 2-year, 10-year, and 25- year storm events. As was the case in prior plans, this plan also contains standards addressing water quality, groundwater recharge and channel protection. Other plan elements were similar to those contained in the previously discussed Act 167 plans.

No additional hydrologic analyses have been conducted on the Multi-Creek watersheds as part of this Plan, and release rates for the 2-year, 10-year, and 25-year storms shall remain in effect.

Planning Regions

The municipalities in Dauphin County have been grouped into three (3) Planning Regions for purposes of developing this Plan; northern, central and southern. The reasons for this segmented approach include:

1. The level of effort needed for this Plan varies significantly between the planning regions. The largest effort was anticipated to be needed in the southern planning region, because this is the first Act 167 planning effort in that region. The central and northern regions are largely covered by existing watershed-wide plans.

2. Given that there are forty (40) municipalities involved in Dauphin County, the separation into planning regions facilitates logistical efforts. Each Planning Region and the municipalities they include are listed in Table 2.

Table 2: Dauphin County Planning Regions

NORTHERN PLANNING REGION	
MUNICIPALITY	**WATERSHEDS**
Berrysburg Borough	Wiconisco
Elizabethville Borough	Wiconisco
Gratz Borough	Mahantango / Wiconisco
Halifax Borough	Armstrong / Susquehanna River
Halifax Township	Armstrong / Clark / Gurdy / Powell / Wiconisco / Susquehanna
Jackson Township	Armstrong / Gurdy / Powell / Wiconisco
Jefferson Township	Armstrong / Clark / Powell / Wiconisco
Lykens Borough	Wiconisco
Lykens Township	Mahantango / Wiconisco
Mifflin Township	Mahantango / Wiconisco
Millersburg Borough	Wiconisco / Susquehanna
Pillow Borough	Mahantango
Reed Township	Clark / Powell / Susquehanna
Upper Paxton Township	Armstrong / Gurdy / Mahantango / Wiconisco / Susquehanna
Washington Township	Armstrong / Wiconisco
Wayne Township	Armstrong / Clark / Powell
Wiconisco Township	Mahantango / Wiconisco
Williams Township	Mahantango / Wiconisco
Williamstown Borough	Wiconisco

CENTRAL PLANNING REGION	
MUNICIPALITY	**WATERSHEDS**
City of Harrisburg	Paxton / Spring (West) / Susquehanna
Dauphin Borough	Stony / Susquehanna
East Hanover Township	Bow / Clark / Manada / Stony / Swatara
Middle Paxton Township	Beaver / Clark / Stony / Fishing / Paxton / Powell / Susquehanna
Lower Paxton Township	Beaver / Fishing / Paxton / Spring (West)
Paxtang Borough	Spring (West)
Penbrook Borough	Paxton / Spring (West)
Rush Township	Clark / Stony / Wiconisco
South Hanover Township	Beaver / Kellock / Manada / Swatara
Susquehanna Township	Paxton / Fishing / Spring (West) / Susquehanna
West Hanover Township	Beaver / Fishing / Kellock / Manada / Stony

SOUTHERN PLANNING REGION	
MUNICIPALITY	**WATERSHEDS**
Conewago Township	Conewago / Spring (East) / Swatara
Derry Township	Spring (East) / Swatara
Highspire Borough	Laurel / Susquehanna
Hummelstown Borough	Swatara
Londonderry Township	Conewago / Swatara / Susquehanna
Lower Swatara Township	Laurel / Spring (East) /Swatara / Susquehanna
Middletown Borough	Swatara / Susquehanna
Royalton Borough	Swatara / Susquehanna
Steelton Borough	Laurel / Susquehanna
Swatara Township	Beaver / Laurel / Paxton / Spring (West) / Swatara / Susquehanna

Planning Regions Description

Northern Planning Region

General: Located in the northern section of Dauphin County, this Planning Region includes the Mahantango Creek Watershed, and land areas draining directly to the Susquehanna River from the mouth of the Mahantango Creek to the southern border of Middle Paxton Township. It also includes the area of the existing Wiconisco Creek Watershed Plan, and the Mid-Dauphin Basins Plan which includes Gurdy Run and the Powell Creek, Armstrong Creek, Clark Creek, Stony Creek and Fishing Creek watersheds. Rural in character, population density is low with the majority of land use being agriculture and forest. Population centers include several small boroughs. Topography is characteristic of the ridge and valley physiographic province. Drainage areas typically gently slope towards the Susquehanna River.

Geology: The ridges of the Mahantango Creek watershed are composed mainly of sandstone and conglomerate. Valleys are underlain by sandstone and shale. River drainage areas are composed of sandstone, shale and alluvial materials.

Soils: The majority of soils are the Dekalb-Lehew association soils found on the ridges and mountains and the Calvin-Leck Kill-Klinesville association found on the valley floors. The vast majority of soils are classified as hydrologic group "C" soils. The hydrologic soil groupings are an indication of the soil's ability to allow stormwater runoff to infiltrate through the soil. This is an important consideration in selecting and designing post-construction Best Management Practices. Hydrologic soil group information was taken from the Dauphin County soil survey. Table 3 lists the hydrologic soils groups, and infiltration rates. Hydrologic soils maps are provided in this Plan document only for areas having detailed hydrological modeling as part of this planning effort. The disc that is provided with this plan contains a county-wide hydrologic soils map. Plate 1 of this Plan shows the hydrologic soils for the modeled watersheds.

Table 3: Hydrologic Soil Groups (HSG)

HYDROLOGIC SOIL GROUP	INFILTRATION RATE (INCH/HOUR)	RUNOFF POTENTIAL
A	0.30 – 0.45	Low
B	0.15 – 0.30	Moderate
C	0.05 – 0.15	Moderate to High
D	0.00 – 0.05	High

Central Planning Region

General: Located in the central portion of Dauphin County, the Central Planning Region is composed of direct drainage to the Susquehanna River and a relatively small portion of Swatara Creek drainage located in East Hanover and South Hanover Townships. It also includes the area of the existing Paxton Creek Watershed Plan, Spring Creek (East) Watershed Plan, and the Multi-Creek Watershed Plan which includes Kellock Run, and the Beaver Creek, Bow Creek, and Manada Creek watersheds. The western area of this Planning Region is dominated by urban and suburban land uses with the eastern area comprised of rural land uses including agriculture and low density residential. The topography of this Planning Region can be characterized as typical of the ridge and valley physiographic province.

Geology: Areas of drainage to the Susquehanna River are composed of sandstone, shale and alluvial materials. The eastern portion of this Planning Region is generally underlain with sandstone and shale.

Soils: Susquehanna River drainage areas are characterized by urban alluvial materials. These soils are associated with urban land and alluvial deposits and have no class listing. The eastern portion of this Planning Region is dominated by the Berks-Beddington-Weikert soil association. The vast majority of soils are classified as hydrologic group "C" soils.

Southern Planning Region

General: Watersheds covered in the Southern Planning Region include small watersheds draining directly to the Susquehanna River, Swatara Creek, and Conewago Creek. In addition, the Planning Region includes Spring Creek (East), Burd Run, Laurel Run, Iron Run, Hoffers Creek, and Brills Run. The Planning Region is generally characterized by a mix of urban, suburban and rural land uses. Detailed land cover information was included in the modeled watersheds of Spring Creek (East), Burd Run, and Laurel Run. The topography is characteristic of the Piedmont physiographic province featuring level terrain composed of low hills.

Three (3) watersheds located in the Southern Planning Region were identified as requiring detailed modeling. They were Spring Creek (East), Laurel Run, and Burd Run. It should be noted that there are two (2) modeled streams in Dauphin County named Spring Creek. Spring Creek (East) which is part of this planning effort is located in the eastern portion of Dauphin County as opposed to Spring Creek (West) which is located in the western portion of Dauphin County. Spring Creek (West) was completed as a prior watershed-wide Act 167 Plan.

Geology: This Planning Region is primarily underlain by sandstone, shale, mudstone and areas of limestone. Pockets of conglomerate are also present.

Soils: The Susquehanna River drainage area is composed of urban land. The remaining land area is composed of a mix of Hagerstown-Duffield, Lewisberry-Penn-Athol, Brecknock-Neshaminy and Duncannon-Chavies-Tioga soil Associations. 57% of the soils are classified as hydrologic group "B" soils, while the remaining 43% are classified as hydrologic group "C" soils. Plate 1 shows the hydrologic soils groups for the three (3) modeled watersheds.

Floodplain Data

A flood occurs when the capacity of a stream channel to convey flow within its banks is exceeded and water flows out of the main channel onto and over adjacent land. This adjacent land is known as the floodplain. For convenience in communication and regulation, floods are characterized in terms of return periods, i.e., the 50-year flood event. In regulating floodplains, the standard is the base flood, i.e., the 100-year flood event. The 100-year flood event is defined as having a 1 percent chance of being equaled or exceeded during any given year.

The Federal Emergency Management Agency (FEMA) has prepared Flood Insurance Studies (FIS) for 38 out of 40 municipalities in Dauphin County. Each of the municipalities adopted floodplain regulations to regulate development within the 100-year floodplain as defined by the FEMA studies, although the degree of control varies from municipality to municipality. Specific information regarding the contents of individual floodplain regulations is available at the municipal government offices. Appendix C lists each municipality, the type of study (detailed or non-detailed), and the date of the Flood Insurance Study.
One drawback that should be noted in using FEMA's delineation of the 100-year floodplain as a basis for regulating floodplains is that FEMA delineates floodplains primarily for larger streams or streams flowing through existing highly developed areas. Headwater streams, or smaller tributaries located in undeveloped areas, do not normally have FEMA delineated floodplains. This leaves these areas unregulated at the municipal level, and somewhat susceptible to uncontrolled development. Flood conditions, due to natural phenomenon as well as increased stormwater runoff generated by land development, are not restricted only to main channels and large tributaries. In fact, small streams and tributaries may be more susceptible to flooding from increased stormwater runoff due to their limited channel capacities.

Pennsylvania's Chapter 105 regulations partially address the problem of non-delineated floodplains. Chapter 105 regulations prohibit encroachments and obstructions, including structures, in the regulated floodway without first obtaining a state Water Obstruction and Encroachment permit. The floodway is the portion of the floodplain adjoining the stream required to carry the 100-year flood event with no more than a one (1) foot increase in the 100-year flood level due to encroachment in the floodplain outside of the floodway. Chapter 105 defines the floodway as the area identified as such by a detailed FEMA study or, where no FEMA study exists, as the area from the stream to 50-feet from the top of bank, absent evidence to the contrary. These regulations provide a measure of protection for areas not identified as floodplain by FEMA studies.

Land Cover Data For Modeled Watersheds

The Plan considers two (2) land-cover scenarios for modeled watersheds:

1. The current land cover for the three (3) watersheds modeled in this Plan is based on 2005 aerial photography (Plate 2 – 2005 Existing Land Cover).

2. The future land cover is based on existing municipal zoning regulations and assumes a full build-out scenario (Plate 3 – Full Build Out - Future Land Cover). The areas shown as developed on the 2005 aerial photography are assumed to remain developed in the future. These areas are mapped, unchanged, onto the future land cover map. Undeveloped areas were mapped as built-out, according to current zoning, onto the future land cover map.

Table 4 show the amount of assumed land use for existing and future land cover conditions utilized in the HMS-Model.

Table 4: Assumed Existing and Future Land Use and Land Cover

SPRING CREEK (EAST) WATERSHED	EXISTING LAND COVER		FUTURE LAND COVER		CHANGE FUTURE - EXISTING
LAND USE	**ACRES**	**%**	**ACRES**	**%**	**% Change**
WATER	127.1	0.83%	127.1	0.83%	0.00%
LOW DENSITY RESIDENTIAL	1,829.80	11.98%	6,158.80	40.33%	28.35%
MEDIUM DENSITY RESIDENTIAL	1,065.30	6.98%	3,691.50	24.17%	17.19%
HIGH DENSITY RESIDENTIAL	415.6	2.72%	294	1.93%	-0.79%
URBAN	2,435.10	15.95%	2,744.20	17.97%	2.02%
COMMERCIAL/INDUSTRIAL	1,064.30	6.97%	2,256.10	14.77%	7.80%
OPEN SPACE	1,305.30	8.55%	0	0.00%	-8.55%
FOREST	1,372.10	8.98%	0	0.00%	-8.98%
AGRICULTURE	5,657.10	37.04%	0	0.00%	-37.04%
TOTAL	**15,271.70**	**100.00%**	**15,271.70**	**100.00%**	**N/A**

LAUREL RUN WATERSHED	EXISTING LAND COVER		FUTURE LAND COVER		CHANGE FUTURE - EXISTING
LAND USE	**ACRES**	**%**	**ACRES**	**%**	**% CHANGE**
WATER	5.2	0.21%	5.2	0.21%	0.00%
LOW DENSITY RESIDENTIAL	100.2	4.09%	850.7	34.71%	30.62%
MEDIUM DENSITY RESIDENTIAL	191.1	7.80%	648.8	26.48%	18.68%
HIGH DENSITY RESIDENTIAL	304.6	12.43%	326.4	13.32%	0.89%
URBAN	63.9	2.61%	77.7	3.17%	0.56%
COMMERCIAL/INDUSTRIAL	318.2	12.98%	541.8	22.11%	9.13%
OPEN SPACE	166	6.77%	0	0.00%	-6.77%
FOREST	500	20.40%	0	0.00%	-20.40%
AGRICULTURE	801.4	32.70%	0	0.00%	-32.70%
TOTAL	**2,450.6**	**100.00%**	**2,450.6**	**100.00%**	**N/A**

BURD RUN WATERSHED	EXISTING LAND COVER		FUTURE LAND COVER		CHANGE FUTURE - EXISTING
LAND USE	**ACRES**	**%**	**ACRES**	**%**	**% CHANGE**
WATER	4.7	0.53%	4.7	0.53%	0.00%
LOW DENSITY RESIDENTIAL	11.4	1.29%	129.3	14.64%	13.35%
MEDIUM DENSITY RESIDENTIAL	23.9	2.71%	18.3	2.07%	-0.64%
HIGH DENSITY RESIDENTIAL	308.6	34.93%	384.1	43.48%	8.55%
URBAN	71	8.04%	114.7	12.98%	4.94%
COMMERCIAL/INDUSTRIAL	223.8	25.33%	232.3	26.30%	0.97%
OPEN SPACE	60.4	6.84%	0	0.00%	-6.84%
FOREST	42.4	4.80%	0	0.00%	-4.80%
AGRICULTURE	137.2	15.53%	0	0.00%	-15.53%
TOTAL	**883.4**	**100.00%**	**883.4**	**100.00%**	**N/A**

EXISTING MUNICIPAL REGULATIONS/RELATED PLANS

An analysis of existing municipal regulations is not only required by Act 167, but will assist in developing requirements and recommendations for implementation within the municipalities of Dauphin County. Tables 5, 6, & 7 are a summary of existing regulations for municipalities within each Planning Region.

Northern Planning Region

Table 5: Northern Planning Region Ordinance Review

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Berrysburg Borough	No separate ordinance.	No SALDO. In this case, the county SALDO applies. The County SALDO, in Section 505, addresses storm drainage.	No ordinance.	No designated floodplains.
Elizabethville Borough	No separate ordinance.	No SALDO. In this case, the county SALDO applies. The County SALDO, in Section 505, addresses storm drainage.	No ordinance.	Floodplain regulations contained in Borough Code, Chapter 8. Section 103 allows development in floodplains subject to conditions. Development within 50 feet of streams in designated floodplains is prohibited without first obtaining a permit from PADEP.
Gratz Borough	No separate ordinance. Addressed in SALDO.	Adopted in 1975, Section 605.1 addresses storm drainage. It states that storm drainage facilities must be designed to handle anticipated peak discharge from the subdivided property.	Adopted in March 1992, the floodplain regulations found in Section 504.4 prohibit most development within the floodplain.	Contained in the Borough's Zoning Ordinance.
Halifax Borough	Ordinance requires the post-development peaks for the 1 and 10 year storm be managed to pre-development levels. Infiltration and impervious surface reduction is encouraged.	Has an adopted ordinance.	No ordinance.	No ordinance.
Halifax Township	No separate ordinance. Addressed in SALDO.	Located in Section 507, the stormwater regulations cite design storms from 10 to 25 years for various discharges. Also, peaks for post-development discharges are to be controlled to pre-development peak flows for these design storms. The SALDO also encourages open space preservation of stream frontage and prohibits building sites in floodways.	No ordinance.	Contained in the Township's SALDO.
Jackson Township	No separate ordinance.	Section 506 of SALDO addresses storm drainage. Innovative stormwater management facilities are to be used when and where feasible to control water volumes, address water quality and infiltration and avoid point source discharges at property boundaries. The ordinance also requires that the post construction peak discharge rates be managed to be no greater than preconstruction rates for the 2, 10, and 25 year storms. Infiltration of the increase in volume of runoff for the 25 year storm is also required.	No ordinance.	Floodplain ordinance adopted in 1999. The ordinance allows development in the floodplain subject to conditions; however, development within 50 feet of streams in identified floodplains is prohibited.
Jefferson Township	No separate ordinance.	No SALDO. In this case, the county SALDO applies. The County SALDO, in Section 505, addresses storm drainage	No ordinance.	Floodplain ordinance allows conditional development in floodplain.
Lykens Borough	No separate ordinance.	SALDO, in Section 605, addresses storm drainage only.	Adopted in 1975/1980.	Floodplain ordinance allows conditional development in floodplain.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Lykens Township	No separate ordinance. Addressed in SALDO.	The Township's SALDO requires that post development peak discharges be managed to be no greater than the pre- development peak discharge for the 2 and 10 year storms.	Adopted in 1997, contains floodplain regulations in Article 11. The regulations prohibit most forms of development in the floodplain. Permitted uses may not utilize fill, structures or storage of equipment or materials. Some low impact uses that do not require structures, fill, or storage of materials and equipment are permitted. Article 12 establishes environmental protection overlays, including stream corridors.	Contained in Zoning Ordinance.
Mifflin Township	No separate ordinance. Addressed in SALDO.	Adopted in 1979, storm drainage is addressed in Section 605.1. Storm drainage facilities must be designed to handle the anticipated peak discharge from the subdivided property as well as the anticipated increase of runoff after development from up slope properties.	No ordinance.	The Mifflin Township Floodplain Ordinance allows development of the floodplain subject to certain conditions.
Millersburg Borough	No ordinance.	No ordinance. Dauphin County's SALDO applies. The ordinance, in section 505, addresses storm drainage.	No ordinance.	Section 61.1 of the Floodplain Ordinance allows development in the floodplains subject to conditions.
Pillow Borough	No ordinance.	Adopted in 1978.	No ordinance.	Ordinance that imposes FEMA minimum regulations.
Reed Township	No ordinance.	Adopted in 1990.	No ordinance.	The Floodplain Ordinance prohibits construction and development in any identified floodplain.
Upper Paxton Township	No separate ordinance. Addressed in SALDO.	The Township's SALDO, adopted in 1965, contains stormwater management criteria in Section 501. Requirements were added in 1999. The design standard requires post construction peak discharge to be managed to no greater than the pre development peak for the 2, 10, 25, and 50-year storm. The ordinance also advises preserving the pre-development drainage and topography to maximum extent possible.	Floodplain regulations are contained in section 1204.A of the Zoning Ordinance. The ordinance was adopted in 1996. The regulations allow accessory uses only, by special exception, in the floodway and development in other floodplain areas subject to conditions.	Contained in Zoning ordinance.
Washington Township	No separate ordinance. Addressed in SALDO.	SALDO adopted in 1991. Section 4.02B states that drainage easement will be provided in any subdivision traversed by a waterway. The easement is to extend a minimum of 10' from the defined edge of the waterway. Section 4.06 promotes groundwater recharge in order to limit increased runoff from development. Section 4.06C addresses storm water management facilities and storm drainage facilities. Permanent control measures/facilities shall be designed to assure that the maximum rate of stormwater runoff is no greater after development that prior to development at all points of discharge from the subject site for design storms of 2, 10, 25, and 100 year storm events. Section 4.06D lists specific requirements for storm drainage facilities, pipes, inlets and drainage swales.	Floodplain regulations contained in zoning ordinance. Adopted in 1996. Section 907A allows accessory uses only, by special exception, in floodway and development in other floodplain areas is subject to conditions.	Addressed in zoning ordinance.
Wayne Township	No separate ordinance. Addressed in SALDO.	Section 805 of SALDO contains stormwater management criteria. The ordinance allows for innovation in design, encourages cluster development and infiltration. A 10 year storm is used for calculation.	No ordinance.	Addressed in section 805 of SALDO. Requires floodplain be kept free of structures, fill, and other encroachments, although some activities such as roads, ponds, and stormwater facilities are allowed.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Wiconisco Township	No separate ordinance. Addressed in SALDO.	Adopted in 1975, the SALDO requires all subdivision plans adhere to certain requirements to minimize flood damage. Section 605.1 states that storm drainage facilities must be designed to handle peak discharge of subdivided property as well as increased runoff from up slope development. Section 502.2 also states that a drainage easement will be provided for any subdivision traversed by a waterway.	Article 3, Section K of the Zoning Ordinance states that certain obstructions may not be placed in a stream channel or open drainage way and any structure permitted on the lot should have minimal obstruction to the flow of water.	The Floodplain Ordinance allows low impact uses in the floodway provided that they do not require structures, fill or storage of materials and equipment. In the flood fringe and general floodplain areas, development is allowed subject to conditions.
Williams Township	No ordinance.	The Township does not have SALDO or zoning ordinances. However, the County SALDO applies. Storm drainage is addressed in section 505 of County's ordinance	No ordinance.	The floodplain regulation prohibits new construction or development in any identified floodplain. Section 3.01A and Section 3.01B allows modifications or improvements to existing structures involving less than 50% of the fair market value.
Williamstown Borough	No separate ordinance.	No SALDO. In this case, the County SALDO applies. The County SALDO, in Section 505, addresses storm drainage.	No ordinance.	Floodplain ordinance allows conditional development in floodplain.

Central Planning Region

Table 6: Central Planning Region Ordinance Review

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
City of Harrisburg	No separate ordinance. Addressed in Zoning Ordinance.	Adopted in 1990.	Title 9, Part 9 of the City's Zoning Ordinance contains stormwater management regulations. It identifies Release rate districts within the City's various watersheds.	Addressed in Zoning Ordinance.
Dauphin Borough	No separate ordinance. Addressed in SALDO.	Section 504 contains provisions that regulate drainage.	Section X contains a floodplain ordinance. The regulations have standard requirements.	Contained in the Zoning Ordinance.
East Hanover Township	A Stormwater and Flood Reduction Ordinance was adopted on March 18, 2008. The Ordinance provides performance standards and design criteria for stormwater management, flood reduction and mitigation planning. It also seeks to manage stormwater runoff, soil erosion, sedimentation, and maintain and promote groundwater recharge.	Adopted in 2003.	Section 211 of the Zoning Ordinance contains floodplain regulations. The floodplain is designated as an overlay zone that includes the FEMA mapped 100-year floodplain. Areas not included in FEMA studies are identified as areas within 50 ft from top of bank. The ordinance prohibits the construction of most structures in the floodplain,	Contained in Zoning Ordinance.
Lower Paxton Township	Addressed in SALDO.	Article 1116 and subsequent amendments address stormwater management. Four stormwater management districts are identified in the township. These districts provide standards for 3 watersheds identified in existing Act 167 plans and for areas currently not subject to an Act 167 plan.	Ordinance adopted in July 2006. Contains floodplain management regulations.	Regulations contained in Section 504 of zoning ordinance. In Floodplain Overlay District Floodplain ordinance allows conditional development in floodplain
Middle Paxton Township	The Township has a separate stormwater ordinance that also includes drainage regulations. The ordinance is written to allow incorporation of the Act 167 plan standards. It also references the plan's release rates as standards. Section 307 contains water quality criteria. Infiltration and minimization of impervious cover are shown as general requirements in Section 301.	Adopted 2001.	Adopted in 2000.	The Township's Floodplain Ordinance prohibits most structures and other obstructions from the floodway. The floodplain requirements are located in a separate ordinance.
Paxtang Borough	No ordinance.	Adopted 1958.	Adopted 1999.	Floodplain ordinance allows development in the floodplain subject to flood proofing and elevation requirements and other standards for design and construction in the floodplain.
Penbrook Borough	Contained in zoning ordinance.	SALDO, adopted in 2004, requires post development peak flows be managed to the flow rates assigned to an area for areas covered by an Act 167 plan.	Contains stormwater management regulations. Adopted in 1981, Section 226-8 identifies distinct release districts in the Borough.	Floodplain design standards contained in Section 509 of SALDO. However, Borough has no designated floodplains.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
Rush Township	No separate ordinance.	No SALDO. In this case, the County SALDO applies. The County SALDO, in Section 505, addresses storm drainage.	No ordinance.	Floodplain ordinance prohibits construction and development in any designated floodplain.
South Hanover Township	No separate ordinance. Addressed in SALDO	The Township's SALDO was adopted in 1977. Part 4, Section 401.9 and Part 6, Sections 601 and 602 address stormwater management requirements. The ordinance requires post-development peak flows be managed to the release rates assigned by the Multi-Creek Act 167 Plan. Development outside the Multi-Creek Watershed is required to mitigate the 10-year post-development peak rate of discharge to 2-year pre-development peak rate.	Adopted in 1995, the Zoning Ordinance designates floodplains as a separate zoning district in Part 14 of the ordinance. They are comprised of the FEMA mapped 100-year floodplain. It allows development in the Floodplain District subject to strict development and construction conditions. Floodplain development is also regulated by Part 8 of the Township's SALDO.	Addressed in Zoning Ordinance.
Susquehanna Township	No separate ordinance. Addressed in SALDO	Section 612 of the Township's SALDO contains stormwater management standards. The ordinance specifies the management criteria for Act 167 plans for the Paxton and Spring Creek watersheds. All other watersheds have a 100% release rate.	A floodplain overlay district is located in the Township's Zoning Ordinance. Structures and other uses are permitted in the flood fringe subject to the requirements of the underlying district.	Addressed in Zoning Ordinance.
West Hanover Township	Stormwater Management Ordnance (Chapter 168) adopted in 2005. The ordinance calls for 2-, 10-, and 25-year design storms, and requires that the post-development peak runoff rate be managed to specified release rates per the Multi Creek Act 167 plan.	Section 173-24 of SALDO addresses floodplain management and cites the overlay zoning district as additional requirements.	Zoning ordinance addresses floodplain management in Article 15 with a Floodplain Overlay District. The Floodplain Overlay District is comprised of the FEMA mapped 100-year floodplain. Zoning regulations prohibit new construction and development within 50 feet of the Floodplain Overlay Districts. Article 16 establishes an Environmental Protection Overlay district, which contains a Stream Protection Overlay District to be established on a property when subdivided, developed or during the zoning permit application process. The minimum stream buffer for such a district is 25 feet and a conservation easement must be in place in the area.	Addressed in Chapter 108 of Township code.

Southern Planning Region

Table 7: Southern Planning Region Ordinance Review

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
Conewago Township	No separate ordinance. Addressed in SALDO.	Part 5, Section 506 requires submittal and approval of an E&S plan for all earth moving activities. Also, a SWM plan must be prepared and stormwater drainage facilities are required. Standard: limit 25 year storm post-development runoff to 2 year storm pre-development volume and velocities.	Establishes drainage regulations and requirements for submittal of an E&S plan and surface water control plan (Part 10; 1012). Part 15 establishes a floodplain district which allows development in the floodplain if all provisions are met.	Addressed in Zoning Ordinance.
Derry Township	Ordinance updated 5/15/06 and contained in Chapter 174 of township ordinances. Article III requires all regulated earth disturbance activities must be designed to address E&S control and water quality protection. It requires that the project must have an approved E&S and BMP operation and maintenance plan. In addition, section 174-12 contains post-construction water quality requirements.	Ordinance requires submittal of E&S plan (185-21). Section 185-26 requires that all subdivision and land development activities must incorporate stormwater management controls. The project must be designed so that the peak discharge of the calculated post development runoff to any point on adjacent property does not exceed the peak discharge of the calculated pre-development runoff at the same point.	Ordinance allows for establishment of Floodplain Overlay District (Chapter 225; Article XXXII). Development is allowed in the Floodplain Overlay District, if it is permitted in underlying district, except prohibited uses, only when the effect of such development on flood heights is fully offset by accompanying steam or floodplain improvements.	Addressed in Zoning Ordinance.
Highspire Borough	No separate ordinance. Addressed in Subdivision & Land Development Ordinance.	Ordinance requires submittal and approval of Erosion and Sedimentation plan (Section 506). Also, a Stormwater Management plan must be prepared and stormwater drainage facilities are required. Standard: limit 25 year storm post-development runoff to 2 year storm pre-development volume and velocities.	Ordinance addresses floodplain management in Part II (Amended 6/29/94). No development in floodplain that would result in an increase in 100 year flood elevation more than 1 foot.	Addressed in Zoning Ordinance.
Hummelstown Borough	A Hummelstown Borough Stormwater Management Ordinance was adopted on March 10, 2005. The ordinance contains erosion and sediment control requirements; stormwater runoff and design criteria; water quality protection criteria; channel protection criteria; and infiltration requirements.	Part 5 of the ordinance establishes design standards for E&S and SWM control. All earthmoving activities must have approved E&S plan. SWM plan must be approval. Minimum design criteria shall be a 10 year storm with a 20 minute duration. Ordinance addresses floodplain management with no development allowed in the floodway. Development is allowed in the flood fringe within standards.	Drainage control regulations are listed in Section 1413. Prior to any earthmoving activities, the applicant must submit E&S and SWM plans for approval.	Addressed in Subdivision & Land Development Ordinance.
Londonderry Township	Stormwater management standards are contained in Chapter 26 (Water), Part 1 of the Township's ordinances (SWM and E&S Control Ord. No. 1987-2). All earth disturbing activities affecting 5,000 square feet or more of land must have an approved SWM plan (Section 141). Section 131 contains SWM standards. Also, section 136 requires an approved E&S plan be submitted for the project.	Section 305 of the SALDO requires that an E&S plan be submitted for approval. Section 406 requires that the SWM and E&S Control Ordinance be adhered to in its entirety.	Floodplain Management standards are contained in Part 15 of the ordinance. It establishes floodplain districts. No structures are allowed in the Floodway District. Limited development in allowed in the Flood Fringe District as long as it is accordance with the underlying district and adheres to all flood proofing and other requirements.	Addressed in Zoning Ordinance.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
Lower Swatara Township	SWM and E&S Control Ordinance (amended through 2006): Applies to land development and earth disturbance activities. Establishes SWM districts. Requires an ESC/SWM plan. Standard: 25 year post-development peak rate of stormwater runoff reduced to 2 year pre-development peak rate (26-111H).	Ordinance amended through 2008. Reference made to SWM plan requirement of SWM ordinance (22-507). Requires ESC plan (22-506).	Establishes floodplain management district (27-2101). Sets forth floodplain management regulations (27-2103). Allows new structures in floodway with special exception. Standard for flood fringe development-no increase in 100 year flood elevation more than 1 foot.	Addressed in Zoning Ordinance.
Middletown Borough	No separate ordinance. Addressed in SALDO and Zoning Ordinance.	Ordinance contained in Chapter 238. Sections 238-19 and 28 list standards for storm drainage installations and erosion and sediment control measures.	Ordinance adopted in 1985 and located in Chapter 260. Requires building applicant to submit stormwater drainage facilities and erosion control plans. Article XI, section 260-87 & 88 contain standards for Floodplain District. Development allowed in floodplain if meets all standards.	Addressed in Zoning Ordinance.
Royalton Borough	No separate ordinance. Addressed in SALDO.	Applicant must submit E&S and SWM plans for approval. The SWM system must be designed to specifications. The minimum design criterion is the 10-year storm.	Ordinance adopted 6/18/87. Establishes floodplain district. Meets FEMA requirements. No new construction in the floodway that would increase flood height. All new building in the flood fringe must conform to standards (Article XV).	Addressed in Zoning Ordinance.
Steelton Borough	Chapter 93-Stormwater Management. Any earth disturbance must have E&S plan and SWM plan. SWM facilities designed to handle peak discharge. Groundwater recharge: encourage facilities that promote recharge. Water quality requirements: provide adequate storage to capture and treat runoff from 90% of the average annual rainfall. Channel protection requirements: storage facility outfall structure designed to provide the 24 hour detention of the 1 year/24 hour storm (Article III).	Ordinance makes reference to E&S and SWM requirements contained in SWM ordinance (Chapter 99; 99-23 & 99-24). Contains floodplain management regulations in section 99-26. No new residences or buildings in floodway. Flood fringe development allowed within standards.	Ordinance establishes floodplain districts. Sets forth floodplain management regulations. Allows new structures in floodway with special exception. Construction allowed in flood fringe area within FEMA standards.	Addressed in SALDO and Zoning ordinances.
Swatara Township	A Stormwater Management Ordinance, contained in Chapter 247, was adopted on 2/8/06. It requires applicants engaged in activities in the Spring Creek and Multi-Creek watersheds to submit a drainage plan consistent with the Spring Creek and Multi-Creek Act 167 Stormwater Management plans. The applicant must meet E&S control, water quality protection, drainage, and stormwater management standards.	Adopted in 1990, the ordinance requires submittal of an E&S plan for all earth disturbance activities. Also requires that a stormwater management plan be implemented for the project and establishes design standards in floodplains. It states that no residences or buildings are allowed in the floodway. Construction is allowed in the flood fringe if all established standards are met.	Ordinance requires that all floodplain management provisions of Chapter 156 and stormwater management provisions of Chapter 247 are complied with in all zones.	Addressed in SALDO and Zoning Ordinance.

Related Plans Review

Analysis of existing related plans is also required by Act 167. The following is a summary of related plans which includes a listing of pertinent plan goals:

Table 8: Related Plans Review

PLANNING REGION	PLAN TITLE	DATE	AUTHOR	PERTINENT PLAN GOALS
All	Dauphin County Comprehensive Plan	2005	Tri-County Regional Planning Commission (TCRPC)	1. Control peak rates of stormwater runoff. 2. Seek to preserve natural buffers adjacent to creeks and drainage ways. 3. Prevent soil erosion. 4. Minimize direct runoff from parking areas.
All	Dauphin County Regional Growth Management Plan	2003	TCRPC	1. Preserve and protect the natural environment. 2. Promote greenways and open space.
All	A Plan for Restoring and Conserving Buffers Along PA Streams	November 1997	PADEP	1. Establish 600 miles of additional buffers in Pennsylvania. 2. Streamside buffers should be restored were appropriate. 3. All existing streamside buffers should be conserved.
All	Susquehanna Greenway Strategic Action Plan	June 2006	Susquehanna Greenway Partnership	1. The Susquehanna Greenway Partnership will conserve, protect, and restore the natural environment of the greenway. 2. The Susquehanna Greenway will bring multiple benefits including environmental stewardship.
Northern and Central	Susquehanna River Conservation Plan	1/16/99	TCRPC	1. Each municipality should either independently or jointly strive to set standards for future development located in the environmentally sensitive areas designated in this plan. 2. Local activities, development proposals, and events should focus on the education and promotion of river conservation. 3. Promote natural buffer retention throughout the river corridor. 4. Create regional park facilities through local partnerships. 5. Encourage local municipalities to become aware of the causes of erosion and runoff and the effects of stormwater management. 6. Protect the water quality of the Susquehanna River and its contributing tributaries.
Southern	Conewago Creek Restoration Plan	May 2006	Conewago Creek Watershed Association	1. Implementation of restoration projects set forth in the plan. These include installation of vegetative buffer strips, terraces, diversions, stream bank stabilization, and grazing land management.
Southern	Swatara Creek Watershed Conservation Plan	October 2000	Swatara Creek Watershed Association (SWA)	1. Develop stormwater management plans for developed areas in the major drainageways of the watershed. 2. Work with local, county, and regional planning organizations to develop and carry out plans for the protection of environmental amenities in the watershed. 3. Support implementation of land conservation techniques in subdivision design. 4. Actively enforce land use controls for areas along waterways in the watershed. 5. Develop and implement stream bank stabilization and habitat enhancement projects for the streams in the watershed. 6. Inventory riparian buffers in the watershed. 7. Inventory NPS pollution problems in the major drainageways of the watershed.

GOALS OF SOUND STORMWATER MANAGEMENT PLANNING

Under natural, undisturbed conditions, watershed hydrology reaches a state of equilibrium. That is, the watershed, its ground and surface water supplies, resulting stream morphology, and water quality are in balance with the existing rainfall and runoff patterns. This equilibrium is displayed by stable channels with minimal erosion, adequate groundwater recharge, adequate base flows, relatively infrequent flooding, relatively high water quality, and as a result of all these conditions, relatively healthy in-stream biological communities. Streams continue to meander, but the lateral movement is so slow and steady that there is no significant impact on the channel flora and fauna.

The goals of the recommended stormwater management requirements and criteria developed for this Plan are to maintain or restore the following six (6) elements of watershed response to stormwater runoff in as close to a natural condition as possible.

Stable Channels – In a natural watershed, the channels of the stream network have adapted themselves, in terms of size, slope, and shape, to the amount of runoff delivered to the stream by its contributing watershed. Typically, the main channel will be large enough to accommodate the runoff from a storm, the magnitude of which will occur approximately every two (2) years. Disturbances in the watershed, including development, disrupt this equilibrium. With development, typically more stormwater runoff reaches the streams more often. This results in the channel attempting to resize itself. This resizing manifests itself in channel instability, bed and bank erosion, shifting sediment deposits, increased localized flooding, and other associated water quality problems. Channel instability may also adversely impact adjacent property and infrastructure.

Groundwater Recharge – In an undisturbed watershed, runoff is minimal relative to the magnitude of the storm event. Natural ground cover, undisturbed and un-compacted soils, and uneven terrain provide an excellent environment for maximum infiltration to occur. When development occurs, these factors are minimized or removed, causing more rainfall to become runoff that flows into receiving streams. Consequently, less water is retained in the watershed to replenish groundwater supplies.

Base Flows – Loss of groundwater recharge, as described above, leads to insufficient groundwater available to replenish streams during dry weather. As a result, streams that may have an adequate base flow during dry weather under natural conditions may have minimal flow or become completely dry in developed watersheds.

Flooding – The main stream channel in an undisturbed watershed typically can accommodate the runoff from a storm with approximately a two (2) year return period. As the watershed becomes developed, this volume of stormwater runoff delivered to the stream will occur more frequently. Until the channel reaches a new equilibrium, this increase of runoff will result in overbank flows. It is important to realize that this equilibrium may take many years to be attained once the new runoff patterns are in place. In watersheds with continuous development and constant addition of new impervious surfaces, a new equilibrium may not be reached. Additionally, floodplain encroachment and in-stream sediment deposits from channel erosion may exacerbate flooding.

Water Quality – Stormwater runoff from developed surfaces carries a wide variety of contaminants. Pesticides, herbicides, fertilizers, automotive fluids, hydrocarbons, sediment, detergents, bacteria, increased water temperatures, and other contaminants that are found on land surfaces are carried into streams by stormwater runoff. These contaminants can have an adverse impact on the quality of the stream. Additionally, sediment from in-channel erosion has an adverse impact on stream habitat.

Stream Biology – The adverse impacts of improperly managed stormwater runoff are evident in the biological changes in impacted streams. As streams degrade, the biological communities within the stream also degrade. Consequently, fewer species and reduced total biomass are the result.

It is important to understand that all of the above impacts, as well as watershed hydrology, rainfall, and stormwater runoff are interconnected. The implications are far reaching. How we manage our watersheds has a direct impact on the water resources of the watershed. Any decision that affects land use has implications for stormwater management and, in turn, impacts the quality of watersheds and water resources. The quality of water resources within the watersheds has an effect on the quality of life, and also has economic consequences. This understanding is the focal point of current stormwater management approaches.

The current philosophy of stormwater management is reflected in the required standards. The philosophy, and thus the standards, reflects an attempt to manage stormwater in such a way as to maintain the watershed hydrology as near to existing conditions as possible. Maintaining watershed hydrology is essential to maintaining the water resources of the watershed.

The historical, traditional approach to stormwater management was to collect the runoff and deliver it as quickly as possible, via a system of inlets and pipes, to the nearest receiving waters. Most people now acknowledge that this approach is not an effective way to manage stormwater. An increased volume of stormwater that is delivered quickly to receiving waters has a very detrimental affect on channel morphology and would cause many of the negative impacts described above. As stormwater management views progressed, this historical approach was later replaced with stormwater management standards that managed only runoff peak flows, requiring that the post-development peak discharge had to be less than or equal to the estimated pre-development peak. More recent innovations included:

- Establishing release rates to ensure that the post-development peak discharge would not, due to streamflow travel times, inadvertently cause downstream peak flow to increase.

- Requiring some control at the source to promote filtering of storm runoff to improve the discharge quality.

- Providing Best Management Practice to address water quality.

- Promoting the infiltration of stormwater for groundwater recharge.

- Controlling the volume of runoff to ensure that the runoff volume after development more closely matched the volume prior to development for design storm events.

It is also important to realize that stormwater-generated problems tend to be watershed wide; which means that problems generated in an upstream area can, and do, create problems downstream.

Two (2) points are emphasized regarding the need for a stormwater management approach that emphasizes the total hydrologic cycle:

- Standards must be implemented diligently by all municipalities within Dauphin County. Failures to implement the standards undermine the holistic approach to stormwater management.

- Stormwater runoff can not be properly managed by stormwater management regulations alone. As discussed above, the quantity, quality and impacts of stormwater on receiving streams are directly related to land use decisions. Thinking beyond stormwater management and considering the impact of other regulatory mechanisms such as zoning, subdivision and land development, buffer and floodplain ordinances is very important. Some of these measures are discussed later in the "Additional Recommendations" section. As this section attempts to clarify, the issue of stormwater management is not simply an issue of removing excess water from developed areas; it is an issue of resource management. The issue is entwined with land use decisions and has social and economic implications. To maximize the effectiveness of a stormwater management program, a holistic approach is needed. Stormwater management should be considered in any decision that affects how land is used.

TECHNICAL CONTROL STANDARDS

It is important to note that the criteria and standards developed for this Plan will be applied to all lands contained within Dauphin County, regardless if a previous watershed-wide Act 167 Plan was completed. The existing Water Quality Volume, Groundwater Recharge Volume, and Channel Protection Volume criteria that were implemented from previous Act 167 Plans in Dauphin County will be superseded with this Plan.

This Plan presents a new unified approach for sizing stormwater BMPs throughout Dauphin County to meet peak rates and volume control guidelines, meet pollutant removal goals, maintain groundwater recharge, reduce channel erosion, and consequently control increases in peak flow. The remainder of this section describes the sizing criteria in detail, and presents guidance on how to properly compute and apply the required design volumes. These criteria were obtained from the Pennsylvania Stormwater Best Management Practices Manual and are to be adopted, for all watersheds contained within Dauphin County. The technical criteria are consistent with the Pennsylvania Comprehensive Stormwater Management Policy.

Table 9: Summary of the Technical Criteria

SIZING CRITERIA	DESCRIPTION OF STORMWATER SIZING CRITERIA
Volume Control – Using Control Guideline 1 (CG-1)	- Applicable for any size of development - Do not increase the post-development total runoff for all storms equal to or less than the 2-year, 24-hour storm event - Existing non-forested pervious areas to be considered Meadow (Good) - 20% of existing impervious area, contained within the new proposed limit of disturbance, to be considered Meadow (Good) Use Worksheets 1-5*
Volume Control – Using Control Guideline 2 (CG-2)	- Applicable for development sizes 0 to 1 acre - Capture the first 2" of runoff from new impervious areas - Permanently remove at least the first 1" of captured runoff - As appropriate, infiltrate at least the first 0.5" of captured runoff Use Worksheets 7-8*
Water Quality Controls	- 85% reduction in post-development particulate associated pollutant load (TSS) - 85% reduction in post-development total phosphorus loads (TP) - 50% reduction in post-development solute loads (NO3-N) Use Worksheets 10-13*
Peak Rate Controls	- 1-year, 50-year, & 100-year storm events – 100% Release Rate - 2-year, 10-year, & 25-year – See Release Rate Plates - If the project area has not been studied in detail - 100% Release Rate for the 1-year, 2-year, 10-year, 25-year, 50-year, & 100-year storm events

* Worksheets can be found in the Pennsylvania Stormwater Best Management Practices Manual - December, 2006 – Chapter 8, pages 28 thru 44.

The following established guidelines reflect ten (10) basic and fundamental principles of stormwater management. The principles are listed below to emphasize their importance as the foundation for the technical guidelines that follow:

1. Managing stormwater as a resource
2. Preserving and utilizing existing natural features and systems
3. Managing stormwater as close to the source as possible
4. Sustaining the hydrologic balance of surface and ground water
5. Disconnecting, decentralizing and distributing sources and discharges
6. Slowing runoff down, and not speeding it up
7. Preventing potential water quality and quantity problems
8. Minimizing problems that cannot be avoided
9. Integrating stormwater management into the initial site design process
10. Inspecting and maintaining all BMPs

Volume Control

The focuses of the Volume Control Guidelines are to provide stream channel protection and water quality protection from the frequent rainfalls that comprise a major portion of runoff events throughout Dauphin County. These guidelines are essential for:

Protecting Stream Channel Morphology: Increased uncontrolled runoff volume results in an increase in the frequency of bank full or near bank-full flow conditions in stream channels. The increased presence of high flow conditions in riparian sections has a detrimental effect on stream shaping, including stream channel and overall stream morphology. Consequently, stream bank erosion is greatly accelerated. As stream banks are eroded and undercut; meanders, pools, riffles, and other essential elements of stream habitat are lost or diminished. Strategies employed by the Control Guidelines include a combination of volume reduction and extended detention to reduce the bank-full flow occurrences.

Maintaining Groundwater Recharge: A significant percent of the annual precipitation infiltrates into the soil mantle under natural conditions. A majority of the precipitation is absorbed and transpired by vegetation. Part of the infiltrated water moves in the soil mantle to emerge as springs and seeps, feeding local wetlands and surface streams. The rest of the infiltrated water enters deep groundwater aquifers that supply drinking water wells. Without groundwater recharge, surface stream flows and supplies of groundwater for wells will diminish or disappear during drought periods. Based on land use and soil characteristics, certain land areas recharge more groundwater than others; therefore, protecting the critical recharge areas is important in maintaining the hydrologic water cycle.

Preventing Downstream Increases in Runoff Volume and Flooding: Increased volume of runoff and prolonged duration of runoff from multiple development sites can increase peak flow rates and duration of flooding from stormwater runoff caused by relatively small rain events. Replicating pre-development stormwater runoff volumes for small storms can substantially reduce the problem of frequent "nuisance" flooding. Although the control of runoff volumes from small storms significantly helps to reduce flooding, during large storms events, additional measures may be necessary to provide adequate relief from the serious flooding that occurs during such low frequency events.

Replicating the Pre-Development Hydrology: The objective of stormwater management is to develop a design or system that replicates the natural hydrologic conditions of a watershed to the maximum extent practicable. However, the very process of clearing the existing vegetation from the site removes the evapotranspiration component of the natural hydrologic regime. Unless the evapotranspiration component is replaced in post-development, the stormwater runoff increase can be substantial.

Control Guideline 1 (CG-1)

- CG-1 defines the storage volume required to ensure that the regulated activity does not increase the total runoff volume for the 2-year/24-hour event.
- A regulated activity is considered any earth disturbance activity or any activity that involves the alteration or development of land in a manner that may affect stormwater runoff.
- CG-1 is applicable for any sized regulated activity.
- CG-1 assumes that existing non-forested pervious areas must be considered meadow (good condition) for pre-development hydrologic calculations.
- CG-1 assumes that twenty (20) percent of existing impervious area, when present on a project site, and contained within the new proposed limit of disturbance, must be considered meadow (good condition) for pre-development hydrologic calculations for redevelopment.

Control Guideline 2 (CG-2)

- CG-2 is independent of site constraints, and should be considered if CG-1 is not followed.
- CG-2 is not applicable for regulated activities greater than one (1) acre.
- CG-2 sizes stormwater facilities to capture at least the first two (2) inches of runoff from all contributing new impervious surfaces
- Of the two (2) inches captured, at least the first one (1) inch of stormwater runoff from the new impervious surfaces shall be permanently removed from the runoff flow, i.e. it shall not be released into the Surface Waters of the Commonwealth. Removal options include reuse, evaporation, transpiration, and infiltration.
- As applicable, infiltration facilities should be designed to accommodate infiltration of the entire permanently removed runoff volume, however, in all cases at least the first one-half (0.5) inch of the permanently removed runoff should be infiltrated.

Water Quality Control

The volume control achieved through applying CG-1 and CG-2 may also remove a major fraction of particulate-associated pollutants from impervious surfaces during most storms.

CG-1 will provide water quality control and stream channel protection as well as flood control protection for most storms if the BMPs drain reasonably well and are adequately sized and distributed.

CG-2 will not fully mitigate the peak flow rate for larger storms, and will require the addition of secondary BMPs for peak rate control. These secondary BMPs may also provide water quality control. When these secondary BMPs are added to assure peak flow rate mitigation during severe storms, the incorporation of vegetation can provide effective water quality controls.

Control Guideline for Total Water Quality

- Achieve an 85% reduction in post-development particulate associated pollutant load (as represented by Total Suspended Solids (TSS)).
- Achieve an 85% reduction in post-development total phosphorus loads (TP).
- Achieve a 50% reduction in post-development solute loads (as represented by nitrates (NO3-N)).

The Water Quality Control Guideline is a set of performance-based goals. The guideline does not represent specific effluent limitations, but presents composite efficiency expectations that can be used to select appropriate BMPs.

These pollutant reductions may be estimated based on the pollutant load for each land use type and the pollutant removal effectiveness of the proposed BMPs, as shown in Chapters 5 and 6 and discussed in Chapter 8 of the PA BMP Manual.

When the proposed development plan for a site is measured by type of surface (roof, parking lot, driveway, lawn, etc.), an estimate of potential pollutant load can be made based on the volume of stormwater runoff from those surfaces, with a flow-weighted pollutant concentration applied. The total potential non-point source load can then be estimated for the parcel, and the various BMPs, both structural and non-structural, can be considered for their effectiveness in pollutant removal. This method is described in detail in Chapter 8 of the Pennsylvania BMP Manual.

Peak Rate Control (Release Rates)

The intent of the release rate percentage concept is to identify the general characteristics of the subwatershed interactions and their combinations and define their relative impacts on total stream flows. The release rate defines the percentage of the pre-development peak rate of runoff that can be discharged from a site after development. It applies uniformly to all land development or alterations within an individual subwatershed.

Existing Release Rates

- The 2-year, 10-year, and 25-year release rates associated with previously completed watershed wide Act 167 plans shall remain in effect. Refer to Release Rate Plates associated with existing plans.

Proposed Release Rates

- The 2-year, 10-year, and 25-year release rates associated with Laurel Run, Burd Run, and Spring Creek (East) shall be implemented as part of this Plan.
- The 1-year, 50-year, and 100-year release rate is 100% for all lands contained with Dauphin County.
- The 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year release rate is 100% for all lands contained within Dauphin County that have not had detailed modeling completed.

The general approach employed in Dauphin County was to establish release rates for each subwatershed by determining the peak rate of runoff from the subwatershed and its contribution to peak discharges in downstream reaches. This procedure was accomplished using the HEC-HMS modeling program developed by the U.S. Army Corps of Engineers. The specific steps in the approach are as follows:

1. Perform overall watershed modeling using HEC-HMS. The subwatershed peak flows and the total combined peak flows at the subwatershed junctions are shown for the 2005 Existing Land Use Condition in Table 10.

2. Identify the modeled flow contribution that a particular subwatershed contributes to each of the modeled downstream reaches.

3. Calculate the release rate percentage for each subwatershed at each downstream reach.

4. Assign a single release rate percentage for each subwatershed.

5. Compare the hydrographs of the subwatershed junctions to all points within the specific watershed to check whether peak flow increases occurred at any point within the watershed. If the full build out future condition has a greater peak

flow then the existing condition, then the release rates are modified accordingly to prevent the peak flow increase.

The final modeling of this Plan provides release rates that do not increase the full build out future peak flows above the existing condition peak flows at any point within the modeled watersheds.

Refer to Appendix B – Technical Analysis, for additional technical information regarding these release rates.

Table 10: Subwatershed and Outlet Peak Flows for Existing Land Use Conditions

BURD RUN WATERSHED AND OUTLET PEAK FLOWS FOR EXISTING CONDITIONS (CFS)					
SUBWATERSHEDS	**2-YEAR**	**10-YEAR**	**25-YEAR**	**50-YEAR**	**100-YEAR**
B1	36	124	182	229	280
B2	58	184	263	327	398
B3	45	133	187	229	276
B4	77	169	219	256	296
B5	49	134	185	224	267
HMS JUNCTION #1	94	307	444	555	677
HMS JUNCTION #5	198	582	819	1007	1213
BURD RUN OUTLET	**235**	**701**	**987**	**1214**	**1462**

LAUREL RUN WATERSHED AND OUTLET PEAK FLOWS FOR EXISTING CONDITIONS (CFS)					
SUBWATERSHEDS	**2-YEAR**	**10-YEAR**	**25-YEAR**	**50-YEAR**	**100-YEAR**
L1	15	90	148	198	255
L2	14	47	68	85	103
L3	8	60	103	141	186
L4	10	67	113	155	203
L5	10	52	85	113	145
L6	8	41	67	89	114
L7	2	21	38	54	72
L8	16	75	119	157	200
L9	3	24	41	56	74
L10	24	107	169	222	282
L11	42	140	204	256	314
L12	7	36	57	75	95
L13	25	125	201	268	345
L14	19	75	114	146	183
HMS JUNCTION #1	15	90	148	198	255
HMS JUNCTION #2	28	135	215	282	357
HMS JUNCTION #3	35	192	314	419	538
HMS JUNCTION #5	66	388	644	866	1121
HMS JUNCTION #6	90	502	827	1111	1438
HMS JUNCTION #7	178	856	1372	1815	2321
HMS JUNCTION #8	23	109	173	228	291
HMS JUNCTION #10	57	329	543	730	944
LAUREL RUN OUTLET	**196**	**929**	**1483**	**1959**	**2501**

SPRING CREEK (EAST) WATERSHED AND OUTLET PEAK FLOWS FOR EXISTING CONDITIONS (CFS)					
SUBWATERSHEDS	**2-YEAR**	**10-YEAR**	**25-YEAR**	**50-YEAR**	**100-YEAR**
SP1	126	408	616	803	1020
SP2	28	156	267	373	500
SP3	34	136	214	285	368
SP4	14	79	137	193	261
SP5	46	203	332	452	596
SP6	18	84	139	188	247
SP7	51	205	326	438	570
SP8	16	102	181	258	351
SP9	70	238	362	474	604
SP10	122	344	494	623	771
SP11	10	45	73	99	128
SP12	29	117	183	240	304
SP13	25	82	122	157	196
SP14	35	148	237	317	411
SP15	33	72	95	112	131
HMS JUNCTION #1	34	136	214	285	368
HMS JUNCTION #2	73	347	574	800	1058
HMS JUNCTION #3	18	84	139	188	247
HMS JUNCTION #4	16	102	181	258	351
HMS JUNCTION #5	164	795	1325	1833	2433
HMS JUNCTION #6	179	609	929	1218	1558
HMS JUNCTION #7	420	1658	2637	3552	4641
HMS JUNCTION #8	434	1708	2713	3653	4766
HMS JUNCTION #9	531	2022	3177	4245	5499
SPRING CREEK OUTLET	**536**	**2043**	**3210**	**4290**	**5558**

ECONOMIC IMPACT OF STORMWATER MANAGEMENT STANDARDS

A major cause for concern is the economic impact of urban stormwater runoff. For example, in 1997 the US EPA conservatively estimated the total cost to the American economy from illness and loss of economic output due to urban stormwater pollution to be millions of dollars each year (US EPA, 1998). Therefore, measures to control stormwater runoff quality, rate, and volume are necessary.

Site planning that integrates comprehensive stormwater management into the development process from the outset may result in efficiencies from traditional detention basin size reduction or elimination, less redesign to retrofit water quality and infiltration measures into a plan, and decreased agency approval time. Early stormwater management planning may decrease the size and cost of structural solutions. Stormwater management efforts which incorporate BMP structural technologies into the site design at the final stages sometimes result in the construction of unnecessarily large facilities.

The following two (2) examples illustrate the methods to design stormwater management facilities/structural BMPs in accordance with the volume and peak rate control strategies developed within this Plan. Examples of possible efficiencies gained by incorporating structural and non-structural BMPs are illustrated as well.

EXAMPLE ONE

An 8-lot single family residential development, which is located in Burd Run Watershed release rate district B5, is analyzed below. The 2-year design storm (50% chance of occurrence annually) is examined to illustrate the method and cost to adhere to Control Guideline 1 (CG-1). Multiple design storms are examined to illustrate the method and cost of applying release rates to peak runoff volumes.

The SCS Runoff Curve Number Method is used for runoff volume calculations in accordance with the format of the PA BMP Manual. The Rational Method is used for peak runoff rate calculations due to the relative small size of the watershed.

<u>Given Values:</u>

PARCEL SIZE:	15 acres
EXISTING NUMBER OF LOTS:	1 lot
PROPOSED NUMBER OF LOTS:	8 lots + residual
LOCATION:	Subwatershed B5 of Burd Run
HYDROLOGIC SOIL GROUP	'B' – Entire Site

EXISTING COVER TYPE/CONDITION:	Meadow (13-Acres) Woods (2-Acres)
EXISTING SENSITIVE NATURAL RESOURCES:	Woods (2-Acres)

PROPOSED COVER TYPE/CONDITION:	Meadow (6-Acres) Woods (1-Acre) Impervious (4-Acres) Open Space (4-Acres)
PROPOSED SENSITIVE NATURAL RESOURCES:	Woods (1-Acre)*

*Understanding the natural systems characterizing the site is important in any stormwater management design. The developer is encouraged to protect these site features during land development to the maximum extent practicable.

Adherence to CG-1 is demonstrated below using a combination of Non-Structural BMP Credits and Structural BMPs that control volume through infiltration.

Figure 1: Example 1 – Pre-Development Conditions

Figure 2: Example 1 – Post-Development Conditions

The PA BMP Manual lists "Wooded" areas as a Sensitive Natural Resource. In this example, one (1) acre of woods will remain, undisturbed on the site and be protected during construction. (Note that existing cover conditions used in calculations must conform to the prescribed set of acceptable covers, as well as the rules governing use of existing impervious area under Control Guideline 1.)

Refer to the PA BMP Manual for additional guidance, rules and limitations prior to applying Control Guideline 1 or Control Guideline 2.

Based on the above data the following values can be computed:

Computed Values:

Non-Structural BMP Credits:

Protect Sensitive Natural Resources

Stormwater Management Area	=	Site Area – Protected Area
	=	15 – 1 (Acre of Woods)
	=	**14-Acres** (for pre and post development)

The Stormwater Management Area is the land area which must be evaluated for volume of runoff in both pre development and post development conditions.

The Protected Area is not used in the following pre or post development volume calculations. Similarly, one would not incorporate offsite areas into volume calculations.

Minimum Soil Compaction

Meadow Area (post development) protected from compaction = 6 Acres
(6-Ac x (43,560-ft^2 / Ac)) x 1/3" x 1/12 = **7,260-ft^3** *

Lawn Area (post development) protected from compaction = 2 Acres
(2-Ac x (43,560-ft^2 / Ac)) x 1/4" x 1/12 = **1,815-ft^3** *

*Formulas are from PA BMP Manual Worksheet 3. Areas used for this credit must be protected from compaction during construction. Credits for lawn area (Open Space), as shown on the PA BMP Manual worksheets are taken for only 2 acres, because specific measures are planned to protect only 2 acres of lawn area (Open Space) surrounding the dwellings in this example.

Disconnect Roof Leaders to Vegetated Areas

Roof Area = 8 (Units) x 1000 (square feet/Unit) = 8,000-ft^2.
8,000-ft^2 x 1/3" x 1/12 = **222-ft^3** **

**Formula is from PA BMP Manual Worksheet 3. The 1/3" credit is used in this example, because roof runoff discharges across the lawn area and is received by rain gardens, which are structures specifically placed to receive and infiltrate runoff. A 1/4" credit would be used for roof runoff not discharged to a specific infiltration structure.

Change in Runoff Volume for the 2-year, 24-hour storm event, calculated by SCS Curve Number Runoff Method. Similar to PA BMP Manual Worksheet 4.

2-year, 24-hour Rainfall Depth = 2.9"

Existing Conditions: [Protected Area = 1-Ac Woods]

COVER	SOIL TYPE	AREA (SF)	ACREAGE	CN	S	IA	Q RUNOFF (IN)	RUNOFF VOLUME (FT^3)
Woods	B	43,560	1	55	8.18	1.64	0.17	610
Meadow	B	566,280	13	58	7.24	1.45	0.24	11,415
			14				**Total**	**12,025**

Proposed Conditions: [Protected Area = 1-Ac Woods]

COVER	SOIL TYPE	AREA (SF)	ACREAGE	CN	S	IA	Q RUNOFF (IN)	RUNOFF VOLUME (FT^3)
Open Space	B	174,240	4	61	6.39	1.28	0.33	4,756
Impervious	B	174,240	4	98	0.20	0.04	2.67	38,813
Woods	n/a	n/a	n/a	Runoff volume from Protected Area not included				
Meadow	B	261,360	6	58	7.24	1.45	0.24	5,268
			14				**Total**	**48,838**

Change in Runoff Volume for the 2-year, 24-hour storm event:
= 48,838-ft^3 – 12,025-ft^3 = **36,813-ft^3**
= required infiltration and non-structural credit volume

Summation of Non-Structural BMP Credits:
= 222-ft^3 + 1,815-ft^3 + 7,260-ft^3 = **9,297-ft^3**

*Per Chapter 8 of the PA BMP Manual, Non-Structural Credits may be **no greater than 25%** of the total required infiltration volume to meet CG-1.*

Check 25% Non-Structural Credit Limit:
= 9,297-ft^3 / 36,813-ft^3 = **25.254%**
Credits are over the allowable 25% Non-Structural credit by 0.254% of 36,813-ft^3. Therefore, this percentage (0.254% = 94-ft^3) cannot count toward meeting CG-1.

Reduced Non-Structural Credit to meet 25% Criteria:
= 9,297-ft^3 – 94-ft^3 = **9,203-ft^3**
= Non Structural BMP Credits as limited by 25% cap from PA BMP Manual.

Required Structural BMP infiltration volume:
= 36,813-ft^3 – 9,203-ft^3 = **27,610-ft^3**
= Volume to be infiltrated using Structural BMPs.

Structural BMPs:

Rain gardens and infiltration basins are structural BMPs used in this example to fulfill the infiltration requirements not fully met by Non-Structural BMP Credits.

Rain Gardens

One (1) rain garden is proposed for each lot. It is assumed for this example that the entire roof area and lot area of each lot drains to its respective rain garden, driveway impervious area is ignored, and all lots are equal in size. These rain gardens are sized based on two criteria:

A. To stay within loading ratio limits in Appendix C of the PA BMP Manual.
B. To be of sufficient size to accommodate the expected runoff volume.

A1. Maximum loading ratio of impervious area to infiltration area = 5:1
Total roof area (impervious area) = 8,000-ft^2
= 8,000-ft^2 / 5 = **1,600-ft^2**
= minimum bottom area of all rain gardens per impervious loading ratio

A2. Maximum loading ratio of total drainage area to infiltration area = 8:1
Total drainage area = (open space) = 174,240-ft^2 + impervious area (roofs) 8,000-ft^2 = 182,240-ft^2
= 182,240-ft^2 / 8 = **22,780-ft^2**
= minimum bottom area of all rain gardens per total drainage area loading ratio

The loading ratio of the total drainage area to infiltration area governs, therefore, each rain garden bottom surface area shall be:
= 22,780-ft^2 / 8 lots = 2,848-ft^2

B1. Total roof area = 8,000-ft^2 = 4.59% of 4-Ac of proposed impervious.
4.59% of 38,813-ft^3 (runoff from Proposed Conditions Chart) = **1,782-ft^3**
Runoff volume from roofs = **1,782-ft^3**

B2. Total lawn (open space) area = 4-Ac = 100% of proposed open space.
100% of 4,756-ft^3 (runoff from Proposed Conditions Chart) = **4,756-ft^3**
Runoff volume from lawns = **4,756-ft^3**

Runoff volume load tributary to each rain garden:
= (1,782-ft^3 + 4,756-ft^3) / 8 lots = **817-ft^3**

The rain garden depth equals:
= The volume tributary to each, divided by the required area of each
= 817-ft^3 / 2,848-ft^2 = **0.29-ft or approximately 3.5"**

A rain garden on each lot 3.5" deep with a surface area of 2,848-ft^2, properly seeded/planted with select vegetation, will be sufficient to contain runoff volume from each roof and lot and be compliant with the PA BMP Manual loading ratio guidelines.

The volume reduction of rain gardens employed among all 8 lots:
= 817-ft^3 x 8 lots = **6,538-ft^3**

An overflow spillway or drain must be provided to convey storms greater than the 2-year, 24-hour storm event.

Infiltration Forebay

The remaining infiltration will occur in a forebay that accepts runoff from all areas of the site. This forebay will be immediately upstream of a traditional stormwater management basin.

Stormwater runoff that has been infiltrated or credited to infiltration without employing additional measures thus far:
= 6,538-ft^3 Rain Garden infiltration + 9,203-ft^3 Non-Structural Credit =**15,741-ft^3**

Runoff volume remaining to be controlled by infiltration forebay to meet CG-1:
= 36,813-ft^3 – 15,741-ft^3 = **21,072-ft^3**

Of the original 4-Acres of impervious area, 166,240-ft^2 (95.41%) is tributary to the infiltration forebay due to the storm sewer that conveys runoff into the stormwater basin from the street. This impervious area produces 37,031-ft^3 of runoff (which is 95.41% of the 38,813-ft^3 of total impervious runoff) during the 2-year, 24-hour storm, therefore there is adequate volume tributary to supply the infiltration forebay.

The forebay must infiltrate 21,072-ft^3 of this volume for the stormwater management design meet CG-1. The infiltration forebay will accept runoff from various ground cover conditions, and from an area that is larger than necessary to provide the required infiltration volume of 21,072-ft^3. For purposes of calculating a minimum forebay-bottom infiltration area to comply with the PA BMP Manual Appendix C loading ratios, choose an area that will produce the necessary runoff volume to be infiltrated, and base the minimum forebay infiltration area on it.

In this example it is assumed that an impervious area of approximately 94,600-ft^2, which will produce the 21,072-ft^3 of runoff yet to be infiltrated during the 2-year, 24-hour storm. Runoff from this impervious area was calculated by using the SCS runoff equation from TR-55. The 5:1 impervious loading ratio guideline will yield a minimum infiltration forebay bottom area of:
= 94,600-ft^2 / 5 = **18,920-ft^2**

The Infiltration forebay depth equals:
= 21,072-ft^3 / 18,920-ft^2 = **1.11-ft** or **13.4-in**
For this example, an orifice with an invert 13.4" above the forebay bottom will be placed on the outlet structure to ensure the correct volume is infiltrated.

Available volume on top of the infiltration depth can be used to control peak runoff rates; however the PA BMP Manual recommends in Appendix C that no greater than two (2) feet of head be allowed to avoid sealing the soil structure of an infiltration BMP. An infiltration forebay, limited to a depth of two (2) feet is used in this example upstream of a larger traditional detention basin to comply with this guideline.

Drawdown time is another parameter to be checked in this example. A drawdown time of 72-hours is the maximum recommended in Chapter 3 of the PA BMP Manual. Infiltration tests at the forebay location resulted in a **½" per hour** infiltration rate.

Drawdown Time:
= 13.4-in / (0.5-in/hr) = **27-hours**

Drawdown time for water above the infiltration volume in the forebay is ignored in this example because it will exit the basin quickly, relative to the drawdown time of the infiltration volume. If extended detention or other circumstances that cause gradual draining are required, the designer must account for total drawdown time of the entire volume.

Economic Implications of Employing Structural and Non-Structural BMPs

The primary economic benefit of using non-structural credits and rain gardens is found in the reduction of the primary downstream infiltration structure size. In this example, the minimum size of the infiltration forebay bottom, based on the 5:1 impervious loading ratio was 18,920-ft^2. If the infiltration forebay was tasked with the total infiltration load to meet CG-1, the minimum bottom size would have been 33,200-ft^2. This square footage is based on assuming that an impervious area of approximately 166,000-ft^2 produces the total CG-1-required infiltration volume of 36,813-ft^3**.** Therefore, smaller, distributed BMPs used throughout the site result in an infiltration BMP that covers 57% of what would be required without those smaller BMPs. A larger primary downstream infiltration BMP brings with it an opportunity cost in the form of taking up space which could be used for additional marketable land, and a direct cost in the form of increased earthwork.

Opportunity Cost Savings:
Consider one (1) acre of subdivided residential land costs $70,000 on average. Implementing a stormwater design that reduces the total BMP area of the infiltration forebay from 33,200-ft^2 to 18,920-ft^2, or by 0.33-acres, leaves open ground with a value of approximately $23,100. Depending on factors such as minimum lot size, allowable density, etc., this ground could potentially be used to site additional dwelling units which would have been otherwise unavailable.

Direct Cost Savings:
It is conservatively assumed that the forebay in this example is three (3) feet in depth (two (2) feet of water depth plus considering one (1) foot of freeboard around the berm). As identified in Opportunity Cost Savings calculation, reducing the infiltration forebay area by 14,280-ft^2 could eliminate approximately 1,590-yd^3 of earth moving. At $25/cubic yard for bulk excavation, the direct savings realized by reducing the infiltration forebay size would be $39,750, or $4,970 per lot in this example.

Cost of Rain Gardens:
The cost of constructing rain gardens will detract from the savings of implementing a stormwater design plan as presented. However, the cost of constructing each rain garden is less than the per lot cost savings realized by constructing a smaller infiltration forebay.

Each rain garden has an area of 2,848-ft^2 and an assumed 6" depth. Total volume of the eight (8) rain gardens with these specifications is 422-yd^3. At $25/ cubic yard for bulk excavation, the total cost of all rain garden excavation is $10,550. Assume an additional 20% expense for special soil and seed mixes and landscaping for a total cost of approximately $12,700, or $1,600 per lot.

Even considering the cost of rain gardens in this example, a per lot savings of $3,370 is realized.

Peak Rate Control

Rational Method Calculation of Peak Runoff Rates

Existing Rational Runoff Coefficient (weighted) = 0.19	**Proposed Rational Runoff Coefficient (weighted) =** 0.40
Existing Time of Concentration = 15 Minutes	**Proposed Time of Concentration =** 10 Minutes

This example uses the Rational Method to calculate peak flow rates for the site due to the relatively small acreage. The site is located in Burd Run Watershed, subwatershed B5, which requires release rates according to the following table:

1-year	Post Development release rate 100% of Pre-development Rate
2-year	Post Development release rate 70% of Pre-development Rate
10-year	Post Development release rate 95% of Pre-development Rate
25-year	Post Development release rate 95% of Pre-development Rate
50-year	Post Development release rate 100% of Pre-development Rate
100-year	Post Development release rate 100% of Pre-development Rate

Rainfall intensities are obtained from the 2009 PennDOT IDF curves. Subwatershed B5 is located in PennDOT Region 3 for all storms. Note that sensitive natural resources are not taken into account for peak rate analysis, thus the full 15-acre site is evaluated.

Storm	Pre-development Runoff Rate (cfs)*	Post Development Undetained Runoff Rate (cfs)*	Release Rate Applied to Pre-development Rate	Post Development Allowable Runoff Rate (cfs)
1-year	7.13	18.16	100%	7.13
2-year	8.51	21.79	70%	5.96
10-year	11.27	29.06	95%	10.71
25-year	12.88	33.05	95%	12.24
50-year	14.03	35.96	100%	14.03
100-year	15.18	38.50	100%	15.18

* Rational unit conversion factor applied.

It is estimated for this example, that a **77,650-ft^3** or 1.782-ac-ft sized detention basin, with an appropriately configured outlet structure would be required to meet the peak rate control requirements. It is assumed for this example that the entire site is tributary to the basin, and there is no bypass flow.

Recall that the infiltration forebay will be placed directly upstream of the traditional stormwater basin, and will flow into the stormwater basin in this example. The infiltration depth within the forebay was 1.11-ft. The forebay is limited by PA BMP Manual guidelines to two (2) feet of depth to avoid compacting and sealing the infiltration surface with head pressure.

It is acceptable to route post development Rational Method basin inflow hydrographs through the infiltration forebay before the traditional stormwater management basin to take advantage of the forebay volume above and below the outlet placed at 1.11-ft above the forebay bottom. This method takes advantage of the required infiltration volume in the forebay, and volume above the infiltration volume up to the two (2) foot depth limit in the forebay to help mitigate peak flow rates leaving the site. The effect is that the total volume in the infiltration forebay becomes a part of the 77,650-ft^3 of basin volume required to control peak flow rates leaving the site. See below for an explanation of this:

Recall the infiltration forebay bottom minimum surface area = **18,920-ft^2**

Recall the depth within the infiltration forebay required to capture the remainder of the CG-1 volume = **1.11-ft**

Total depth within forebay = **2.0-ft**

Remaining depth available for peak rate attenuation within forebay:
= 2.0-ft – 1.11-ft = **0.89-ft**

Total volume within infiltration forebay:
= 18,920-ft^2 x 2.0-ft depth (assuming vertical sides) = **37,840-ft^3**

Total required volume of traditional stormwater basin downstream of infiltration forebay:
= 77,650-ft^3 – 37,840-ft^3 = **39,810-ft^3**

Values are approximate and will vary depending on outlet structure configuration and basin depth.

This example does not incorporate the effects of rain garden volume on the peak rate attenuation calculations, due to the inherent limitations of the Rational Method. In reality, the rain garden volumes may have a significant effect by reducing peak rates of runoff, especially for the more frequent design storms. Therefore, the stormwater management design presented in this example can be considered conservative. It should be noted that, using the Rational Method to model multiple rain gardens and basins in series, each with a unique time of concentration (and resulting unique rainfall intensity), is a questionable practice. The designer is encouraged to be aware of the Rational Method limitations, and to consider using the SCS TR-55 / TR-20 method if complex watershed modeling is intended.

EXAMPLE TWO

Example Two explains the computations associated with the implementation of Control Guideline 2 (CG-2). The site is a one (1) acre parcel with some existing impervious cover, on which a car dealer expansion lot will be built to contain additional inventory. CG-2 compliance depends mainly on containing runoff volume from pre-development and post development impervious areas, and staying less than or equal to one (1) acre of regulated activity.

Implementation of CG-2 is independent of existing and proposed ground cover conditions (other than impervious cover) and hydraulic soil groups.

Given Values:

PARCEL SIZE:	1 acre
NUMBER OF LOTS:	1 lot located in District B5 of Burd Run
EXISTING LAND USE:	**PROPOSED LAND USE:**
0.2 Acres Impervious 0.8 Acres Open Space	0.5 Acres Impervious 0.5 Acres Open Space

Volume Control to Meet CG-2:

The total area is less than one (1) acre, thus CG-2 criteria will be implemented.

Based on the CG-2 criteria, the first two (2) inches of runoff from the new proposed impervious area is required to be captured by proposed stormwater management facilities.

One (1) inch of runoff from new impervious area is required to be removed from the runoff flow permanently. This example uses infiltration to remove the runoff permanently. Other removal options include reuse, evaporation, transpiration, etc. This volume is considered to be a component of the two (2) inches of runoff discussed above, and not in addition to it.

The PA BMP Manual describes the removal volume as the "first" one (1) inch of runoff, indicating that it should be diverted from the stormwater system and held separately. The first inch of runoff typically contains the greatest amount and concentration of pollutants. Thus, it is of greatest benefit to segregate and infiltrate (or otherwise remove) it from the system.

One option for segregating the first inch of runoff is to use a drainage box in which a lower outlet would be diverted to an infiltration bed. A higher outlet would become active when the infiltration bed was filled to capacity and convey stormwater runoff to the remaining stormwater system. Some mixing may occur between the first inch of runoff and subsequent runoff, but would be minimal relative to the total first inch of runoff collected and conveyed to the infiltration facility.

Stormwater Facility Sizing

In this example, we will capture the first two (2) inches from both existing and proposed impervious surfaces:

IMPERVIOUS COVER	AREA (AC)	RUNOFF CAPTURE VOLUME (FT^3)
Existing Impervious	0.2	**1,452**
New Proposed Impervious	0.3	**2,178**
TOTAL:	**0.5**	**3,630**

Existing impervious contribution to runoff volume:
(0.2-Ac x 43,560-ft^2/Ac) x (2" x 1/12) = 1,452-ft^3

Proposed impervious contribution to runoff volume:
(0.3-Ac x 43,560-ft^2/Ac) x (2" x 1/12) = 2,178-ft^3

Total runoff volume to be captured by proposed facilities:
1,452-ft^3 + 2,178-ft^3 = **3,630-ft^3**

Infiltration or Permanent Removal Volume

Remove one (1) inch from proposed impervious:

IMPERVIOUS COVER	AREA (AC)	INFILTRATION VOLUME (FT^3)
Existing Impervious	0.2 (n/a)	**n/a**
New Proposed Impervious	0.3	**1,089**
TOTAL	**0.3**	**1,089**

Proposed impervious runoff volume of first inch:
(0.3-Ac x 43,560-ft^2/Ac) x (1" x 1/12) = **1,089-ft^3**

An infiltration bed with a total storage volume of **1,089-ft^3** is proposed to provide the infiltration volume.

Loading ratios, depth limits, and drawdown times apply to infiltration facilities under CG-2 similar to CG-1.

Loading ratio limit of 5:1 results in the following minimum infiltration bed surface area:
(0.3-Ac x 43,560-ft^2/Ac) / 5 = **2,613-ft^2**

Depth of infiltration volume is as follows:
1,089-ft^3 / 2,613-ft^2 = **0.42-ft** or **5-in** (depth is well under the 2-ft limit)

Drawdown time of the infiltration facility is as follows:
Five (5) inches of runoff will infiltrate in ten (10) hours, given the 0.5-in/hr rate used in this example. This is within the 72-hour maximum.

Upon filling the infiltration bed to capacity, runoff is diverted downstream to a detention basin with volume of at least **2,541-ft^3** = 3,630-ft^3 – 1,089-ft^3. It is proposed to accept the remainder of the required runoff volume and treat it by extended detention.

Stormwater management facilities must be designed to control peak rates of runoff to the required release rates for the watershed district. The proposed 2,541-ft^3 detention basin represents a minimum volume to meet CG-2. A larger facility may be required to perform the required peak rate reductions.

Peak Rate Control:

Rational Method Calculation of Peak Runoff Rates

Existing Rational Runoff Coefficient (weighted) = 0.35	**Proposed Rational Runoff Coefficient (weighted) =** 0.57
Existing Time of Concentration = 5 Minutes	**Proposed Time of Concentration =** 5 Minutes

This example uses the Rational Method to calculate peak flow rates for the site due to the small acreage. The site is located in Burd Run Watershed, subwatershed B5, which requires release rates according to the following table:

1-year	Post Development release rate 100% of Pre-development Rate
2-year	Post Development release rate 70% of Pre-development Rate
10-year	Post Development release rate 95% of Pre-development Rate
25-year	Post Development release rate 95% of Pre-development Rate
50-year	Post Development release rate 100% of Pre-development Rate
100-year	Post Development release rate 100% of Pre-development Rate

Rainfall intensities are obtained from the 2009 PennDOT IDF curves. Subwatershed B5 is located in PennDOT Region 3 for all storms.

Storm	Pre-development Runoff Rate (cfs)*	Post Development Undetained Runoff Rate (cfs)*	Release Rate Applied to Pre-development Rate	Post Development Allowable Runoff Rate (cfs)
1-year	1.36	2.21	100%	1.36
2-year	1.65	2.69	70%	1.16
10-year	2.16	3.52	95%	2.05
25-year	2.50	4.07	95%	2.38
50-year	2.76	4.49	100%	2.76
100-year	3.01	4.90	100%	3.01

* Rational unit conversion factor applied.

Recall that a detention basin with minimum volume 2,541-ft^3, is required to fulfill the remainder of the CG-2 two (2) inch capture requirement. This volume must be released over at least a period of 24-hours to be considered extended detention under the CG-2 Guideline. This volume can coexist within a basin that serves the dual purpose of providing peak runoff rate control.

In this example, a detention basin is proposed with a small outlet orifice at the basin bottom that will release 2,541-ft^3 of water over a period of at least 24-hours. Additional volume above the extended detention volume is proposed for peak runoff rate control.

It is estimated for this example, that 779-ft^3 of additional volume is required within the detention basin, above the extended detention volume, to control peak runoff rates.

Total volume of basin, downstream of infiltration bed, for peak rate control:
2,541-ft^3 + 779-ft^3 = **3,320-ft^3**

Thus, a **3,320-ft^3** detention basin, with an appropriately configured outlet structure would be required to meet the peak rate control requirements for the entire one (1) acre site. It is assumed for this example that the entire site is tributary to the detention basin, and there is no bypass flow.

Recall that the infiltration bed will be placed directly upstream of the combined water quality / peak rate control detention basin, and its overflow will flow into the basin in this example. This example uses the infiltration bed volume and extended detention volume to help control peak flow rates leaving the site. Therefore, the post development Rational Method basin inflow hydrographs are routed through the infiltration bed prior to routing these hydrographs through the combined stormwater management basin.

Values are approximate and will vary depending on outlet structure configuration and basin depth.

Economic Implications of Employing CG-2 over CG-1 on small sites

Control Guideline 2 (CG-2) is provided as an option in the PA BMP Manual to alleviate some of the challenges of complying with CG-1 on small sites. The primary economic benefit of the CG-2 option is that smaller required infiltration volumes are typically required.

The one (1) acre site in Example Two would produce the following pre-development runoff volume under CG-1 criteria:

Existing Conditions:

COVER	SOIL TYPE	AREA (SF)	ACREAGE	CN	S	IA	Q RUNOFF (IN)	RUNOFF VOLUME (FT^3)
Meadow	B	36,590	0.84	58	7.24	1.45	0.24	738
Impervious	B	6,970	0.16	98	0.20	0.04	2.67	1,552
			1.0				**Total**	**2,290**

Note that only 80% of existing impervious can be considered in pre-development runoff calculations. All other site area must be considered Meadow (or woods if present).

Proposed Conditions:

COVER	SOIL TYPE	AREA (SF)	ACREAGE	CN	S	IA	Q RUNOFF (IN)	RUNOFF VOLUME (FT^3)
Open Space	B	21,780	0.5	61	6.39	1.28	0.33	595
Impervious	B	21,780	0.5	98	0.20	0.04	2.67	4,852
			1.0				**Total**	**5,447**

Note that actual conditions are used in post development runoff calculations.

Change in Runoff Volume for the 2-year, 24-hour storm event:
5,447-ft^3 – 2,290-ft^3 = **3,157-ft^3**
= required infiltration volume under CG-1 guideline

Required infiltration volume under CG-2 from Example Two = **1,089-ft^3**

CG-2 relieves the designer of infiltrating **2,068-ft^3** of runoff.

For this cost comparison example, assume an infiltration BMP uses a stone bed with 40% void space to contain the infiltration volume.

2,068-ft^3 of infiltration volume would require additional stone bed volume of 5,170-ft^3. (2,068-ft^3 / 40% = 5,170-ft^3 or 191-yd^3)

Savings realized by eliminating 2,068-ft^3 of infiltration and 5,170-ft^3 of stone:
191-yd^3 of Bulk Excavation @ $25/$yd^3$ = $4,775
191-yd^3 of #57 Stone @ $30/$yd^3$ = $5,730
Total savings on construction cost of infiltration BMP = **$10,505**

ADDITIONAL RECOMMENDATIONS

The stormwater management standards developed for this Plan are an excellent beginning for managing stormwater throughout Dauphin County. Under Act 167 provisions and within the defined scope of this Plan, additional stormwater management practices can not be considered requirements. Further, some important and beneficial practices may not be implemented through a stormwater ordinance, but are more appropriately implemented through zoning, subdivision and land development, or floodplain ordinances.

Following are several recommendations to all municipalities of Dauphin County that go beyond the minimum requirements of this Plan. Because sound stormwater management requires a comprehensive approach, municipalities are encouraged to consider implementing these recommendations. Many stormwater management practices are beyond the scope of Act 167 and this Plan and may be implemented only at the discretion of the individual municipality. In addition, the implementation of some practices may not be accomplished, through a vehicle such as a stormwater management ordinance.

These recommendations are put forth as suggestions to municipalities that wish to manage stormwater at a higher level than required under this Plan or Act 167. These suggestions offer increased water quality, groundwater recharge, and peak flow benefits. Not all suggested practices could be implemented by each municipality due to variations in the type of ordinances that are in place. The Dauphin County Conservation District will, to the extent of staff expertise and available hours, work with individual municipalities to implement ordinances who wish to go beyond the minimum required stormwater management standards.

<u>Strengthen Floodplain Management Regulations/ Protect Riparian Corridors</u>

Municipalities should consider revising floodplain management ordinances to prohibit structures, fill, and most forms of development or obstructions in the 100-year floodplain. Major streams and tributaries that have no designated floodplains should have a 100-year floodplain delineated. By keeping the floodplain free of potential obstructions, several goals will be achieved: the flood carrying capacity of the floodplain will be maintained; homes, businesses, and other structures will be kept clear of the floodplain, thereby avoiding flooding problems, and; with preservation of the floodplain in a more natural state, a greater opportunity will exist for water quality benefits from riparian buffers. DCCD's "Riparian Buffer and Floodplain Management Ordinance Provisions" document (Reference 4) provides valuable guidance to municipalities in Dauphin County for the effective municipal management of these vital areas.

Limit Disturbance/Compaction of Topsoil

Municipalities should consider ordinance language that discourages or controls stripping and removal of topsoil from development sites. Topsoil serves as an absorbent layer, providing storage for rainfall. Removal of the topsoil layer reduces, or eliminates this benefit.

Avoiding unnecessary compaction of soils, particularly in areas that are not to be disturbed, should be encouraged. Possible means of discouraging this practice include requiring that the stormwater runoff calculations from post-development disturbed (but not impervious) areas be calculated with a lower hydrologic soil group (e.g., D vs. C) or, with an increase in curve number (e.g., 80 vs. 78).

Limit the Amount of Impervious Cover/ Alternative Development Site Design

Many studies have shown that the biological indicators of stream quality begin to show degradation when the contributing watershed impervious cover reaches approximately 10 percent of the overall watershed area. As the total percent of impervious cover rises above 10 percent, stream quality continues to decline. Prudent application of non-structural and structural stormwater BMPs can reduce the amount of impervious cover potentially created by development. Examples of non-structural methods include low impact, cluster or open space site design. These well documented design approaches act to minimize impervious cover and can be facilitated by flexible zoning and subdivision and land development ordinances. Structural BMPs require the installation of various facilities specifically designed to beneficially manage stormwater. Numerous structural BMPs have been designed and are included in Pennsylvania Stormwater Best Management Practices Manual. It is recommended that municipalities modify and enhance ordinances in order to provide enough flexibility to allow these innovative design methods to be employed by developers to effectively reduce the amount of stormwater generated from a development site.

Municipal Ordinance Revisions

Each municipality should review its existing ordinances and update them to achieve the most effective stormwater management possible. There are abundant resources currently available that discuss the types of revisions to ordinances that can be implemented to allow for better management of stormwater runoff.

PLAN REVIEW, IMPLEMENTATION AND UPDATE PROCEDURES

Plan Review and Implementation

As required by Act 167, this Stormwater Management Plan must be reviewed by municipal, county, and regional planning agencies. A public hearing must be held and the Dauphin County Commissioners must formally adopt the Plan following the public hearing. Once adopted, the Plan, along with the review comments and official county adoption resolution must be submitted to the Department of Environmental Protection for approval. Subsequent to PADEP's approval of this Stormwater Management Plan, implementation of the Plan will be the responsibility of all municipalities within Dauphin County.

The following outlines the sequence of events that must take place to implement this Plan:

Bold text below the events indicates the date at which the event took place.

1. Review of the plan by all municipalities, county planning commission and PADEP.
   FINAL WPAC Meetings (January 28, 2010) – at Hummelstown Borough (Central and Southern Planning Region) and at the Dauphin County Conservation District (Northern Planning Region)

2. A public hearing.
   (February 25, 2010) – at the Dauphin County Conservation District

3. Incorporate in the plan, applicable modifications to address comments received at the public hearing and from reviewing agencies.
   (March 11, 2010) – all comments addressed

4. Formal adoption, by resolution, of the Plan by the Dauphin County Commissioners.
   (April 14, 2010) – by Dauphin County Board of Commissioners

5. Submission of the plan, as adopted by Dauphin County Commissioners, and all review comments to PADEP for plan approval.
   (April 2010) – submission to PADEP

6. Municipal adoption of the Model Ordinance or integration of the Plan's provisions into existing regulations. It is important that the standards and criteria contained in the Plan are implemented correctly, especially if the municipality chooses to integrate the standards and criteria into existing regulations. In either case, it is recommended that the resulting regulatory framework be reviewed by the local planning commission, the municipal solicitor, and/or the Dauphin County Conservation District for compliance with the provisions of the Plan and consistency among the various regulations. Additionally, the adopted regulations may be reviewed by PADEP for compliance with this Plan.

7. Municipal review of Stormwater Management Plans and Stormwater Management Reports for all activities regulated by the Plan and the resulting ordinances. The municipalities will review the Stormwater Management Plans and Stormwater Management Reports for compliance with the standards and criteria of the Plan and shall approve or disapprove the Stormwater Management Plans and Stormwater Management Reports accordingly.

Plan Update Procedures

According to Section 5(a) of Act 167, this Stormwater Management Plan is to be reviewed and updated "at least every five years". The review and update procedure would follow a similar process to the original adoption process including municipal review, public comment, county adoption, and PADEP approval.

The framework for determining if and when the Plan will require review and update would consist of information pertaining to zoning changes, continued development of Dauphin County watersheds, new stormwater-related problems, an increase in severity of existing problems, or construction of significant stormwater facilities or flood control projects.

The Dauphin County Conservation District will evaluate zoning changes, new or intensified stormwater problems, significant stormwater facilities, and flood control projects. This information may be obtained through supplemental municipal questionnaires or personal contact with municipal officials and planning commission members. If it is believed that the existing Plan may need to be updated, the Watershed Plan Advisory Committee will be reactivated. The purpose of the activation will be to investigate the Plan's status and to determine if a Plan Update is required. The committee will formulate a plan review describing the need for an update and would develop recommendations for the Plan Update.

If the Watershed Plan Advisory Committee requires activation to determine if the Plan is to be updated, the Dauphin County Conservation District will notify PADEP. Subsequently, PADEP will be notified of the committee's decision.

It is possible, perhaps even probable; that the need for Plan revisions will be on an individual watershed basis. If this situation should arise, the watershed of concern will be dealt with individually and necessary revisions to the Plan may be incorporated as an addendum rather than revising the entire Plan.

TMDL DISCUSSION

General TMDL Background

PADEP has an ongoing program to assess the quality of waters in Pennsylvania and identify streams and other bodies of water that are not attaining designated and existing uses as "impaired". Water quality standards are comprised of the uses that waters can support and goals established to protect those uses. Each waterbody must be assessed for four different uses as defined in PADEP's rules and regulations at 25 Pennsylvania Code Chapter 93 (Water Quality Standards) in Section 93.3 Protected Water Uses: aquatic life, fish consumption, potable water supply, and recreation. The goals are numerical or narrative water quality criteria that express the in-stream levels of substances that must be achieved to support the uses. PADEP uses an integrated format for the Clean Water Act Section 305(b) - reporting and Section 303(d) - listing. The 305 (b) stream segments have been evaluated for attainment of the four uses. The "Integrated Waters List" represents those streams not achieving the designated uses.

Streams are bodies of flowing surface water that collectively form a network that drains a catchment or basin. For assessment purposes, streams are subdivided into segments. If a stream segment is not attaining any one of its four uses, it is then considered to be "impaired". The source-cause of impairment varies from stream to stream. Oftentimes, there are multiple source-causes attributed for impairment of a particular stream segment.

The primary causes of water quality impairment are sediment/siltation, nutrients, metals, and pathogens. Nonpoint source (NPS) pollution is a general term for water pollution generated by diffuse land use activities rather than from an identifiable or discrete facility. In Pennsylvania the leading nonpoint sources of impairment are:

- Abandoned Mine Drainage (AMD)
- Agriculture
- Urban Runoff/Storm Sewers
- Road Runoff
- Forestry
- Small Residential Runoff
- Atmospheric Deposition

Although these activities cannot be regulated by this Plan, they play a major role in the water quality of surface waters. Figure 3 shows the non-attaining streams and/or segments in Dauphin County and the primary source-cause of the pollution.

As per the 2008 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (PADEP, 2008), there are approximately 223 miles of impaired streams in Dauphin County. Some of these areas of impairment will require the establishment of a Total Maximum Daily Load (TMDL).

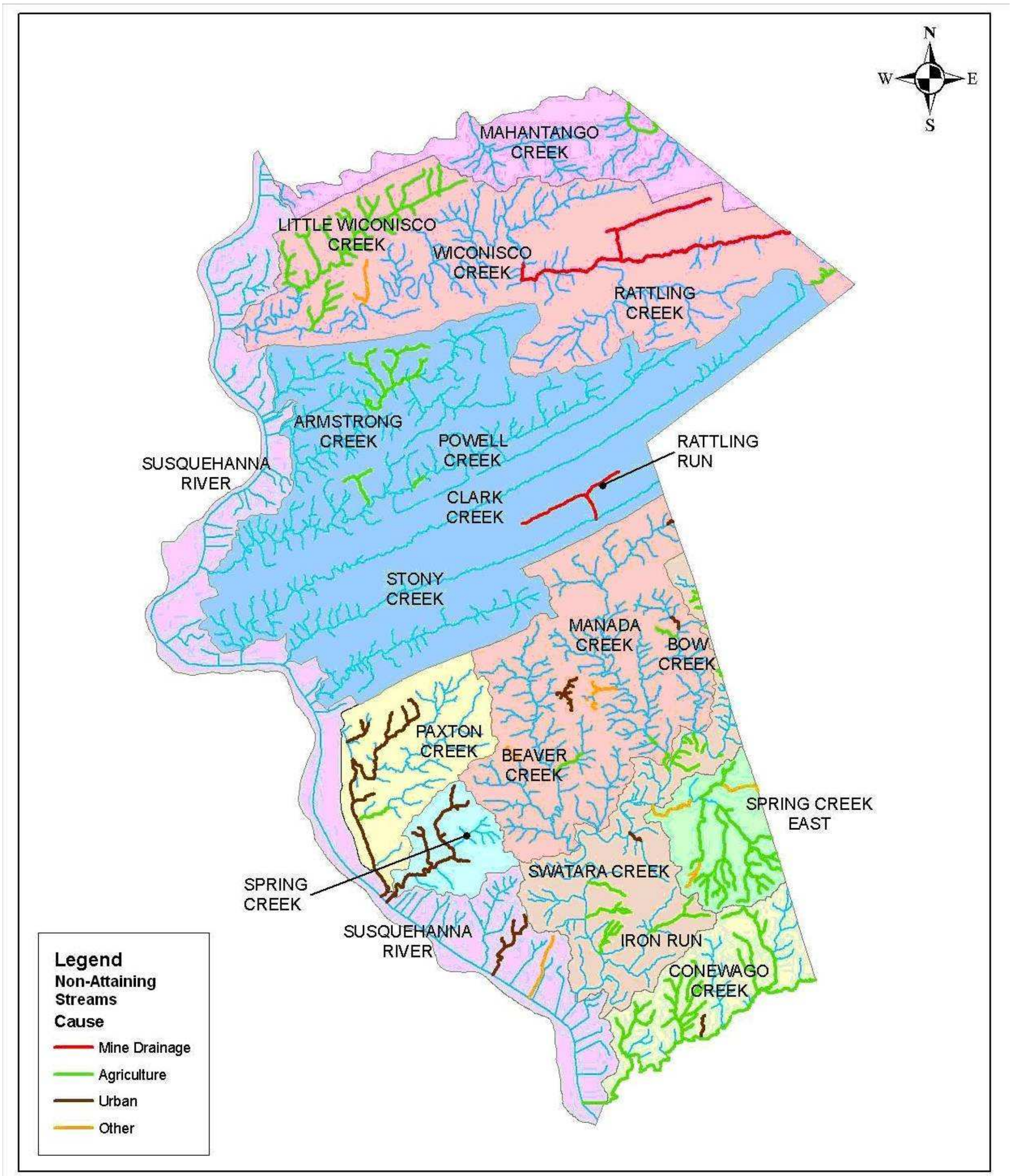

Figure 3: Non-Attaining Streams in Dauphin County

TMDLs are the maximum amount of pollution that a waterbody can assimilate and still be able to meet state water quality standards. TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a water quality standard. All improvement recommendations and activities should be aimed at attaining the limits identified in the TMDL.

Water Quality Status Categories

The water quality status of Pennsylvania's waters is subdivided into the following categories:

Category 1: Waters attaining all designated uses.

Category 2: Waters where some, but not all, designated uses are met. Attainment status of the remaining designated uses is unknown because data is insufficient to categorize the water.

Category 3: Waters for which there are insufficient or no data and information to determine if designated uses are met.

Category 4: Waters impaired for one or more designated use but not needing a total maximum daily load (TMDL). These waters are placed in one of the following three (3) subcategories:

- Category 4A: TMDL has been completed.
- Category 4B: Expected to meet all designated uses within reasonable timeframe.
- Category 4C: Not impaired by a pollutant and not requiring a TMDL.

Category 5: Waters impaired for one or more designated uses by any pollutant. Category 5 includes waters shown to be impaired as the result of biological assessments used to evaluate aquatic life use.

Once waterbodies have been assessed and determined to be impaired under Category 5, Total Maximum Daily Loads (TMDL) must be developed for each of these impaired waterbodies.

TMDLs are established along impaired waterways in accordance with Section 303(d) of the Federal Clean Water Act (CWA). TMDLs are set to address each pollutant with concentrations over the standards and are determined using the following equation:

$$TMDL = WLA + LA + MOS$$

TMDL = Maximum amount of a particular pollutant that can be discharged to a waterway without violating stream water quality standards

WLA = Waste load allocation from point sources such as wastewater treatment plants

LA = Load allocation from nonpoint sources such as stormwater, agricultural runoff and natural background

MOS = Margin of safety

Figure 4 represents the stream segments which are classified as impaired under Category 5 and will require establishment of a TMDL.

Table 11: Streams in Dauphin County Requiring an Establishment of a TMDL (PADEP 2009)

Stream	Length (miles)
Armstrong Creek	3.76
Tributaries to Armstrong Creek	7.74
Asylum Run	1.44
Tributary to Asylum Run	0.72
Tributaries to Beaver Creek	5.40
Bow Creek	0.66
Burd Run	2.70
Tributaries to Burd Run	1.40
Conewago Creek	3.79
Devils Race Course	3.57
Iron Run	2.57
Tributary to Iron Run	0.77
Manada Creek	2.52
Tributaries to Manada Creek	3.41
Paxton Creek	6.16
Tributaries to Paxton Creek	10.05
Pennsylvania Canal	2.64
Powells Creek	1.03
Tributaries to Powell Creek	2.31
Rattling Run	2.56
Slotznick Run	2.90
Tributaries to Slotznick Run	1.32
Spring Creek	6.49
Tributaries to Spring Creek	4.12
Spring Creek East	4.09
Tributaries to Spring Creek (East)	30.39
Tributaries to Susquehanna River	14.20
Swatara Creek	1.11
Tributaries to Swatara Creek	15.31
Total Miles of Stream Requiring a TMDL:	**145.12**

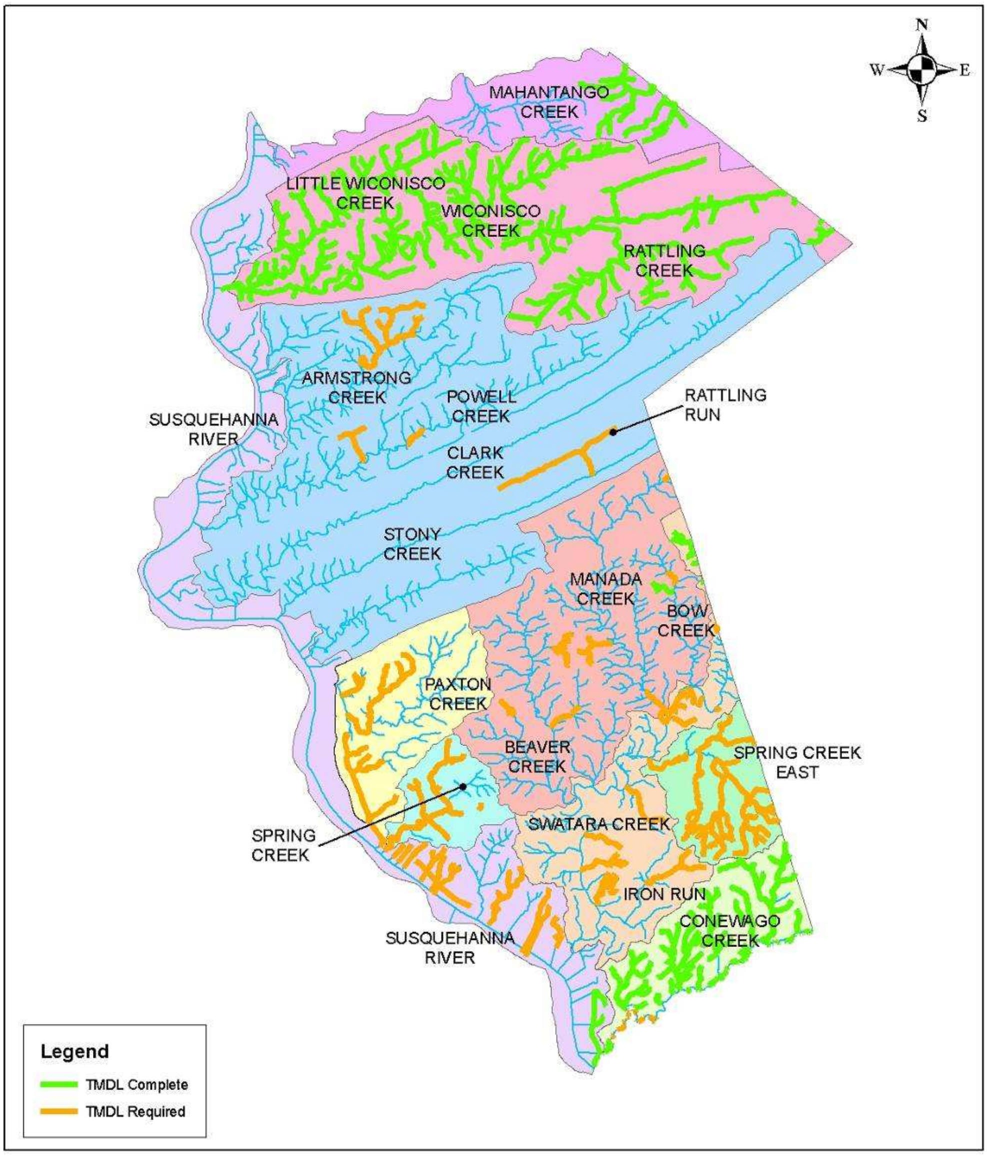

Figure 4: TMDL Status in Dauphin County

Previous Studies

This section summarizes the main findings of some previous studies within Dauphin County and offers some long term suggestions for developing a program to address degradation problems. It should be noted that any previous TMDLs refer to waters designated as impaired in earlier studies and do not necessarily reflect all waters currently designated as such.

Previous Total Maximum Daily Loads (TMDL) studies in Dauphin County show that streams of the different watersheds in the County suffer from impaired water quality due to nutrient levels, metals, sediment/siltation and stream habitat destruction.

Swatara Creek Subwatersheds Impairment

The Swatara Creek Watershed drains an area of 571-square miles of Lebanon and Dauphin counties, of which 128-square miles lie in Dauphin County. The watershed of Swatara Creek itself is not addressed here. The diverse characteristics existing in the subwatersheds that impact its water quality can be best characterized by splitting the watershed geographically into the following watersheds:

1. Manada Creek
2. Beaver Creek
3. Kellock Run
4. Spring Creek (East)
5. Unnamed Tributary to Bow Creek

Table 12: Swatara Creek Subwatershed

STREAM NAME	DESIGNATED USES	PROBLEM
Manada Creek	CWF	Sedimentation
Beaver Creek	WWF	Nutrients

Manada Creek is expected to be under increasing development pressure and the associated increase in stormwater runoff may contribute to increased sedimentation levels in the future. Pennsylvania has a numeric objective of 750 mg/L for total dissolved solids (TDS) and this value might be exceeded due to expected development in the future. Pennsylvania is still developing final nutrient criteria for its watersheds.

Beaver Creek is experiencing a trend of increasing levels of nutrients due to development.

Kellock Run is not listed as impaired.

It is also worth mentioning that decreasing nutrients and sediments levels from the various sources within Swatara Creek Watershed will contribute to the reduction of nutrients and sediment loads in the Chesapeake Bay.

Spring Creek (East) Watershed Impairment

73% of the Spring Creek (East) watershed lies within Dauphin County's borders. It was found that 93% of Spring Creek (East)'s streams miles within Dauphin County are impaired due to siltation (Swatara Watershed Association (SWA), 2000). Siltation in the stream is caused by a combination of agricultural practices and urban development. Agricultural areas dominate the upper and middle reaches of Spring Creek (East), while storm sewers from the downtown area of Derry Township impact the lower reaches. The Dauphin County Conservation District also has documented a very poor macroinvertebrate community near the Spring Creek (East)'s mouth, due to high nutrient concentrations.

Table 13: Spring Creek (East) Watershed

Stream Name	Designated Uses	Miles Impaired	Problem
Spring Creek (East)	WWF	93% of stream miles	Siltation

There is an interaction between the biological, chemical, and physical components of any TMDL analysis within a given watershed. Any alteration to one component may result in unpredicted alteration of the other components. Having a very poor macroinvertebrate community in Spring Creek (East) may mean that the pH, temperature and/or dissolved oxygen (DO) are below their objective threshold.

Unnamed Tributary to Bow Creek Watershed TMDL

The 0.4-square mile watershed contains a total of 1.1-miles of streams. Protected stream uses in the watershed include aquatic life, water supply, and recreation. The entire basin is currently designated as Warm Water Fishes (WWF) in Chapter 93. The Unnamed Tributary 09655 to the Bow Creek Watershed was determined to be impaired from excess nutrient contributions coming primarily from agricultural activities. Phosphorus was determined to be the nutrient limiting plant growth in this tributary.

Table 14: Unnamed Tributary to Bow Creek Watershed

STREAM NAME	SEGMENT ID	AFFECTED LENGTH (MI.)	DESIGNATED USE
Bow Creek	UNT 09655	0.92	WWF

PADEP has established the following TMDL for UNT 09655 to Bow Creek:

Table 15: TMDL for UNT 09655 to Bow Creek (lb./yr.)

POLLUTANT	TMDL	MOS	WLA	LA	REDUCTION
Phosphorus	81.27	8.13	0	73.14	31%

TMDL = Total Maximum Daily Load
MOS = Margin of Safety
WLA = Wasteload Allocation for Point Sources
LA = Remaining Load Allocation for Non-Point Sources

It was recommended that Best Management Practices (BMPs) be employed to achieve the indicated reductions in the TMDL. Typical approaches could include stream bank fencing, planting of riparian buffer zones, strip cropping, contour plowing, conservation crop rotation and heavy use area protection. BMPs aimed at sediment reduction would also be effective in reducing phosphorus levels.

Bear Creek Watershed TMDL

Bear Creek is located with the Wiconisco Creek Watershed and has a drainage area of 4.7-square miles. The Bear Creek Watershed was determined to be impaired due to acid mine drainage (AMD). AMD is responsible for high concentrations of metals; specifically iron, manganese, and aluminum in the watershed.

Table 16: Bear Creek Watershed

STREAM NAME	Stream ID	AFFECTED LENGTH (MI.)	DESIGNATED USE
Bear Creek	17041	4.81	CWF
Bear Creek, UNT	17042	0.46	CWF

A number of alternatives for improving water quality in the Bear Creek Watershed were previously presented to PADEP under various studies. It was recommended that prevention of infiltration of surface water into the underground mine pools be employed to help achieve the loading reductions. Typical approaches would include backfilling of strip areas and crop falls. It was also recommended to use a 30-acre wetland complex to treat the contaminated mine discharge. Other alternatives considered were:

- Collect and treat the drift opening discharges
- Collect and treat both the Lykens Water Level Tunnel and the drift discharges
- Treat the Bear Creek stream flow

Dauphin County Conservation District has completed Phase 1 of a remediation project for Bear Creek Watershed which consists of detention basins being used for the settlement of iron particles. DCCD, in conjunction with the Wiconisco Creek Watershed Association, is pursuing funding sources for Phase 2 to implement some of the recommendations to remediate the effects of AMD in the watershed.

Conewago Creek Watershed TMDL

The Conewago Creek Watershed (53.2-square miles), of which 23.3 square miles are within Dauphin County, was determined to be impaired from excess nutrient and sediment contributions coming primarily from overland runoff. The non-point sources of these pollutants are primarily from agricultural activities. The TMDL focuses on controlling the nutrients and sediments. Phosphorus was determined to be the nutrient limiting plant growth in Conewago Creek. Phosphorus is generally considered to be the limiting nutrient in a waterbody when the nitrogen/phosphorus ratio exceeds 10:1. In Conewago Creek, this ratio is 21:1. The protected uses of the watershed are water supply, recreation, and aquatic life. The aquatic use of Conewago Creek is trout stocking.

Table 17: Conewago Creek Watershed

STREAM NAME	STREAM ID	AFFECTED LENGTH (MI.)	DESIGNATED USE
Conewago Creek	9217	8.77	TSF
Tributaries to Conewago Creek	9265, 9266	3.60	TSF
Tributaries to Conewago Creek	9220, 9223, 9224, 9225	5.14	TSF
Hoffer Creek & Tributaries	9267 & 9274 to 9275	5.68	TSF
Lynch Run & Tributaries	9232 & 9233 to 9242	11.27	TSF

PADEP has established the following TMDLs for two (2) Conewago Creek subwatersheds:

Table 18: TMDLs for Conewago Creek Subwatersheds (lb./yr.)

POLLUTANT	TMDL	MOS	WLA	LA	REDUCTION
SUBWATERSHED A					
Phosphorus	4,522	226	2,103	2,193	40%
Sediments	3,123,517	312,352	N/A	2,811,165	54%
SUBWATERSHED B					
Phosphorus	8,120	406	1,886	5,828	37%
Sediments	6,434,669	637,467	N/A	5,791,202	34%

TMDL = Total Maximum Daily Load
MOS = Margin of Safety
WLA = Wasteload Allocation for Point Sources
LA = Remaining Load Allocation for Non-Point Sources

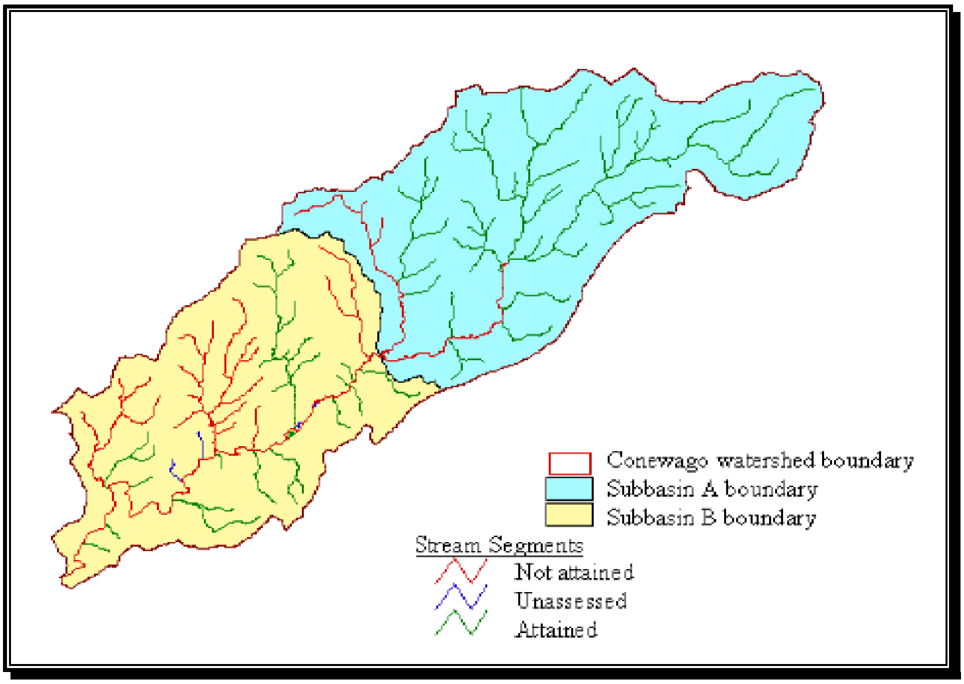

Figure 5: Conewago Watershed Boundary

Currently, a TMDL implementation plan created by the Tri-County Conewago Creek Association is being executed in the watershed. It is recommended that BMPs be employed to achieve the indicated reductions in TMDL. Typical approaches could include planting of riparian buffer zones, contour strips, and cover crops in the areas that contribute the heaviest loadings. BMPs aimed at sediment reduction would also be effective in reducing phosphorus levels. Additional phosphorus reductions could be achieved through installation of animal waste management systems and stone ford cattle crossings, as well as stream bank stabilization and fencing streams to prevent animal access.

Mahantango Creek Watershed Impairment

The Mahantango Creek Watershed drains approximately 164.6-square miles, of which only 17% occur with the boundaries of Dauphin County. Mahantango Creek itself is not listed as impaired, although there are issues with some of the tributaries and a TMDL analysis has been conducted on the portions that are located in Schuylkill County. The portion of the watershed that is located within Dauphin County is classified as WWF by PADEP, except for Pine Creek and its tributaries, which are classified as CWF. The watershed is generally impacted by poor agricultural practices and AMD from its Pine Creek tributary (PADEP, 2001).

Table 19: Mahantango Creek Watershed

STREAM NAME	DESIGNATED USES	PROBLEM
Pine Creek	CWF	Nutrients and AMD
Deep Creek	WWF	Nitrates and Sediments

Rausch Creek Watershed TMDL

Rausch Creek is not within Dauphin County, although portions of the watershed are. Rausch Creek is a tributary of Pine Creek, which is in turn a tributary of Mahantango Creek. Rausch Creek and the two main tributaries are impaired due to Acid Mine Drainage (AMD). AMD is also responsible for high concentrations of metals, specifically iron (Fe), manganese (Mn), and aluminum (Al) in the watershed.

Table 20: Rausch Creek Watershed

STREAM NAME	STREAM ID	AFFECTED LENGTH (MI.)	DESIGNATED USE
Rausch Creek	17266	1.69	CWF
West Branch Rausch Creek	17267	3.57	CWF
East Branch Rausch Creek	17268	2.18	CWF
Tributary to East Branch Rausch Creek	17269	0.36	CWF

PADEP conducted a study in 1969 that resulted in a recommendation for constructing a treatment plant to treat the AMD polluting Rausch Creek. The plant was constructed in 1973 just north of Bear Gap about 0.8-miles upstream of the confluence with Pine Creek. The plant has a capacity of 16-million gallons per day. Excess flow is neutralized with lime slurry and by-passed in the stream channel around the plant.

The treatment plant is currently meeting the TMDL objectives for iron and acidity. The removal of aluminum is very near the TMDL objective and the manganese removal is substantial but needs to be improved to meet the objective. Plans have also been developed to expand the capacity and improve the level of treatment provided by the Rausch Creek Treatment Plant.

It is recommended that backfilling abandoned strip pits, deep mines, and crop falls be implemented to approximate original contours with drainage ditches and vegetation so that runoff would be diverted back into the stream channels. This would help to dilute the affects of the AMD reaching the system.

Wiconisco Creek Watershed TMDL

Wiconisco Creek watershed covers approximately 102 square miles within Dauphin County. Approximately 58.3 miles of streams are listed as impaired within the Dauphin County portion of the watershed. The major causes of impairment are mine drainage and excess nutrients and sediments from agriculture activities. The Wiconisco Creek watershed was broken down into 4 distinct subwatersheds. These are Wiconisco Creek, Little Wiconisco Creek, Rattling Creek and Bear Creek. A TMDL was developed for Bear Creek much earlier than for the rest of the watershed and this area is addressed separately. The three other watersheds have now all had TMDLs developed for their entire lengths within Dauphin County; this also includes all tributaries to the main streams. These TMDLs are currently listed as tentative and have not yet received final approval. The TMDLs have been developed for both attaining and impaired sections of the watershed, with a view to establishing a Total Maximum Daily Load for the watershed as a whole. The table below identifies the different sections of the watershed and their designated uses.

Table 21: Wiconisco Creek Watershed

STREAM NAME	STREAM ID	LENGTH (MI.)	DESIGNATED USE
Wiconisco Creek	16895	36.72	WWF
Tributaries to Wiconisco Creek*	16938	13.14	CWF
Tributaries to Wiconisco Creek**	17052	54.64	WWF
Little Wiconisco Creek and Tributaries	16898	39.65	WWF
Rattling Creek	17052	2.16	HQ-CWF
Tributaries to Rattling Creek	17058	30.14	EV

*All tributaries upstream of the SR 209 Bridge at Loyalton
**All tributaries downstream of the SR 209 Bridge at Loyalton

In order to meet water quality standards, the proposed TMDLs set allowable loadings for metals (iron, manganese and aluminum) and acidity in Wiconisco Creek. Additionally, allowable loads for sediment and nutrients were set for Little Wiconisco Creek and several unnamed tributaries. All TMDLs were established using field data collected by PADEP, other agencies and citizen groups. All of the allocations made in these TMDLs are load allocations made to nonpoint pollution sources.

In order to achieve required reductions in nutrients and sediments, it is suggested that BMPs such as streambank fencing, riparian buffer strips, strip cropping, stormwater retention wetlands, and heavy use area protection, among others, be encouraged throughout the watershed.

The Dauphin County Conservation District is currently in the process of completing a TMDL implementation plan for Little Wiconisco.

General Recommendations

Addressing water quality impairments is achieved most effectively through watershed wide planning and implementation. The water quality based approach is a common method of addressing impairments. The "Integrated Waters List" identifies impaired streams and identifies source-causes of impairment. The next step towards improving the water quality in these streams is to identify the critical areas within the impacted watershed. Critical areas are the geographic regions within a watershed that directly contribute pollutants to the stream. The primary purpose for identifying critical areas is to develop a strategy that effectively addresses the sources of water quality impairment.

An inventory of each watershed that identifies the critical areas allows time, effort, and funds to be targeted towards those sites that most negatively impact water quality. This stage should be completed by a watershed planner with the technical knowledge necessary to accurately identify critical areas and the ability to provide a technical assessment of the severity of each source. The planner will need to prioritize the inventoried sites within the critical area based on the degree to which the sites contribute to the impairment and the overall objectives of the community.

It is important to involve the stakeholders within the watershed at this point in the form of a steering committee. A group such as a local watershed group or the County Conservation District would be able to assist in identifying the stakeholders and coordinate efforts. The planner and steering committee would work together to develop a comprehensive watershed plan and an implementation strategy to address the sites within the critical areas. The goal would be to address the most severe sources of pollutants in an efficient manner. The next step would be developing a comprehensive watershed plan to set definable water quality goals based on the detailed inventory.

Developing an implementation strategy and determining specific BMPs to treat specific sites is the last step. Existing water quality programs should be considered as the implementation strategy is developed. These programs can be coordinated with the implementation strategy in order to achieve a common goal. Thought must also be given to potential funding sources and how they can be used to implement portions of the overall water quality improvement plans. As projects are implemented, the plan should be reviewed and revised as necessary to ensure that the water quality goals are eventually obtained.

Agricultural Activities And Recommendations

Agricultural Activities

Agricultural land use has many beneficial effects on a landscape's response to rainfall and properly managed agricultural activities provide many positive environmental benefits. However, when improperly managed, these activities can cause significant degradation of water quality. Agricultural activities that can cause non-point source pollution include confined animal facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting, and harvesting. The major pollutants that result from these activities are sediment and siltation, nutrients, pathogens, and pesticides. Agricultural activities can also damage habitat and stream channels.

Sediment/Siltation

The most common agricultural cause for surface water impairment is sediment and siltation. This pollutant results from typical agricultural practices such as plowing and tilling, livestock grazing, and livestock access to waterbodies. When appropriate conservation practices are implemented, these activities can be continued while minimizing erosion and enhancing and protecting water quality.

Controlling sheet and gully erosion is the first step in addressing siltation impairments. The majority of erosion problems are a result of plowing and tilling activities and concentrated livestock areas. In Pennsylvania, a written Erosion and Sediment Control Plan is required for all agricultural plowing or tilling activities that disturb 5,000 square feet or more of land. The implementation and maintenance of erosion and sediment control BMPs to minimize the potential for accelerated erosion and sedimentation is also a requirement for all agricultural activities regardless of disturbed area. In addition to reducing sediment pollution, controlling erosion also decreases the transport factors for other pollutants such as nutrients and pesticides.

Nutrients

The second most common agricultural cause for surface water impairment is nutrients. Nutrients related to agricultural activity account for almost 150 miles of impaired streams in Dauphin County. Nutrients such as nitrogen, phosphorus, potassium and other micronutrients are essential to proper plant growth and development. However, when the available nutrients exceed those required for plant development, or when nutrients are improperly applied, they pose potential environmental hazards. Nutrient pollution results from agricultural activities such as fertilizer and manure application, livestock access to waterbodies, and animal concentration areas.

Nutrient management regulations have been developed in Pennsylvania in response to nutrient pollution problems. All livestock operations with animal densities higher than 2,000 pounds of live animal weight per acre of land, available for nutrient application and/or in excess of 8,000 pounds of live animal weight are required to have a Nutrient Management Plan (NMP). A NMP is a tool to help producers allocate nutrients from fertilizer and manure in a manner that maintains adequate nutrient levels for desired crop production and reduces the likelihood of nutrient pollution. Addressing agricultural nutrient impairments requires consideration of where the nutrients are coming from, also called nutrient source factors, and how they get to surface waters, or nutrient transport factors.

Recommendations

Non-point Source Pollution Reduction Programs

Agriculture is the largest contributor to non-point source stream pollution in Dauphin County. The following paragraphs address some practices designed to control this major source of pollution.

Recommended Agricultural Conservation Practices

A variety of agricultural conservation practices are available to help achieve producer's goals while also protecting natural resources. These practices are used to reduce soil erosion and improve and protect water quality. These practices are intended to address specific resource concerns. Individual BMPs are most effective when used together to create a conservation system. A conservation system addresses all of the resource concerns on a particular farm through a combination of different management practices and BMPs that work together. Planning a conservation system ensures that the maximum benefits can be obtained from the individual components, and that the overall management goals are accomplished. The following BMPs have been identified as particularly well suited to address the impairments identified in Dauphin County:

1. <u>Streambank Protection</u>

   Streambank protection provides direct water quality results by reducing the amount of sediment, animal waste and nutrients entering the stream. Protection is implemented by excluding livestock from the stream and establishing buffer zones of vegetation around the stream. The practice can be implemented with or without fencing; however it is much more effective when fencing is installed. This BMP usually requires installation of an alternate watering source for livestock and an animal crossing to allow animals access to pasture on both sides of the stream. The pollutant removal efficiency of this practice, with fencing and off-stream watering applied, is 60% (Nitrogen), 60% (Phosphorus), and 75% (Sediment). Without fencing, the efficiency is reduced to 30% (Nitrogen), 30% (Phosphorus), and 38% (Sediment). This practice is eligible for several funding programs.

2. <u>Riparian Buffers</u>

   Riparian areas, land situated along the bank of a water source, typically occur as natural buffers between uplands and adjacent water bodies. They act as natural filters of non-point source pollutants before they reach surface waters. In agricultural areas many riparian buffers have been removed by agricultural activity to increase tillable acreage and provide animal access to water. Re-establishing riparian buffers by planting forest buffer or grass buffers adjacent to water bodies provides significant water quality benefits. In addition to the filtering benefits that grass buffers provide, forested buffers provide shade to the stream helping to reduce negative thermal impacts.

Riparian buffers are part of a larger group of practices referred to as Conservation Buffers. This general practice is any area or strip of land maintained in permanent vegetation to help reduce erosion and filter non-point source pollutants. This group also includes contour buffer strips, field borders, filter strips, vegetative barriers, and windbreaks.

3. Barnyard Runoff Control

Animal concentration areas (ACA) are a source of sediment and nutrient pollution on agricultural operations. Barnyard runoff control is used to manage stormwater runoff from animal concentration areas to reduce the sediment and nutrients that reach surface waters. Runoff control can be achieved with a variety of methods, but the principals are the same for all of the methods. These principals are keeping "clean" water away from the barnyard and collecting runoff from the barnyard and filtering it with an appropriate BMP or storing it in a manure storage facility for field application. Clean water is diverted away from ACAs with roof runoff structures, diversions, and drainage structures. According to the "*Chesapeake Bay Program Best Management Practices, Agricultural BMPs – Approved for CBP Watershed Models*," when barnyard runoff control is implemented without storage the pollutant removal efficiency is 20% (Nitrogen), 20% (Phosphorus), and 40% (Sediment). When the practice is implemented in conjunction with a manure storage the nitrogen and phosphorus efficiencies are both reduced to 10% and the sediment efficiency remains the same.

4. Nutrient Management

Nutrient management is planning for, and implementation of, the application of organic and inorganic materials to provide sufficient nutrients for crop production in a manner that limits negative environmental impact of their use. A nutrient management plan accounts for all nutrient sources and details the location, timing, rate, and method of nutrient application to crop fields. Implementing a nutrient management plan provides benefit to the farmer by allocating the available nutrients to where they are needed the most to maintain crop yields while also limiting excess nutrients that would otherwise be susceptible to transport eventually contributing to non-point source pollution. Pollutant delivery reductions achieved by implemented nutrient management plans are greatly varied by individual agricultural operations and there is no efficiency directly associated with this practice. Several cost-share programs are available to assist costs associated with plan development and implementation.

5. Animal Waste Management Systems

Animal waste management systems are used for the proper handling, storage, and application of animal waste generated on livestock operations. Wastes are collected from animal confinement areas, and transferred to an appropriate waste storage facility. The waste storage facility enables the producer to store manure during adverse weather conditions when manure nutrients are most likely to reach surface waters. Manure is then field applied when conditions are most conducive to plant nutrient uptake. Waste storage facilities have a nitrogen and phosphorus efficiency of 75%. This practice is eligible for funding through a few of the cost-share programs.

6. Cover Crops

Cover crops are planted in the fall after the primary crop has been harvested. The cover crop grows through the fall and provides ground cover for the field throughout the winter months and early spring when the soil is extremely susceptible to erosion. The cover crop also provides nitrogen removal benefits as it utilizes excess nitrogen in the soil. The cover crop can either be harvested as a commodity crop in the spring or it can be killed and left as ground cover prior to spring planting. Cover crops provide excellent soil erosion protection when the fields need it most. The efficiency of cover crops varies based on when the crop is planted and whether or not the crop is harvested.

7. Conservation Tillage

Conservation tillage is a crop production system that results in minimal disturbance of the surface soil. Maintaining soil cover with crop residue is an important part of conservation tillage. Maintaining ground cover throughout the year has many benefits to crop production, but the most significant water quality benefit is reduction in soil erosion. No-till farming is one form of conservation tillage in which crops are planted directly into ground cover. Minimum tillage farming is another method that involves minor disturbance of the soil, but maintains much of the ground cover on the surface. There is no efficiency associated with this practice. The effects of each tillage system can be calculated by the Revised Universal Soil Loss Equation (RUSLE), which will give an estimation of the annual soil loss for each field.

Potential Funding Sources for Water Quality Impairment

There are a variety of potential sources for funding projects and individual practices that will help improve water quality. This is a review of the major funding programs available for projects addressing water quality impairments, and not an all-inclusive listing. Funding sources available throughout the county include:

Conservation Reserve Enhancement Program (CREP) – This funding program offered by USDA's Farm Service Agency provides financial incentives to protect environmentally sensitive land by removing it from agricultural production and placing it in a conservation easement planted with permanent vegetation. CREP supports installation of conservation buffers, wetlands, and retirement of highly erodible land.

Conservation Security Program (CSP) – The CSP is a program administered by USDA-NRCS that rewards farmers who have already adopted good conservation systems by providing substantial incentives to expand or enhance current conservation efforts.

Environmental Quality Incentive Payment (EQIP) – This is a USDA-NRCS voluntary conservation program that promotes agricultural production and environmental quality as compatible goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. Most agricultural BMPs are eligible for cost-share payments under this program

Growing Greener II – This grant program is available in Pennsylvania to "address some of the state's most pressing environmental problems, spark new growth in core communities, and create new opportunities for citizens". Some of this funding was delegated to PADEP to clean up rivers and streams and address other serious environmental concerns.

Section 319 Funds – This funding source is administered by USEPA. Under Section 319 of the Clean Water Act, State, Territories, and Indian Tribes receive grant money which support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects.

POTENTIAL FUNDING RESOURCES

Funding Resources Introduction

When there is local interest and a local commitment to deal with problems that are caused by stormwater, there is always a need for resources to make the project a reality. There are a variety of public and private resources that may be helpful in completing stormwater projects.

According to Chapter 111, Section 111.21 of Pennsylvania Code, "*Municipalities located in designated watersheds for which watershed stormwater plans have been prepared and adopted by counties and approved by the Department shall be eligible annually for reimbursement for expenses incurred in the adoption or revision of ordinances or regulations and other actual administrative, enforcement and implementation costs incurred in complying with the act and this subchapter.*" Chapter 111 lists the activities that are eligible for reimbursement.

Table 22: Allowable/Ineligible Costs

ALLOWABLE COSTS	INELIGIBLE COSTS
Costs for the preparation and enactment of ordinances and regulations as are necessary to regulate development within the municipality consistent with the applicable watershed stormwater management plans and the act, including: (i) Costs of technical and legal services necessary to prepare and enact regulations, ordinances, administrative forms, maps and similar materials required by the act and (ii) Costs of technical and legal services for required public hearings.	Legal fees resulting from appeals or suits against the Commonwealth.
	Allowances for the purchase of clothing.
Costs for administrative, enforcement and implementation activities, including: (i) Cost for review of the stormwater management component of development plans, (ii) Fees for special technical consultations concerning complex or unusual stormwater management issues, (iii) Costs of monitoring and inspection activities, and (iv) Mileage expenses incurred.	The printing or reproduction of regulations, forms or maps.
	Costs which are offset by permit or review fees imposed by a municipality.
Costs incurred by municipalities for participation in a watershed plan advisory committee and other costs incurred when a municipality is acting under contract to the county for preparation, revision and adoption of watershed stormwater plans which shall be reimbursed by counties from grants awarded to counties under this chapter.	Costs incidental to routine municipal operations.
	Costs for activities or expenses which are not solely required by the act and the watershed stormwater management plan.

This section provides a list of possible funding resources to all municipalities located in Dauphin County as they attempt to address stormwater management financing challenges. The section will examine a range of possible approaches to pay for effective stormwater management.

In formulating a stormwater management funding strategy, it is helpful to think of a framework of money, revenue, and resources that can be selectively applied to specific needs and projects.

"Money" encompasses a range of sources and types of funds that can be secured to support stormwater services and facilities.

"Revenue" is a term usually used in specific reference to the cash flow generated by user fees of various sorts and other relatively consistent income streams such as charges, assessments, rentals, fines, etc.

"Resources" that support stormwater programs take many forms, ranging from developer-contributed capital funds, to federal and state grants and loans, to maintenance of public drainage systems performed by homeowners' associations and private property managers, to land and easement dedications, etc. The term also includes a variety of funding mechanisms that are commonly used to structure how money and resources are applied to specific objectives.

"Needs" are the key driver of program and funding strategies.

Stormwater Management Funding Resources

The following is a list of funding resources which local municipalities may find helpful to begin searching for eligible funding to support solving stormwater management problems in their jurisdictions:

H2O PA Act (Act 63 of 2008) – Grant

H2O PA Act provides grant funding up to a maximum of $20 million. Grants can cover all project-related costs. The Act requires a 50% match with local funding. The matching funds can be from any source (e.g., other grants, tax revenue, etc.). Some in-kind services are also eligible to count toward the matching fund requirement. Apply to the PA Department of Community and Economic Development. Projects must be "shovel ready" (i.e., design complete, permits and rights-of-way obtained) when funds are made available.

Pennsylvania Infrastructure Investment Authority

Governmental agencies are eligible to obtain low interest loans from the Pennsylvania Infrastructure Investment Authority (PENNVEST) to resolve drainage problems.

Loans are available for the construction, improvement or rehabilitation of stormwater systems and installation of best management practices to address point or non-point source pollution associated with stormwater. Examples of stormwater projects eligible for funding include:

- New or updated storm sewer systems to eliminate stormwater flooding or to separate stormwater from sanitary sewer systems;
- Detention basins to control stormwater runoff; and/or
- Stormwater facilities to implement best management practices to reduce non-point source pollution.

Department Of Community and Economic Development (DCED)

Infrastructure Development Program (IDP)

The program makes grants and loans to eligible applicants such as municipalities for specific infrastructure improvements necessary to complement eligible capital investment by private companies and private developers. Some examples of projects that could be funded under this program are the construction or rehabilitation of drainage system infrastructure, the cleanup of hazardous waste materials, and the engineering design, construction, and inspection tools of drainage systems.

Floodplain Land Use Assistance Program

The program provides grants and technical assistance to encourage the proper use of land and the management of floodplain lands within Pennsylvania. Local municipalities in Dauphin County that participate in the National Flood Insurance Program (NFIP), and comply with Act 166 and submit an Annual Report are eligible to receive grants under this program.

PA Department of Environmental Protection (PADEP)

PADEP has dozens of grants and loans to assist individuals, groups, local governments, and businesses with a host of environmental issues. The following is a list of the available funds/loans that are applicable to stormwater problems in Dauphin County:

Enactment & Implementation of Stormwater Ordinances

PADEP can reimburse municipalities for allowable costs incurred to enact and implement ordinances consistent with approved stormwater management plans pursuant to the Pennsylvania Stormwater Management Act (1978 Act 167). Municipalities are eligible for this reimbursement after they enact ordinances to implement the stormwater management plan.

As active participants in the ongoing Act 167 study of Dauphin County, local municipalities in Dauphin County are eligible to receive this grant.

Environmental Education Grants Program

The conservation of Commonwealth resources depends on the effectiveness of the environmental literacy of its citizens. The focus of this Environmental Education Grants Program is to support environmental education through schools, county conservation districts and other nonprofit conservation or educational organizations, including colleges and universities. County, Municipality, Authority, School District, Nonprofit, Conservation District, Non-Profit Conservation or Education Organizations are all eligible for this program. The average grant amount is $10,000.

Flood Protection Grant Program

The program gives funds to government entities responsible for the operation and maintenance of flood protection projects for non-routine maintenance, project improvements and specialized equipment. Local municipalities in Dauphin County are eligible to receive this grant. PADEP has been providing funds for stormwater control projects in the main three River Basins in Pennsylvania: Ohio River Basin, Delaware River Basin, and the Susquehanna River Basin.

Types of projects that are covered under the above referenced grant include: stormwater detention facilities, concrete channels, concrete floodwalls, compacted earth levees, channel improvements, or a combination of a number of these types of alternatives. The average grant amount is $25,000.

Growing Greener Watershed Grant

One purpose of this grant is to help in restoring watersheds and streams, reclaiming mined lands, and remediation of Acid Mine Drainage (AMD). The average grant amount is $95,000. Growing Greener authorizes PADEP to allocate nearly $524 million in grants for local watershed-based conservation projects through 2012. Growing Greener usually supports local projects to clean up non-point sources of pollution throughout Pennsylvania. These projects can include: watershed assessments and development of watershed restoration or protection plans; implementation of watershed restoration or protection projects (stormwater management wetlands, riparian buffer fencing and planting, stream bank restoration, agricultural BMPs); and demonstration/education projects and outreach activities.

An example of this program is the River Conservation Program. This program seeks to maintain, restore, and enhance rivers throughout Pennsylvania. Local municipalities in Dauphin County may apply for grants above $2,500. Before being considered for river conservation, implementation, acquisition, or development projects, a grant applicant must have an approved river conservation plan. Projects must be for capital improvement to land and there must be a reasonable expectation that the project will last for the term of the bond, which is 20 years.

Growing Greener II

$230 million has been allocated to PADEP as a result of the Growing Greener Bond Initiative for existing programs for watershed protection, mine and acid mine drainage remediation, plugging of abandoned oil and gas wells, advanced energy projects, flood protection, and brown fields. Projects must be for capital improvement to land and there must be a reasonable expectation that the project will last for the term of the bond, which is 20 years.

Non-point Source Pollution Prevention Education Mini-grant Program (319)

PADEP provides funding to the PA Association of Conservation Districts to administer this grant program. This program provides mini-grants for the purpose of providing education on non-point source water pollution.

Non-point Source Implementation Program (Section 319)

The program provides funding to implement PA's Non-point Source Management Program. This includes funding for agricultural and urban runoff control, and natural channel design/stream bank stabilization projects, and for development of watershed-based restoration plans. The average grant amount is $110,000.

Stream Improvement Project Reimbursement

This is a reimbursement program intended to provide assistance to local governments, municipal authorities, conservation districts and other similar groups for design and construction projects for properties threatened by direct overbank flooding or stream bank erosion. There must be an imminent threat to improved property such as homes, businesses or industrial buildings for a project to be eligible under this program.

Stormwater Planning and Management Grants

The program provides grants to counties and municipalities for preparation of stormwater management plans and stormwater ordinances. The program requires a 25% local match that can come in the form of in-kind services or cash. While greenways are not specifically funded by the project, they are excellent elements of a stormwater management system. This program is part of the Growing Greener Initiative.

League of Women Voters of Pennsylvania

The League of Women Voters of Pennsylvania Citizen Education Fund (LWVPA-CEF) accepts proposals for water resources education projects through its Water Resources Education Network (WREN) Project. In order to be eligible to receive funding, projects should be designed to encourage individual or collective action that will protect and improve local water resources.

Watershed Protection projects which educate about how to protect, improve, or remediate the watershed from the impacts of non-point source (NPS) pollution. Funding for the watershed protection projects is provided by the PADEP Non-point Source Management Program in compliance with Section 319 of the federal Clean Water Act, administered by the Environmental Protection Agency (EPA).

Environmental Protection Agency (EPA)

Water Quality Cooperative Agreements (Clean Water Act)

Grants are provided to support the creation of unique and new approaches to address issues such as stormwater management, sanitary sewer, and combined sewer overflows.

Targeted Watersheds Grants Program

The Targeted Watersheds Grant program is a competitive grant program that provides funding to community-driven, environmental results oriented watershed projects. To date, more than $37 million has been awarded to 46 watershed organizations. The program also provides capacity building grants to service provider organizations that can deliver training and tools for all watershed organizations across the country.

Chesapeake Bay Program Grants

The EPA's Chesapeake Bay Program (CBP) awards grants to reduce and prevent pollution and to improve the living resources in the Chesapeake Bay. Grants are awarded for implementation projects, as well as for research, monitoring, and other related activities. In addition, the Chesapeake Bay Small Watershed Grants Program provides grants to organizations and local governments working on a local level to protect and improve watersheds in the Chesapeake Bay basin, while building citizen-based resource stewardship. The purpose of the grants program is to support protection and restoration actions that contribute to restoring healthy waters, habitat and living resources of the Chesapeake Bay ecosystem. The Small Watershed Grants Program has been designed to encourage the development and sharing of innovative ideas among the many organizations wishing to be involved in watershed protection activities. The Small Watershed Grants Program is administered by the National Fish and Wildlife Foundation, in cooperation with the U.S. Environmental Protection Agency, Chesapeake Bay Program. The Chesapeake Bay Program is a partnership among Virginia, Maryland, Pennsylvania, the District of Columbia, the Chesapeake Bay Commission, and the federal government.

Five-Star Restoration Program

EPA supports the Five-Star Restoration Program by providing funds to the National Fish and Wildlife Foundation and its partners, the National Association of Counties, NOAA's Community-based Restoration Program and the Wildlife Habitat Council. These groups then make sub grants to support community-based wetland and riparian restoration projects. Competitive projects will have a strong on-the-ground habitat restoration component that provides long-term ecological, educational, and/or socioeconomic benefits to the people and their community. Preference will be given to projects that are part of a larger watershed or community stewardship effort and include a description of long-term management activities. Projects must involve contributions from multiple and diverse partners, including citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, and tribal agencies and local governments. Each project would ideally involve at least five partners who are expected to contribute funding, land, technical assistance, workforce support, or other in-kind services that are equivalent to the federal contribution.

Federal Emergency Management Agency (FEMA)

Flood Mitigation Assistance (FMA)

The Flood Mitigation Assistance (FMA) program helps states and communities identify and implement measures to reduce or eliminate the long-term risk of flood damage to homes and other structures insurable under the National Flood Insurance Program (NFIP). There are three types of grants: planning, project and technical assistance. Technical assistance grants are given to state agencies that provide assistance to communities, so communities apply for planning and project grants. Projects may include (1) elevation, relocation, or demolition of insured structures; (2) acquisition of insured structures and property; (3) minor, localized structural projects that are not fundable by state or other federal programs (erosion-control and drainage improvements); and (4) beach nourishment activities such as planting of dune grass.

Project Impact Grant Program

This program helps communities that have a history of losses from natural disasters or have significant disaster risk, such as those located in watershed floodplain. Funds are provided to help assess risks, build public-private partnerships, and communicate and mentor success.

United States Army Corps of Engineers (ACOE)

Continuing Authorities Program (CAP)

If the ACOE determines a project falls within the CAP, they initiate a short reconnaissance effort to determine Federal interest in proceeding. If there is interest, a feasibility study is performed, and the project continues through a plans and specifications phase, and a construction phase. The cost share is 65% ACOE and 35% local. The federal project limit is $7,000,000.

Floodplain Management Services Program

The program aims to support comprehensive floodplain management planning to encourage and guide sponsors to prudent use of the Nations' floodplains for the benefit of the national economy and welfare. Some examples of the types of projects that would be funded include: flood warning and flood emergency preparedness, flood proofing measures, studies to improve methods and procedures for mitigating flood damages, and preparation of guides and brochures on flood related topics. ACOE may provide up to 100% of funding at the request of the sponsor.

Flood Hazard Mitigation and Riverine Ecosystem Restoration Program

The program is informally known as Challenge 21. It is a watershed-based program that focuses on identifying sustainable solutions to flooding problems by examining nonstructural solutions in flood-prone areas, while retaining traditional measures where appropriate. Projects might include the relocation of threatened structures, conservation or restoration of wetlands and natural floodwater storage areas.

Aquatic Ecosystem Restoration (CAP Section 206)

Applicants receiving grants under this authority may carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest, and are cost-effective. There is no requirement that an existing ACOE project be involved.

Natural Resources Conservation Service (NRCS)

Small Watershed Program and Flood Prevention Program

The program helps participants solve natural resource and related economic problems on a watershed basis. Some examples of projects that could be funded under this program are watershed protection, flood prevention, erosion and sediment control, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres.

Emergency Watershed Protection (EWP)

The program helps protect lives and property threatened by natural disasters such as floods. The program includes watershed plans, river basin surveys and studies, flood hazard analyses, and floodplain management assistance. The focus of these plans is to identify solutions that use land treatment and nonstructural measures to solve resource problems. NRCS requires that the measures that are taken must be environmentally and economically sound and generally benefit more than one property owner. Examples of these measures are clearing debris from clogged waterways, restoring vegetation, and stabilizing river banks.

EWP also provides funds to purchase floodplain easements as an emergency measure. Floodplain easements restore, protect, maintain, and enhance the functions of the floodplain; conserve natural values including fish and wildlife habitat, water quality, flood water retention, ground water recharge, and open space; reduce long-term federal disaster assistance; and safeguard lives and property from floods, and the products of erosion. It is important to note that it is not necessary for a national emergency to be declared for an area to be eligible for assistance. EWP can provide up to 90 percent cost share in limited resource areas as determined by the US Census.

Each EWP project, with the exception of floodplain easements, requires a sponsor who applies for the assistance. A sponsor can be any legal subdivision of State or local government. They determine priorities for emergency assistance while coordinating work with other Federal and local agencies. The role of sponsors is to provide legal authority to do repair work, obtain necessary permits, contribute funds or in-kind services, and maintain the completed emergency measures.

Environmental Quality Incentives Program

The USDA Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) was established to provide a voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan.

Farm and Ranch Lands Protection Program (FRPP)

The USDA Natural Resources Conservation Service's Farm and Ranch Lands Protection Program (FRPP) is a voluntary program that helps farmers and ranchers keep their land in agriculture and prevent conversion of agricultural land to non-agricultural uses. The program provides matching funds to organizations with existing farmland protection programs that enable them to purchase conservation easements. These entities purchase easements from landowners in exchange for a lump sum payment, not to exceed the appraised fair market value of the land's development rights. The easements are for perpetuity unless prohibited by state law. Eligible land is land on a farm or ranch that has prime, unique, statewide, or locally important soil or contains historical or archaeological resources; is subject to a pending offer by an eligible entity; and includes cropland, rangeland, grassland, pasture land, and incidental forest land and wetlands that are part of an agricultural operation.

Creation of a Stormwater Authority/Utility

A stormwater authority/utility is a method of providing a dedicated funding source for municipalities' stormwater programs. Steps to create an authority/utility include a feasibility study, public outreach, evaluations of rate structure options, an implementation strategy and providing a service. Authorities/utilities may be considered by any single municipality or as a central entity with multiple municipalities participating. The authority/utility could be set up to address items such as capital improvements, operations and maintenance, stormwater quality, regulations and enforcement, engineering and planning, and administrative functions.

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APPENDICES

APPENDIX A – WATERSHED LEVEL PLANNING FOR PEAK DISCHARGES
APPENDIX B – TECHNICAL ANALYSIS
APPENDIX C – FLOOD INSURANCE STUDIES
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APPENDIX A
WATERSHED LEVEL PLANNING FOR PEAK DISCHARGES

APPENDIX A
WATERSHED LEVEL PLANNING FOR PEAK DISCHARGES

GENERAL WATERSHED RUNOFF CONTROL PHILOSOPHY

The regional philosophy in Act 167 introduces a different stormwater management approach than is found in the traditional on-site approach. The difference between the on-site stormwater control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts throughout an individual watershed. The objective of typical on-site design is to control post-development peak flow rates from the site itself; however, a watershed-level design is focused on maintaining existing peak flow rates in the entire drainage basin. The watershed approach requires knowledge of how the site relates to the entire watershed in terms of the timing of peak flows, contribution to peak flows at various downstream locations, and the impact of the additional runoff volume generated by the development of the site. The proposed watershed-level stormwater runoff control philosophy is based on the assumption that runoff volumes will increase with development and the philosophy seeks to manage the increase in volumes such that peak rates of flow throughout the watershed are not increased. The controls implemented in this Plan are aimed at minimizing the increase in runoff volumes and their impacts, especially for the 2-year storm event.

The basic goal of both on-site and watershed-level philosophies is the same, i.e. no increase in the peak rate of stream flow. The end products, however, can be very different as illustrated in the following simplified example.

Presented in Figure A.1 is a typical on-site runoff control strategy for dealing with the increase in the peak rate of runoff with development. The Existing Condition curve represents the pre-development runoff hydrograph. The Developed Condition hydrograph illustrates three important changes in the site runoff response with development:

- A higher peak rate
- A faster occurring peak (shorter time for the peak rate to occur)
- An increase in total runoff volume

The "Controlled" Developed Condition hydrograph is based on limiting the post-development runoff peak rate to the pre-development level through use of detention facilities but the volume is still increased. The impact of "squashing" the post-development runoff to the pre-development peak without reducing the volume 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 (2) hours long in this example) under the "Controlled" Developed Condition.

Considering the outflow from the site only, the maintenance of the pre-development peak rate of runoff is an effective management approach. However, Figures A.2 and A.3 illustrate the potential detrimental impact of this approach. Figure A.2 represents the existing hydrograph at the point of confluence of Watershed A and Watershed B.

The timing relationship of the watersheds is that Watershed A peaks more quickly (at time t_{pA}) than the Total Hydrograph, while Watershed B peaks later (at time T_{pB}), than the Total Hydrograph, resulting in a combined time to peak approximately in the middle (at time T_p). Watershed A is an area of significant development pressure, and all new development proposals are met with the on-site runoff control philosophy as depicted in Figure A.1. The eventual end product of the Watershed A development under the "Controlled" Development Condition is an extended peak rate of runoff as shown in Figure A.3. 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 summation of Watershed A and Watershed B, the Total Hydrograph peak is increased under these conditions to the "Controlled" Total Hydrograph. The conclusion from the example is that simply controlling peak rates of runoff on-site does not guarantee an effective watershed level of control because of the increase in total runoff volume. The net result is that downstream peaks can increase and extend for longer durations.

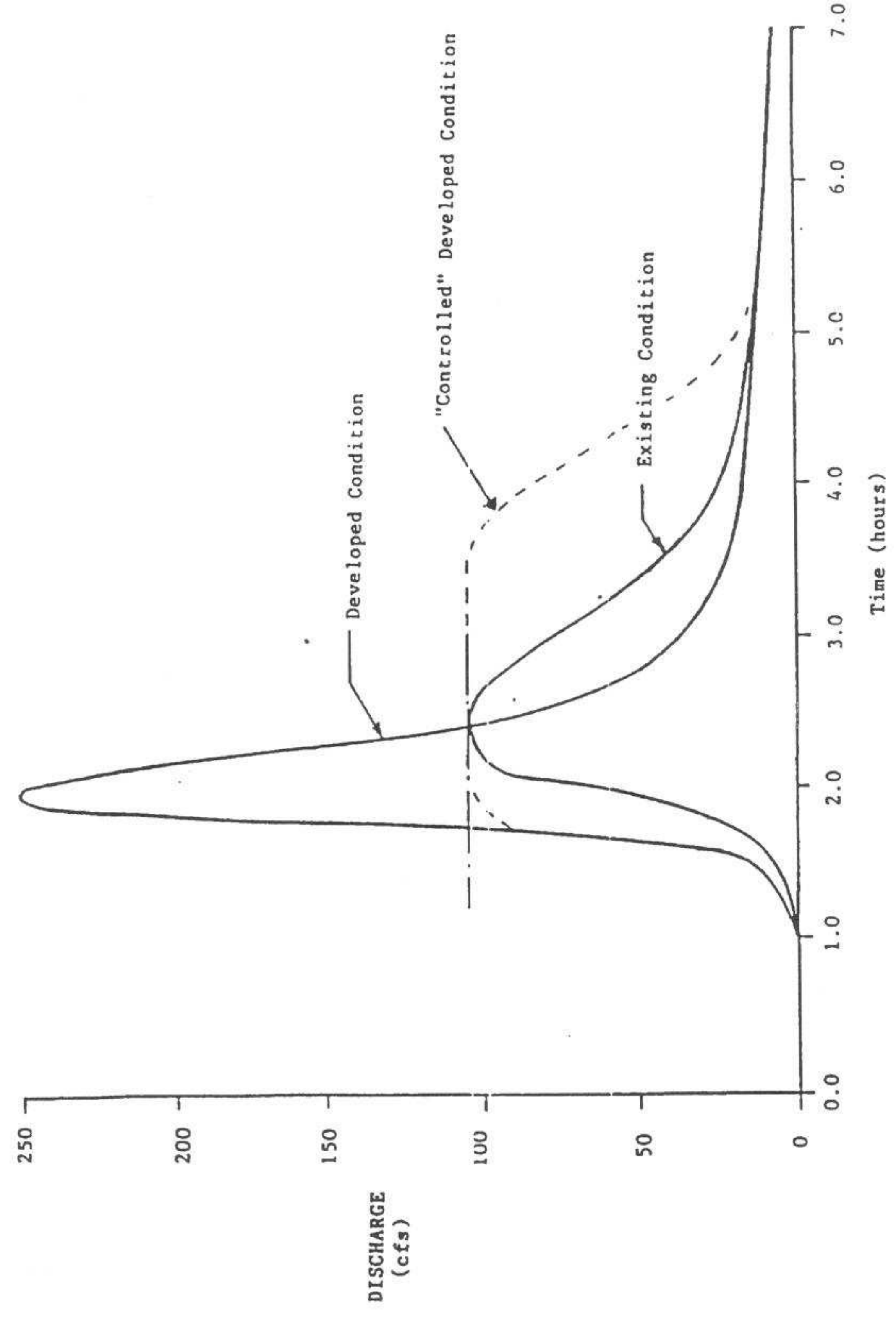

Figure A.1: Typical On-Site Runoff Control Strategy

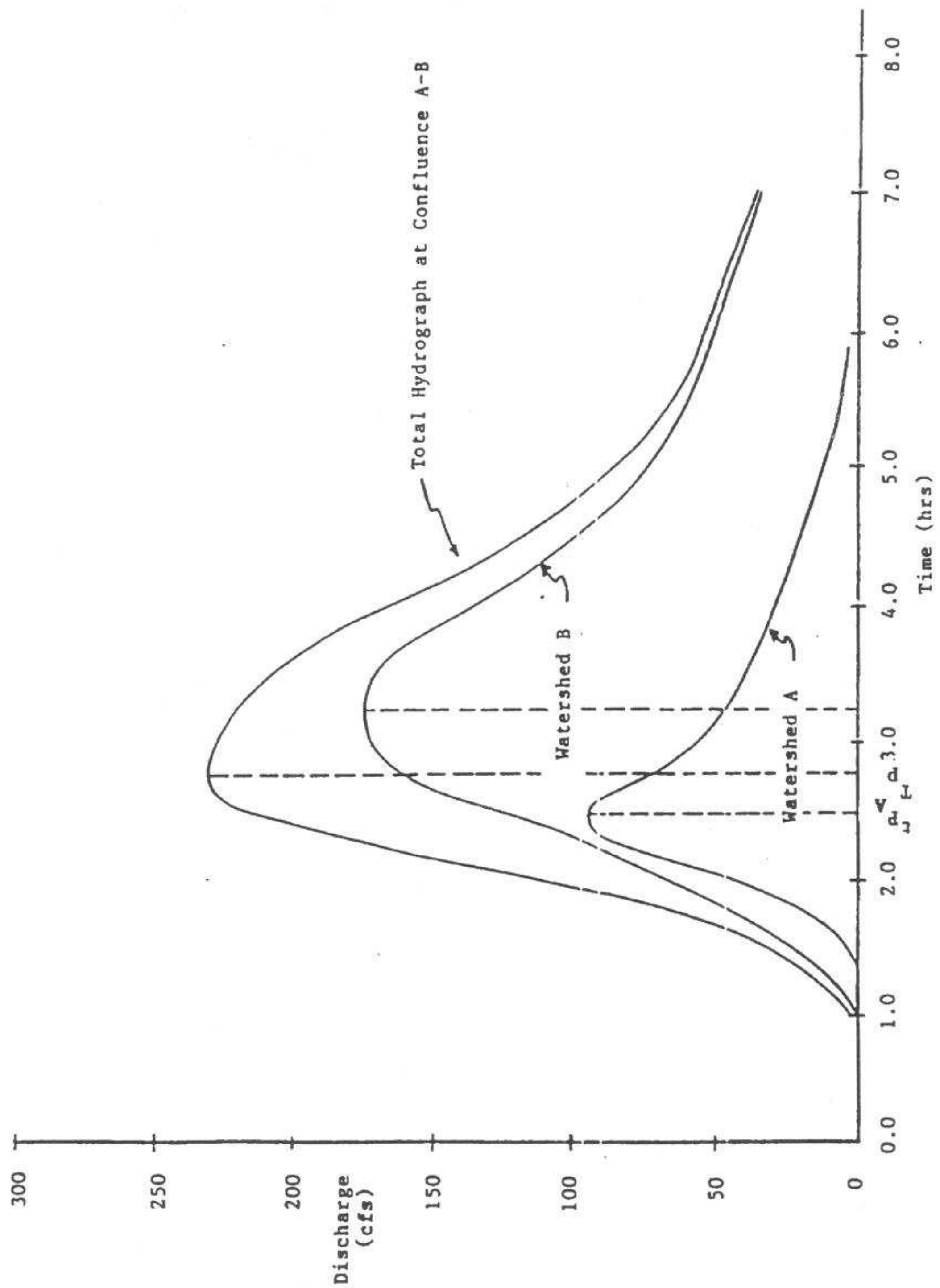

Figure A.2: Existing Hydrograph (Pre-Development)

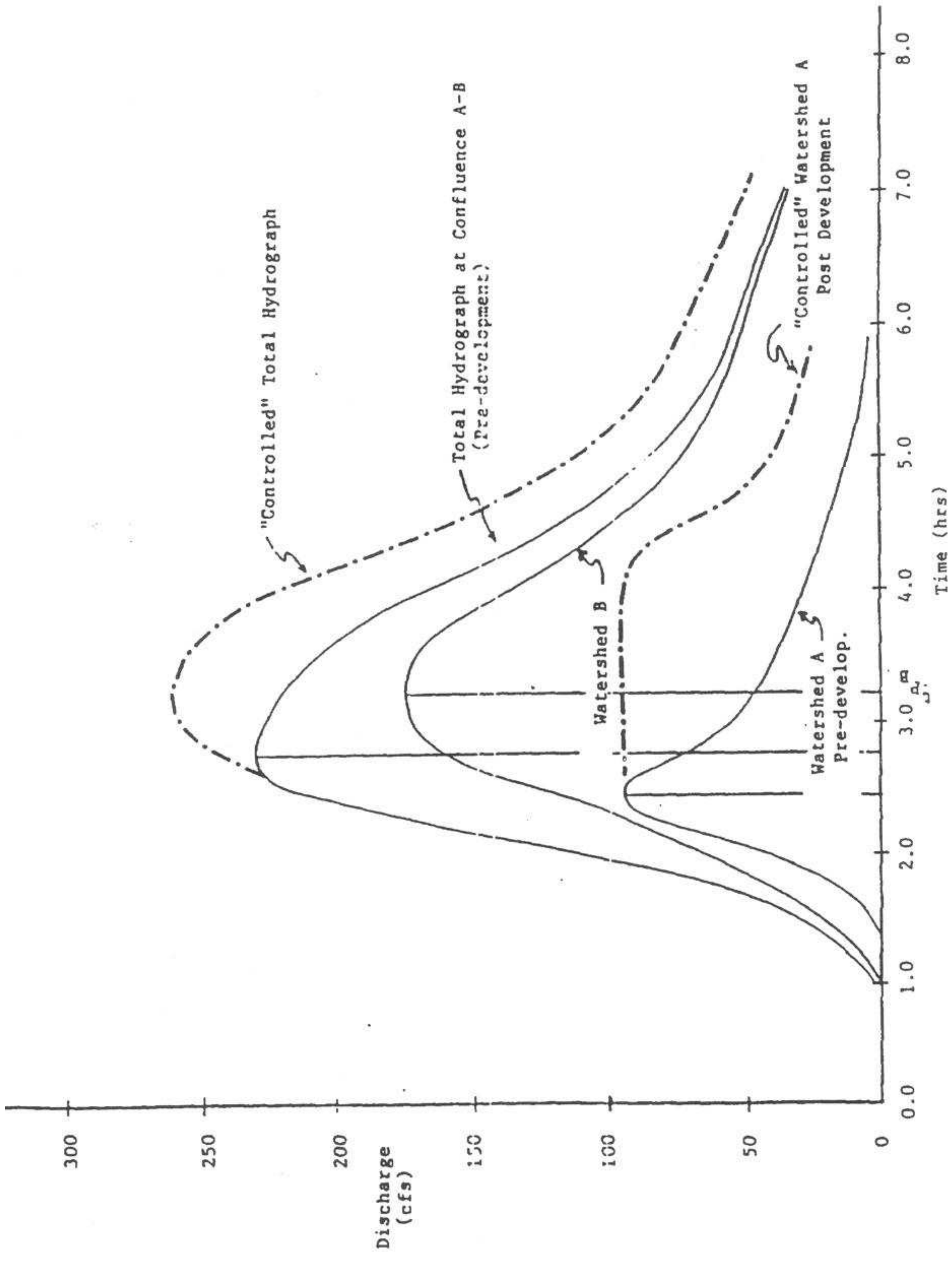

Figure A.3: Controlled Runoff Condition (Post-Development)

RELEASE RATE CONCEPT

The previous example indicated that, in certain circumstances, it is not 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 potential increase are how the various parts of the watershed interact, in time, with one another and the increased rate and volume of runoff associated with development and increases in impervious surfaces. The critical runoff criteria for a given site or watershed area is not necessarily its own pre-development peak rate of runoff but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest. This concept is best explained through the use of a few simplified charts.

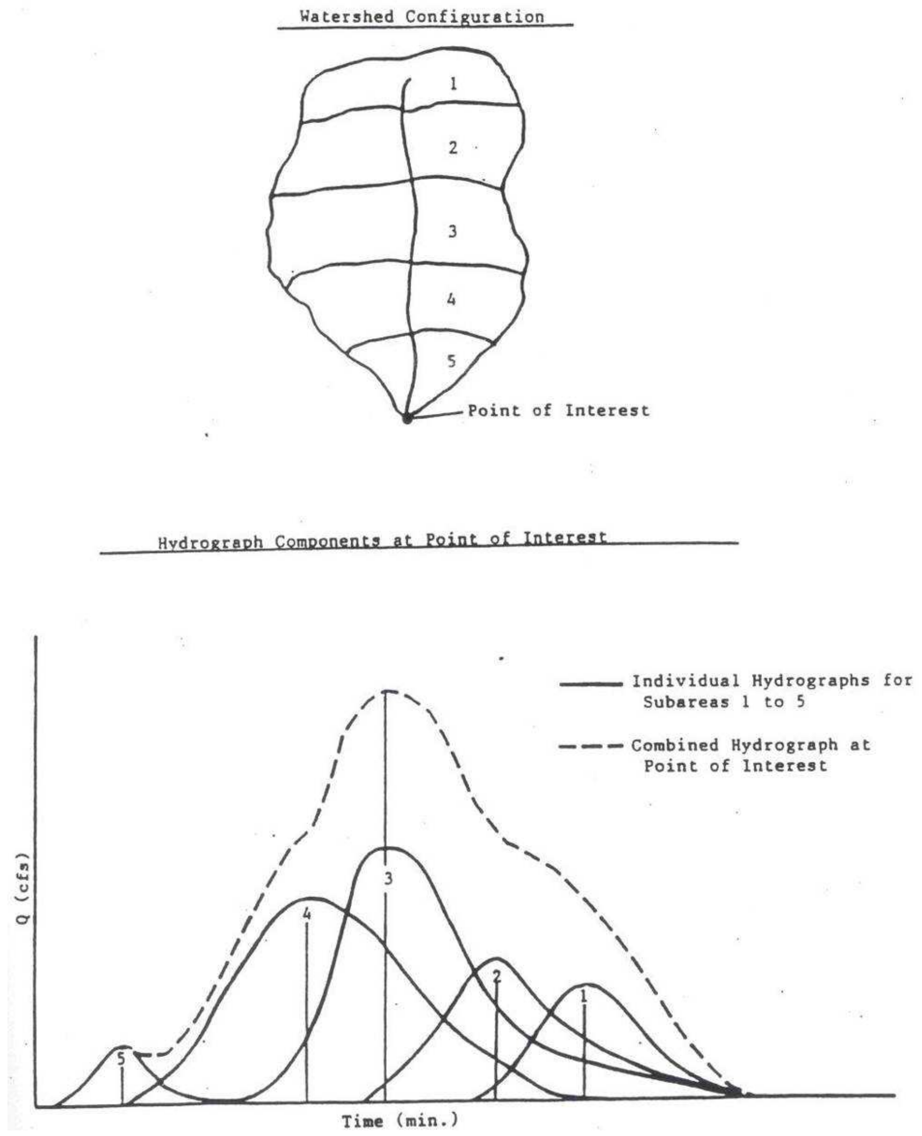

Figure A.4: Hydrograph Analysis Example

Figure A.4 indicates how the individual runoff contributions from a number of sites or watersheds create the total hydrograph at 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. The five areas do not contribute at the same time, however. Flows from Area 1 must travel the farthest to get to the point of interest. Area 5 flows contribute immediately 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 A.4.

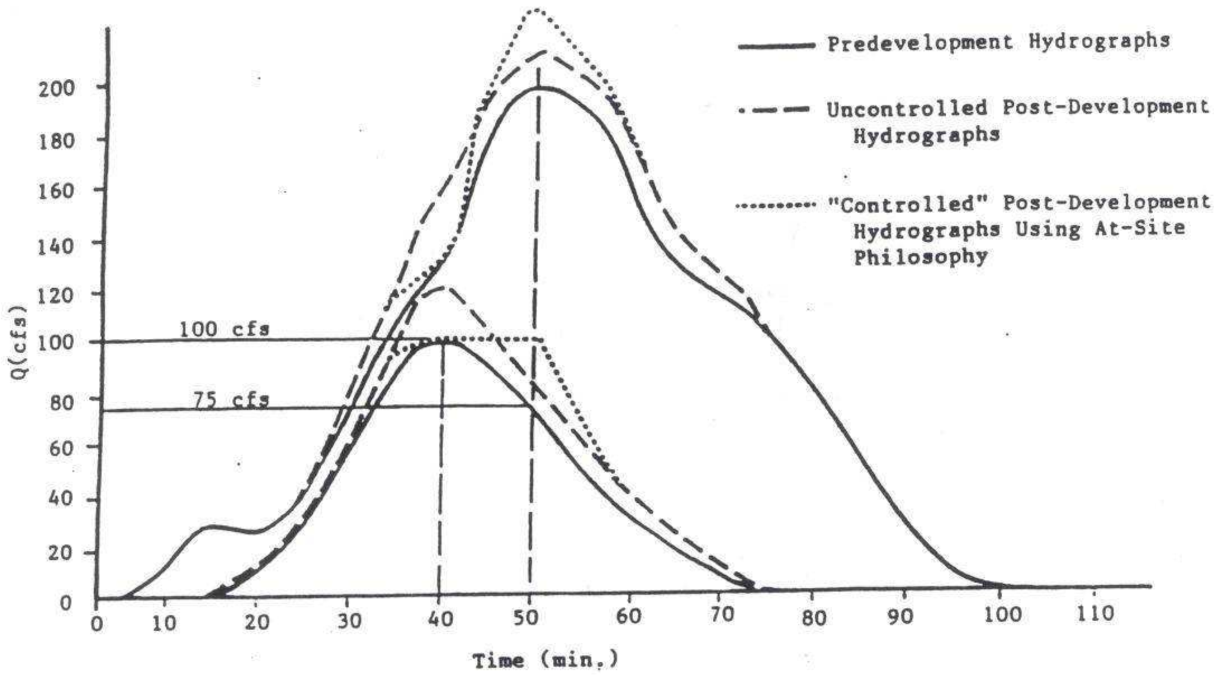

Figure A.5: Hydrograph Analysis for Example Area 4

The release rate concept is perhaps best described by looking at how Area 4 contributes to the hydrograph at the point of interest. Figure A.5 shows the total hydrograph from Figure A.4 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 A.5 are the possible outcomes of development occurring in Area 4. Specifically, the 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 to 120-cfs for the "uncontrolled" option and 100-cfs for the "controlled" at-site philosophy option versus 75-cfs for the pre-development condition. Therefore, the total peak flow at the point of interest from Areas 1 through 5 must increase for both options. 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 the pre-development contribution of 75-cfs. Note that the 75-cfs represents 75% of the 100-cfs peak flow from Area 4. Herein lies the basis for the release rate concept.

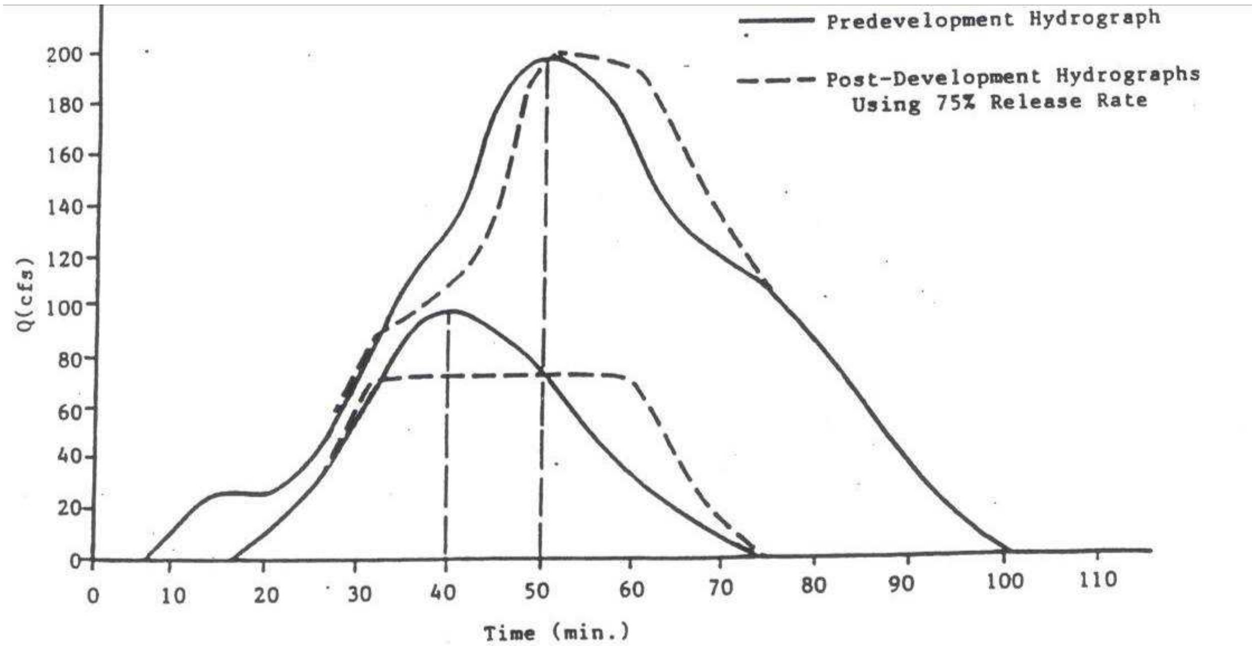

Figure A.6: Release Rate Runoff Control for Example Area 4

Conventional at-site detention philosophy would control post-development peak runoff flows to 100% of pre-development levels. The release rate concept would dictate a more stringent level of control based on downstream conditions. For Area 4, the release rate would be 75%, meaning that each individual land development within Area 4 would have to control post-development peak runoff rates to 75% of pre-development levels as illustrated in Figure A.6. Only through this increased level of control for Area 4 would the point of interest peak flows not be exceeded. The conclusion, therefore, 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 sub-watersheds, is defined in equation form as follows:

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

Note that the release rate concept has been developed using Area 4 from Figure A.4 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 have 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.

The specification of a 100% release rate as a performance standard would represent the conventional approach to runoff control philosophy, namely controlling the post-development peak runoff to pre-development levels. This is a well-established and technically feasible control that is effective at-site and, where appropriate, would be an effective watershed-level control.

Despite its benefits, there are several problems with the release rate concept. One of the problems is that some areas can reach unreasonably low release rates. This can be seen in the release rate equation, which dictates that sub-watersheds that peak farther away from the entire watershed will have a lower release rate. Indeed, sub-watersheds whose runoff drains almost completely before or after the watershed peak will approach a release rate of zero (because the numerator approaches zero).

Another problem is that release rates are highly dependent on and sensitive to the timing of hydrographs. Since natural storms follow a different timing than design storms, it is still possible that watershed wide controls designed with release rates only, will encounter increased runoff problems. This is because the runoff rates are still much higher in the developed condition, and increased volumes over an extended time can combine to increase peak flow rates. Similar to the traditional on-site detention pond, release rates are purely a peak "rate" type of control.

Patterns of development may also determine how effective designs are that only use release rates, or any control based on timing. This is because rates based on timing assume a certain development and rainfall patterns, and the model uses uniform parameters across a sub-watershed. In reality, the actual development and rainfall patterns can be highly variable across a sub-watershed and can be quite different than the Future Full Build Out land use scenario used in the planning study. This uncertainty can affect any type of control, but controls based on timing alone are especially sensitive to these parameters. Some controls, such as volume controls, are less sensitive since they remove a certain amount of runoff from the storm event wherever development occurs. In a sense, volume controls tend to more closely simulate what occurs in a natural system.
Combining volume controls with peak rate controls would be more effective than having only peak rate controls. Volume controls have several advantages such as:

- Increased runoff volume may infiltrate and therefore recharge groundwater supplies. This does not happen with rate controls since all of the runoff excess is discharged in a short time frame.

- Volume controls tend to mimic natural systems (i.e., excess runoff volume is infiltrated) and thus are more effective in controlling natural storms since they are not highly sensitive to timing issues.

- Volume controls often have enhanced water quality benefits.

Volume Control Guideline 1 and Volume Control Guideline 2 as implemented in this Plan, provide the benefits described above.

APPENDIX B
TECHNICAL ANALYSIS

APPENDIX B
TECHNICAL ANALYSIS

HYDROLOGIC MODEL PREPARATION

As part of this Plan, three (3) watersheds in southern Dauphin County were examined and had detailed hydrologic modeling performed. The entire watershed of Burd Run, Laurel Run and Spring Creek (East) were modeled using HEC-HMS, the US Army Corps of Engineers' Hydrologic Modeling System developed by the Hydrologic Engineering Center.

The HEC-HMS model incorporates a variety of parameters to determine the amount of stormwater runoff generated during a particular rainfall event. The HEC-HMS model simulates stormwater runoff characteristics for the previously mentioned watersheds using 2005 land cover (which was used in the existing condition model) and a full build-out land cover condition (which was used in the future condition model). The various parameters entered into the hydrologic model include sub-watershed area, lag time, reach lengths and slopes, reach cross sectional dimensions, soil-type, land cover (expressed as a curve number), and design rainfall depths. More details and explanations about these parameters are listed below:

RAINFALL DATA

Rainfall data used in the HEC-HMS model was obtained from NOAA Atlas 14. NOAA Atlas 14 provides precipitation frequency estimates based on the analysis of annual maximum series which are converted to partial duration series results.

Rainfall Data

PRECIPITATION FREQUENCY ESTIMATES (INCHES)						
	1-year	**2-year**	**10-year**	**25-year**	**50-year**	**100-year**
1-hour	1.09	1.32	1.90	2.23	2.48	2.75
2-hours	1.26	1.53	2.26	2.73	3.12	3.55
3-hours	1.38	1.68	2.48	2.99	3.42	3.88
6-hours	1.70	2.06	3.04	3.70	4.27	4.90
12-hours	2.08	2.50	3.74	4.60	5.37	6.22
24-hours	2.40	2.90	4.36	5.43	6.38	7.48

SUB-WATERSHED AREAS

The Burd Run Watershed was delineated into five (5) sub-watersheds. Laurel Run Watershed was delineated into fourteen (14) sub-watersheds. Spring Creek (East) Watershed was delineated into fifteen (15) sub-watersheds. The delineation was based on natural sub-watershed divides and significant problem area/obstruction locations. The delineation of these sub-watershed areas created points of interest at junctions where the sub-watersheds were hydraulically connected in the HEC-HMS model. The existing and future models contained the same sub-watershed areas.

LAND COVER – SCS CURVE NUMBER

Burd Run, Laurel Run, and Spring Creek (East) Watersheds were modeled utilizing an empirical Curve Number method to estimate total excess precipitation for storms based on cumulative precipitation, soil cover, land use, and antecedent moisture condition. Curve Numbers (CN) were created to simulate the existing 2005 land cover, and the future full build-out stormwater runoff characteristics of the watersheds. The Curve Number is a function of the land use, its condition, and the hydrologic soil group. For each sub-watershed, a composite Curve Number was developed using GIS by overlaying the soils and land use coverage while spatially analyzing the percent of each land use and soil condition. The composite Curve Numbers are consistent with the land use categories and criteria delineations based on the following table:

DAUPHIN COUNTY ACT 167 LAND USE CATEGORIES AND CRITERIA:		CURVE NUMBERS			
	Hydrologic Soil Group:	**"A"**	**"B"**	**"C"**	**"D"**
Agriculture	[Good Condition]	39	61	74	80
Commercial/Industrial	---	81	88	91	93
Forest	[Good Condition]	30	55	70	77
High Density Residential	[1/4 – acre as the Average Lot Size]	61	75	83	87
Low Density Residential	[1 – acre as the Average Lot Size]	51	68	79	84
Medium Density Residential	[1/2 – acre as the Average Lot Size]	54	70	80	85
Open Space	[Unoccupied area i.e. golf courses, ball fields, parks]	39	61	74	80
Urban	[1/8-acre as the Average Lot Size]	77	85	90	92
Water/Wetland	---	100	100	100	100

"A", "B", "C", & "D" refer to the hydrologic soil groups. Soils are classified into the four (4) hydrologic soil groups according to their minimum infiltration rate. The infiltration rates of soils vary widely and are affected by surface intake rates as well as subsurface permeability.

LAG TIME

Lag time was computed according to Snyder's Method.

$$\text{Lag Time} = CC_t(LL_c)^{0.3} \text{ where,}$$

- C: Conversion factor (1.0 for English System)
- C_t: Basin Coefficient
- L: Length of the main stream from the outlet to the divide
- L_c: Length along the main stream from the outlet to a point nearest the watershed centroid

There are three basic parts to a stormwater hydrograph:

(1) The rising limb or concentration curve
(2) The crest segment
(3) The recession curve or falling limb

Analytical properties of a stormwater hydrograph are:

(1) Lag time (basin lag) which is the time interval from the center of mass of the rainfall excess to the peak of the hydrograph
(2) Time to peak (T_p) which is the time interval from the start of rainfall excess (direct runoff) to the peak of the hydrograph
(3) Time of concentration (T_c) which is the time interval from the end of the rainfall excess to the point on the falling limb of the hydrograph where the recession curve begins (the point of inflection). Time of concentration is also known as the travel time between the furthest point on the watershed to the point represented by the hydrograph or point of interest.

Key properties of any hydrograph that will affect design flows are the peak flow rate, the time to peak, and the duration of runoff. The Snyder Method attempts to estimate these three key properties. Consequently, the lag time is directly connected to the specific characteristics of each watershed such as: length to centroid, length of main stream, and the basin coefficient.

TIME OF CONCENTRATION

Determining the Time of Concentration for each sub-watershed was based on the procedure outlined in Chapter 3 of TR-55 – Urban Hydrology for Small Watersheds. Sheet flow was limited to 150 feet and the times of concentration were computed from information contained on USGS maps and verified by field views.

REACH LENGTHS, SLOPES, AND CROSS - SECTIONAL DIMENSIONS

Reach lengths and slopes were determined by visual inspection of USGS quad maps. Representative cross-sectional dimensions were measured in the field for each modeled reach in HEC-HMS. The reaches were modeled utilizing the Muskingum Cunge 8-point routing procedure. This procedure is based on the continuity equation and the diffusion form of the momentum equation. Manning "n" values were input into the model based on the channel and left and right overbanks.

INFILTRATION

Future developments within Dauphin County will be required to meet both water quality and water quantity standards. Infiltration is a part of the water quantity standards. This parameter is the volume of water to be infiltrated into the ground post-development and is intended to approximate the volume of runoff that was originally infiltrated into the ground during pre-development conditions. The main reason for maintaining recharge/infiltration within each sub-watershed is to ensure preservation of existing groundwater recharge rates for the watershed and, therefore, preserve existing water table elevations, despite a substantial increase in impervious area caused by increased development. In addition, infiltration has benefits in terms of maintaining stream and wetland hydrology even during periods of dry weather. Given that natural surfaces have higher recharge/infiltration rates and that development increases impervious surfaces, development inevitably causes a net decrease in recharge/infiltration. There are a number of structural as well as non-structural BMPs that can be utilized to meet this infiltration criterion. In reality, this standard will be met on an individual development level. This will involve multiple practices employed across the watershed to replenish the portion of the total watershed infiltration that would potentially be removed from the groundwater supply by development.

1. Infiltration taken into account within the HEC-HMS model was consistent with Control Guideline 1 (CG-1) that was implemented within the Plan. The 2005 land use existing model was created and Curve Numbers adjusted to account for the requirements of CG-1:

   - Forested areas are to have Curve Numbers in accordance with TR-55 guidelines
   - Non-forested pervious areas are assigned Curve Numbers based on soil type and the assumption that they resemble meadow (good condition)
   - 20% of existing impervious area shall be considered meadow (good condition)

   a. The percentage of impervious cover was estimated for the following land use categories: Commercial/Industrial, High Density Residential (HDR), Medium Density Residential (MDR), Low Density Residential (LDR) and Urban. Each subarea is multiplied by its percentage of assumed imperviousness area from the following table to determine the amount of existing impervious cover.

LAND USE CATEGORY	IMPERVIOUSNESS %
Commercial/Industrial	80
HDR	38
LDR	20
MDR	25
Urban	65

   b. A separate Curve Number is assigned to impervious areas based on the dominant hydrologic soil group that is associated with each land use category.

   c. The remaining 80% of the impervious cover is to have Curve Numbers as calculated in accordance with TR-55 guidelines.

2. The “Existing – CG-1” HEC-HMS model was utilized to compute the volume of stormwater runoff (Ac-ft) for existing conditions.

3. The “Future” HEC-HMS model was utilized to compute the volume of stormwater runoff (Ac-ft) for full build-out conditions.

4. The “Existing – CG-1”conditions model was compared to the “Future” full build-out model. The difference in runoff volume for the 2-year/24-hour storm was determined.

5. The difference in runoff volume (Ac-ft) was inserted into the HEC-HMS full build-out model as a diversion volume to compute the impact of infiltration.

6. The infiltration requirement for proposed development was modeled as “diversions” in all of the HEC-HMS future condition models. The “diverted” volume was computed after implementing the CG-1 criteria.

This infiltration modeling effort was utilized to simulate the volume requirement of infiltration that is proposed to be in place once the provisions of the Model Ordinance are adopted by all the municipalities of Dauphin County into their respective municipal ordinances.

Meeting the CG-1 infiltration requirement will typically not be enough stormwater management control to return post-development peak runoff rates to pre-development levels if the overall goal is not to increase post-development peak runoff at any point in the watershed. Therefore, the release rate concept was applied to the CG-1 full build-out model to achieve the overall goal of no increases in the post-development peak runoff rates at any point in the Burd, Laurel, and Spring Creek (East) watersheds.

MODEL CALIBRATION

As previously discussed, the HEC-HMS model incorporates a number of user-defined variables to generate runoff hydrographs. However, the accuracy of the model remains unknown unless it is calibrated to another source of runoff information. Possible sources of information include stream gauge data, high water marks (where detailed survey is available to facilitate hydraulic analysis), and other hydrologic models. The most desirable source of calibration information is stream gauge data as this provides an actual measure of the runoff response of the watershed during actual rain events. Unfortunately, there are no known rain and stream gauges with enough historical data within the areas under study to use this approach for calibration.

FEMA flow rates are available for some points of interest throughout the watersheds, but these flows were typically determined in the late 1970’s and are considered somewhat outdated.

PSU-IV – Estimating Design Flood Peaks on Ungauged Pennsylvania Watersheds was evaluated with adjustments for limestone and urbanization as a possible source for comparison. Although this method is widely regarded as a good approximation of peak flows, it uses data from the early 1980’s and, consequently, was not chosen for calibration purposes. The other limitation is that this method is applicable only for areas that range between 1.5 square miles and 150 square miles.

USGS WRI 00-4189 Techniques for Estimating Magnitude and Frequency of Peak Flows for Pennsylvania Streams was used to determine the target flow rates for the existing hydrologic model. This method uses regression equations to estimate the magnitude and frequency of floods on ungaged streams in Pennsylvania. These regression equations were developed on the basis of peak flow data collected at 313 stream flow-gaging stations throughout Pennsylvania. This procedure was developed in 2000, which is the most up-to-date method and takes into account forest area, urban development, carbonate (limestone) area, and controlled areas (significant storage/reservoirs).

Once the target flow rates were established based on the USGS WRI 00-4189 method, the basin coefficient (C_t) used to compute the lag time was adjusted (calibrated) until the peak flows computed by the HEC-HMS model were consistent with the target flow rates for the 10-year storm in the existing conditions model.

MODELING RESULTS & RELEASE RATE COMPUTATION

Once the HEC-HMS model was calibrated and the existing conditions peak flows were established after the implementation of the volume control guidelines, release rates were determined. Based on a comparison of existing and future land use, most sub-watersheds will experience varying degrees of development through the full build-out future condition. Some sub-watersheds are close to being fully developed at this time, while others will have more intense development pressures. Therefore, since all sub-watersheds will experience some development, all sub-watersheds were analyzed to determine whether release rates are required to prevent downstream flooding caused by the assumed future development.

Release rates for the 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year storms are included in this Plan. The 2-year, 10-year, and 25-year were determined via detailed HEC-HMS modeling. The 1-year, 50-year, and 100-year storms were assigned a 100% release rate without any detailed modeling.

The following steps were taken to determine the release rates:

- An initial release rate was computed for each sub-watershed by dividing the sub-watershed peak contribution (Qsc) to the overall watershed peak by the sub-watershed peak (Qsp).

- The hydrographs within HEC-HMS of each junction point were then compared to all points within each specific watershed of the Burd Run, Laurel Run, and Spring Creek (East) watersheds to check whether peak flow increases occurred at any point within each of the watersheds. If the full build-out future condition had a greater peak runoff than the existing condition, then the release rates were modified accordingly to prevent the peak flow increase.

- The final modeling of Burd Run, Laurel Run and Spring Creek (East) watersheds provides release rates for the 2-year, 10-year, and 25-year storm events that do not increase the future peak flows above the existing condition peak flows at any point within the watersheds.

APPENDIX C
FLOOD INSURANCE STUDIES

Table C-1: DAUPHIN COUNTY MUNICIPAL FLOOD INSURANCE STUDIES		
MUNICIPALITY	**TYPE**	**STUDY DATE**
Conewago Township	Detailed Study	April 30, 1986
Dauphin Borough	Detailed Study	September 1976
Derry Township	Detailed Study	September 1977
East Hanover Township	Detailed Study	July 1979
Elizabethville Borough	Non-Detailed Study	June 25, 1976
Gratz Borough	Non-Detailed Study	December 14, 1979
Halifax Borough	Detailed Study	March 1979
Halifax Township	Detailed Study	March 1972
Harrisburg City	Detailed Study	November 1976
Highspire Borough	Detailed Study	October 1976
Hummelstown Borough	Detailed Study	September 1976
Jackson Township	Non-Detailed Study	October 15, 1985
Jefferson Township	Non-Detailed Study	October 15, 1982
Londonderry Township	Detailed Study	September 1979
Lower Paxton Township	Detailed Study	October 15, 1980
Lower Swatara Township	Detailed Study	October 1976
Lykens Borough	Detailed Study	March 1980
Lykens Township	Non-Detailed Study	October 15, 1985
Middletown Borough	Detailed Study	June 1976
Middle Paxton Township	Detailed Study	February 1979
Mifflin Township	Non-Detailed Study	June 25, 1976
Millersburg Borough	Detailed Study	February 1980
Paxtang Borough	Detailed Study	September 1979
Pillow Borough	Detailed Study	November 1987
Reed Township	Detailed Study	May 1979
Royalton Borough	Detailed Study	October 1976
Rush Township	Non-Detailed Study	August 19, 1985
South Hanover Township	Detailed Study	November 1976
Steelton Borough	Detailed Study	October 1976
Susquehanna Township	Detailed Study	October 1976
Swatara Township	Detailed Study	August 3, 1981
Upper Paxton Township	Detailed Study	March 1979
Washington Township	Detailed Study	December 17, 1987
Wayne Township	Non-Detailed Study	March 14, 1980
West Hanover Township	Detailed Study	September 1979
Wiconisco Township	Detailed Study	October 15, 1980
Williams Township	Non-Detailed Study	December 14, 1979
Williamstown Borough	Non-Detailed Study	August 5, 1985

APPENDIX D
PROBLEM AREAS AND OBSTRUCTIONS

APPENDIX E
STORMWATER MANAGEMENT MODEL ORDINANCE