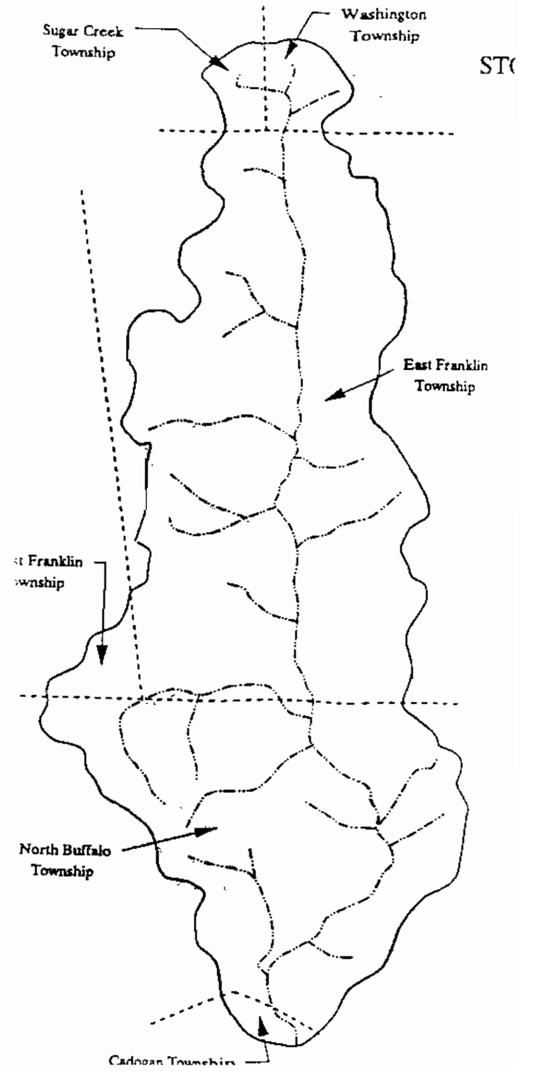
Armstrong County

Act 167
Stormwater Management
Plan
Glade Run Watershed

This plan has been prepared by the Armstrong County Department of Planning and development with a 75 percent grant from the Department of Environmental Resources for the Armstrong County Commissioners. It contains revisions based upon review comments from the Glade Run Watershed Advisory Committee and the Department of Environmental Resources and the Armstrong County Board of Commissioners. Consulting Services for the preparation of the Plan were provided by The Chester Engineers.



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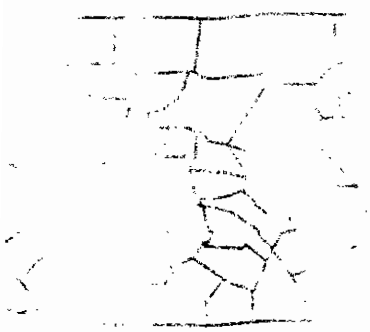
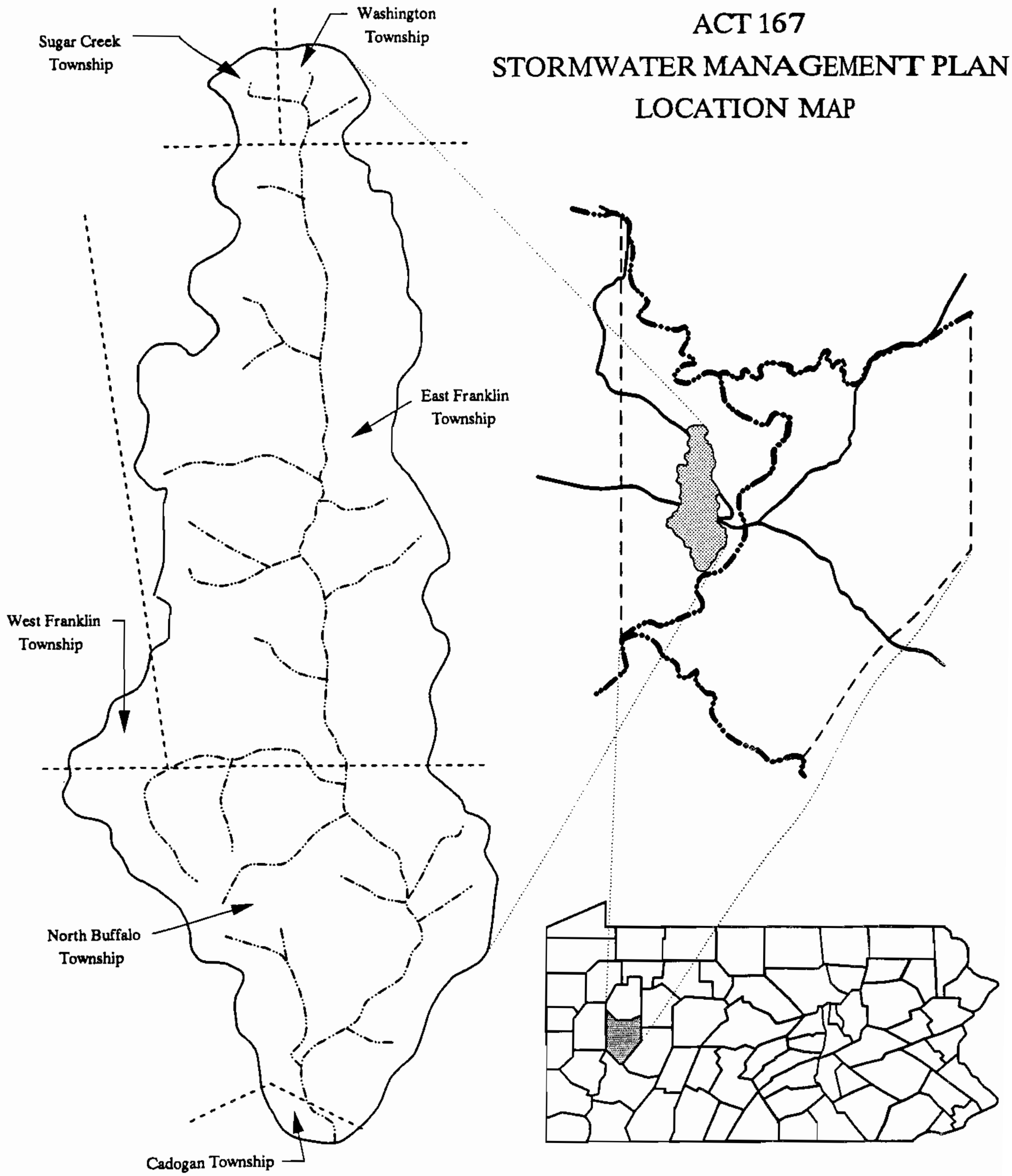


GLADE RUN WATERSHED
ACT 167
STORMWATER MANAGEMENT PLAN
LOCATION MAP



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GLADE RUN STORM WATER MANAGEMENT PLAN

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ARMSTRONG COUNTY

GLADE RUN WATERSHED

STORMWATER MANAGEMENT PLAN

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SECTION I
INTRODUCTION

On October 4, 1978, with the passage of the Storm Water Management Act (Act 167) and its companion bill, the Flood Plain Management Act (Act 166), the Commonwealth embarked on a significant new course to reduce flooding and the problems caused by inadequately controlled stormwater runoff. Recognizing the repeated threats to public health and safety, the legislature mandated a comprehensive approach to planning and managing excess stormwater runoff. Act 167 sets up a program for managing accelerated runoff so that it does not lead to flooding, while Act 166 provides for the preservation and restoration of floodplains which are natural stormwater storage areas.

During the past forty years, substantial portions of Pennsylvania landscape have changed dramatically. With the advent of the automobile, residential, commercial, and industrial development spread across the countryside transforming it from predominantly farms and rural villages to sprawling urban-suburban communities. The alteration of natural surface contours through the construction of buildings, streets, and large parking areas has modified rainfall/runoff patterns to such an extent that local flooding problems are now plaguing communities throughout the Commonwealth.

In some areas, these problems occur on a house-to-house basis where runoff from one or more lots in a single development results in damage to walls or driveways or causes ponding on a neighbor's lot. In others, runoff from streets and storm sewers in one residential development or from a large commercial development causes flooding of lands and buildings further downstream. This cumulative effect of development has resulted in the flooding of both small and large streams, with property damages running into the millions of dollars and even causing loss of life.

The statement of legislative findings at the beginning of Act 167 sums up the critical interrelationship between development, accelerated runoff, and flood plain management:

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

- A comprehensive program of stormwater management, including reasonable regulation of development and activities causing accelerated runoff, is fundamental to the public health, safety and welfare and the environment (see Section III).

In the past, stormwater management was oriented primarily toward a single site or development. Good stormwater management was getting the water off the site as quickly as possible and into the nearest stream or river. Minimal attention was given to the effects on downstream locations (frequently because they were another municipality) or to designing stormwater controls within the context of the entire watershed.

Act 167 changes this approach by instituting a comprehensive program of stormwater planning and management. It requires the counties to prepare and adopt watershed stormwater management plans for each watershed located in the county, as designated by the Pennsylvania Department of Environmental Resources (DER). These plans are to be prepared in consultation with the municipalities located in the watershed, working through a Watershed Advisory Committee. The watershed plans are to be completed within two years of the legislature's approval of the stormwater management guidelines prepared by DER to implement Act 167. DER also is authorized to administer grants to the counties to assist or reimburse them for 75 percent of the costs of preparing the stormwater plans.

The study team and county planning staff defined four major objectives for Act 167 Stormwater Management Plan:

1. Establish baseline (i.e., existing) stormwater runoff conditions in the watershed against which the effects of future activities can be compared.

2. Identify existing flooding problems and develop approaches to the abatement of these problems.

3. Develop approaches which will eliminate the compounding of existing problems and the creation of new problems as future development occurs.

4. Establish basic management and regulatory responsibilities for implementation of the technical recommendations of the watershed stormwater plans.

The scope of work consisted of eighteen distinct tasks. They were developed to accomplish the study's four objectives, as well as respond to Act 167 and the DER Stormwater Management Guidelines.

The study does not deal to any extent with the concerns of water quality relative to stormwater management. Storm runoff often carries numerous pollutants, especially in urban areas. Also, in communities with combined storm and sanitary sewers, inadequately controlled runoff frequently leads to sewer overflows and discharges of untreated wastes directly into a stream.

TECHNICAL APPROACH FOR THE STUDY

As indicated previously, the technical work program was structured to fulfill the objectives of the study, to meet the requirements and standards of Act 167, and to be consistent with the DER guidelines. The work included an analysis of the current effects that various rainfall intensities have on the study watersheds, as well as the prediction of the future stormwater impacts of projected (ten-year) development.

The technical analysis utilized the Penn State Runoff Model (PSRM) for estimating existing and future runoff characteristics. The Penn State Model was selected because of its relative ease of application and its ability to evaluate impacts of future land development on storm runoff and flooding conditions throughout an entire watershed. In addition, this method was identified in the guidelines as being appropriate for stormwater planning under Act 167.

LEGAL/INSTITUTIONAL APPROACH

This portion of the study dealt with three interrelated issues:

- The primary laws governing stormwater management in Pennsylvania.
- The institutional options for organizing an effective stormwater management effort in the study area watershed.
- Guidelines for incorporating stormwater provisions into municipal zoning, subdivision and land development, and building codes to implement the technical recommendations.

As part of the analysis, various laws were reviewed to determine specific areas of concern, requirements, duties, penalties and remedies, along with interrelationships with the other statutes. In addition to the laws related directly to stormwater management, common law relative to private and public nuisances and state and local municipal immunity statues were reviewed, with attention to the remedies that they provide for stormwater related problems.

Defining the legal constraints for stormwater management in Pennsylvania proved very helpful in other phases of the study. The analysis of Act 167 assisted in the technical work by clarifying the purposes and intent of Act 167 and the basic standards established by Act 167 for stormwater management. The legal analysis also provided a basis for determining the types and nature of regulatory measures that could and should be applied to implement the Stormwater Management Plan.

This is an important consideration, since Act 167 requires local governments to adopt and enforce necessary land use and development controls to implement the plan.

The study includes proposals for ordinance provisions designed to implement the recommended technical measures. These ordinance standards are intended to provide a guide to the municipalities in enacting or amending their existing ordinances. They cannot be incorporated directly into an existing municipal ordinance, but they do indicate the types of provisions that are required and in which ordinances they properly belong.

Finally, the institutional section outlines alternative organizational arrangements for developing and managing stormwater control facilities and for administering the local ordinances. The stormwater plans cannot be implemented effectively on a piecemeal basis. A watershed management approach and intergovernmental cooperation is required. Therefore, this study identifies several approaches that the municipalities, counties, and state can take to implement a workable stormwater management system. The system should be capable of performing various required functions, including planning, construction, operation and maintenance, regulation, and financing. The management system finally selected for the watershed will be influenced by physical, economic, and development characteristics of the watershed.

CONTENTS OF THE PLAN

The Stormwater Management Plan report is presented in two parts. Part I contains the plan text and describes the background and general characteristics of the study area, the method used for data collection, the analytical tools used, results of the analyses, and stormwater runoff control alternatives. Specific management and regulatory responsibilities are identified as they relate to developers and local, county, and state agencies. Part II contains the completed municipal questionnaires, a summary of the obstruction permits in the study area, and release rate percentage maps. Copies of the computer model printouts, and DER obstruction permits are on file with the county.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORM WATER MANAGEMENT PLAN

SECTION II
LEGAL FRAMEWORK FOR STORMWATER MANAGEMENT

An analysis of stormwater management would not be complete without some discussion of the law that created the stormwater management program, along with the other laws that relate to its implementation. This is particularly true in the case of the Storm Water Management Act (Act 167), where there is little or no administrative regulations or case law to interpret its meaning and provisions.

This is an area of law that is not widely understood by local officials, developers and property owners. Pennsylvania's common law relating to drainage rights has developed over decades into a very complex system, and it is not always easy to determine who has what rights and when. Many persons are still not aware of the extent to which Act 167 redefines prior common law. Further, many municipal officials, engineers, and developers are not well informed on other laws which relate to stormwater, development regulation, and governmental liabilities.

In addition to Act 167, other laws that collectively provide the legal posers and mandates to implement a comprehensive Act 167 are:

- Dams Safety and Encroachments Act (Act 325-1978).
- Clean Streams Law (specifically, the erosion and sedimentation regulations adopted pursuant to the Law).
- Flood Plain Management Act (Act 166-1978).
- Municipalities Planning Code (Act 247, as amended).

STORM WATER MANAGEMENT ACT (ACT 167-1978)

The purpose and policy of Act 167 is to:

- Encourage planning and management of stormwater runoff in each watershed which is consistent with sound water and land use practices.

- Authorize a comprehensive program of stormwater management designated to preserve and restore the flood carrying capacity of Commonwealth stream; to preserve to the maximum extent practicable natural stormwater runoff regimes and natural course, current and cross-section of water of the Commonwealth; and to protect and conserve groundwaters and groundwater recharge areas.

- Encourage local administration and management of stormwater consistent with the Commonwealth's duty as trustee of natural resources and the people's constitutional right to the preservation of natural, economic, scenic, aesthetic, recreational and historic values of the environment.

There are two key sections of Act 167: Section 5, which sets up the watershed stormwater planning programs, and Section 13, which establishes the basic standard to manage stormwater runoff to prevent harm to persons and property. A primary goal of Act 167 is to prevent future problems resulting from uncontrolled runoff, including flooding, erosion and sedimentation, landslides, and pollution and debris often carried by storm runoff. A secondary intent is the elimination or correction of existing stormwater and flooding problems.

Watershed Stormwater Plans

As discussed in the preceding chapter, one of Act 167 innovative features is the creation of a public stormwater planning and management and control system at the watershed level. The plans are to be prepared for each watershed delineated by DER.

The counties must organize a watershed advisory committee composed of representatives from the municipalities in the watershed. The committee is to advise the county during the planning process, and the plans are to be adopted by the county commissioners and approved by DER after public review and comment. The completed plans must be consistent with local land use plans and state plans, such as regional water quality state water plan and flood plain programs.

After the adoption and approval of a watershed Stormwater Management Plan, the location, design and construction of stormwater management systems, obstructions, flood control projects, subdivisions and major land developments, highways and transportation facilities, facilities for the provision of public utilities and facilities owned and financed in whole or in part by the Commonwealth (including PennDOT) shall be conducted in a manner consistent with the plan (Section 11). This provision gives the stormwater plan a definite legal status. Unlike municipal comprehensive plans, which are only advisory documents, watershed stormwater plans will be legally binding.

Also, within six months of the approval of the watershed Stormwater Management Plan, each municipality in the watershed must adopt the land use and development ordinances to implement the plan (Section 11). These regulations must be consistent with the plan, as well as standards of Act 167. Failure to adopt and implement the necessary ordinances could result in the state withholding funds from the Commonwealth's General Fund for which the municipality might be eligible.

Basic Standard for Stormwater Management

The basic premise of Act 167 is that those whose activities will generate additional runoff, or increase its velocity, or change the direction of its flow, should be responsible for controlling and managing runoff so that these changes will not cause harm to other persons or property either now or in the future. The policy is that Pennsylvania's legal system will no longer condone those who negligently disregard the impact of runoff from their activities. It will not allow them to shift the burden of runoff management to the public and downstream property owners.

DAMS SAFETY AND ENCROACHMENTS ACT (ACT 325-1978)

Act 325 replaces several older state statutes dealing with dams safety, water obstructions and encroachments. Act 325 is the primary source of regulation for dams*, existing and new obstructions, encroachments, fill in floodplains, culverts, bridges, retaining walls, and outfalls (e.g., of storm sewers) in a stream or a (100-year) flood plain. Act 325 requires permits for the construction, alteration, or abandonment of dams, obstructions and encroachments. The owners of existing obstructions or encroachments are also required to obtain permits. Permits are issued by DER pursuant to Act 325 and regulations (25 PA Code Chapter 105).

DER is the prime agency responsible for administering Act 325. It is important to note that once the watershed stormwater plan is approved, then DER must review obstruction permits in light of the plan's standards and criteria. Also, municipalities should not issue local building permits until any necessary obstruction permits are obtained.

CLEAN STREAMS LAW (EROSION/SEDIMENTATION REGULATIONS)

Pennsylvania's Clean Streams Law was enacted in 1937, and its original scope was limited to regulating discharges of sewage and industrial wastes. Since its original enactment, its scope and duties have expanded substantially. In 1972, DER determined that sediment constitutes a water pollutant under the provisions of the law and promulgated regulations for the control of erosion and sedimentation caused by earth-moving activities (25 PA Code, Chapter 102).

The general requirement of the erosion/sedimentation regulations is that earth-moving activities (including excavations, land development, mineral extraction or any other activity that disturbs the surface of the land) be conducted in a manner to prevent accelerated erosion and resulting sedimentation of streams and other watercourses, such as culverts. Persons engaged in earth-moving activities must prepare erosion/sedimentation control plans for the site.

*In some cases, larger retention/detention facilities may qualify as dams under the definition of the Act and regulations and, therefore, require a permit from DER.

FLOOD PLAIN MANAGEMENT ACT (ACT 166 - 1978)

Act 166 requires municipalities with flood plain areas to participate in the National Flood Insurance Program and to adopt flood plain management regulations that control new development, at least, in accordance with the minimum requirements established by the Federal Insurance Administration.

Preservation of natural floodplains and a comprehensive program of flood plain management are a key part of effective overall stormwater management. Natural flood areas should be maintained as part of the watershed's natural stormwater control system. Similarly, effective future stormwater management will help to preserve flood plain areas and assure that properties not now subject to flooding do not become so in the future.

MUNICIPAL PLANNING CODE (ACT 247, AS AMENDED)

The Municipal Planning Code (MPC) is related to stormwater management because of the authorities it grants to municipalities and counties.* The MPC enables communities to prepare comprehensive land use plans and capital facilities programs. It also empowers them to prepare and adopt zoning (including regional zoning), subdivision and land development, planned residential development, and official map ordinances. The various municipal codes (borough, township, etc.) authorize communities to adopt building/housing codes pursuant to their health, safety, and general welfare powers.

These are the major planning and regulatory mechanisms that municipalities will use to implement the watershed plans. Section 11 of the Act 167 specifically requires municipalities to adopt ". . . such ordinances . . . , including zoning, subdivision, and development, building code, and erosion, and sedimentation ordinances . . ." to regulate development activity consistent with the watershed plan and Act 167.

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*The MPC excludes first and second class cities and counties.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION III
EXISTING CONDITIONS AND PROBLEMS

EXISTING RUNOFF CHARACTERISTICS

The analysis of existing runoff characteristics in the Glade Run Watershed utilized a computer model developed initially at Penn State University in the mid-1970s and generally accepted by the engineering community. The Penn State Runoff Model (PSRM) generates runoff flow information for selected points along a drainage facility or stream as the product of contributing flows from subareas within the drainage basin. It does so by estimating the runoff generated by specified storm events in each defined subarea based upon the physical characteristics of the area, then routes that runoff flow through the drainage system in accordance with the hydraulic character of the drainage facilities and channels.

The Glade Run Watershed was divided into 120 subareas or subbasins, each of which is a minor drainage area. The runoff generated in each subarea was estimated for storm recurrence intervals of 2, 5, 10, 25, 50, and 100 years. The amount of runoff generated in each subarea from each of the storms is a function of the size and shape of the subarea, its average slope, the percentage of impervious surface, soil permeability, and vegetative cover. Together these factors determine how much rainfall ultimately enters the drainage system as runoff during a storm event, with the remainder permeating into the ground or returning to the atmosphere either as evaporation or as transpiration.

Land cover information from which acreages of pervious/impervious areas were derived were interpreted from mosaics of panchromatic aerial photographs and Landsat Thematic Mapper satellite imagery. Interpretation was performed manually or through a combination of digital and manual analysis that takes advantage of computer processing for radiometric analysis, while capitalizing on the ability of human interpreters to detect patterns related to land cover types. The derived information was entered into a raster (grid cell) data base and combined with other information themes to provide the required acreage figures.

Digital elevation data for the watershed was acquired from the U.S. Geological Survey. Information from the Soil Conservation Service (SCS) Soil Survey for Armstrong County was digitized and added to the data base through scandigitizing the five soils survey maps covering the watershed.

The results of the Geographic Information System (GIS) analysis for input to the PSRM consisted of information classes summarized by subwatershed. These included:

- Acreage contained in each subwatershed.
- The amount of pervious/impervious areas categorized by major soils classes.
- Average slope of each subwatershed.
- Median and mode slope of each subwatershed.
- Acreage of land cover classes in each subwatershed.

Figure III-1 presents the land cover classes as determined by the process described above. In addition, land cover classes for the future (projected ten years into the future) were obtained from the Armstrong County Land Use Development Plan. Figure III-1 was then modified to show future development in the watershed. This information is presented on Figure III-2 (Future Land Cover Map).

SURVEY OF EXISTING OBSTRUCTIONS

Information on obstructions and their capacities was obtained in several ways. A series of questionnaire forms dealing with aspects of stormwater was distributed to each municipality with a request that they be completed. Several of the

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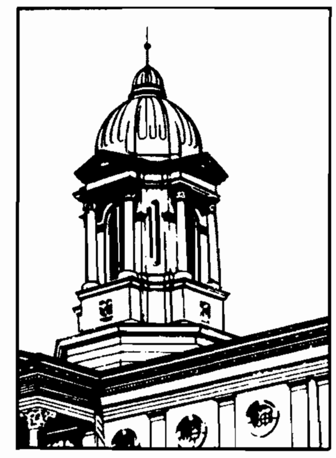
Stormwater Management Plan
Glade Run Watershed



Existing Land Cover Map

Legend

- Watershed Boundary
- Municipal Boundary
- Woodland
- Cropland
- Pasture
- Highway/Roads
- Urban/Industrial
- Water
- Residential

N

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scale feet

FIGURE III-1

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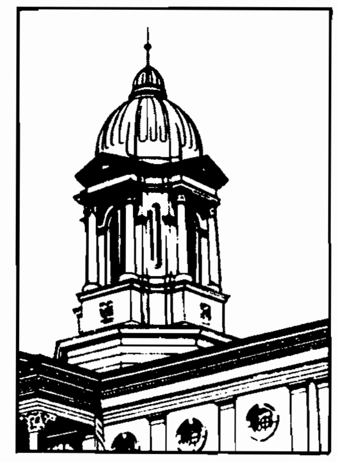
Armstrong County
Stormwater Management Plan
Glade Run Watershed



Future Land Cover Map

Legend

- **Watershed Boundary**
- **Municipal Boundary**
- Woodland
- Cropland
- Pasture
- Highway/Roads
- Urban/Industrial
- Water
- Residential

FIGURE III–2

5000 0 5000 10000
scale feet

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municipalities completed one or more forms identifying obstructions in the storm drainage system.

Field inspections of all obstructions were performed and measurements made of their characteristics. A map showing the location of these obstructions and pertinent information is included on Figure III-3. A total of 243 obstructions were described and included in the survey. Copies of the survey forms are on file with the Armstrong County Department of Planning.

DEVELOPMENT IN FLOOD HAZARD AREAS

The Glade Run Watershed map shown on Figure III-4 delineates the 100-year flood plain adjacent to all streams in the watershed, as defined by the United States Geological Survey. The official flood plain delineations, however, are those prepared for each municipality by the Federal Emergency Management Agency (FEMA). The FEMA maps are incorporated in this plan by reference and may be reviewed at the Armstrong County Planning Department.

The enactment and implementation of flood plain development regulations in accordance with requirements of the Pennsylvania Flood Plain Management Act (Act 166) should either prevent most kinds of development from being constructed within the existing flood plain or ensure that development is adequately flood proof and that stream carrying capacities are maintained.

Any expansion of the flood prone area caused by future increases in runoff or by changes in the direction or velocity of stormwater flows would subject existing or future development in areas not protected by flood plain regulations to damages from flooding, as well as increasing the severity of damages to structures located within the existing flood plain. Therefore, a primary objective of this plan is to prevent increases in the quantity of runoff and changes in the velocity or direction of flows which would alter the existing hydraulic characteristics of streams within the watershed in ways which would cause harmful impacts.

EXISTING AND PROPOSED COLLECTION SYSTEMS

The information upon which this plan are based also included a survey of the existing stormwater collection systems. The survey was compiled by means of a questionnaire and was field confirmed.

Information about existing stormwater collection facilities was needed for two crucial reasons:

- The operation of the PSRM requires information about the character of the system in order to mathematically replicate the hydraulics of the watershed. Information was needed about the velocity of flow in both natural and man-made sections of the drainage system and about how existing bridges, culverts and impoundments impact the movement of runoff through the watershed.

- The capacity of the existing stormwater collection system establishes how large a storm can be accommodated without surcharging the collection facilities.

The municipalities in the Glade Run Watershed do not have storm sewer systems nor do they have plans for the construction of such systems.

At the present time, the design and capacity of new stormwater structures, such as culverts, is determined by standards contained in municipal regulations and by the standards established by the Pennsylvania Department of Transportation (PennDOT).

EXISTING PROBLEMS

To ensure that the study addressed the existing problems within each watershed, a data collection questionnaire was prepared and given to each municipality. The county assisted in the completion of the questionnaire and the information received was included as a part of the plan.

Armstrong County
Stormwater Management Plan
Glade Run Watershed

Obstruction Map

Legend

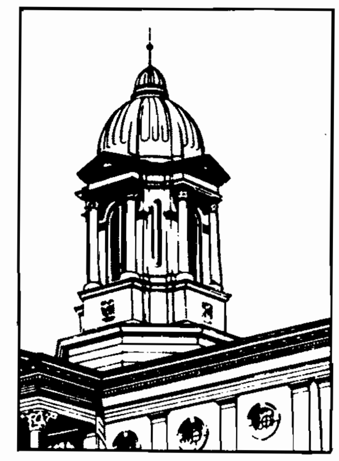
- Watershed Boundary
- Municipal Boundary
- •123 Obstruction and Number

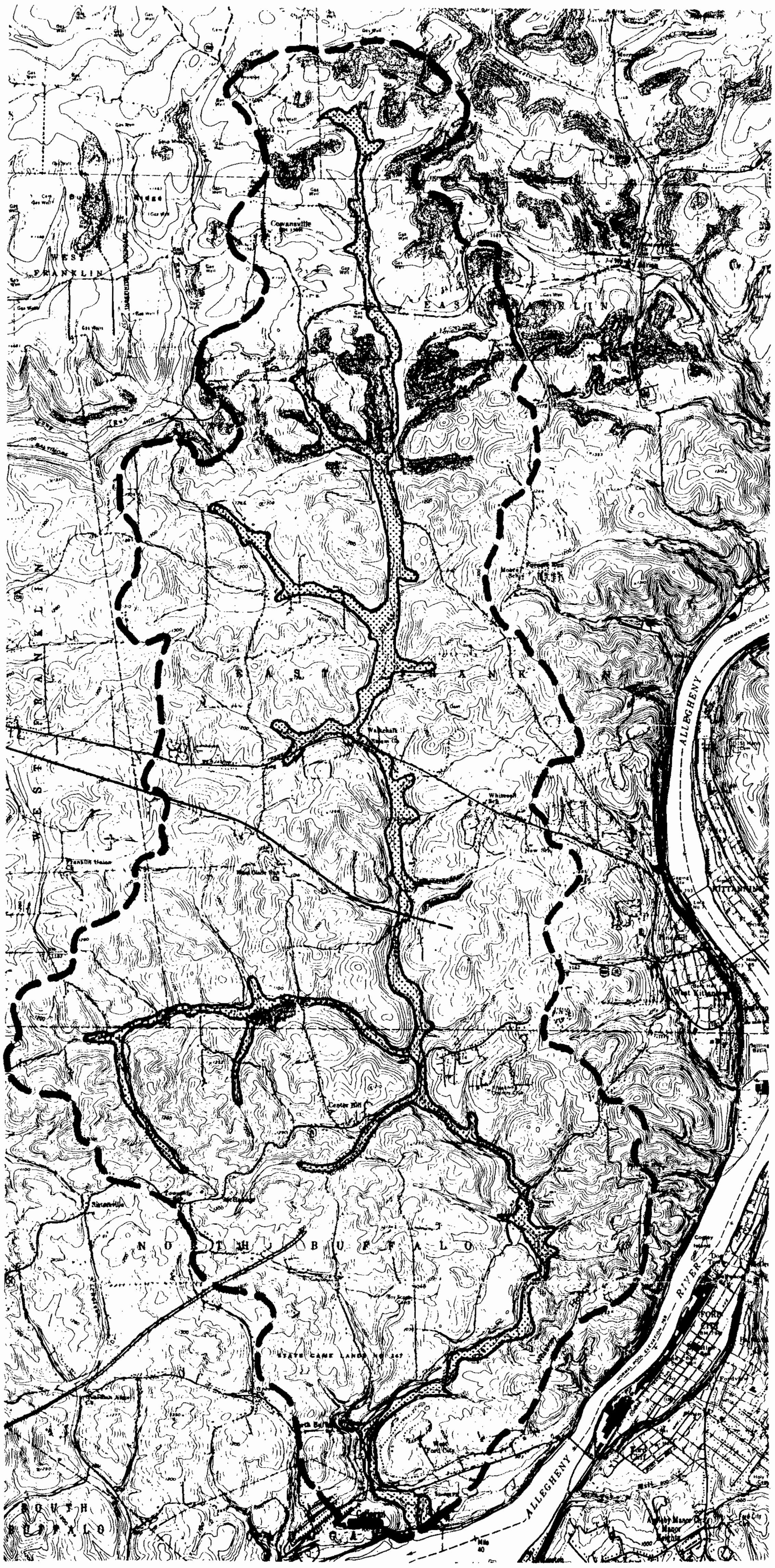
FIGURE III–3

5000 0 5000 10000

scale feet

Armstrong County
Stormwater Management Plan
Glade Run Watershed





100 Year Flood Boundary

Legend

- Watershed Boundary
- Municipal Boundary
- 100 Year Flood Boundary

5000 0 5000 10000

scale feet

FIGURE III–4

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Stormwater problems result when a rain event exceeds the flow capacity of the conveyance system. This capacity can be determined either through field measurements of flow velocity and flow area or by hydraulic computations, provided that the channel slope and physical characteristics of the system are known. The questionnaires were used as a means of collecting information from municipal records and interviews with municipal officials to obtain information related to existing stormwater collection systems and localized problems. Figure III-5 summarizes this information. The results of the questionnaires are presented by municipality as follows:

Sugar Creek Township

Located in the northwest corner of the watershed, the portion of Sugar Creek Township located within the study area is only 219 acres. This represents only 1.3 percent of the total municipal area and 1.34 percent of the watershed area.

As a result of its location in the uppermost portion of the watershed and the fact that it contains such a small land area, it would be expected that few stormwater problems exist in this portion of Sugar Creek Township. This was shown to be true as no flooding problems were identified as a result of the questionnaire. In addition, the sparse development that exists in this area has resulted in little need for any type of stormwater conveyance or control facilities. There are no flood control or storm sewer projects either existing or planned in this portion of the township.

The fact that flooding problems have not been reported in this area is not unexpected. The Flood Insurance Rate Map indicates that there are no areas where flooding is expected to occur even during the 100-year event.

Washington Township

Located in the northeast corner of the watershed, the portion of Washington Township located within the study area is only 473 acres. This represents 3.3 percent of the total municipal area and 2.9 percent of the watershed area.

As a result of its location in the upper portion of the watershed and the fact that it contains such a small land area, it would be expected that few stormwater problems exist in this portion of Washington Township. This was shown to be true as no flooding problems were identified as a result of the questionnaire. In addition, the sparse development that exists in this area has resulted in little need for any type of stormwater conveyance or control facilities. There are no flood control or storm sewer projects either existing or planned in this portion of the township.

The fact that flooding problems have not been reported in this area is not unexpected. The Flood Insurance Rate Map indicates that there is only a small area where flooding is expected to occur during the 100-year event. There is no development located within or near this area.

East Franklin Township

Located in the central portion of the watershed, the portion of East Franklin Township located within the study area is 9,275 acres, making it the largest municipality located within the Glade Run watershed. This represents 46.0 percent of the total municipal area and 56.8 percent of the watershed area.

Based on the survey of existing drainage problem areas, six problems were reported in East Franklin Township. Of these, five were due to either road crossings or culverts having insufficient capacity to pass storm flows generated within the watershed. One problem resulted when an area in the watershed was clear cut logged thereby changing the land cover type and resulting in excessive runoff.

There are no flood control or storm sewer projects either existing or planned in this portion of the township.

West Franklin Township

Located in the west-central corner of the watershed, the portion of West Franklin Township located within the study area is only 350 acres. This represents 2.2 percent of the total municipal area and 2.14 percent of the watershed area.

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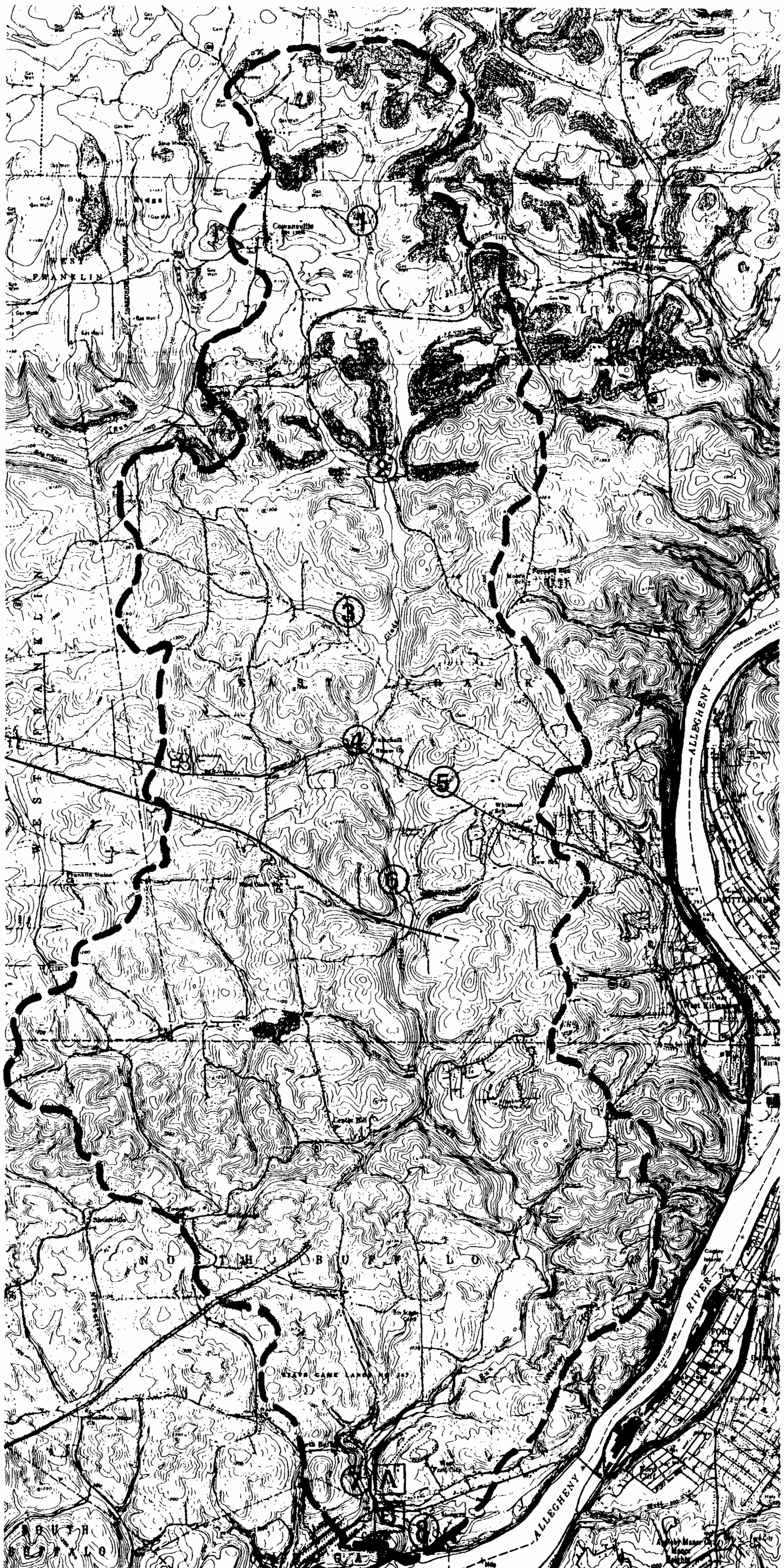
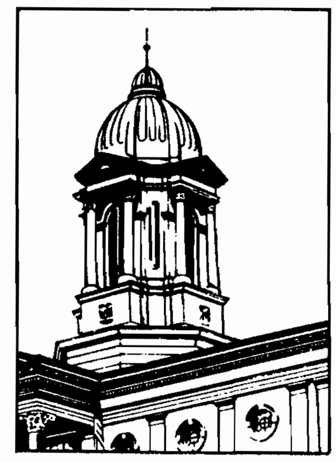
Stormwater Management Plan
Glade Run Watershed





Existing Drainage Problem Areas

Legend

- Watershed Boundary
- Municipal Boundary
- ④ Existing Drainage Problem Areas
- [A] Existing Flood Control Projects

Descriptions

Existing Flood Control Projects

[A] Gabion Wall Along Glade Run, Constructed by PennDOT, 1984

[B] Gabion Wall Along Glade Run, Constructed by PennDOT, 1980

Existing Drainage Problem Areas

① Problems developed when area was clear cut logged.

② Flooding problems

③ Flooding problems due in part to downstream obstruction.

④ Flooding problems due in part to downstream obstruction.

⑤ Flooding problems due in part to downstream obstruction.

⑥ Flooding problems due in part to downstream obstruction.

⑦ Flooding problems due in part to downstream debris deposits.

⑧ Flooding in lower reach of Glade Run resulting from flooding in Allegheny River.

FIGURE III-5

5000 0 5000 10000
scale feet

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As a result of its location in the upper portion of a tributary to Glade Run and the fact that it contains such a small land area, it would be expected that few stormwater problems exist in this portion of West Franklin Township. This was shown to be true as no flooding problems were identified as a result of the questionnaire. In addition, the sparse development that exists in this area has resulted in little need for any type of stormwater conveyance or control facilities. There are no flood control or storm sewer projects either existing or planned in this portion of the township.

The fact that flooding problems have not been reported in this area is not unexpected. The Flood Insurance Rate Map indicates that there is only a small area where flooding is expected to occur during the 100-year event. There is no development located within or near this area.

North Buffalo Township

Located in the south portion of the watershed, the portion of North Buffalo Township located within the study area is 5,897 acres, making it the second largest municipality located within the Glade Run Watershed. This represents 36.0 percent of the total municipal area and 36.12 percent of the watershed area.

Based on the survey of existing drainage problem areas, two problems were reported in North Buffalo Township. Of these, one was due to debris deposits in the stream and the other was the result of flooding in the Allegheny River which caused problems in the mouth of Glade Run.

Two flood control projects were identified in North Buffalo Township. Both involved the construction of gabion walls along the Glade Run stream channel to prevent bank erosion and to improve channel characteristics. Both of these projects were constructed by PennDOT.

Cadogan Township

Located in the southwest corner of the watershed, the portion of Cadogan Township located within the study area is only 114 acres. This represents 18.0 percent of the total municipal area and 0.7 percent of the watershed area.

As a result of its location in the upper portion of the watershed and the fact that it contains such a small land area, it would be expected that few stormwater problems exist in this portion of Cadogan Township. This was shown to be true as no flooding problems were identified as a result of the questionnaire. There are no flood control or storm sewer projects either existing or planned in this portion of the township.

RECOMMENDED APPROACHES TO PROBLEMS

Immediate corrective actions can be taken to abate many of the local minor flooding situations. These events usually occur where the storm culvert either clogs or is too small in size (hydraulically inadequate) to carry the flow. Locations of these problems areas are listed on Figure III-5 and on Table III-1. These listings are based on the information obtained from the questionnaires distributed to municipal officials. Although the development of specific solutions to these problems will involve a detailed hydrology/hydraulic engineering study and, thus, is beyond the scope of this study, the following approaches should be considered for implementation:

- Structures which currently are flooding on a regular basis should be evaluated for corrective measures. Appropriate designs should be completed and a capital budget and construction schedule established. During the design process, the downstream effects must be investigated to ensure that the problems are not simply moved to another location.

TABLE III–1
EXISTING DRAINAGE PROBLEM AREAS

MAP NUMBER*	LOCATION	MUNICIPALITY	PROBLEM	SOLUTION**
1		East Franklin Township	Flooding	Install new culvert Revegitate upstream area
2	Route 268	East Franklin Township	Flooding Sedimentation	Install new culvert
3		East Franklin Township	Flooding	Dredge the creek downstream of the problem area
4	Benjamin Franklin Highway	East Franklin Township	Flooding	Increase the size of culvert beneath the bridge
5		East Franklin Township	Flooding	Increase the size of culvert beneath the bridge
6		East Franklin Township	Flooding	Increase the size of culvert beneath the bridge
7		North Buffalo Township	Flooding	Dredge Channel to remove debris deposits and restore channel capacity
8		North Buffalo Township	Flooding of Allegheny River causing backup in Glade Run	None Proposed

* Corresponds to Drainage Problem Area numbers shown on the map.
** Solutions are generalized as provided by municipal representatives either based upon specific studies of the problems or their knowledge of the circumstances.

- Debris catching structures should be installed at the upstream end of conduits which consistently clog, and periodic maintenance activities should be implemented. (United States Department of Agriculture Soil Conservation Service, Soil Survey of Armstrong County, February 1977.)

More specific recommendations are presented on Table III-1, with general approaches to each of the identified problems being discussed.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION IV
BASICS OF HYDROLOGY

HYDROLOGIC CYCLE

The study of water in the atmosphere, on the earth, and within the earth's crust is known as hydrology. The cycle of rain falling from clouds; running off into streams, rivers, lakes, and oceans; and evaporating to form new clouds is known as the hydrologic cycle. During this cycle, flooding problems occur when the volume of runoff reaching a constricted point of interest (pipe, culvert, bridge, channel) in its travels is greater than the volume which can safely pass that point. Although many factors interact to affect the hydrologic mechanism, those with the most significance that influence the volume of runoff are:

- Precipitation - the volume of rain that falls on a specific ground area over a given period of time.
- Surface storage - the volume of rain that is stored on the surface of that specific ground area.
- Infiltrate - the volume of rain that is absorbed into the ground in that specific area.
- Overland flow - the volume of rain that runs off of a specific ground area since it is neither stored on the surface nor infiltrates into the ground.
- Channel flow - the volume of rain which is carried by a natural or man-made conduit.

The following is a brief description of these factors and the effect that land development activities have on them.

Precipitation

Precipitation is the most variable factor influencing runoff. Neither the amount nor the location of rain that falls is uniform even within a given watershed. This highly variable nature would preclude the possibility of practical hydrologic analysis if it were not for the accumulation and analysis of rainfall measurements made over the years.

This collecting of information and the associated analyses have resulted in the ability to establish the probability of occurrence of storm events of specific magnitudes and durations. These probabilities are expressed as 1, 2, 3, . . . 100-year storms. The probability of a 1-year storm occurring in any given year is 100 percent (100/1). Similarly, the probability of a five-year storm occurring in any given year is 20 percent (100/5); a 10-year storm, 10 percent; a 50-year storm, 2 percent; and a 100-year storm, 1 percent. Certain generalizations regarding storm events can be made:

- Any storm may occur one or more times during any given year.

- The more intense the rainfall, the less likely will be its occurrence.

- Higher intensity rainfalls occur over shorter periods of time.

- Rainfall intensity during a storm increases over time to a maximum and then decreases over time to zero.

In order to deal with the variable nature of rainfall, statistical analysis is used. Government agencies such as the National Weather Service and the Pennsylvania Department of Environmental Resources (DER) have compiled long-term rainfall data and have published rainfall-duration-frequency information. Figure IV-1 shows a standard rainfall intensity distribution chart relating inches of rain per hour

COMPOSITE 100-YEAR STORM

(1) Duration (min.)	(2) Intensity (in./hr.)	(3) Rainfall (inches)
5	7.4	0.62
10	6.1	1.02
20	4.7	1.57
30	3.9	1.95
40	3.3	2.20
60	2.5	2.50
90	1.9	2.85
120	1.55	3.10

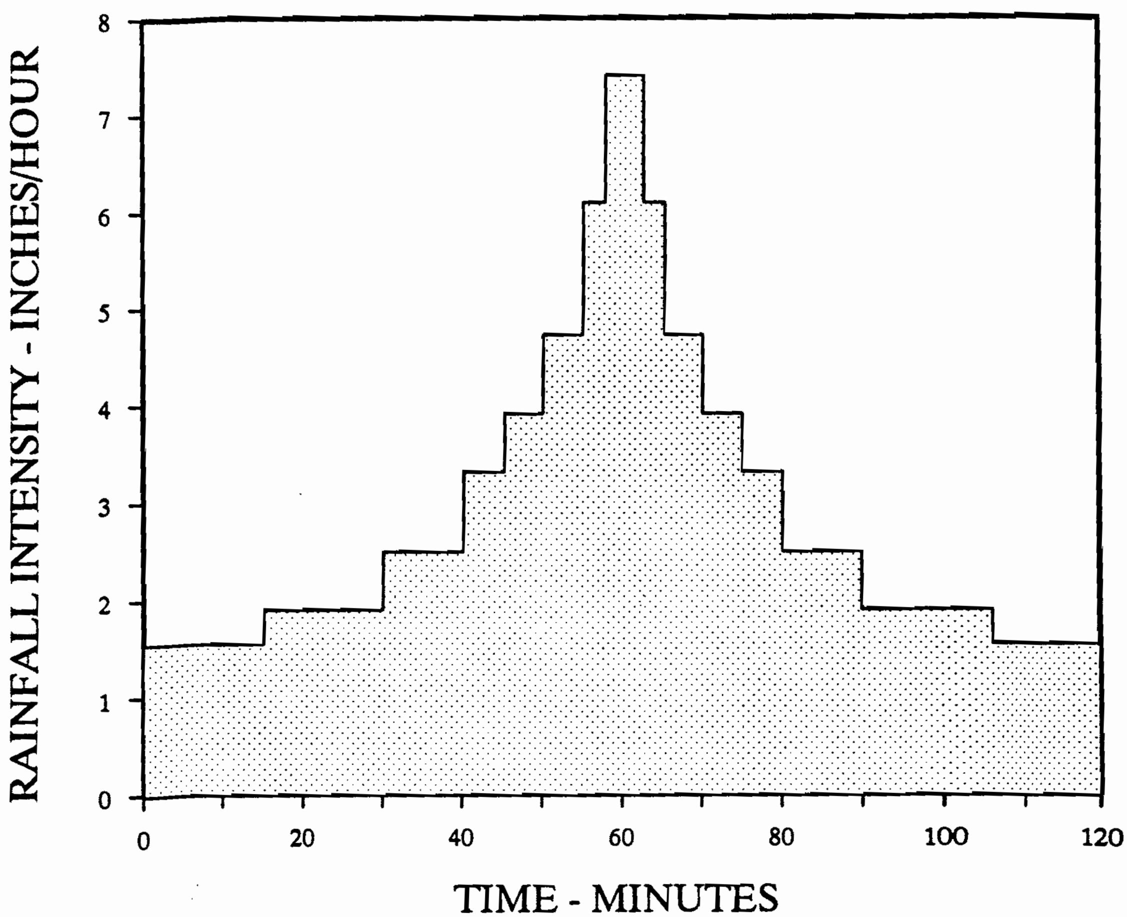


FIGURE IV-1

to time. The example shown is for a 100-year storm event and presents both the intensity of the rainfall (Column 2) and the total amount of rainfall (Column 3). This type of information is used for planning and design purposes to predict the gross amount of rainfall and the associated intensities which must be taken into account. Although development has no direct effect on the amount or intensity of rainfall, it does increase both the volume to be handled and the rate at which overland flow takes place.

Surface Storage

Rainfall is trapped in natural or man-made depressions in the terrain. Development activities often change the terrain in order to make more acreage available for buildings, to improve aesthetics, or to eliminate health hazards. When a reduction in storage occurs, both the volume and the rate of runoff increase. Conversely, the rebuilding of storage capabilities by using stormwater management techniques, such as detention facilities, reduces the volume and rate of runoff.

Infiltration

Absorption of rainfall into the terrain is known as infiltration; conversely, the amount of rainfall which is not absorbed is known as runoff. Considerable study has been done to determine the percentage of total rainfall which will infiltrate into various soil types and alternative ground covers. The Soil Conservation Service Technical Release No. 55 is used by many engineers to determine these values. Typically, the infiltration rate for sandy soil with thick vegetation ground cover could be 85 percent, compared to only 50 percent for clay soils with similar cover. The type of ground cover further influences the percentage of runoff. Thick lush forests are characterized as high-rate infiltration areas, whereas areas with only bare ground cover will have lower infiltration rates and correspondingly higher runoff rates.

When development occurs, ground cover is reduced or eliminated with the resulting increase in the rate and quantity of runoff. It is possible for runoff values to increase dramatically from 15 to 95 percent if a forest growing in good absorbing soils is converted to a shopping mall with large paved parking areas. In this example, the runoff rate would increase six to seven times, thus impacting adjacent properties and/or downstream waterways. Proper planning during the design phase of a development project will enhance infiltration rates through the use of various infiltration techniques (gravel drains, open spaces, etc.).

Overland and Channel Flow

That portion of flow runoff traveling on land prior to reaching a stream channel is overland flow. Of importance is the velocity at which the flow travels. This is influenced by terrain slope, surface cover characteristics, and the shape of the flow conveyance system.

Channel flow consists of that portion of precipitation that reaches the channel by runoff from the surface (overland flow) or by flowing through the soil as groundwater. The resultant stream flow is total runoff, and the rate of flow is referred to as rate of runoff expressed in cubic feet per second (cfs).

As development occurs, the flow characteristics may be altered. Often the alterations result in an increase in the flow velocity, as well as an increase in volume. For example, if a farm is converted to a housing plan, the runoff which once infiltrated into the natural ground cover or traveled overland through fields and pastures now travels in gutters and storm sewers. This new conveyance system is smoother; and as a result, the flow travels at a faster speed.

ESTIMATING THE RATE OF RUNOFF

To calculate the rate of runoff at a point of interest (pipe, culvert, bridge, channel), the total area of the watershed which drains to that point is determined. Then, by estimating the various values of the hydrologic cycle that influence runoff (precipitation, surface storage, infiltration, overland, and channel flow) the rate of runoff can be computed. This estimated runoff is then compared with the capacity of the opening at the point of interest. If the actual capacity is less than the calculated capacity, the runoff will back up and flooding will occur.

Hydrographs

A hydrograph is a graphic procedure for showing the rate of runoff to time at a point of interest which could be a bridge, culvert, or constricted channel section. There are a variety of ways to prepare a hydrograph. The most accurate is by comparing recorded rainfall to recorded stream flow at a bridge. This is an ideal approach but is rarely possible due to the lack of recording stations at points of interest. Lacking this data, common practice involves the generation of runoff information by estimating values for individual elements of the hydrologic cycle.

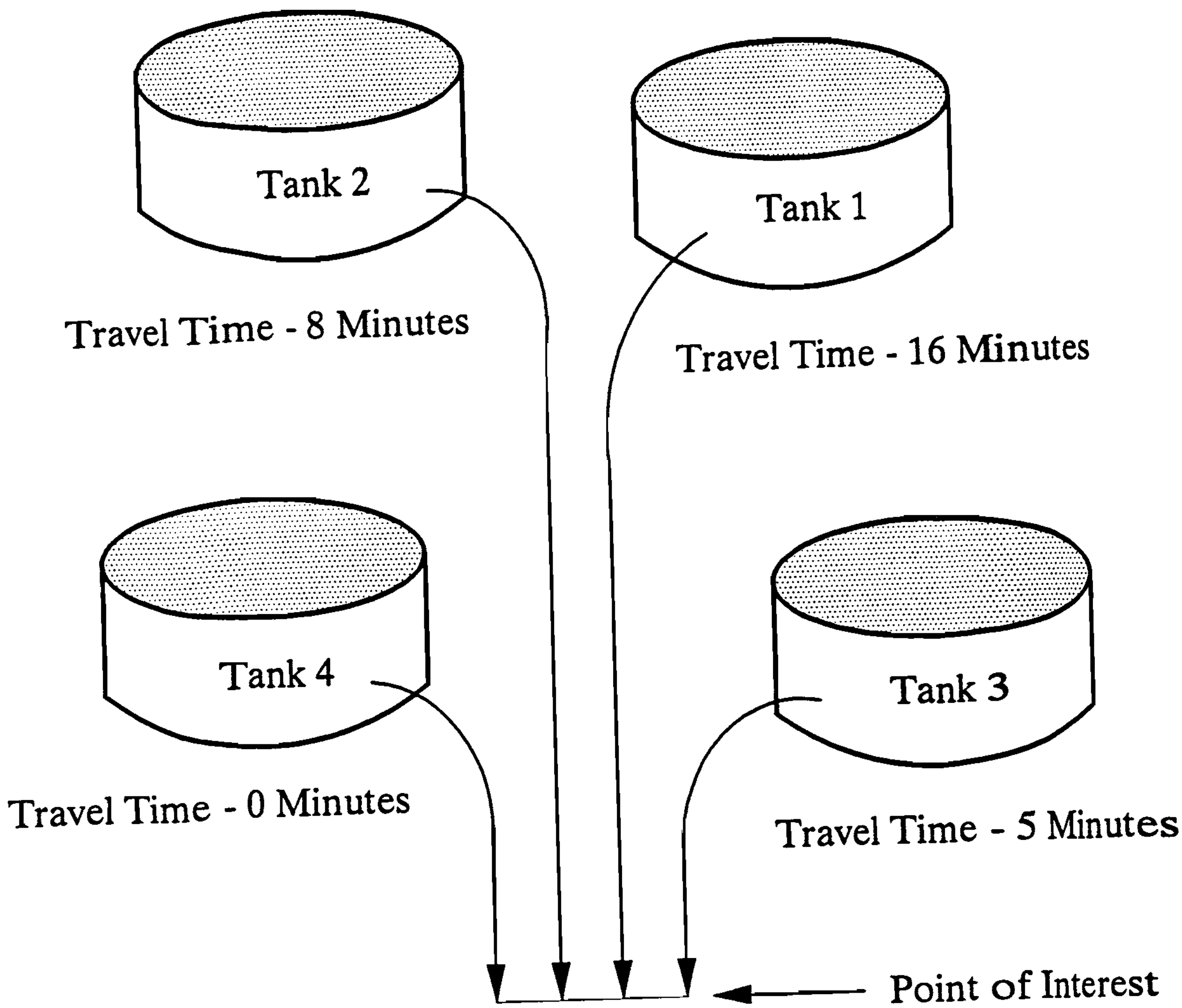
To illustrate how a hydrograph is prepared, the following example uses equal size water tanks in place of watershed subbasins (Figure IV-2). The example simulates ideal field conditions which differ from those encountered in a watershed in the following areas:

- The total flow volume from each tank is the same. In an actual watershed the runoff quantity and rate varies greatly due to the influences of soil infiltration, storage, and size of the basin (and subbasins).

- The rate of flow from each tank is uniform. In the example, it takes five minutes to open the valves completely in each tank (similar to the beginning of a rainfall). At this point the maximum flow is four gallons per minute. Fifteen minutes later, the tanks are drained completely (similar to end of rainfall) with the rate of flow reducing uniformly from four gallons per minute to zero over this 15-minute period. In nature, this is replaced by rainfall intensity values which vary over time in a nonlinear manner.

- A travel time value for the water from each tank to pass the point of interest has been assumed, making the cumulative runoff rate at that point readily determinant. In an actual watershed these travel time values are determined from flow velocities and are difficult to compute accurately because of the variation in the physical characteristics of the flow channel (changes in slope and cover type).

Tank Travel Times



Source: Allegheny County, Act 167 Pilot Stormwater Management Plans, 1982.

FIGURE IV-2

The key to understanding a hydrograph is to understand the formation of the total hydrograph from the subbasin runoff contributions. In the case of the water tank example, the total rate of flow passing the point of interest is a result of the contributions from the individual tanks.

Figure IV-3 is the hydrograph associated with Tank 3. In this figure it has been assumed that it takes five minutes (travel time) for the first drop of water released from the tank to reach the point of interest (Graph A). Figure IV-3 also shows the increase (Graph B) and decrease (Graph C) in flow rate at the point of interest resulting from the opening of the valve (five minutes) and the draining of the tank (15 minutes). Thus, the maximum flow rate from Tank 3 occurs at the point of interest ten minutes after starting to open the valve. This time represents the combined time of travel (five minutes) and valve opening (five minutes).

When all the tank valves are opened simultaneously similar graphs are created for the other tanks (see Figure IV-4). Because all flow rates and volumes are the same in this example, the only variation between each hydrograph is the travel time for the first drops from the various tanks to reach the point of interest. It is to be noted that the beginning point for each hydrograph in Figure IV-4 represents that point in time when the flow from a tank begins to pass the point of interest.

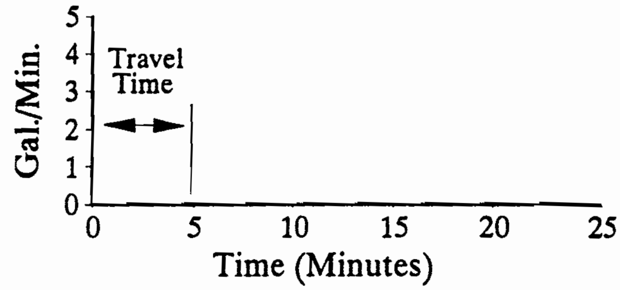
As each tank drains, the volume of water in the tank reduces; and the gallons per minute discharging from the tank reduces to zero. As shown in the hydrograph in Figure IV-4, the last drop leaving Tank 3 passes the point of interest 25 minutes after the first drop leaves the tank. The figure also shows that the flow at the point of interest from Tank 3 reaches its maximum rate at ten minutes.

Figure IV-4 also shows the rate of flow for the other tanks which were developed in a similar fashion. All of these hydrographs are plotted over a common time span.

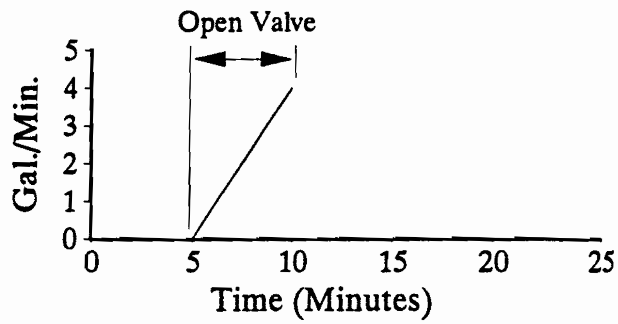
To determine the cumulative rate of flow from each tank at the point of interest and for a selected point in time, the flow rates associated with each tank at that time are totaled. Figure IV-4 has a cumulative rate table giving the contributing rate for various points along the hydrographs. The points are plotted giving the cumulative

Tank 3 Flow Rate Graph

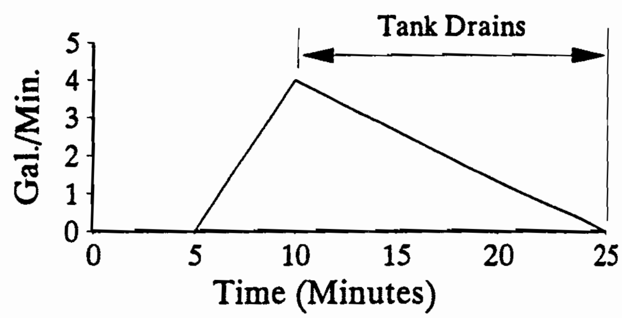
Graph A:



Graph B:



Graph C:

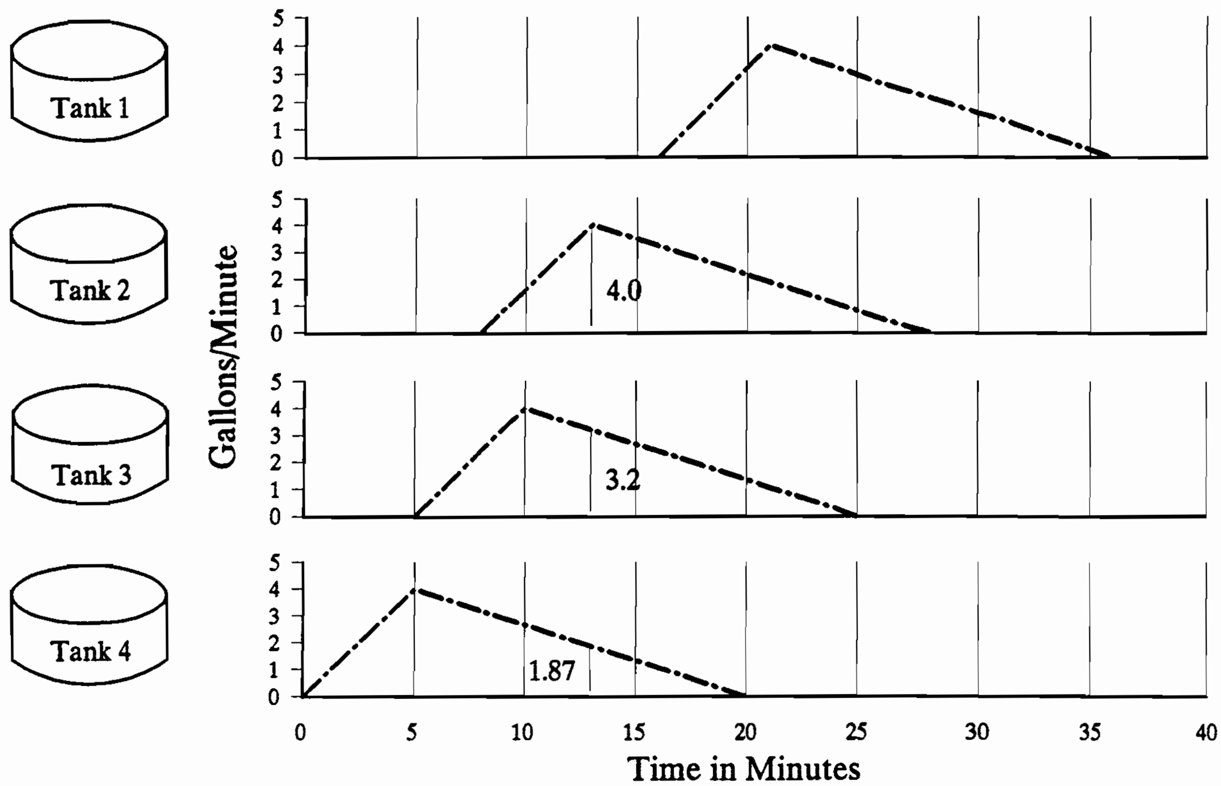


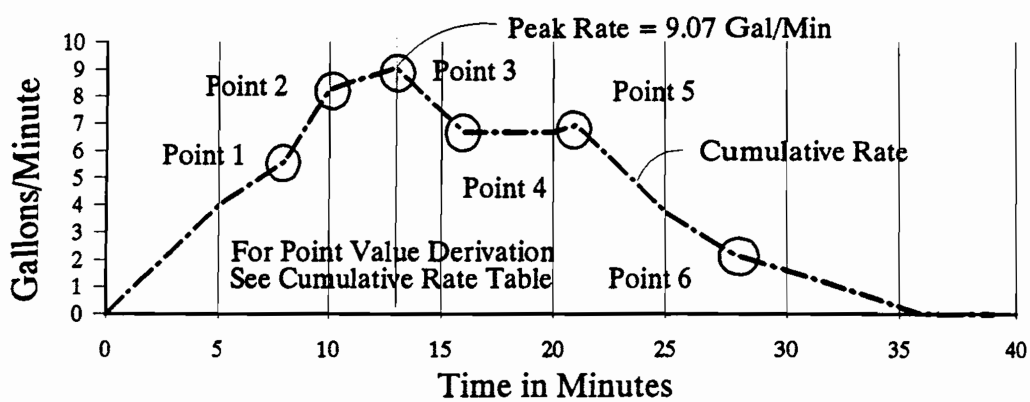
Time (Minutes)	0	5	6	7	8	9	10	15	20	25	30	35
Flow Rate (Gal/Min)	0	0	.8	1.6	2.4	3.2	4.0	2.7	1.3	0	0	0

Source: Allegheny County, Act 167 Pilot Stormwater Management Plans, 1982.

FIGURE IV-3

Cumulative Flow Rate





Cumulative Rate Table						
		Contribution in Gal./Min.				
Point	Time (Min.)	Tank 1	Tank 2	Tank 3	Tank 4	Total
1	8	0.00	0.00	2.40	3.20	5.60
2	10	0.00	1.60	4.00	2.67	8.27
3	13	0.00	4.00	3.20	1.87	9.07
4	16	0.00	3.20	2.40	1.07	6.67
5	21	4.00	1.87	1.07	0.00	6.94
6	28	2.13	0.00	0.00	0.00	2.13

Source: Allegheny County, Act 167 Pilot Stormwater Management Plans, 1982.

FIGURE IV-4

flow rate at the point of interest, and the peak rate is the highest value (Point 3). For this example, the peak rate of flow is nine gallons per minute, occurring 13 minutes after all the valves were opened. It should be noted that the travel time for Tank 1 is 16 minutes, which means that flow from Tank 1 has not even arrived at the design point when the peak rate occurs.

This example uses ideal conditions with uniform values. If the size of the tanks varies, if the time required to open the valves varies, if the time of draining the tanks varies, or if the maximum rate from each tank varies, the concept explained above to develop the cumulative flow rate would be the same. However, the individual hydrographs would take varying shapes with a resulting change in the cumulative flow rate.

Applying the Example to Watershed Conditions

By altering some of the values used in the example, it is possible to relate this application to actual watershed conditions. In a watershed, flow rates from each subbasin within the watershed will vary to reflect size and infiltration characteristics, travel times will vary reflecting channel slope and configuration, and maximum flow rates may change as infiltration characteristics are reduced due to land use changes. The following variations to the example are used to illustrate this point.

- The flow rate from Tank 2 contributing to the peak rate is equal to the maximum flow rate from the tank of four gallons per minute. If a change in conditions occurred whereby the maximum flow rate from Tank 2 increased to five gallons per minute, the peak rate would increase from nine to ten gallons per minute. In a watershed, this is what occurs when development increases the rate of runoff from a site.

- The travel time for Tank 1 is greater than that time at which the cumulative peak rate occurs (13 minutes). If the travel time is reduced to less than 13 minutes, then Tank 1 also will begin to contribute to the peak rate, again resulting in an increase in the peak. In a watershed, this could occur when flow velocity increases and the travel time is reduced. For example, changing a natural channel to a concrete-lined ditch or a storm sewer system increases velocity and reduces travel time to the point of interest.

- The maximum flow rate of four gallons per minute from Tank 3 occurs before the peak rate. If the maximum flow rate of four gallons per minute were to be maintained for a longer time (see dashed line in Figure IV-4 - Tank 3), the contributing rate from Tank 3 would increase from 3.25 to 4.0 gallons per minute, and the peak rate would increase from 9.0 to 9.75. In a watershed this could occur if new development increased the volume of runoff and the developer constructed a detention facility and released the maximum rate over a longer period of time.

A comprehensive strategy of stormwater management requires an understanding of the hydrologic cycle and how to estimate the rate of runoff. This chapter uses a simple example to illustrate the basic principles. The following chapter applies these principles to a sample watershed and shows the importance of analyzing the interrelationship of subbasin flow with the watershed peak rate of runoff. It illustrates how stormwater problems may occur in the absence of watershed planning. A strategy is then developed that leads to the technical recommendations of the Stormwater Management Plan.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION V
TECHNICAL APPROACH TO WATERSHED PLANNING

One of the key features of the Storm Water Management Act (Act 167) is its mandate to implement comprehensive watershed control of stormwater runoff. This requires stormwater planning at the watershed level and that watershed plans develop standards for managing stormwater to prevent adverse impacts, both at a particular site and anywhere downstream where the potential for harm can be reasonably identified. Therefore, any technical approach to stormwater planning must consider runoff impacts throughout the watershed.

To achieve this objective, the study utilized an approach similar to the simplified example of the water tanks. Using computer simulation modeling and desk-top calculations, the study area watersheds were divided into numerous subbasins. Runoff flow rates of the subbasins were computed and analyzed, both individually and in terms of the collective effects in the watershed. In this way it was possible to determine how each subbasin's runoff rate contributes to the watershed's flow rates. This approach led to an analysis of the practice of defining stormwater management controls only with respect to a particular subbasin and how such practices actually may result in increases to the rate of runoff at some downstream location.

This chapter explains the problems of designing stormwater controls without comprehensive watershed planning using a sample watershed. It describes the strategy (referred to as the release rate percentage concept) developed to address these problems, as well as identifying hydraulically sensitive subbasins in the four study area watersheds. In addition, this chapter includes a discussion of the design storm frequencies, which are storm events that the stormwater management system will be designed to accommodate.

SAMPLE WATERSHED HYDROGRAPH

A sample watershed with five subbasins is shown in Figure V-1. Figure V-2 includes a hydrograph of the watershed which presents the individual hydrographs for each subbasin and the cumulative rate of runoff for the total basin. The subbasin runoff graphs are typical hydrographs developed in the same manner described for the water tanks in the previous section. However, these hydrographs reflect the variables associated with the hydrologic cycle. Assumed values were used for this example.

To further illustrate the development of the hydrograph, Figure V-3 isolates the runoff from Subbasin 3. As can be seen, the travel time through Subbasins 4 and 5 is 40 minutes. This represents the time at which Subbasin 3 begins contributing discharge to the point of interest, which in this example is the base of the watershed. Subbasin 3's maximum runoff of 500 cubic feet per second (cfs) occurs at 60 minutes, and the contributing rate to the watershed peak is 400 cfs occurring at 70 minutes (Figure V-2 and V-3).

For purposes of this example, it is assumed that a development is proposed for the entire Subbasin 3, which increases the subbasin's maximum rate to 800 cfs (Figure V-4). After utilizing appropriate stormwater management techniques, the runoff rate is reduced to 600 cfs but is still higher than the maximum rate prior to development (500 cfs). This increase is in contradiction to Section 13(1) of Act 167 since the maximum rate after development is greater than the maximum rate before development. For this example, the developer proposes a detention facility with the release rate equal to the maximum rate of 500 cfs prior to development (Figure V-5).

As shown in Figure V-5, the maximum rate from Subbasin 3 occurs at 60 minutes, which is prior to the watershed peak that occurs at 70 minutes. The release rate from the proposed detention facilities extends the time duration that the maximum rate of 500 cfs is released, and the rate contributing to the watershed peak increases proportionally. Therefore, although the developer may appear to be in compliance with Act 167, the actual effect of the detention facility for this subbasin is an

SAMPLE WATERSHED PLAN (5 Subbasins Total)

Source: Allegheny County, Act 167 Pilot Stormwater Management Plans, 1982.

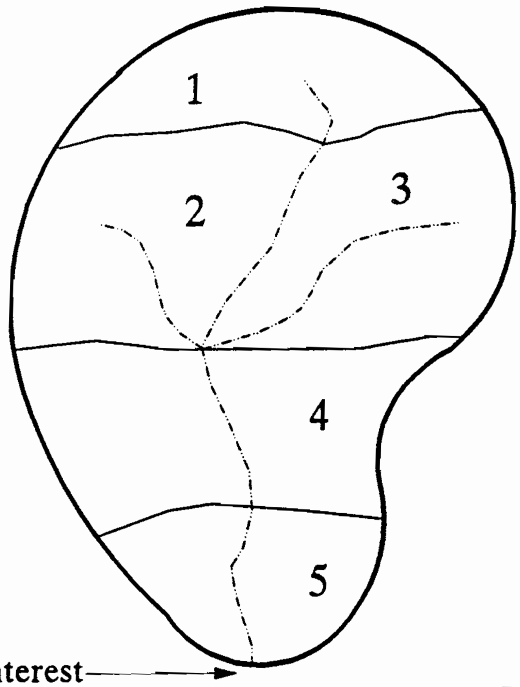


FIGURE V-1

SUBBASIN HYDROGRAPH

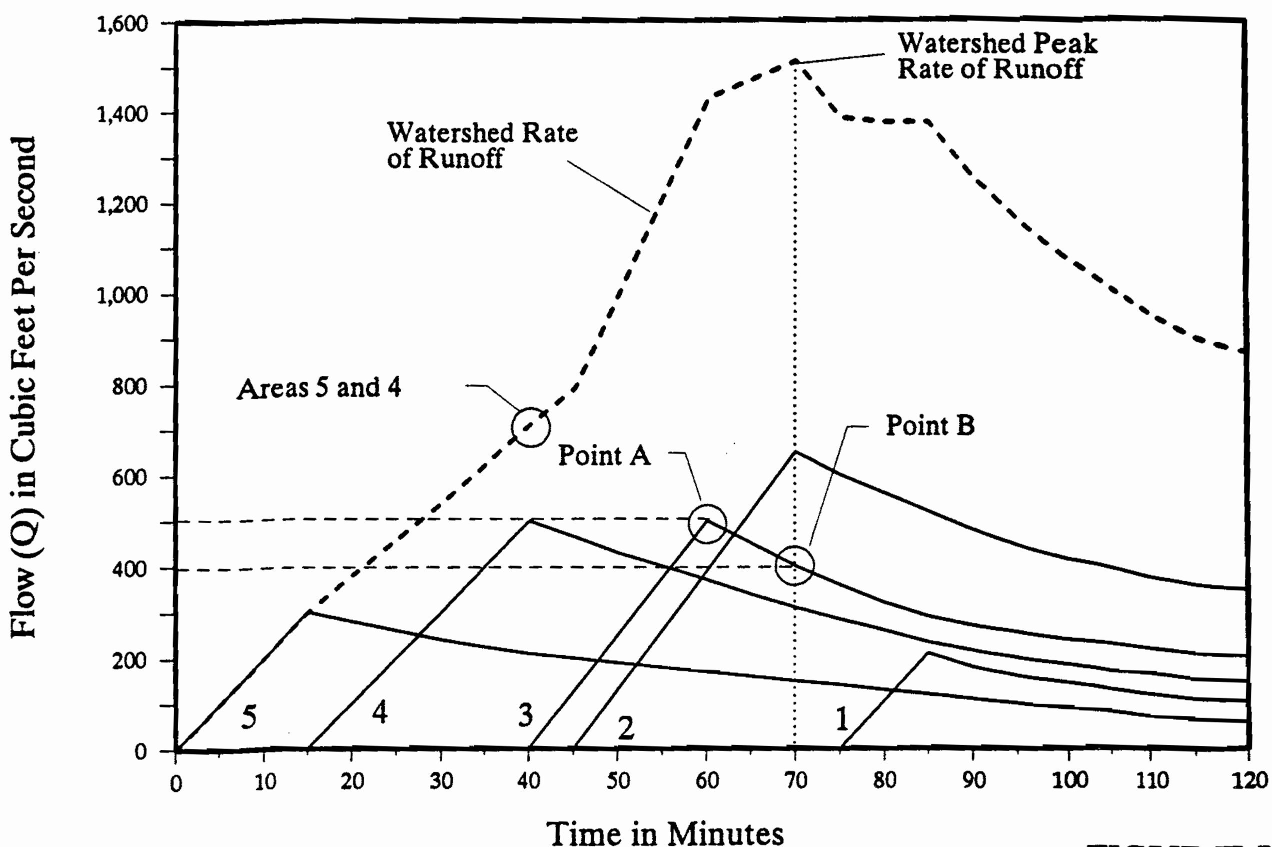


FIGURE V-2

SUBBASIN HYDROGRAPH

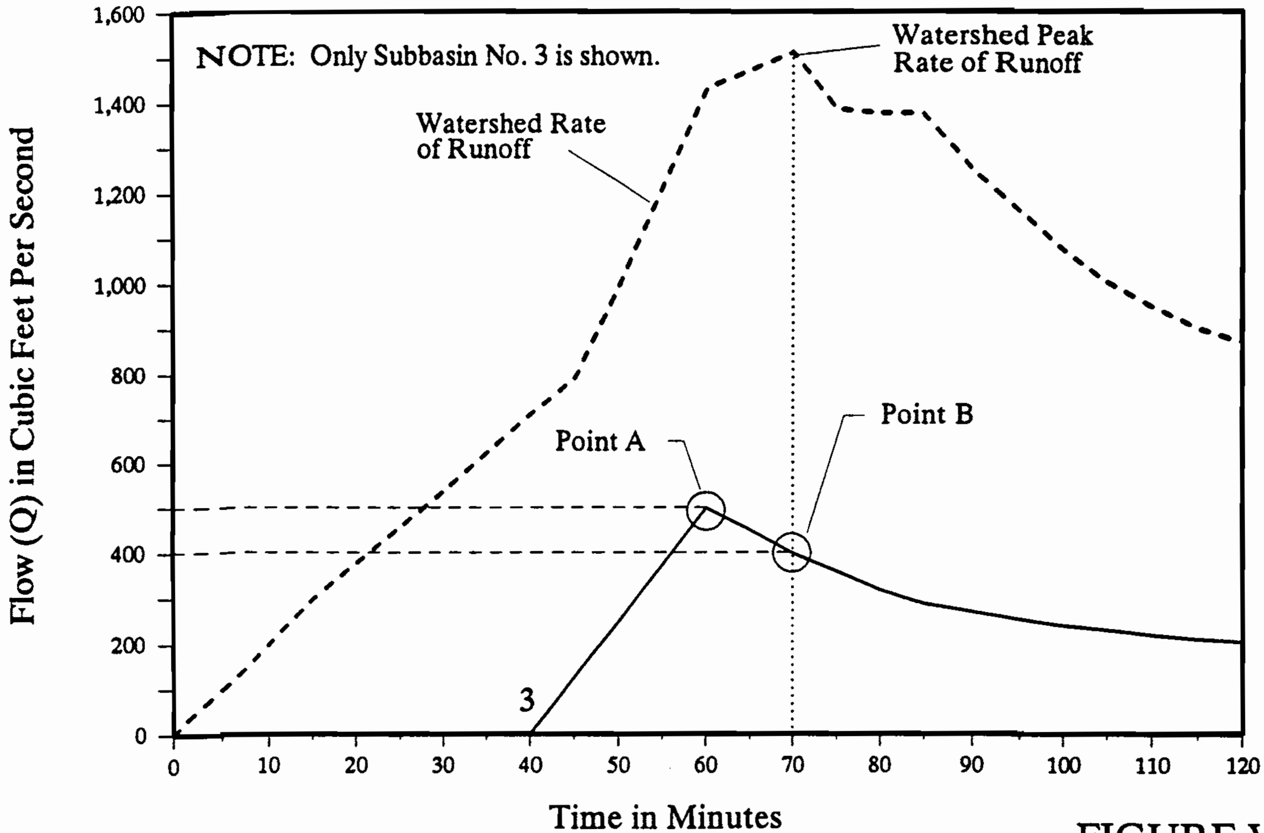


FIGURE V-3

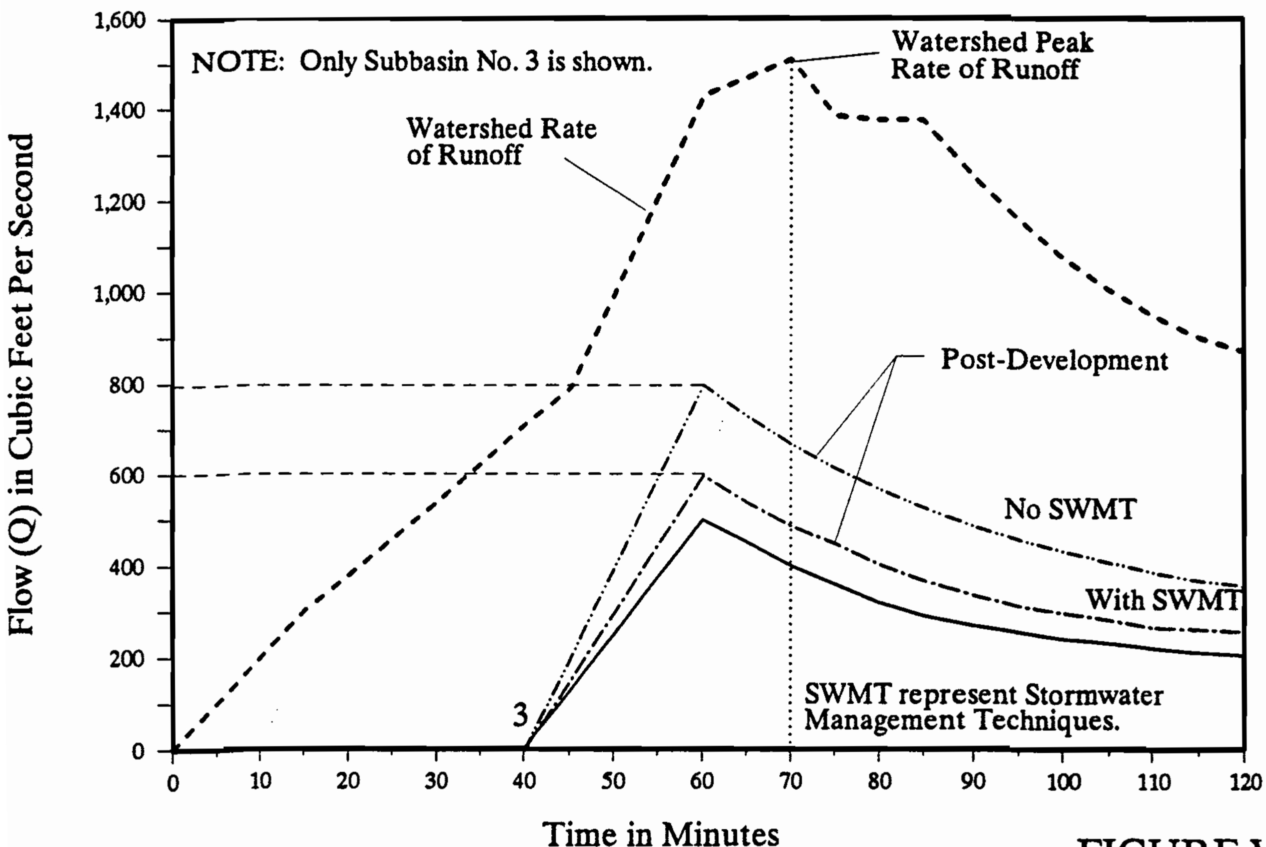


FIGURE V-4

SUBBASIN HYDROGRAPH

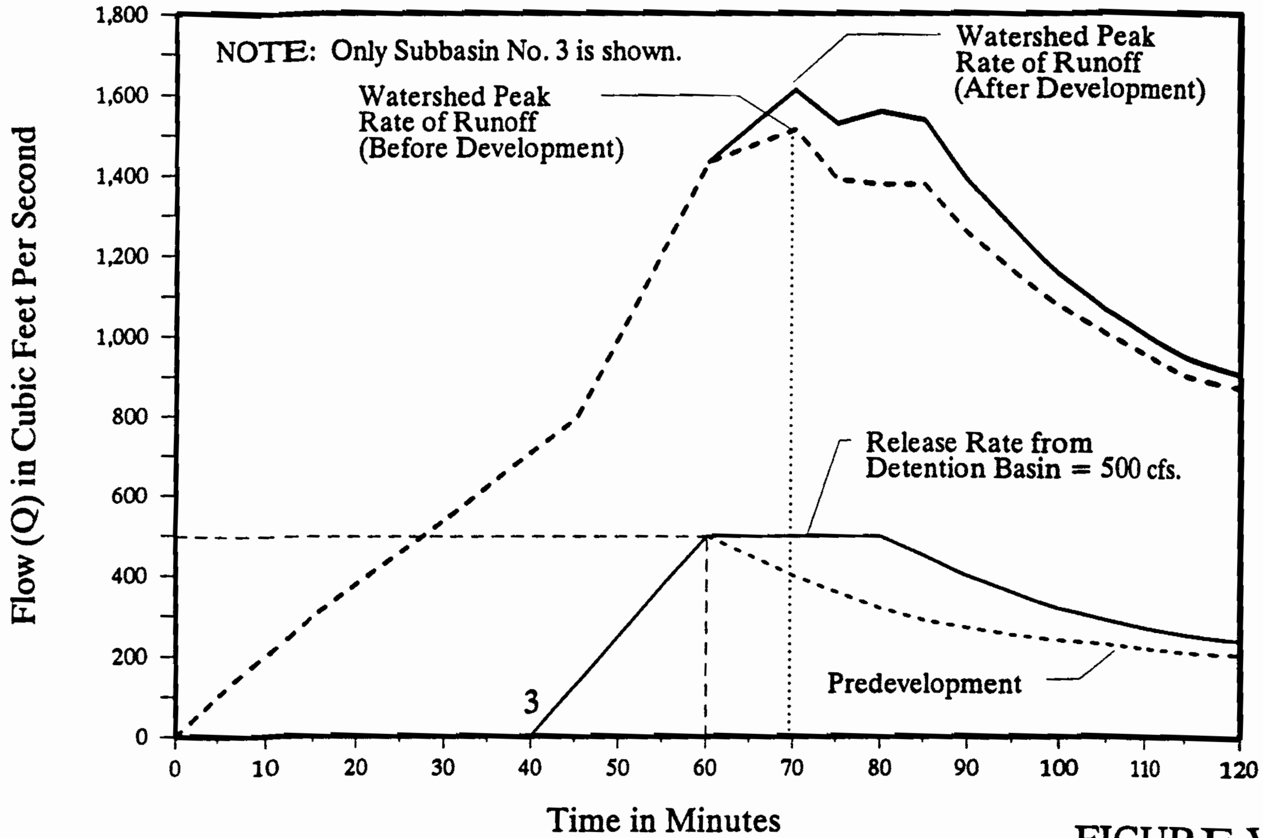


FIGURE V-5

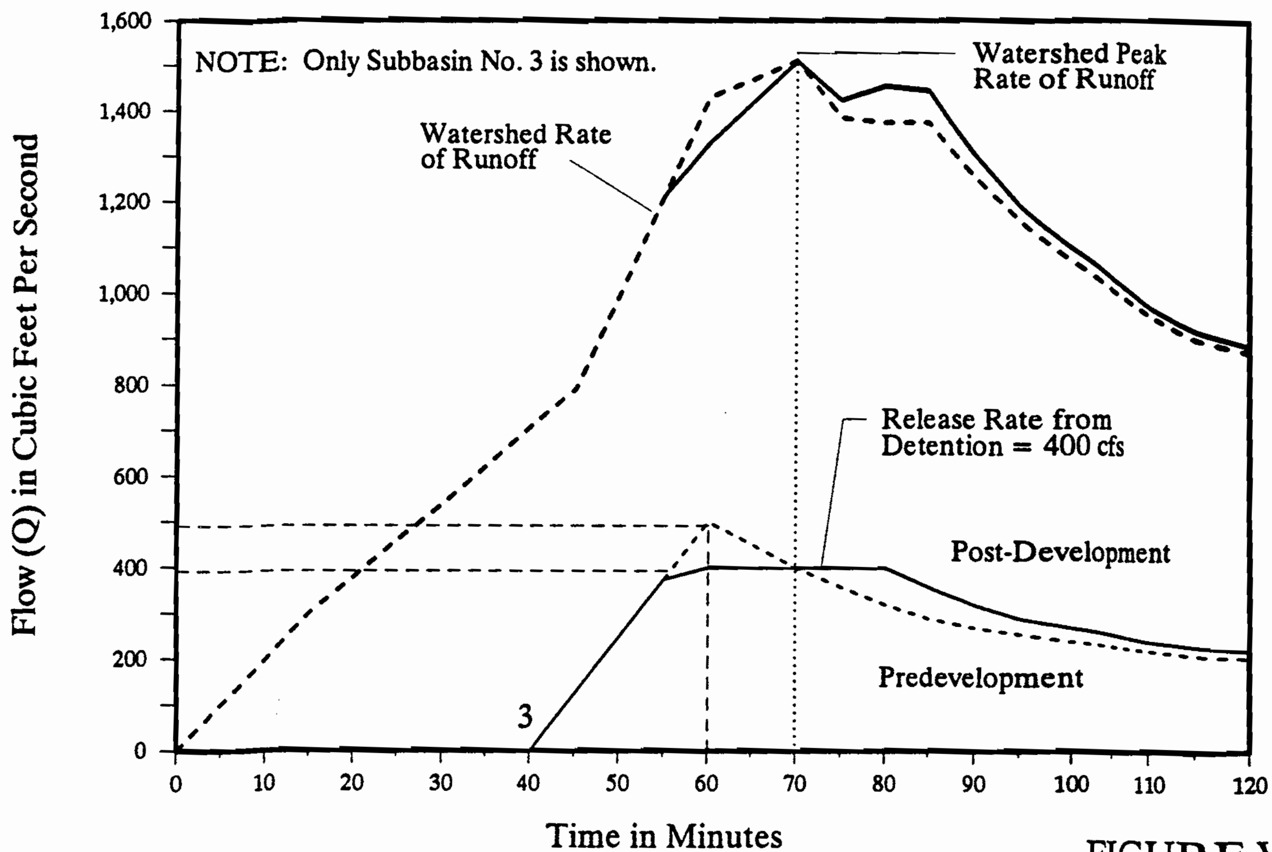


FIGURE V-6

increase from 400 to 500 cfs in its watershed contributing rate and, consequently, an increase in the watershed peak by 100 cfs.

This result will not occur for every subbasin. It will happen where the subbasin's maximum rate occurs prior to the time that the watershed peak occurs. In this example, the peak for Subbasin 1 occurs after the watershed's peak, and, therefore, a similar detention facility would not result in the same problem.

The detention facility used in Subbasin 3 illustrates the inherent problem that may be created at any point of interest when the detention release rate is equal to the site's maximum predevelopment discharge rate. In Subbasin 3, this predevelopment release rate is 500 cfs, although the subbasin only contributes 400 cfs to the total watershed peak. To avoid increasing the watershed peak and the potential for harm, the release rate from the detention facility should be 400 cfs rather than 500 cfs (Figure V-6). Thus, the size of the detention facility must increase to retain the additional volume.

The safe release rate can be determined for a subbasin by calculating the ratio of the subbasin maximum runoff rate to the subbasin rate of runoff contributing to the watershed peak. For Subbasin 3, the release rate percentage would be:

$$\frac{\text{Subbasin Contributing Rate}}{\text{Subbasin Maximum Rate}} = \text{Release Rate Percentage}$$

$$\frac{400 \text{ cfs}}{500 \text{ cfs}} = 80\ \%$$

By applying the release rate percentage, the development is able to match the subbasin rate contributing to the predevelopment watershed peak.

RELEASE RATE PERCENTAGE CONCEPT

The previous section described the release rate percentage concept using a simplified example. This section presents the general strategy that was used to develop the release rate concept into a watershed planning technique.

The intent of the release rate concept with its associated percentages is to identify (for a total watershed) the general characteristics of subarea interactions and combinations and their relative impact on potentially damaging flood flows. This concept was developed to be fully responsive to the intent and needs of Pennsylvania Act 167. The release rate concept provides a performance standard for storm drainage control in a watershed. The significance of it lies in the fact that the concept provides an effective tool for comprehensive watershed stormwater planning.

The overall approach is to establish release rate percentages for each subbasin within a watershed by determining the maximum rate of runoff and the rate contributing to downstream subbasins. This is achieved by using the Penn State Runoff Model (PSRM) to develop the necessary flow rate values. The specific steps in the approach are:

- Perform overall watershed modeling using the (PSRM).

- Identify the actual flow contribution that a particular subarea contributes to a point of interest. In this case, the points of interest are defined as each of the downstream subbasins.

- Develop release rate percentages that consist of the individual subarea contribution to the peak flow rate at the point of interest, divided by the individual subarea peak flow rate.

The primary element of this process is the selection of the points of interest in the watershed. The overriding justification for the selection of points of interest is the desire to provide overall watershed storm runoff control through effective control of individual subarea storm runoff. Comprehensive control of storm runoff for the entire watershed can be achieved if each individual tributary or branch of the major drainage system is controlled.

In the past, points of interest were established at the confluence points of all tributaries and branches to the primary drainage system. In addition, the municipalities identified existing storm runoff problems at various points throughout the watershed. These include inadequately sized structures that flood, erosion problems, and frequent maintenance problems.

The fact that desk-top calculations were employed limited the number of points of interest that could reasonably be examined. Recently this was changed, however, in that release rate percentages are now calculated as a part of the PSRM program. It is possible, therefore, to calculate release rate percentages for each subbasin with respect to all of the other subbasins and then to select the limiting rate of release.

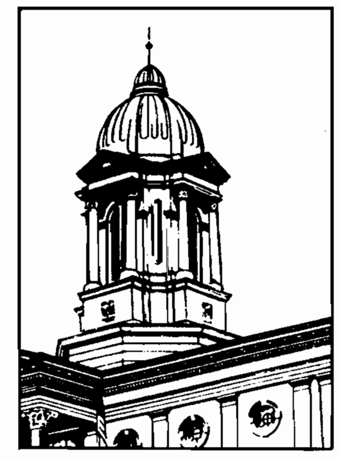
The subbasins in the study area are delineated in Fiqure V-7. The release rate percentages are presented in Table V-1 by subbasin.

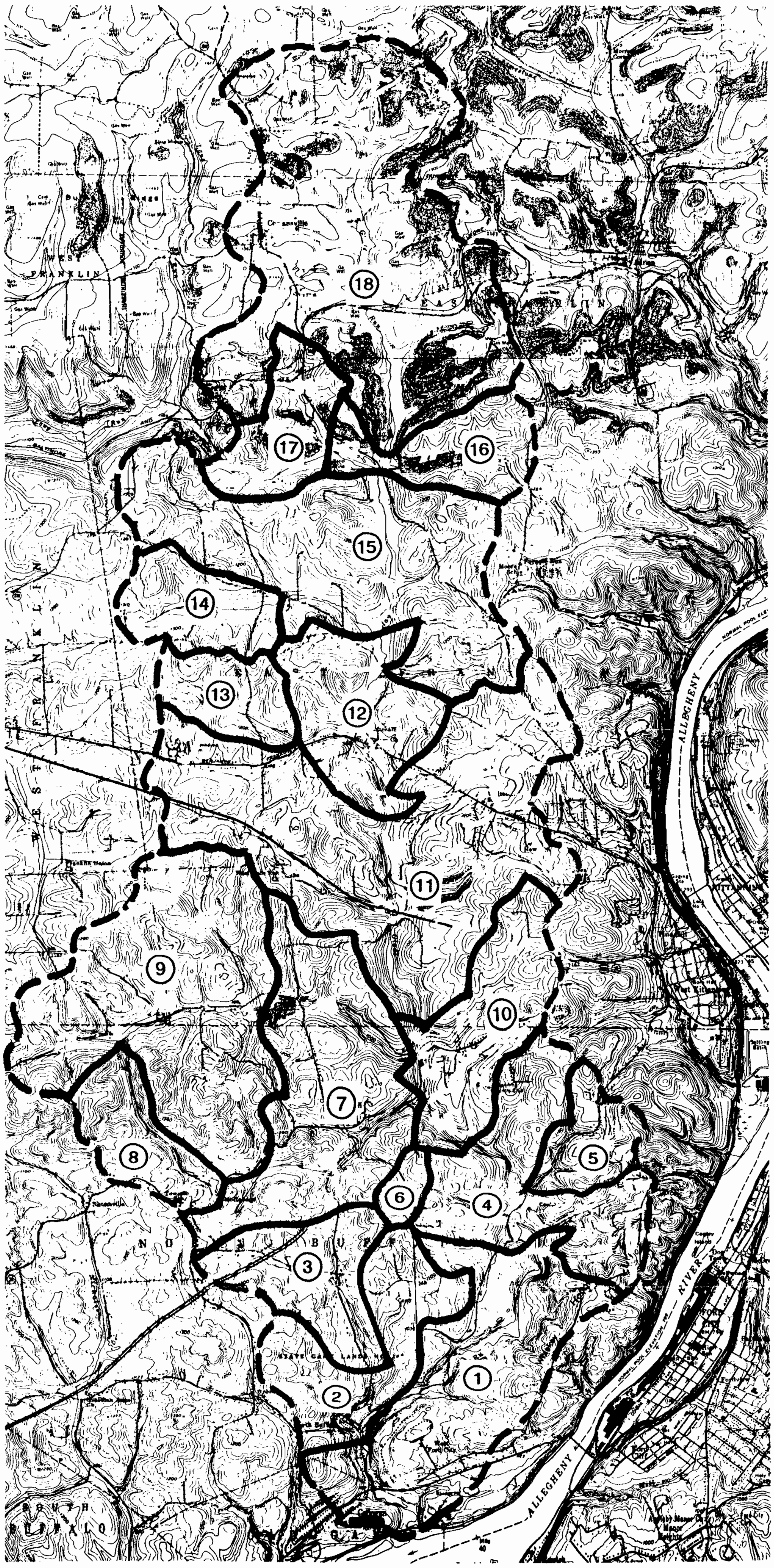
Lower Limit of Assigned Release Rate Percentages

The direct application of release rate percentage computational techniques produces calculated release rate percentages ranging from 1 percent to 100 percent. The application of release rate percentages approximating zero would preclude any runoff from a site. Control to this extreme would essentially prohibit development and would be unacceptable. It is therefore necessary to define an acceptable lower limit to assigned release rate percentages. Two factors to be considered in determining an appropriate and acceptable lower limit to assigned release rate percentages are: (1) economic risk/benefit considerations, and (2) hydrologic or streamflow effects.

The Little Lehigh Creek Watershed Plan attempted to provide quantitative information in support of the location of a breakpoint between where the calculated

Armstrong County
Stormwater Management Plan
Glade Run Watershed





Release Rate Percentage Map

Legend

- Watershed Boundary
- Municipal Boundary
- Sub-basin Boundary
- ③ Sub-basin Number

RELEASE RATE PERCENTAGES

RELEASE RATE AREA	TOWNSHIP	RELEASE RATE PERCENTAGE
1	Cadogan	100
1	North Buffalo	100
2	North Buffalo	60
3	North Buffalo	70
4	North Buffalo	70
5	North Buffalo	100
6	North Buffalo	90
7	North Buffalo	80
7	East Franklin	80
8	North Buffalo	50
9	North Buffalo	60
9	East Franklin	60
9	West Franklin	60
10	North Buffalo	60
10	East Franklin	60
11	East Franklin	70
12	East Franklin	60
13	East Franklin	90
14	East Franklin	70
15	East Franklin	80
16	East Franklin	70
17	East Franklin	60
18	East Franklin	50
18	Sugar Creek	50
18	Washington	50

N

5000 0 5000 10000
scale feet

FIGURE V-7

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TABLE V-1

GLADE RUN STORMWATER MANAGEMENT PLAN
ARMSTRONG COUNTY, PENNSYLVANIA

RELEASE RATE PERCENTAGES

RELEASE RATE AREA	TOWNSHIP	RELEASE RATE PERCENTAGE
1	Cadogan	100
1	North Buffalo	100
2	North Buffalo	60
3	North Buffalo	70
4	North Buffalo	70
5	North Buffalo	100
6	North Buffalo	90
7	North Buffalo	80
7	East Franklin	80
8	North Buffalo	50
9	North Buffalo	60
9	East Franklin	60
9	West Franklin	60
10	North Buffalo	60
10	East Franklin	60
11	East Franklin	70
12	East Franklin	60
13	East Franklin	90
14	East Franklin	70
15	East Franklin	80
16	East Franklin	70
17	East Franklin	60
18	East Franklin	50
18	Sugar Creek	50
18	Washington	50

release rate should be strictly adhered to through implementation of runoff controls and where no control option should be used. The plan presents an analysis of the cost for a "typical" development of the construction of stormwater detention basins under various release rate percentages. The conclusion drawn from the cost analysis is as follows:

> The conclusion from all of the above is that there is no obvious breakpoint release rate from a cost standpoint and that the only way to determine if a particular breakpoint can achieve the goal of no increase in peak flow throughout the watershed is to establish one, develop the pertinent criteria, and examine the resultant peak flows. To that end, a 50 percent release rate has been selected as the breakpoint based on the following rationale:
>
> - A 50 percent release rate is the median value and represents a straight compromise between runoff control cost and absolute control effectiveness.
>
> - A 50 percent breakpoint release rate does not preclude meeting the no increase in peak goal as documented by the watershed analysis. (Little Lehigh Creek Watershed Act 167 Storm Water Management Plan)

The evident difficulty in defining the costs and economic value of the benefits associated with various levels of control point to the advisability of applying a hydrological/streamflow basis analysis to the identification of a reasonable lower limit to assigned release rate percentages. As was alluded to in the Little Lehigh Creek Plan, an assessment of the potential effect of the flows from subbasins with calculated release rates below specified levels upon peak discharges at downstream reaches represents a reasonable basis for selecting a low end cut off point. If it is possible to identify a release rate below which the impact on downstream discharges is demonstrably negligible, that release rate could reasonably be selected as the lower limit to assigned release rate percentages.

Such an analysis was completed for the Glade Run Watershed to indicate the relationship between calculated release rate percentages and the magnitude of the impact of peak discharges from the tributary subbasins on peak discharges at the downstream reaches. The analysis was conducted as follows:

- Calculated release rate percentages at each downstream reach for each tributary subbasin were tabulated. This information was obtained from intermediate output files produced by the PSRM model runs.

- Modeled peak discharges at each reach and peak runoff rates from each tributary subbasin were extracted from the PSRM output files.

- These data sets were merged to produce a matrix which contained calculated release rate percentages and the associated peak discharge for the affected reach together with the peak runoff rate from the subbasin.

- The ratio (expressed as a percentage) of tributary peak runoff rate to the associated downstream reach peak discharge was determined for each calculated release rate percentage.

- The ratios of subbasin peak runoff rates to peak discharges at the associated downstream reaches were plotted against calculated release rate percentages.

- Polynomial regression analyses were performed to produce a best fit curve for the data representing all points through the watershed.

The resulting graph is presented as Figure V-8. Based on the analysis performed, the values on the "Y" axis represent the maximum percentage that flows from a subbasin could increase peak flows at the associated point of interest if the subbasin discharges were attenuated so that the peak runoff rate was extended sufficiently long to match with the timing of the peak rate of discharge at the point of interest. In other words, if the peak runoff rate from a subbasin is 50 cfs and the peak discharge from a point of interest is 100 cfs, the ratio of subbasin peak runoff to point of interest peak discharge is 50 percent ("Y" axis value). Therefore, no matter what is done relative to changing the timing of the release of the runoff, the most that the peak discharge at the point of interest can be increased is 50 percent.

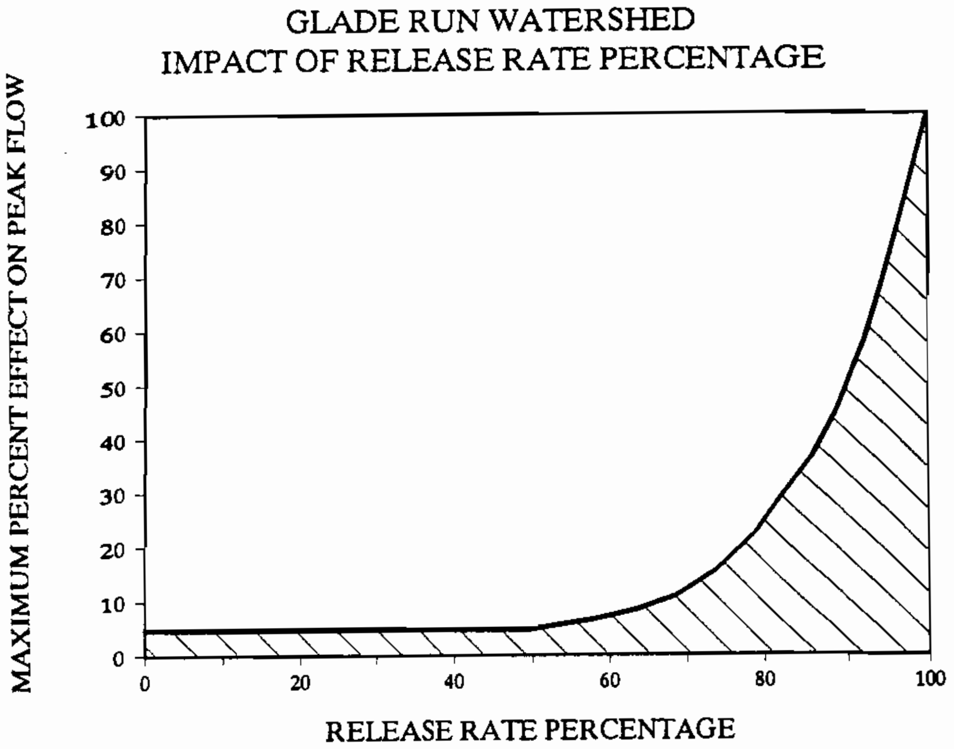


FIGURE V-8

Figure V-8 indicates that a curve through the data approaches an asymptote at a release rate of roughly 50 percent. The ratio of peak subbasin runoff to peak point of interest discharges averages 1.3 percent for cases with calculated release rate percentages less than 50 percent. In contrast, the ratio of peak subbasin runoff to peak point of interest discharges averages 10.5 percent for cases with calculated release rate percentages 50 percent and greater. This supports the selection of 50 percent as the lower limit to assigned release rate percentages for stormwater controls.

Subbasins using release rates below 50 percent result in large detention facilities that retain high volumes of runoff. Therefore, the lowest value determined during the analysis which is above 50 percent was selected as the limiting value and used as the release rate percentage for the subarea.

In some instances all of the calculated release rate percentages for a subarea may be below 50 percent. It is preferable for these subareas to release the flow more quickly prior to the time when the watershed peak occurs. This only occurred in one subbasin in the Glade Run Watershed. The release rate percentage for this subbasin was therefore increased to 100 percent.

The release rate percentages do not exceed 100 percent although theoretically greater percentages may be possible. This would be the situation for subbasins whose maximum rate occurs after the watershed peak. However, sufficient restrictions in capacity (either from inadequately sized culverts or natural restrictions) exist within the watershed that result in flooding so that essentially no increases in the flow rate should be allowed. These restrictions resulted in projected flooding problems in the results of the modeling for all storm return frequencies including the two-year storm.

An additional reason to establish the maximum release rate of 100 percent is to ensure that the depth of flooding and the potential for erosion is not increased downstream from specific sites. It is recommended that future plan updates consider the need to allow release rates in excess of 100 percent where the potential for flooding and erosion have been eliminated.

In order for the release rate concept to work, it must be used for all development within a watershed which results in an increase in the postdevelopment runoff from the site. A development may comprise only a portion of the subbasin, but the release rate percentage for the development will be the same throughout the subbasin. The percentage, therefore, represents an average value. For example, a subbasin with a release rate percentage of 80 may be divided into two subbasins with new release rates of 78 and 82 established. Further, it may be possible to set the release rate of one subbasin and alter the rate for other subbasins, provided that no harm is caused. As can be seen, the release rate concept possesses considerable flexibility as a tool for comprehensive watershed planning.

Application of the Release Rate Percentage

The release rate percentage is a tool for watershed level planning, developed to ensure that runoff control plans for individual sites consider downstream stormwater runoff impacts. As such, the release rate percentage functions as a performance standard; that is, it defines an end result which is to be attained. With this approach an individual developer can select and design those drainage control measures that are most appropriate to the site as long as the applicable release rate percentage for the subbasin is met. Acceptable stormwater control techniques are discussed in subsequent chapters of this report.

To utilize the release rate for a particular site in one of the subbasins, the developer would:

- Compute the predevelopment and postdevelopment runoff for the individual site using the SCS TR-55 method for the 2-, 10-, and 100-year storm, using no stormwater management techniques. If the postdevelopment rate of runoff is greater than the predevelopment runoff, proceed to the next step, otherwise the requirements of Act 167 have been met.

- Apply on-site stormwater management techniques to increase infiltration and reduce impervious surfaces. Recompute the postdevelopment runoff rate for the 2-, 10-, and 100-year storm; and if the rate is still greater than the predevelopment rates, stormwater detention will be required.

- Using the subbasin release rate percentage and the predevelopment rate of runoff, multiply to find the release rate from the detention facility. The detention facility will be designed in accordance with the procedure described in subsequent chapters.

It should be noted that stormwater storage can be provided on site or off site. The possibility for regional or off-site facilities provides increased management flexibility within a watershed. In many areas the most cost-effective solution may be several developments sharing a joint facility. Municipalities also may benefit from this approach. They may maximize development in appropriate areas and provide regional storage through the use of natural or artificial lakes, flood plains, and valleys with steep slopes that are unsuitable for development. However, where off-site storage is to be used, the developer must ensure that no flooding or harm will be caused by runoff between the new development and the off-site storage area. This may require the protection of the stream channel or the construction of a storm sewer to convey runoff to the storage site.

The release rate percentage provides a standard for the watershed plan to define what measures are reasonably necessary to manage stormwater so as to prevent injury to persons and property in a watershed.

DESIGN STORM FREQUENCY

The DER "Storm Water Management Guidelines" describe design frequencies as the peak rates of discharge for which the components of drainage systems are designed. Typically, 2-, 10-, and 100-year storm events are the recurrence intervals used for design. A ten-year flood discharge can be expected to be equaled or exceeded once in a ten-year period. This ten-year flood also may be described as having a 10 percent chance of occurring within any given year.

For this study, the design storm frequency criteria were selected to respond to watershed conditions and to meet the objective of Act 167 to minimize stormwater damage. The selection process was influenced by studying hypothetical examples of various design storm runoff rates for predevelopment and postdevelopment conditions, combined with a knowledge of what is considered reasonable for the study watershed.

The following example helps to illustrate the design storm frequency criteria selection rationale. The following table shows predevelopment and postdevelopment peak rates of discharge for a sample development.

	Design Storm		
	2 year	10 year	100 year
Predevelopment	50 cfs	75 cfs	100 cfs
Postdevelopment	100 cfs	150 cfs	200 cfs

Two conclusions are evident from this table:

- If the design storm frequency criteria requires that only the 100-year event be used, the postdevelopment discharge for the two- and ten-year storm will be greater than the predevelopment rate, and a problem may be caused downstream.

- If the criteria requires that only the two-year event be applied, the 100-year postdevelopment discharge will be allowed to pass downstream creating the potential for a problem.

If the stormwater conveyance system from the development site to the river were capable of accommodating a 100-year event with no flooding or harm caused downstream, designing only for a 100-year storm would be acceptable. This study found through the questionnaires and interviews with local officials, along with the results of the modeling program, that structures in the watershed flood periodically. Based on the information obtained, the study also identified that some existing structures are adequate only for a two-year storm. Therefore, the lower limit design storm frequency criteria to be used will be the two-year storm event. Future plan updates may identify that the capacity of the existing system has been modified to accommodate greater than the two-year design storm, or that existing bottlenecks in the system can be replaced with larger structures. If so, the two-year event may be increased accordingly.

The upper limit design storm frequency criteria to be used for the watershed is the 100-year event. This is chosen because it is consistent with sound design practices and is the traditional upper limit storm event.

Another consideration in selecting the 100-year storm as the upper limit design storm is to maintain the 100-year flood plain boundaries at their present locations. This will become increasingly important to development located along the fringe of this boundary.

If less than the 100-year storm is selected as the upper limit storm, say the 25-year or 50-year storm, then stream flows above this storm will be allowed to increase. The net result may be that the flood zone will be increased. Structures not previously located in the flood plain boundary may then experience damage or harm due to changing conditions.

Storm Frequency Distribution

As described earlier in the chapter on the hydrologic cycle, rainfall happens with variable intensity, in terms of amount (inches) that falls per hour. To calculate the peak rate of runoff from a portion of a watershed (i.e., a development), it is necessary to know the duration of the storm event (total time) and the rainfall distribution (i.e., inches/hour) during the event.

Certain design storms must be used to analyze stormwater runoff in predevelopment and postdevelopment conditions and for the design of stormwater control facilities. The rationale for selecting the 2-, 10-, and 100-year storm frequencies as the design storms was explained previously. The particular pattern of rainfall intensity distribution shall be that specified by the Soil Conservation Service (SCS) Type II pattern, with a duration of 24 hours. The design storms and total depth of precipitation during the 24-hour period for the Glade Run Watershed are:

Design Storms Return Period	24-Hour Precipitation Depth in Inches
2-year	2.60
10-year	3.90
100-year	5.50

Coincidentally, the SCS Type II pattern is used by many engineers and is the storm pattern used in SCS TR-55. This is an additional reason why TR-55 is recommended as the computational technique to be used by developers when preparing stormwater plans.

DETERMINING HYDRAULICALLY SENSITIVE AREAS

As an aid to future planning, an attempt was made to identify which subbasins in the watershed are particularly sensitive to storm runoff impacts, both present and future. (The overall subbasin delineation used in the modeling is shown on Figure V-9.) Two factors were considered in determining these subbasins. They were:

- Significant increases projected in the subbasin's peak runoff rates due to future development.

- Areas identified with existing stormwater problems.

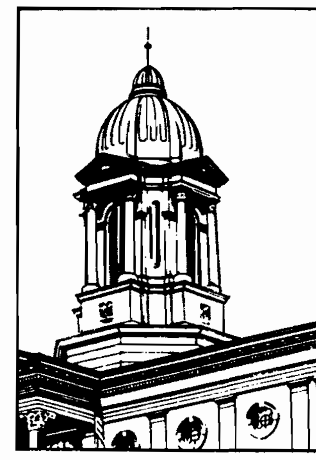
Projected runoff rates for the first item above were computed for the watershed based on the present and ten-year future land use maps. Runoff for each subbasin is shown on Tables V-2 and V-3 for the 2-, 5-, 10-, 25-, 50-, and 100-year storms. Increases in the peak rate of flow due to future development (with no stormwater runoff controls) may be computed by taking the difference in the two tables.

Stormwater problems were identified as locations where the projected stormwater flow on Tables V-2 and V-3 exceed the capacity of an existing obstruction.

Act 167 is not recommending that more stringent stormwater runoff controls be implemented in the watershed above hydraulically sensitive areas. Such measures could be considered flood control. The purpose of the Act 167 plan is to maintain stormwater runoff at present conditions.

Consideration should be given in the future to increasing the capacity of these obstructions and the drainage ways through sensitive areas whenever remedial work is being performed. During periods of reconstruction or replacement, the

Armstrong County
Stormwater Management Plan
Glade Run Watershed



5000 0 5000 10000
scale feet

Sub–basin Delineation Map

Legend

- Watershed Boundary
- Municipal Boundary
- Sub-basin Boundary
- 3 Sub-basin Number

SUB–BASIN LOCATIONS

Subbasin Number	Township	Subbasin Number	Township
1	Sugar Creek	65	East Franklin
2	Sugar Creek,	66	East Franklin
2	Washington	67	East Franklin
3	Washington	68	ME*
4	Washington	69	East Franklin
5	ME*	70	East Franklin
6	Washington	71	East Franklin,
7	Washington	71	North Buffalo
8	Washington	72	ME*
9	ME*	73	East Franklin,
10	Sugar Creek,	73	North Buffalo
10	Washington,	74	North Buffalo
10	East Franklin	75	North Buffalo
11	SugarCreek,	76	North Buffalo,
11	East Franklin	76	West Franklin
12	East Franklin	77	North Buffalo,
13	ME*	77	West Franklin
14	East Franklin	78	ME*
15	East Franklin	79	East Franklin,
16	East Franklin	79	North Buffalo,
17	ME*	79	West Franklin
18	East Franklin	80	North Buffalo
19	East Franklin	81	East Franklin,
20	East Franklin	81	North Buffalo
21	ME*	82	ME*
22	East Franklin	83	East Franklin,
23	East Franklin	83	West Franklin
24	East Franklin	84	East Franklin,
25	East Franklin	84	West Franklin
26	ME*	85	ME*
27	East Franklin	86	East Franklin,
28	ME*	86	North Buffalo
29	East Franklin	87	ME*
30	East Franklin	88	North Buffalo
31	East Franklin	89	North Buffalo
32	ME*	90	North Buffalo
33	East Franklin	91	ME*
34	East Franklin	92	North Buffalo
35	East Franklin	93	East Franklin,
36	East Franklin	93	North Buffalo
37	East Franklin	94	North Buffalo
38	ME*	95	ME*
39	East Franklin	96	North Buffalo
40	ME*	97	North Buffalo
41	East Franklin	98	North Buffalo
42	East Franklin	99	ME*
43	East Franklin	101	North Buffalo
44	ME*	102	North Buffalo
45	East Franklin	102	North Buffalo
46	East Franklin	103	ME*
47	East Franklin	104	North Buffalo
48	East Franklin	105	North Buffalo
49	East Franklin	106	North Buffalo
50	ME*	107	ME*
51	East Franklin	108	North Buffalo
52	ME*	109	North Buffalo
53	East Franklin	110	North Buffalo
54	East Franklin	111	ME*
55	East Franklin	112	North Buffalo
56	ME*	113	North Buffalo
57	East Franklin	114	North Buffalo
58	East Franklin	115	North Buffalo
59	East Franklin	116	North Buffalo
60	ME*	117	ME*
61	East Franklin	118	North Buffalo
62	East Franklin	119	ME*
63	East Franklin	120	North Buffalo,
64	ME*	120	Cadogan

*Represents Modeling Element and is not presented on the mapping.

FIGURE V–9

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TABLE V-2

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR EXISTING CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow						Obstruction Capacity Adequacy*
	Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	
1	1	1	10	10	10	20	
2	10	20	30	50	60	100	
3	1	10	10	10	20	20	
4	10	20	30	40	60	70	
5	20	40	70	100	130	190	
6	20	50	70	110	140	210	3
7	10	10	10	20	20	30	
8	20	40	50	70	90	110	
9	50	80	120	180	230	320	
10	60	110	150	220	290	400	1
11	10	10	20	20	30	30	
12	10	10	20	30	30	50	
13	70	120	180	250	330	450	
14	80	150	220	320	400	550	
15	1	10	10	20	20	20	
16	10	30	40	60	80	110	
17	100	180	260	380	490	670	6
18	130	260	380	560	720	1,000	
19	40	60	80	100	120	150	
20	50	80	100	140	170	220	
21	170	320	450	660	850	1,170	2
22	10	20	20	30	30	40	
23	30	50	60	90	110	150	
24	20	40	50	70	90	120	
25	40	60	90	120	160	220	
26	60	110	160	220	280	370	
27	80	130	180	250	320	420	
28	240	450	620	890	1,140	1,560	0
29	260	490	670	960	1,240	1,690	
30	1	10	10	20	20	30	

*Obstruction Capacity Adequacy Classifications:

0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
4 = Has capacity to convey the 25-year storm, but not the 50-year storm.
5 = Has capacity to convey the 50-year storm, but not the 100-year storm.
6 = Has capacity to convey the 100-year storm.

TABLE V-2

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR EXISTING CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow						Obstruction Capacity Adequacy*
	Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	
31	20	40	50	80	100	140	
32	280	520	710	1,030	1,330	1,810	
33	280	520	720	1,040	1,350	1,830	
34	10	20	20	30	40	50	
35	40	70	100	140	180	230	1
36	20	30	30	50	60	70	
37	50	90	120	160	200	260	0
38	100	170	230	310	390	520	3
39	120	210	280	380	480	630	1
40	400	710	980	1,370	1,780	2,410	
41	420	750	1,030	1,430	1,850	2,490	
42	20	30	40	50	60	80	
43	40	60	80	110	140	180	2
44	460	800	1,100	1,530	1,970	2,650	6
45	480	830	1,140	1,570	2,030	2,730	0
46	10	10	20	20	30	40	
47	50	90	120	160	210	280	
48	10	10	20	30	40	50	
49	20	50	70	100	130	180	2
50	80	140	190	270	350	480	
51	90	170	230	320	410	550	
52	560	980	1,350	1,860	2,390	3,220	3
53	580	1,000	1,390	1,910	2,450	3,300	
54	10	20	20	30	40	50	
55	40	70	90	120	150	200	
56	620	1,060	1,460	2,010	2,580	3,470	
57	620	1,070	1,470	2,020	2,600	3,490	
58	1	10	10	10	20	30	
59	10	20	30	50	60	80	
60	630	1,090	1,500	2,060	2,650	3,560	

*Obstruction Capacity Adequacy Classifications:

0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
4 = Has capacity to convey the 25-year storm, but not the 50-year storm.
5 = Has capacity to convey the 50-year storm, but not the 100-year storm.
6 = Has capacity to convey the 100-year storm.

TABLE V-2

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR EXISTING CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow						Obstruction Capacity Adequacy*
	Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	
61	650	1,110	1,530	2,110	2,710	3,650	2
62	1	10	10	20	30	40	
63	20	40	60	80	100	140	
64	670	1,150	1,580	2,180	2,800	3,770	
65	670	1,150	1,590	2,190	2,810	3,780	
66	10	10	10	20	20	30	
67	30	50	70	100	130	180	
68	700	1,190	1,640	2,270	2,910	3,920	1
69	730	1,240	1,700	2,340	3,000	4,040	1
70	40	60	80	110	130	170	
71	50	80	110	150	190	240	
72	770	1,300	1,770	2,450	3,130	4,210	
73	770	1,300	1,780	2,450	3,140	4,220	
74	10	20	20	20	30	30	
75	30	60	80	110	130	180	1
76	10	10	20	20	30	40	
77	30	60	80	110	150	190	
78	70	120	160	220	290	380	5
79	100	180	250	350	450	600	6
80	10	10	20	20	30	40	
81	20	40	50	80	100	140	
82	120	220	300	430	550	730	
83	1	10	10	10	20	30	
84	20	40	60	90	120	170	
85	140	260	360	510	670	890	
86	180	310	430	620	810	1,070	3
87	950	1,590	2,180	3,030	3,870	5,250	6
88	950	1,600	2,180	3,040	3,890	5,260	6
89	1	10	10	10	20	20	
90	40	60	80	120	150	210	0

*Obstruction Capacity Adequacy Classifications:
0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
4 = Has capacity to convey the 25-year storm, but not the 50-year storm.
5 = Has capacity to convey the 50-year storm, but not the 100-year storm.
6 = Has capacity to convey the 100-year storm.

TABLE V-2

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR EXISTING CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow						Obstruction Capacity Adequacy*
	Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	
91	980	1,650	2,250	3,140	4,010	5,430	
92	990	1,660	2,260	3,160	4,030	5,460	
93	10	20	20	30	30	40	
94	10	20	30	40	60	80	
95	1,000	1,680	2,290	3,190	4,070	5,500	
96	1,000	1,700	2,310	3,230	4,120	5,580	
97	10	20	30	30	40	60	
98	30	50	70	100	130	180	
99	1,020	1,730	2,360	3,300	4,210	5,690	
100	1,030	1,740	2,370	3,310	4,220	5,720	0
101	10	30	40	50	60	80	
102	20	40	60	80	110	140	
103	1,040	1,770	2,410	3,360	4,290	5,800	
104	1,050	1,790	2,430	3,390	4,310	5,830	
105	10	10	20	20	30	40	
106	10	20	30	40	50	80	
107	1,060	1,800	2,450	3,410	4,350	5,870	
108	1,060	1,800	2,450	3,420	4,350	5,880	
109	1	10	10	20	30	40	
110	10	20	30	40	60	80	
111	1,070	1,820	2,470	3,450	4,390	5,930	
112	1,080	1,850	2,520	3,520	4,490	6,070	
113	10	20	20	30	40	50	
114	40	70	90	130	160	220	3
115	10	10	20	20	30	40	
116	30	50	70	100	120	160	
117	70	120	170	230	290	390	
118	90	160	210	300	390	520	5
119	1,140	1,960	2,660	3,720	4,730	6,380	
120	1,160	2,000	2,720	3,790	4,830	6,500	5

*Obstruction Capacity Adequacy Classifications:

0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
4 = Has capacity to convey the 25-year storm, but not the 50-year storm.
5 = Has capacity to convey the 50-year storm, but not the 100-year storm.
6 = Has capacity to convey the 100-year storm.

TABLE V-3

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR FUTURE CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow						Obstruction Capacity Adequacy*
	Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	
1	1	1	10	10	10	20	
2	10	20	30	50	60	100	
3	1	10	10	10	20	20	
4	10	20	30	40	60	70	
5	20	40	70	100	10	190	
6	20	50	70	110	140	210	3
7	10	10	10	20	20	30	
8	20	40	50	70	90	110	
9	50	80	120	180	230	320	
10	60	110	150	220	290	400	1
11	10	10	20	20	30	30	
12	10	10	20	30	30	50	
13	70	120	180	250	330	450	
14	80	150	220	320	400	550	
15	1	10	10	20	20	20	
16	10	30	40	60	80	110	
17	100	180	260	380	490	670	6
18	130	260	380	560	720	1,000	
19	40	60	80	100	120	150	
20	50	80	100	140	170	220	
21	170	320	450	660	850	1,170	1
22	10	20	20	30	30	40	
23	30	50	60	90	110	150	
24	20	40	50	70	90	120	
25	40	60	90	120	160	220	
26	60	110	160	220	280	370	
27	80	130	180	250	320	420	
28	240	450	620	890	1,140	1,560	0
29	260	490	670	960	1,240	1,690	
30	1	10	10	20	20	30	

*Obstruction Capacity Adequacy Classifications:
0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
4 = Has capacity to convey the 25-year storm, but not the 50-year storm.
5 = Has capacity to convey the 50-year storm, but not the 100-year storm.
6 = Has capacity to convey the 100-year storm.

TABLE V-3

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR FUTURE CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow						Obstruction Capacity Adequacy*
	Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	
31	20	40	50	80	100	140	
32	280	520	710	1,030	1,330	1,810	
33	280	520	720	1,040	1,350	1,830	
34	10	20	20	30	40	50	
35	40	70	100	140	180	230	1
36	20	30	30	50	60	70	
37	50	90	120	160	200	260	1
38	100	170	230	310	390	520	3
39	120	210	280	380	480	630	1
40	400	710	980	1,370	1,780	2,410	
41	420	750	1,030	1,430	1,850	2,490	
42	20	30	40	50	70	80	
43	40	70	90	120	150	190	1
44	460	800	1,110	1,530	1,970	2,650	6
45	490	840	1,150	1,590	2,040	2,740	0
46	10	10	20	20	30	40	
47	130	190	230	290	350	420	
48	10	10	20	30	40	50	
49	30	50	70	100	130	180	2
50	160	250	310	400	490	620	
51	180	280	350	460	560	710	
52	660	1,060	1,430	1,940	2,470	3,320	3
53	690	1,090	1,470	2,000	2,540	3,410	
54	10	20	30	30	40	50	
55	60	90	110	150	180	240	
56	740	1,170	1,560	2,120	2,690	3,600	
57	740	1,170	1,570	2,140	2,710	3,620	
58	10	10	20	20	30	40	
59	20	40	50	70	80	110	
60	770	1,210	1,610	2,200	2,780	3,710	

*Obstruction Capacity Adequacy Classifications:
0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
4 = Has capacity to convey the 25-year storm, but not the 50-year storm.
5 = Has capacity to convey the 50-year storm, but not the 100-year storm.
6 = Has capacity to convey the 100-year storm.

TABLE V-3

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR FUTURE CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	Obstruction Capacity Adequacy*
61	780	1,240	1,650	2,260	2,850	3,800	2
62	20	30	40	40	50	60	
63	40	60	80	110	130	170	
64	820	1,290	1,710	2,340	2,950	3,930	
65	830	1,300	1,720	2,350	2,960	3,940	
66	10	10	10	20	20	30	
67	30	60	80	110	140	190	
68	860	1,350	1,780	2,440	3,070	4,090	1
69	920	1,430	1,870	2,560	3,200	4,250	1
70	70	100	130	160	190	230	
71	90	130	160	200	250	310	
72	990	1,520	1,970	2,690	3,350	4,440	
73	990	1,530	1,980	2,700	3,360	4,450	
74	10	20	20	20	30	30	
75	30	60	80	110	130	180	1
76	10	10	20	20	30	40	
77	30	60	80	110	150	190	
78	70	120	160	220	290	380	5
79	100	180	250	350	450	600	6
80	10	10	20	20	30	40	
81	20	40	50	80	100	140	
82	120	220	300	430	550	730	
83	1	10	10	10	20	30	
84	20	40	60	90	120	170	
85	140	260	360	510	670	890	
86	180	320	440	630	810	1,070	3
87	1,170	1,840	2,410	3,310	4,140	5,520	6
88	1,170	1,840	2,410	3,320	4,150	5,530	6
89	1	10	10	10	20	20	
90	40	60	80	120	150	210	0

*Obstruction Capacity Adequacy Classifications:

0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
4 = Has capacity to convey the 25-year storm, but not the 50-year storm.
5 = Has capacity to convey the 50-year storm, but not the 100-year storm.
6 = Has capacity to convey the 100-year storm.

TABLE V-3

ESTIMATED CUMULATIVE PEAK DISCHARGE FOR FUTURE CONDITIONS

Sub-Basin	Estimated Cumulative Peak Flow						Obstruction Capacity Adequacy*
	Q(2)	Q(5)	Q(10)	Q(25)	Q(50)	Q(100)	
91	1,210	1,900	2,480	3,420	4,280	5,710	
92	1,210	1,900	2,490	3,430	4,310	5,740	
93	10	20	20	30	30	40	
94	10	20	30	40	60	80	
95	1,210	1,920	2,510	3,470	4,340	5,780	
96	1,220	1,940	2,540	3,510	4,400	5,870	
97	10	20	30	30	40	60	
98	30	50	70	100	130	180	
99	1,250	1,980	2,590	3,580	4,490	5,980	
100	1,250	1,980	2,600	3,590	4,510	6,000	0
101	10	30	40	50	60	80	
102	20	40	60	80	110	140	
103	1,270	2,010	2,640	3,650	4,580	6,090	
104	1,270	2,030	2,660	3,670	4,610	6,120	
105	10	10	20	20	30	40	
106	10	20	30	40	50	80	
107	1,280	2,040	2,680	3,700	4,640	6,170	
108	1,280	2,040	2,680	3,700	4,650	6,170	
109	1	10	10	20	30	40	
110	10	20	30	40	60	80	
111	1,290	2,060	2,700	3,730	4,680	6,220	
112	1,300	2,090	2,750	3,810	4,790	6,370	
113	10	20	20	30	40	50	
114	40	70	90	130	160	220	3
115	10	10	20	20	30	40	
116	30	50	70	100	120	160	
117	70	120	170	230	290	390	
118	90	160	210	300	390	520	5
119	1,360	2,200	2,890	4,000	5,040	6,690	
120	1,380	2,240	2,950	4,080	5,130	6,800	4

*Obstruction Capacity Adequacy Classifications:

0 = Does not have capacity to convey 2-year storm flow.
1 = Has capacity to convey the 2-year storm, but not the 5-year storm flow.
2 = Has capacity to convey the 5-year storm, but not the 10-year storm.
3 = Has capacity to convey the 10-year storm, but not the 25-year storm.
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municipality or agency performing the work should ensure that sufficient capacity is provided to eliminate future flooding at these locations.

DISTRIBUTED STORAGE

Traditionally, the approach to stormwater management has been to control the runoff on an individual site basis and to consider this control as being fully responsive to the overall stormwater management needs of the watershed. The choice of stormwater controls generally was made on the basis of convenience at the site. It most frequently involved the rapid elimination of the runoff with storm sewers (or ditches). Storm sewers are an excellent means of controlling stormwater runoff when they are used properly. Unfortunately, this has not always been the case. Too often the use of storm sewers simply led to concentrating and speeding up the runoff at some other point in the watershed.

In recent years the response to this problem has been to control excess stormwater on-site. The general philosophy has become to manage stormwater as close to the point where it falls as possible. On-site management techniques described in Chapter VI, are proving to be cost effective and environmentally sensitive. However, they often cannot by themselves guarantee that there will be no adverse impacts on the watershed. What is required is the development of watershed level strategy for managing storm runoff.

Comprehensive planning for the control of stormwater runoff is becoming an increasingly significant part of overall development objectives for existing, as well as developing, urban communities. Successful management of stormwater runoff and the overall urban water resources system, depends on the ability of urban planners and managers to:

- Predict the effects of increased urban development on stormwater runoff.

- Define the response of the drainage system to particular storm events.

- Select the cost-effective and optimum stormwater control system for a particular watershed.

Defining the Distributive Storage Concept

New and innovative approaches to stormwater management are being developed by stormwater specialists. There is a growing commitment to find cost-effective control techniques which both preserve and protect the natural drainage system and which involve a comprehensive approach to stormwater management for the entire watershed. One of these concepts is distributed storage. Simply defined, distributed storage is the process of utilizing the most suitable site or sites for regional detention facilities.

The combination of on-site detention and distributed storage approaches may significantly improve the capability of land developers and communities to control stormwater on a watershed basis. The ideal design solution might be a system that absorbs or detains all the water falling on a site to the extent that the quantity and rate of water leaving the site is not significantly different after development than it was before. This ideal solution is often difficult to achieve particularly given the natural constraints of many sites in the study area. Therefore, the optimum approach may be to strike a balance between on-site and off-site management, using on-site detention and distributed storage techniques.

The types of on-site detention and distributed storage devices being referred to here are:

- Temporary ponding on ground surfaces.

- Temporary ponding on paved areas.

- Temporary ponding on roofs of buildings.

- Storage in permanent ponds having provision for variable depth.

- Treatment of ground surfaces to absorb and/or detain water.
- Routing of runoff to infiltration pits to both recharge groundwater supplies and reduce total flows to drainage systems.
- Collection of stormwater for supplementary water supplies.

These are essentially the same stormwater management techniques described in Chapter VI. The important difference here is that they are being combined into an on-site and off-site management strategy. The goal should be the development and use of the most cost-effective and environmentally sensitive stormwater runoff controls. There is a need to balance a range of factors: capital costs, operation and maintenance costs, risk of significant water-related damage, environmental protection and enhancement, public convenience, and other community development objectives.

One of the benefits to the distributed storage approach is that it offers stormwater planners and managers new flexibility in selecting alternative sites for storage facilities. Also, it increases the opportunities for utilizing stormwater control facilities to meet other community needs. For example, certain recreation areas might easily be used to provide temporary stormwater storage, or natural or artificial ponds and lakes can serve both recreation and stormwater management objectives. In many watersheds, the installation of one or more regional detention facility may prove to be the cost-effective and hydraulically sound stormwater management system.

Selecting Distributed Storage Locations

The distributed storage concept selects detention facility locations by analyzing the flow routing in the watershed, rather then by choosing possible locations solely where land is available. The key to the distributed storage method is the selection of sites that are hydraulically appropriate for off-site (regional) storage. The final selection of which storage area actually is constructed should be made by assessing the advantages of the identified storage locations.

Locations for distributed storage are determined by analyzing the flow routing in the watershed and selecting spots where streams join (confluences) and where peak runoff rates from two subbasins pass at approximately the same time. Table V-4 lists peak flow combinations at major points of confluence (the sites that were analyzed are also shown on Figure V-10). Areas where distributed storage would be most effective are those where the time to peak from two subbasins are equal (or nearly equal).

Delaying one of the subbasins by using a detention pond (or some other delaying facility) will separate the peak runoff rates passing the confluence point. For example, reviewing Table V-4 for Site No. 1, the time to peak for Subbasins 6 and 8 is 725 minutes. If a detention pond is provided for the flow through Subbasin 6, a delay in the time to peak will occur for that subbasin. The result will be a decrease in the combined peak rate of runoff for Subbasins 6 and 8 at the next downstream point of interest (Subbasin 14).

Further, this will have a domino effect all the way down the watershed by altering the routing time of Subbasin 6. If designed properly, the detention facility will control the outflow rate, also decreasing the rate of runoff.

A total of eight sites were examined for the suitability of locating distributed storage sites. Of these, only Site Nos. 1 and 3 offer any significant potential for distributed storage.

Glade Run's physical characteristics are such that while the main stem of Glade Run is rather long, there are no major tributaries or confluences along its flow path. The tributary streams which augment the flow in Glade Run result from small watersheds. Examining the travel times listed on Table V-4, it can be seen that in almost every case, the peak flow from a tributary stream has already passed when the peak from Glade Run reaches that point. Storming the flow from these tributaries would have a negative effect of delaying the release of runoff until the main watershed peak approaches. Therefore, only Site Nos. 1 and 3 offer potential for implementing the distributed storage concept. Even then, these sites are at the

TABLE V-4

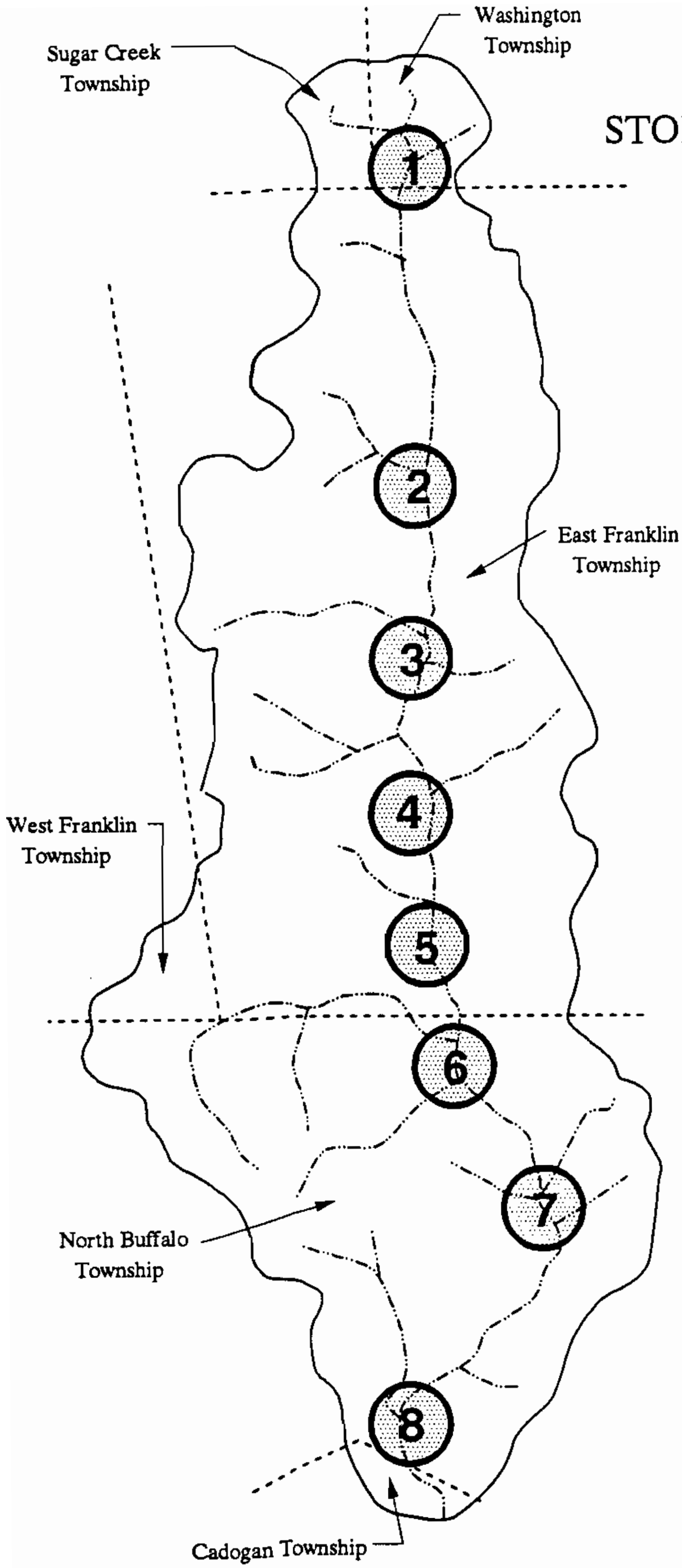
FLOW COMPARISON FOR DISTRIBUTED STORAGE

SITE	SUB-BASIN IN		SUB-BASIN OUT	Q-2 FLOW (cfs)	TIME TO PEAK (minutes)	Q-10 FLOW (cfs)	TIME TO PEAK (minutes)	Q-100 FLOW (cfs)	TIME TO PEAK (minutes)
1	6	*		23	725	72	725	207	725
	8			22	725	49	725	114	725
			14	82	725	219	725	552	725
2	18	*		130	745	378	755	1,005	755
	27			75	730	179	735	422	735
			29	261	750	665	765	1,689	765
3	38	*		100	725	228	725	515	725
	39			122	735	278	740	632	740
			41	422	745	1,029	750	2,495	750
4	51			91	730	230	735	553	735
	45	*		476	750	1,141	760	2,733	760
			53	580	750	1,387	770	3,303	765
5	61	*		646	745	1,532	780	3,651	770
	67			30	725	73	725	180	725
			69	727	755	1,695	795	4,043	785
6	73	*		773	755	1,777	795	4,221	785
	86			176	750	435	765	1,072	770
			92	986	770	2,264	790	5,458	800
7	98			29	725	72	725	180	725
	100	*		1,028	790	2,375	810	5,715	820
	102			20	735	56	735	143	730
			104	1,053	785	2,431	810	5,827	815
8	112	*		1,080	825	2,519	850	6,074	855
	118			89	735	214	735	521	735
			120	1,162	835	2,717	860	6,498	865

* Represents the flow in Glade Run.

GLADE RUN WATERSHED
ACT 167
STORMWATER MANAGEMENT PL

POTENTIAL DISTRIBUTED STORAGE SITES



LEGEND

Watershed Boundary

Stream

Political Boundary

8 Potential Storage Site Area

FIGURE V-10

top of the watershed and offer only some relief from localized flooding. Their effect on the overall watershed peak will be negligible.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION VI
STORMWATER MANAGEMENT TECHNIQUES

INTRODUCTION

Early stormwater management efforts concentrated on removing the stormwater as quickly as possible by routing the runoff through a storm sewer system. As the development of watersheds in urban areas increased, the effect of simply passing stormwater runoff downstream became readily apparent. The result was an increase in total flow, peak flow rate, stream velocity, and flow depth which frequently led to flooding and stormwater damage of downstream properties. It is now recognized that the most rational and effective approach to controlling runoff is to maintain natural runoff flow characteristics. This can be accomplished by maximizing natural infiltration processes, reducing impervious surfaces, preserving flood plains, and controlling storm flows in the watershed.

As explained previously, when it is determined that the postdevelopment runoff rate exceeds the predevelopment rate, the first attempt should be to reduce the increased runoff by utilizing on-site stormwater management techniques. There are numerous technically acceptable techniques which have varying degrees of applicability in the study area, depending on site and watershed characteristics. Some of the most widely used ones are catalogued here, along with a brief discussion of their key features, advantages, and disadvantages.

It will be up to each developer to select the techniques that are most appropriate to the type of project and characteristics of his or her development site. It is likely that in most situations, a combination of on-site controls will be the effective and least costly stormwater management system. To determine the most appropriate set of techniques for a particular site, several factors should be evaluated:

- Soil characteristics (i.e., soil permeability, erodibility)
- Topography
- Subsurface conditions
- Drainage patterns (i.e., proximity to stream flooding problems)
- Costs
- General advantages and disadvantages of each technique

ON-SITE STORMWATER CONTROL METHODS

Reduction of Runoff with Infiltration Storage

Infiltration storage is designed to release all or part of the stored runoff into the groundwater. The infiltrated water may appear a short distance downstream as surface water but at a later time. A large quantity will optimally be stored, transmitted in the aquifer system, and released much later at a remote point from the surface water drainage system.

Areas having sandy and silty sand soils prove to be locations well suited to all types of infiltration controls. Sandy and silty sand soils fall into the well drained category characterized by high infiltration transmission rates. These high infiltration transmission rates allow rapid transmission of the runoff away from the surface drainage system. When poorly drained soils, represented by fine silts and clays, underlay the infiltration control device, the effectiveness of the device will be diminished. This may be the case for large portions of the study area and, therefore, it should be used with caution. If this method is proposed as the primary means to reduce runoff for large development sites or for sites located in landslide-prone soil locations, a soils engineer's report should be obtained.

Seepage Basins or Recharge Basins

Seepage or recharge basins are large excavations designed to allow a large percentage of the annual rainfall to recharge the aquifer. Generally these basins are located in aquifer recharge areas, but they may be used whenever the water table is always 48-inches or more below the ground surface. Runoff from a development is collected in various storm drainage systems prior to being conveyed into the basin.

If a basin is sized to recharge as much stormwater as possible, then it should be excavated to take the area's maximum design rainfall from all paved areas. However, to be economically feasible, the basins are designed to recharge a certain percentage of the annual rainfall and control flood peaks by overflowing early during intense rainfall events.

The construction of a seepage or recharge basin is rather complex. A considerable amount of recharge occurs through the sidewalls of the basin. The bottom of the basin should be kept free of silt. A sediment trap is a required portion of an overall system design in order to limit the removal of accumulated bottom silt. In addition, an emergency overflow structure is required to bypass excess runoff. Figure VI-1 shows a typical system design.

Seepage Pit

Seepage pits are small excavations designed to overflow during intense storms but provide infiltration storage to reduce flood peaks. Sites where soil permeability is over 0.15 ft/day and which do not have seasonal high water tables are acceptable for utilization of seepage pits as stormwater runoff controls.

Figure VI-2 shows three alternatives for providing overflow capabilities when the seepage pit's capacity is reached. Some additional construction guidelines are: (1) the minimum size of a pit should be sufficient to maintain infiltration at predevelopment levels (the minimum size is dependent on both the porosity of the soil and the number of rainfalls per year); (2) the water table should be no less than

SEEPAGE OR RECHARGE BASIN

Source: Allegheny County, Act 167 Pilot Stormwater Management Plans, 1982.

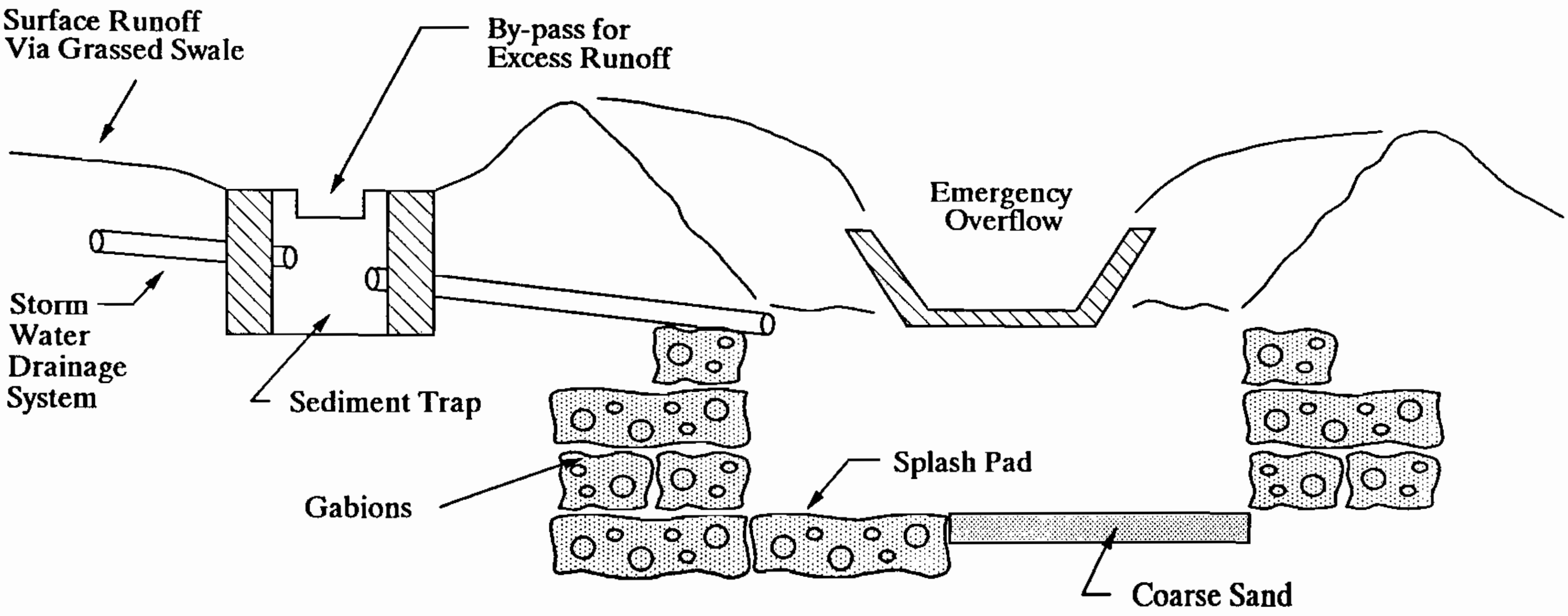
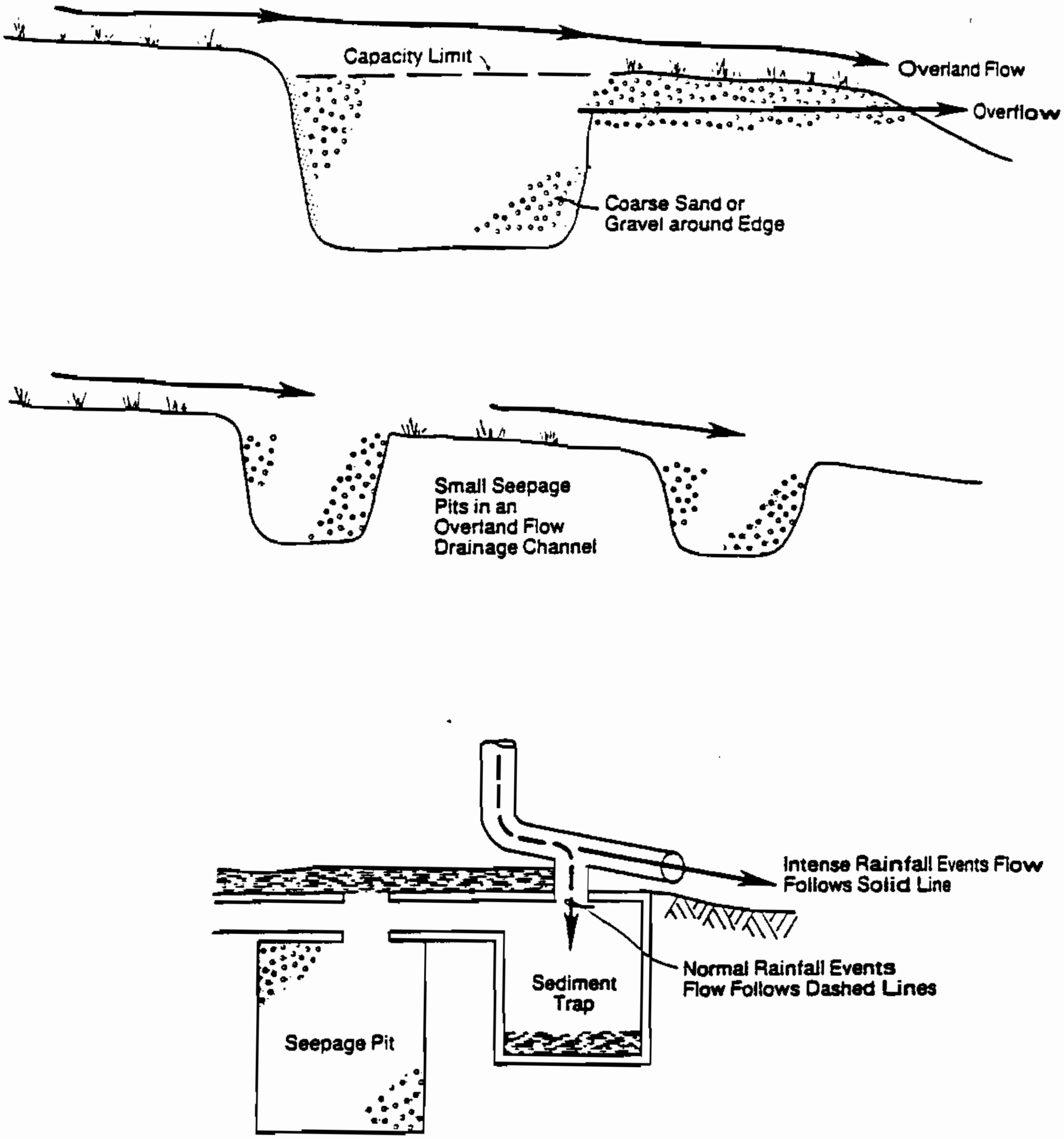


FIGURE VI-1

Seepage Pits



Source: Allegheny County Act 167 Pilot Stormwater Management Plans, 1982

FIGURE VI-2

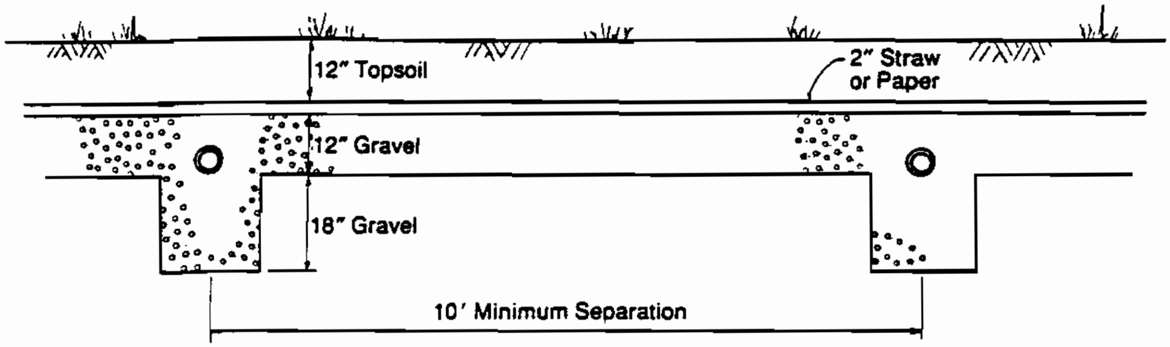
48-inches below the bottom of the pit; and (3) the ratio of the bottom area to side area should not exceed 1:2.

Seepage Beds or Ditches

Seepage beds dispose of runoff by infiltration into the soil through a system of perforated drainage pipes laid in ditches. The runoff should pass through a sediment trap prior to entering the distribution system. The sediment trap can be designed as shown in Figure VI-3 with a structure to bypass runoff from extreme rainfall events.

Only sites with periodically high water tables or where the drainage of soil is extremely poor are unsuitable for application. A typical seepage bed site is shown in Figure VI-3.

Seepage Bed



Source: Allegheny County, Act 167 Pilot Stormwater Management Plans, 1982.

Figure VI-3

Terraces, Diversions, Runoff Spreaders, Grassed Waterways, and Contoured Landscapes

These measures are normally used to increase the time of concentration runoff and will provide the additional benefit of reducing total runoff by infiltration on sites with well drained soils. For detailed design information, the Soil Conservation Service's Engineering Field Manual for Conservation Practices should be consulted.

Table VI-1 summarizes some of the major considerations relevant to the design and use of the various infiltration techniques. It illustrates that numerous factors must be evaluated in the selection of the techniques. For this reason, it is not possible to prescribe uniform application of such techniques; the determination must be made on a site-by-site basis.

Delay of Runoff

The delay of runoff is accomplished by the two basic principles of detention and retention. Retention involves a much larger delay period and small release rates. Detention reduces the peak rate of discharge by attenuating the hydraulic response of storm runoff. Retention involves a much larger impoundment volume permitting storage of stormwater for a period of up to 48 hours.

Therefore, detention is defined as detaining a large portion of the stormwater runoff associated with a storm for a period of time approximately equal to the natural runoff duration. Retention is, then, the holding of stormwater for some period of time longer than the natural runoff period. The ultimate objective is to reduce the peak discharge rate by storing a certain amount of storm runoff and allowing it to be released at a flow rate that is designed to not cause harm.

Rooftop Retention

Rooftop retention utilizes the built-in structural capabilities of rooftops to store a certain amount of rainfall that falls on them. In may cases, existing roof structures

TABLE VI-1

SUMMARY OF CONSIDERATIONS RELEVANT TO INFILTRATION DESIGN

	Land Acquisition	Excavation and Fill	Erosion Protection	Fencing	Inlet Structure	Sediment/Debris Control	Soil Permeability	Groundwater Level	Groundwater Supply	Structural Soil Limitations	Landscaping	Engineering and Site Design	Operation and Maintenance	Financing	Sewer Septic Fields	Depths to Bedrock
Seepage Basins	●	●	●	●	●	●	●	●	●			●	●	●	●	●
Infiltration Beds *		●	●		●	●	●	●	●		●	●	●	●	●	●
Porous Pavement			●			●	●	●	●	●		●	●	●	●	●

* Dutch drains, seepage pits, and seepage beds.

Source: "Stormwater Management Design: A Manual of Procedures and Guidelines, prepared by Roy F. Weston, Inc. for the Maryland Department of Natural Resources, April 1976.

require little modification to function as retention structures. Flat rooftops are best suited for this purpose; however, small runoff checks, "fin dams," can be installed on sloping roofs to provide some attenuation of the resulting runoff hydrograph.

On flat rooftops, the major change involves the installation of simple outlet control devices. New flat roofed commercial buildings should consider the use of rooftop storage. An emergency overflow system must be provided in order to prevent stormwater from spilling over the edge of the roof. A rainfall detention ponding ring for flat rooftops is shown in Figure VI-4.

Road Embankment Stormwater Detention

Topographical characteristics of many land areas adjacent to roadway embankments make them very much adaptable for use as detention facilities. This can be achieved by designing the culverts to pond where appropriate. Many PennDOT, county, and municipal structures can be designed to operate in this fashion. Stepped slopes and benching are also effective in detaining flow and reducing the time of concentration by slowing the runoff flow velocity.

Parking Lot Detention

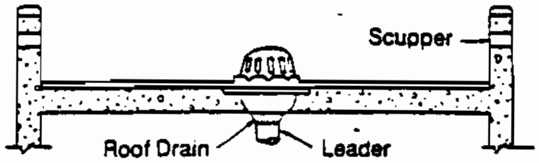
Parking lot detention involves the design of pavement surface, curbing, and stormwater inlet structures to temporarily store and release stormwater runoff. Initial construction costs for implementing these measures are only a small percentage above the cost of constructing conventional parking lots.

These measures should be designed only to specifically control runoff from the particular parking area and avoid handling any additional runoff. The facility should be designed to drain completely and avoid the formation of ice.

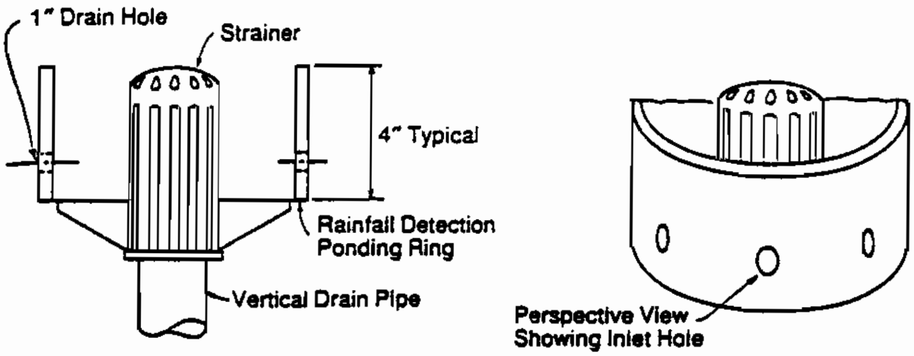
Multiple Use Impoundment Areas

These areas utilize sites having primary functions other than runoff control. In new developments, such multiple use should be incorporated into the preliminary design.

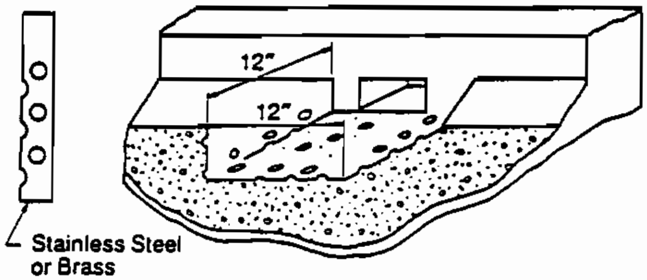
Rooftop Detention Devices



Typical Roof System with Controlled Release Roof Drain and Overflow Scupper
Source: Becker et al., 1973.



Source: Allegheny County, Act 267 Pilot Stormwater Management Plans, 1982.



Controlled Roof Drain
Source: Becker et al., 1973.

FIGURE VI – 4

A hard surface basketball or tennis court can be designed to drain adjacent grassed or paved areas. The stormwater would collect in grass swales around the edge of the court, seep through a gravel drain to retain the sediment load, and discharge onto a porous asphalt surface. Some type of emergency drain should be provided.

Grassed areas also can be landscaped to serve as small retention areas. Direct discharge from a pipe to these areas should be avoided. Figure VI-5 shows some conceptual designs.

Detention Basins

Detention basins are dry impoundments designed to store a portion of the stormwater runoff during a storm event and then release the stored volume slowly. Typically they are used in areas where runoff volume has been increased and it is desirable to reduce the runoff rate. Three design elements must be calculated:

- The inflow rate which is the stormwater runoff entering the basin.

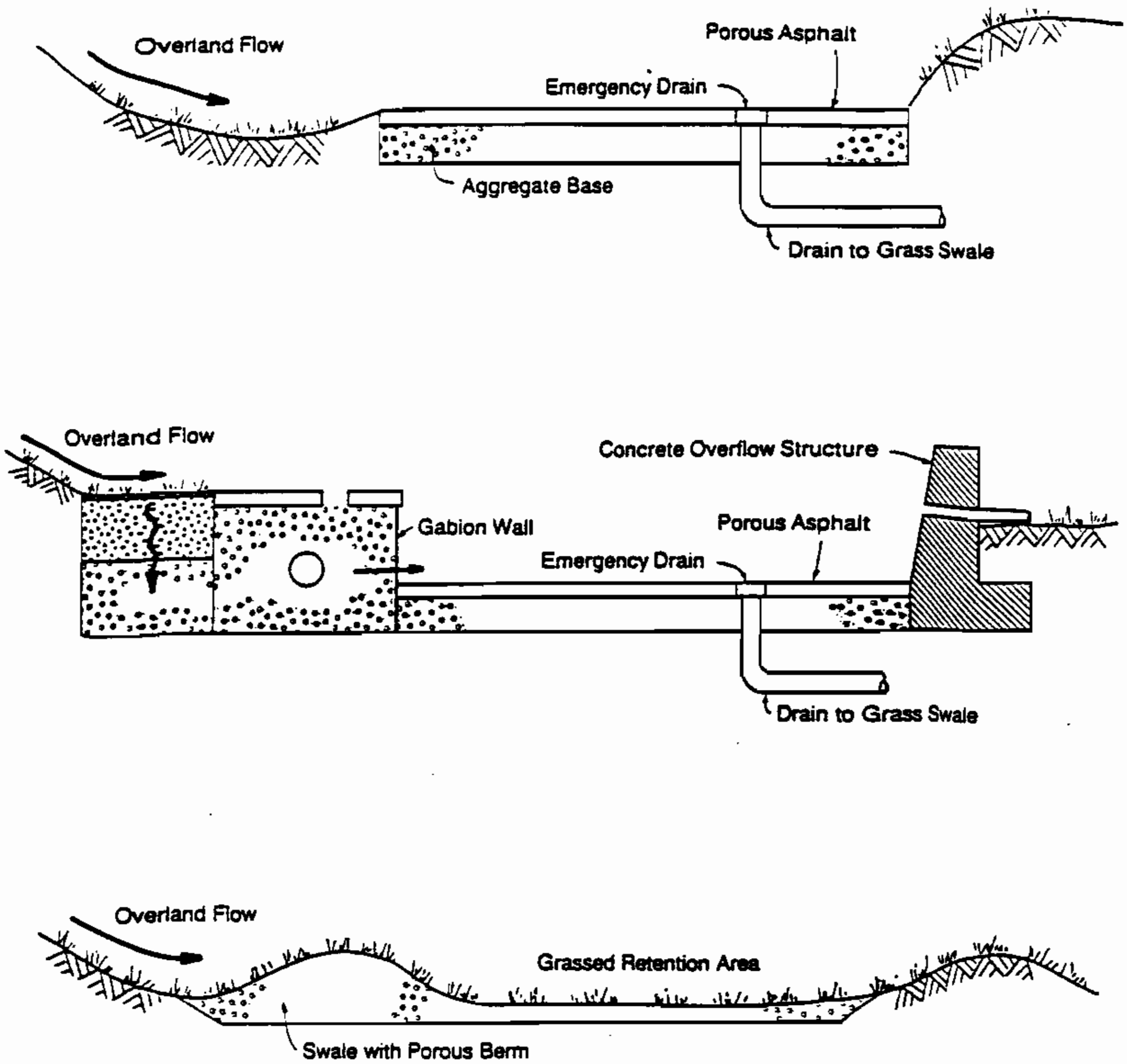
- The outflow rate which is the runoff rate released from the basin.

- The storage capacity of the basin computed in acre feet by water elevation in the basin. A basin two acres in area, for example, has two acre feet of storage for each foot of depth in the basin.

Figure VI-6 represents a typical example of detention basin storage. As can be seen, the postdevelopment discharge with no detention storage is greater than the predevelopment value. Detention storage is then used to reduce the discharge to an allowable quantity. The horizontal line for the postdevelopment curve with detention storage represents that period when the outlet flow rate is at a maximum and the detention basin is filling to its maximum elevation. As the inflow rate into the basin reduces to less than the outflow rate, the basin begins to drain.

In earlier chapters, the design of detention basins in response to watershed plans was described and the release rate percentage concept explained to ensure that

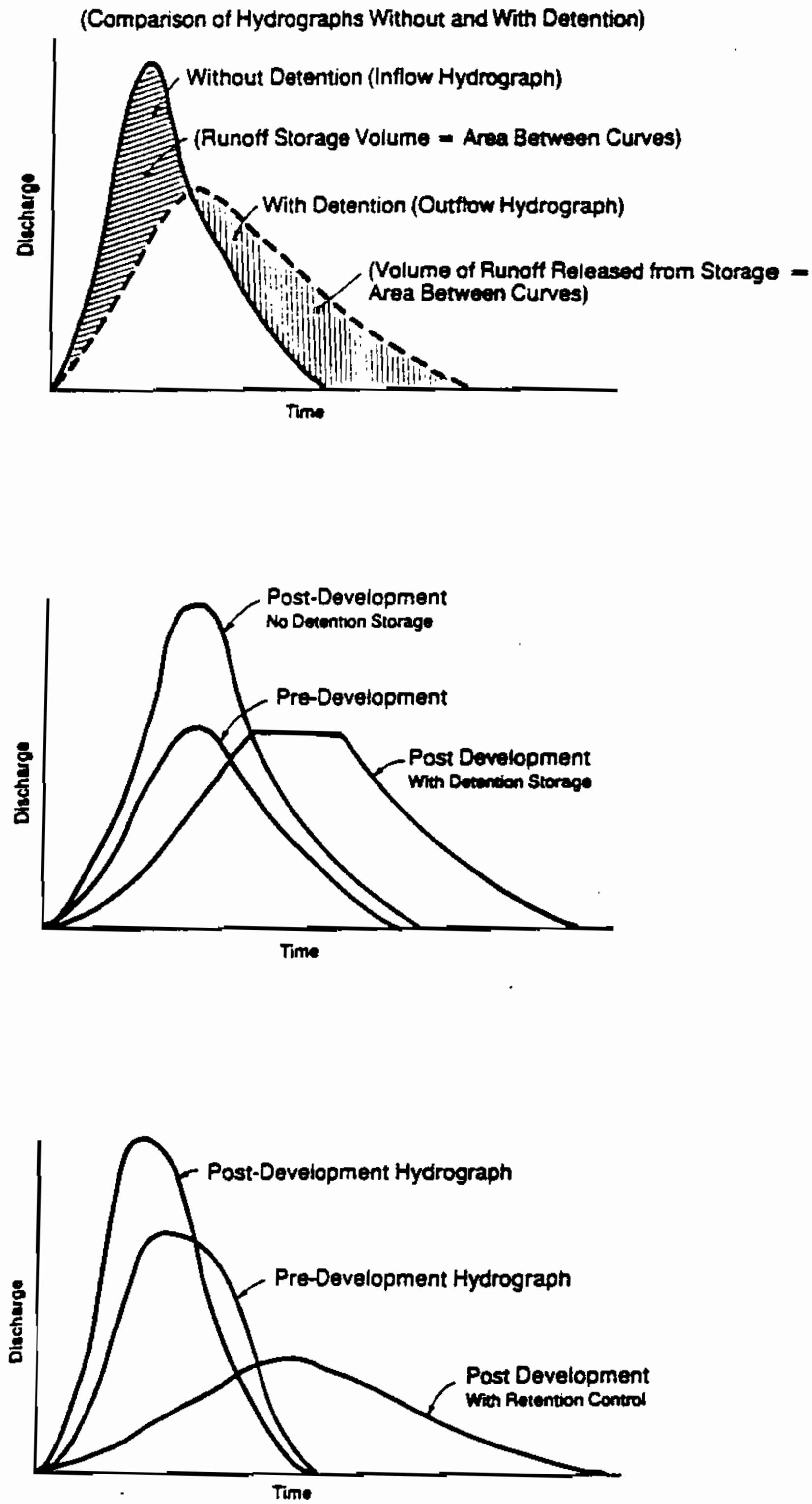
Multi-Use Impoundment Areas



Source: Allegheny County Act 167 Pilot Stormwater Management Plans, 1982

FIGURE VI-5

Storage Concept For Detention and Retention Basins



Source: Allegheny County Act 167 Pilot Stormwater Management Plans, 1982

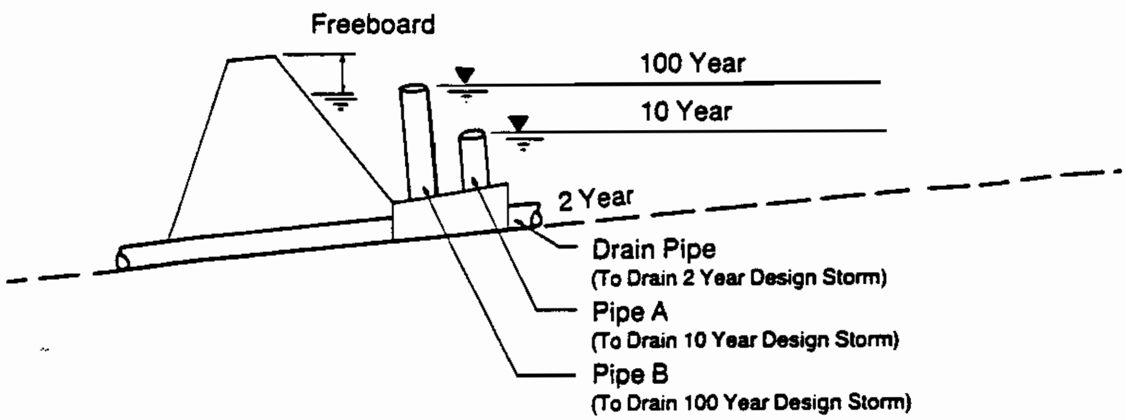
FIGURE VI-6

flooding problems do not result as the maximum discharge rate from the basin is extended over time.

Multistage outlet structures must be used for all detention basins in order to provide discharge control for different storm frequency events. The objective is to control the characteristics of the outflow rate so as to imitate the characteristics of the predevelopment runoff rate for the 2-, 10-, and 100-year design storm. This can be accomplished by locating outlet structures at various elevations in the basin.

Figure VI-7 shows a cross section through a typical detention basin. The elevation of pipe A is set at the design height that the ten-year event is expected to reach in the basin, and pipe B is set for the 100-year event. The drain pipe is designed for a two-year design storm. The outlet flow discharge rate from the basin will vary in response to the design storm event entering as inflow to the basin.

Multi - Stage Outlet of a Detention Basin



Source: Allegheny County, Act 167 Pilot Stormwater Management Plans, 1982.

Figure VI-7

Retention Basins

These structures are used when extreme limits on downstream flow rate or velocity are required. The outflow rate will be relatively low and extended over a longer period of time when compared with the outflow period of a detention basin. This requires large amounts of storage for detaining stormwater for periods greater than 24 hours.

Permanent Ponds

Permanent ponds may be designed to function as detention/retention structures by providing an elevation difference between the principal and emergency spillways. This elevation difference, above normal pond levels, must provide adequate storage volume for detention capacity. These ponds are unquestionably more aesthetically appealing than a typical dry impoundment basin. In addition, the pond can be designed to provide some recreational benefits.

Underground Detention/Retention Tanks

In areas where land is of very high value, these tanks can serve the same function as basins, but they conserve the land area. This method is very expensive because of high material costs for construction and possible pumping requirements.

Table VI-2 summarizes some of the management considerations relevant to the selection and design of detention and retention techniques. The table highlights key elements that should be evaluated during the design process. Additional elements of consideration will exist for each site to reflect the individual characteristics of the area.

Summary

Tables VI-3 and VI-4 highlight the advantages/disadvantages, and operation and maintenance considerations of the above described stormwater management techniques. As noted previously, no one technique is uniquely suited to a particular

TABLE VI-2

SUMMARY OF CONSIDERATIONS RELEVANT TO DETENTION/RETENTION DESIGN

	Land Acquisition (1)	Excavation and Fill	Erosion Protection	Fencing (2)	Pumping Facilities	Piping	Inlet Structure	Hyd. Control Device (outlet)	Spillway Structure (outrall)	Multi-purpose Use	Modif. of Existing Features (3)	Modif. of Existing Structures (4)	Landscaping (5)	Engineering and Site Design	Operation and Maintenance	Financing	Easement/Access
Detention/Retention Basin	●	●	●	●			●	●	●	●			●	●	●	●	●
Detention/Retention Tanks		●			●	●				●				●	●	●	●
Permanent Ponds	●	●	●					●	●	●	●		●	●	●	●	●
Parking Lot Retention			●				●	●	●	●		●		●	●	●	
Roof-top Retention								●	●			●		●	●	●	
Open Space Detention			●				●	●	●	●	●		●	●	●	●	●
Road Embankment Detention			●	●					●		●			●	●	●	●

(1) Acquisition of land exclusively for construction of control structures.
(2) Fencing servicing security and/or safety purposes.
(3) Regrading, new roads, new bridges, etc.
(4) Changes in design (roof-tops, parking lots, etc.) serving a control function.
(5) Planting should be suitable to usage of the site

Source: Roy F. Weston, Inc, op. cit.

TABLE VI-3

ADVANTAGES AND DISADVANTAGES OF ON-SITE METHODS

METHOD	ADVANTAGES	DISADVANTAGES
REDUCTION OF RUNOFF/INFILTRATION STORAGE		
Dutch Drains	– Reduces the total volume of runoff. – Reduces the peak runoff discharge rate. – Enhances the groundwater supply. – Provides additional water for vegetation in the area. – Reduces the size of down-slope stormwater control facilities.	– Losses efficiency if intensive storms follow in rapid succession. – Subject to clogging by sediment. – Limited to application for small sources of run-off only, i.e., roof drains, small parking lots, tennis courts. – Maintenance is difficult when the facility becomes clogged. – Limited application in poor infiltration soils.
Porous Pavement	– Reduces the total volume of runoff. – Reduces the peak runoff discharge rates. – Enhances the groundwater supply. – Provides additional water for vegetation in the area. – Reduces the size of down-slope stormwater control facilities. – Less costly than conven-tional pavements for most applications. – Safety features – superior skid resistance and visi-bility of pavement markings. – Provides pavement drainage without contouring. – Prevents puddling on the surface.	– More prone to water stripping than conven-tional mixtures. – Subject to clogging by sediment. – Water freezing within the pores takes longer to thaw and limits infiltration. – Motor oil drippings and gasoline spillage may pollute groundwater. – Limited application in poor infiltration soils. – recent studies suggest that porous pavement's advantage will reduce with time.

Source: Allegheny County, Act 167 Stormwater Management Plans, 1982.

TABLE VI-3

ADVANTAGES AND DISADVANTAGES OF ON-SITE METHODS

METHOD	ADVANTAGES	DISADVANTAGES
Seepage/Recharge Basins	– Reduces the total volume of runoff. – Reduces the peak runoff discharge rates. – Enhances the groundwater supply. – Construction borrow pits often can be converted to a large seepage basin to serve multiple areas.	– Must be fenced and regularly maintained. – If porosity is greatly reduced, it may be necessary to bore seepage holes or pits in the base. – No filtering supplied by the topsoil. – Usefulness limited in poor infiltrations soils.
Seepage Pits	– Reduces the total volume of runoff. – Reduces the peak runoff discharge rates. – Enhances the groundwater supply. – Provides additional water for vegetation in the area. – Reduces the size of down-slope stormwater control facilities.	– Looses efficiency if intensive storms follow in rapid succession. – Subject to clogging by sediment. – Maintenance is difficult when the facility becomes clogged. – Limited utility in poor soils.
Seepage Beds/Ditches	– Reduces the total volume of runoff. – Reduces the peak runoff discharge rates. – Enhances groundwater supply. – Reduces the size of down-slope stormwater control facilities. – Distributes stormwater over a larger area than other infiltration techniques. – May be placed under paved areas if the bearing capacity of the paved area is not affected. – Safer than seepage or recharge basins.	– More expensive than other infiltration techniques. – Replacement of entire system if clogging by sediment should occur. – Maintenance of sediment traps must be frequent and consequently more expensive.

Source: Allegheny County, Act 167 Stormwater Management Plans, 1982.

TABLE VI-3

ADVANTAGES AND DISADVANTAGES OF ON-SITE METHODS

METHOD	ADVANTAGES	DISADVANTAGES
Terraces, Diversions, Runoff Spreaders, Grassed WAterways, and Contoured Land-scapes	– Increases the overland flow time, increasing the time of concentration and allowing for increased infiltration. – Vegetative swales are less expensive than curb and gutter systems.	– On poorly drained soils, these techniques may leave ground waterlogged for extended periods after storms. – vegetative channels may require more maintenance than curb and gutter systems. – Roadside swales become less feasible as the number of driveway entrances requiring culverts increase.
	DELAY OF RUNOFF	
Rooftop Retention	– No additional land requirements. – Not unsightly or a safety hazard. – May be adapted to existing structures.	– Leaks may cause damage to buildings and contents. – Stored runoff will greatly increase the load imposed on structural support. This increased construction expense may be greater than the savings resulting from reducing the size of downslope stormwater management facilities.
Parking Lot Detention	– Adaptable to both existing and proposed parking facilities. – Parking lot storage is usually easy to incorporate into parking lot design and construction.	– May cause an inconvenience to people. – Ponding areas are prone to icing, requiring more frequent maintenance.

Source: Allegheny County, Act 167 Stormwater Management Plans, 1982.

TABLE VI-3

ADVANTAGES AND DISADVANTAGES OF ON-SITE METHODS

METHOD	ADVANTAGES	DISADVANTAGES
Multiple Use	– Serves more than one purpose. Employing areas of grass, a certain amount of stormwater will infiltrate and improve the quantity of water recharged by natural filtering processes. – If porous pavement is used on basketball or tennis courts, additional infil–tration will be provided.	– Difficult to maintain the porosity of multi–use areas.
Detention/Retention Basins	– Offers design flexibility for adapting to a variety of uses. – Construction of ponds is relatively simple. – May allow significant reduction in the size of downslope stormwater management facilities. – May have some recreational and aesthetic benefits if runoff is not carrying heavy sediment loads.	– Facilities that empty out completely can have an unsightly nature and be a detriment to the developments. – Difficulty in establishing a regular maintenance program. – In a residential development, it may be difficult to determine whose responsi–bility it is to pay for the maintenance program. – Consumes land area which could be used for other purposes.
Permanent Ponds	– Will provide both a reduction in peak runoff rates and a source of recreation in any residential area. – Only minor modifications are required to adapt an existing pond for use as a permanent stormwater management facility.	– Stormwater runoff having a high sediment or pollutant load should not be controlled in existing ponds because of its adverse impact on the natural conditions.

Source: Allegheny County, Act 167 Stormwater Management Plans, 1982.

TABLE VI-3

ADVANTAGES AND DISADVANTAGES OF ON-SITE METHODS

METHOD	ADVANTAGES	DISADVANTAGES
Underground Retention/ Detention Tanks	– Minimal interference with traffic or people. – Can be used in existing as well as newly developed areas. – Potential for using storm-water for nonpotable uses.	– Subsurface excavation could be extremely expensive depending upon the type and amount of rock encountered.

Source: Allegheny County, Act 167 Stormwater Management Plans, 1982.

TABLE VI-4
OPERATION AND MAINTENANCE CONSIDERATIONS

	Dredging	Debris / Sediment Removal	Weed Control	Insect Control	Mechanical Maintenance	Mowing	Cleaning	Bottom Retilling	Repair	Inspection
Detention / Retention Basins		●	●	●		●			●	●
Detention / Retention Tanks				●	●		●		●	●
Ponds	●	●	●	●					●	●
Parking Lot Detention							●		●	●
Roof-top Retention							●		●	●
Open Space Detention		●				●				●
Road Embankment Detention		●	●	●			●		●	●
Seepage Basins		●	●	●		●		●		●
Infiltration Beds*		●					●			●
Porous Pavement							●		●	●
Open Channels		●	●			●				●
Pipe Systems		●					●		●	●

* Dutch drains, seepage pits, and seepage beds.

Source: Roy R. Weston, Inc., op. cit.

runoff problem. Rather, a combination of techniques will result in an effective stormwater management system for the site.

For example, in a development consisting of homes built on quarter acre lots, the residential streets and parking areas could be porous pavement; the roof downspouts could lead to a dutch drain, which also could be a grassed waterway picking up overflow from other controls. Mulch planting could be located beside lattice sidewalks. The excess runoff from all these controls would be collected by either a detention pond or seepage basin at the most downslope area of the development.

In other words, each individual technique would provide a portion of the required stormwater runoff control with the drainage routed overland from each facility to the detention pond or seepage basin. Storage would be provided by a detention pond or a seepage basin. Some additional storage, plus induced infiltration, would be provided by the areas of porous pavement, mulch planting, lattice walks, and dutch drains. Runoff to the pond would be conveyed by a waterway over a dutch drain with an over planting of grass.

Should the soils underlying the site be only moderately drained, then the infiltration controls could be linked by underdrains or gravel trenches. Any excess runoff would drain slowly to the downslope detention facility and eventually to the receiving stream.

The overall stormwater management plan would provide the required reduction of peak runoff without causing on-site flooding. By the use of relatively inexpensive infiltration mechanisms and combined runoff control methods, the expense of stormwater conveyance systems and detention storage is greatly reduced. When planning all new developments, sufficient time should be provided for a careful investigation and selection of the most cost-effective means of stormwater management.

WATER QUALITY CONSIDERATIONS*

The effects of urban runoff from increased development can be detrimental to the natural characteristics of a stream. Before development, only natural vegetation exists. This vegetation allows for much of the stormwater to be infiltrated into the ground. After development occurs, however, driveways, rooftops, and other impervious surfaces reduce the amount of stormwater that can infiltrate into the ground thus generating more runoff from a site. It is estimated that for moderately developed conditions, such as a subdivision with one quarter acre lot homes, there is a 50 percent increase in the amount of stormwater runoff generated. The water that previously infiltrated into the ground runs off these impervious surfaces and floods the receiving stream. This increase in the amount of runoff generated increases the velocity of the stream, and an increased stream velocity causes more downstream channel erosion. The erosion of the banks deposits sediments into the stream which have adverse effects on the stream. A large concentration of sediment in a stream gives the stream a muddy appearance and ultimately reduces the amount of oxygen available for aquatic life.

The additional runoff tends to flood areas that are usually not flooded during similar storm events. This flooding can produce property damage, road flooding, and health hazards.

The following sections discuss some of the water quality aspects of stormwater runoff and also some of the methods available for water quality improvements. These topics have been generalized in Table VI-5.

Erosion and Sedimentation Control Measures

The ability of water flow to transport material is a function of flow velocity and the erosion resistance of the material. As stormwater runoff flow rates increase, the flow velocity increases and more eroded material is transported. As the water

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*Chesapeake Bay Foundation, Best Management Practices for Stormwater Control, Harrisburg, Pennsylvania, November 1988.

TABLE VI-5
WATER QUALITY
IMPROVEMENTS VIA DETENTION AND FLOW ATTENUATION*

WATER POLLUTANTS

SOURCES OF URBAN STORMWATER POLLUTANTS

- Demolition and construction operations
- Land grading and excavation
- Products of erosion from wind and water
- Material stockpiles
- Salt application on streets and other paved surfaces
- debris from litering and vehicle movements
- Particulates from stacks of heating equipment and industry
- Fertilizer, pesticide, herbicide and other chemical applications
- Leaves, grass clippings and trimmings
- Petroleum spillage and leakage
- Disposal of waste materials in storm sewers
- Dumping of refurs in streets and roadside ditches
- Innundation of wastewater treatment facilities by flood waters
- Sewer catch basins not cleaned regularly

POLLUTANTS IN SEDIMENT

- Sediment is the largest single impact on water quality from stormwater runoff (may constitute 70% of total load)
- High sediment yields from grading, excavation, domolition and construction
- Pollutants in sediment can be classified as:
  - non-organic solids
  - organic materials
  - trace metals
  - soil salts
  - chemicals (fertilizers, pesticieds, herbicides)

SUSPENDED SOLIDS

- Material transported by runoff not becoming sediment remains in suspension in receiving waters
- Suspended solids has a mojor impact on water quality

DISSOLVED SUBSTANCES

- Dissolved substances also caused an adverse impact on water quality; they are assimilated and diluted by receiving waters

POLLUTANT CONTRIBUTIONS FROM STREETS

STREETS, ALLEYS AND ROADWAYS

- Transportation routes are a major contributor to pollution
- Represents more than 50% of the loading in some locations
- Snow and ice contain significant amounts and high concentrations of pollutants (i.e., salt)

PAVEMENT SURFACES

- The type of surface influences the amount of litter and debris accumulations because of wear and effects of weather
- About 25% of total litter and debris on streets is pavement material
- Litter, dust and dirt accumulations are greater on asphalt streets than on concrete streets

EFFECTS OF DETAINING STORMWATER AND REDUCING DISCHARGE RATES

- A large fraction of the sediment is trapped
- Natural treatment processes are underway
- There is an opportunity for special treatment
- The rate at which stormwater is discharged from the site of interest into receiving waters is controlled
- Pollutant loadings of stormwater released from storage are attenuated
- The above factors combine to mitigate the adverse impacts of the stormwater discarges on water quality

* "Design, Operation and Maintenance of Stormwater Detention Systems: A Professional Development Course," H. G. Poertner, C. Y. Kuo, Ph.D.

begins to be deposited in streams and storm sewers. This process, known as sedimentation, continues as the flow rate and flow velocity reduces. New development further increases the sedimentation problem by removing natural vegetation and making the bare ground susceptible to erosion.

Many practices have been developed for the control of erosion, sedimentation, and streambank erosion resulting from the development related, land disturbing activities. These practices are well documented in DER soil erosion management manuals.

Storm or Combined Sewer Drainage Systems

There are several considerations relative to maintaining or improving the capacity of storm sewer systems. If these control measures are to be an integral part of a community's stormwater management system, they must be maintained properly. Otherwise, they can result in additional stormwater problems and potential damage.

Sewer System Maintenance Programs

Storm or combined sewer systems are designed to collect and transport stormwater and/or wastewaters. If the sewer system is not maintained properly, effective capacity is reduced. This can occur because of root infestation, internal blockage, inflow, infiltration, and broken pipelines.

Sewer system maintenance programs can be effective in reducing stormwater pollutant loadings. Such programs should include regularly scheduled inspection, cleaning, and repair of sewers and flow regulating devices. These efforts assure availability of full hydraulic capacity and early discovery of trouble spots. Accurate records should be kept to aid scheduling of preventive maintenance and to make system modifications. Effectiveness of these efforts is dependent on the diligence with which they are pursued.

Sewer cleaning programs vary depending on: capital resources available, size of the sewer system, availability of equipment, and condition of the sewer system.

Sewer cleaning programs vary depending on: capital resources available, size of the sewer system, availability of equipment, and condition of the sewer system. They are labor intensive, and their costs vary according to: (1) cleaning method used, (2) extent of blockage or need for cleaning, and (3) frequency of cleaning. Several cleaning methods can be used. Physical methods such as dragging a scouring unit ("snake" or "pig") through a line section is practical only in smaller lines. For larger sewers, hand or hydraulic cleaning may be required.

Flushing can be modeled mathematically to enable the contractor or maintenance supervisor to select the most economical flushing system that would achieve a desired cleaning efficiency within the system's constraints (Lager and Smith, 1974). The cleansing efficiency is a function of the flush discharge, flush volume, sewer slope, length, flow rate, and diameter.

Polymer injection into sewer systems has resulted in significant temporary hydraulic friction reductions and, consequently, a temporary increase in sewer line capacities. In stormwater applications, sewer surcharges associated with wet weather flow generally are of short duration. Therefore, a marginally inadequate sewer line can have its capacity temporarily increased by polymer injections at critical periods. This allows more of the flow to reach the treatment plant and decreases flooding from sewer discharges.

Sewer rehabilitation should be considered only when surveys indicate that infiltration and inflow add excessive flows to the system. Common techniques include sewer replacement, pipe lining, and grouting, Because the engineering and economic analyses required to make cost-effective decisions are beyond the scope of this report and because such detailed analyses generally are included in facilities plans, readers interested in more details on methodologies are referred to the EPA report entitled, "Handbook for Sewer System Evaluation and Rehabilitation" (EPA-430/9-75-021).

Sewer System Operations Programs

The concept of "operation" of sewers is relatively new. The intent is to route and store combined sewer flows to make the most effective use of interceptor and line capacities. This, in effect, maximizes storage within sewer systems during storm events to minimize overflows.

Implementation of this concept requires installation of various physical structures within the sewer system, various monitoring devices, telemetry equipment, and a computer system. Such system controls are being developed and applied in several cities throughout the country. The degree of automatic control or computer intelligence level varies widely among different cities.

Although these control systems to a large degree are structural in nature, effective operation of these systems requires trained personnel and a workable operating plan. Operators must have an intimate familiarity with the operating options available and the results of various operating modes. Care must be taken to avoid problems of basement flooding or simply transferring overflows from one area to another. Training requirements become more rigorous as the system becomes more complex. Compared with other alternatives, this is a highly cost-effective strategy.

Sewer capacity could be increased effectively if extraneous flows were removed. For example, ordinances may prohibit discharge to sewers from roof drains.

Reducing Loads

- Catch-basin Cleaning

  Catch basins built along the curb line of a street for the admission of runoff to a sewer or subdrain function primarily as grit chambers to prevent sewer line clogging, Basins should be cleaned on a regular basis, preferably before storms flush out large amounts of pollutants. This should be done to reduce the potentially severe results of what generally is known as the "first-flush" phenomenon. This theory states that very high pollutant concentrations occur during the initial stages of a storm, from washoff and flushing of accumulated material from catch basins and storm sewers.

There are four alternative methods of catch-basin cleaning: (1) manual, (2) eductor, (3) bucket (clam-shell or orange-peel), or (4) vacuum sweeper. The manual method is most common and consists of bailing out the water and removing the debris (with long-handled dippers), which in turn is piled on the street for collection and hauling to a disposal site. Using a mechanical bucket and hydraulic hoist has the advantage of speed, but the disadvantages are spillage of material onto the street while transferring material from the catch basin and bucket passage into small catch basin inlets. Both the eductor and vacuum sweeper methods can be employed as dual-purpose alternatives. The eductor method consists of a vacuum tank truck and sewer jet hose to suck up the material to be removed and when not in use for catch-basin cleaning can be used with clean water for street flushing. The vacuum sweeper method, a relatively recent development, can be used for both street and catch-basin cleaning. However, both the vacuum sweeper and eductor methods require manual precleaning of the basin to remove large objects.

- Street Sweeping

Street sweeping, a long, established practice typically carried out with brush or vacuum type sweepers has the dual advantages of controlling pollutants at their source and maintaining street aesthetics.

Overall efficiency of particle removal (in one pass or cleaning cycle) by brush type sweepers is approximately 50 percent of dry weight solids. As can be expected, sweeper efficiency varies with particle size -- 15 percent for small particles (about 40 cu) to 80 percent for large particles (2,000 cu). An increase in the removal of dust and dirt can be achieved either by operating at a slower speed than normal (about 5 miles per hour) or by making several passes (i.e., multiple cleaning cycles) over the same area. Two cleaning cycles would be required to achieve an overall effectiveness of 70 percent, while values greater than 90 percent (about four cleaning cycles) probably cannot be achieved with present brush type equipment (Sartor and Boyd, 1972).

Street sweeping can be applied beneficially in most urban areas; however, the impact of this technique is more obvious in areas with separated storm sewer systems. For combined systems, loads from other sources must be evaluated in order to establish load reduction criteria. For example, it may be prudent to spend scarce public funds to reduce overflow events, and concentrate on sweeping only for aesthetic reasons. Hence, a detailed cost-effectiveness analysis should reveal an optimal contaminant removal rate per dollar spent.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION VII
ALTERNATIVE INSTITUTIONAL SYSTEMS

This institutional section includes a discussion of the alternative organizational arrangements for developing and managing stormwater control facilities and for administering the local development ordinances. This study uses the term "Institutional System" to describe the interrelated and interdependent network of agencies and functions involved in stormwater management. The institutional system includes both specific agencies (such as the DER and local governmental units), as well as the functions that they perform, including planning, development (construction), operation and maintenance, regulation, and financing.

Many of the problems associated with managing stormwater involve the fact that stormwater cannot be managed effectively on a piecemeal basis. Stormwater management, at a minimum, must be done on a watershed basis and necessarily requires intergovernmental action. This study identifies several approaches that can accomplish the various required functions.

EXISTING INSTITUTIONAL SYSTEM

All levels of government -- federal, state, county, and municipal -- and their respective agencies have differing roles relating to stormwater management. The following paragraphs provide a description of the responsibilities for each of these entities.

Federal

The United States Congress passed the Clean Water Act (PL 92-500) in 1972. This piece of legislation and subsequent amendments deal primarily with the water quality aspects of storm runoff. Since water quality and water quantity are interrelated, PL 92-500 does impact on stormwater quantity activities. The federal agency responsible for implementation of the Clean Water Act is the Environmental Protection Agency (EPA), which administers its programs through its Region III office located in Philadelphia. In the water field, a principal function of the EPA, in addition to administration of the Clean Water Act, is to assist in the research, development, and implementation of a national urban runoff program. Because of limited funds, however, it seems likely that this program will not be fully carried out.

A second federal agency involved in stormwater management is the United States Soil Conservation Service (SCS), which is a part of the United States Department of Agriculture. SCS provides technical assistance to farmers in rural areas and to developers and municipalities in urban areas in terms of land management practices relating to sedimentation and erosion control. Through this program, stormwater control is taken into consideration.

Another federal agency involved in stormwater management is the United States Corps of Engineers (Corps), which is a part of the Department of Defense. The Corps deals exclusively with the navigable waterways, i.e., the rivers of the United States. The Corps has an extensive flood plain management program that includes the preparation of flood insurance studies. In addition, as a responsibility of the Flood Plain Management Branch of the Corps, technical assistance is provided to local municipalities through utilization of computer models for determining runoff. The Corps also is an excellent repository of hydrologic information within watersheds.

The United States Department of Housing and Urban Development (HUD), has some functional responsibility over stormwater management. Through its Community Development Block Grant Program, stormwater management studies and facilities construction may be eligible for grant funds.

State Agencies

The General Assembly of the Commonwealth of Pennsylvania was responsible for the adoption of legislation relating to stormwater management. There are two state executive agencies having functional responsibilities in stormwater management: the Department of Community Affairs (DCA), and the Department of Environmental Resources (DER). DCA administers the Flood Plain Management Act. This Act is the companion act to the Storm Water Management Act (Act 167). DCA, under the provisions of Act 167, also has a review function in cooperation with DER for all watershed plans.

The DER is the primary agency responsible for stormwater management in Pennsylvania. The Department has the power and duty to: (1) coordinate the management of stormwater in the Commonwealth; (2) provide, in cooperation with the DCA, technical assistance to counties and municipalities in implementing Act 167; (3) after notice and public hearing and, subject to the requirements of the Act, publish guidelines for stormwater management and model stormwater ordinances for use by counties and municipalities; (4) review, in cooperation with the DCA, and approve all watershed plans and revisions thereto; (5) cooperate with the appropriate agencies of the United States government or other states or any interstate agencies with respect to the planning and management of stormwater; (6) serve as the state agency for the receipt of monies from the federal government or other public or private agencies or persons and expend these monies as appropriated by the General Assembly for studies and research with respect to planning and management of stormwater; (7) conduct studies and research regarding the causes, effects, and hazards of stormwater and methods for stormwater management; (8) conduct and supervise educational programs with respect to stormwater management; (9) require the submission of records and purposes of the Act; (10) after notice and hearing, designate watersheds for the purpose of Act 167; and (11) perform such other acts consistent with Act 167 required to carry out the purposes and policies of Act 167.

Regional Agencies

The only regional agency in southwest Pennsylvania is the Southwestern Pennsylvania Regional Planning Commission (SPRPC). This agency has no direct function in stormwater management activities and heretofore has done no stormwater management planning.

County Agencies

The Armstrong County Department of Planning administers the county's subdivisions regulations, which could potentially regulate stormwater management in certain developments as well as several of the townships.

Any municipality other than Armstrong County may adopt by reference the Subdivision and Land Development (S/LD) Ordinance of the County, and may by separate ordinance designate the Armstrong County Planning Commission as its official administrative agency for review and approval of plats. Further, the Armstrong County Board of Commissioners can amend and repeal subdivision and land development ordinances limited to land in those cities, borough, incorporated towns, and townships wholly or partly within Armstrong County which have no subdivision and land development ordinance in effect.

The above described situation could allow the county to become the focal point for administering stormwater through modifications to its S/LD ordinance.

Local Government

The local townships within the Glade Run Watershed have a variety of functions under the existing institutional system. Their primary functions are to adopt stormwater management plans prepared by the county agencies. Another responsibility deals with the implementation of stormwater management through local land use controls adopted by local governments. Act 167 states that a municipality must adopt and implement ordinances and regulations pertaining to proper stormwater management. The municipality must adopt these ordinances within six months following the adoption and approval of the watershed stormwater plan. These local controls include zoning, subdivision, building codes, erosion and sedimentation ordinances, and other ordinances necessary to implement the plan. Under these ordinances, the review and approval of proper stormwater management techniques such as on-site facilities would be included in the municipal review of development plans.

Each municipality is also responsible for the operation and maintenance of any stormwater controls associated with local municipal facilities, such as storm sewers, roads, bridges, parks, and public projects. In many cases, municipalities are assuming responsibility for maintenance of stormwater retention facilities constructed by developers, along with streets, sidewalks, sewers and other public facilities.

Property Owner

The final level of responsibility for stormwater management lies with the individual property owner, be it a developer of residential, commercial, or any other property, or a public body performing its proprietary functions. It is the responsibility of that property owner to design and construct stormwater control facilities in accordance with the terms of Act 167 (Section 13). Should there be a Stormwater Management Plan adopted, then the property owner must conform to the criteria and standards set forth in the watershed plan and to the local ordinances adopted by the municipality. In some cases, after a residential plan has been developed, a home owners' association is formed, and it assumes the responsibility for stormwater facilities.

EXISTING LOCAL STORMWATER MANAGEMENT CONTROLS

Table VII-1 delineates the existing development controls that are in place in the municipalities in the watershed. These controls include subdivision, zoning, building codes, erosion and sedimentation controls, stormwater management ordinances, and environmental ordinances.

Adequate construction inspection and enforcement seems to be a problem for many communities because of lack of personnel and financial resources. Most communities rely heavily on the county for plan review and inspections related to stormwater management measures.

TABLE VII-1

EXISTING MUNICIPAL LAND USE AND DEVELOPMENT CONTROLS

Municipalities	Building Code	Zoning	Grading	Subdivision	Floodplain	Land Development	PRD	Erosion & Sedimentation	Conservation	Stormwater	Other (see note)
Sugar Creek Township											1&2
Washington Township											
East Franklin Township		●			●						2
West Franklin Township											1&2
North Buffalo Township		●									
Cadogan Township					●						

NOTES: 1 - Planning Commission
2 - Building Permits

ALTERNATIVE INSTITUTIONAL SYSTEMS

The preceding section outlined legal authorities and mandates, and the various organizations and their current functions and activities related to stormwater and flood plain management. Since an organized approach to stormwater management (beyond the level of the individual development site) is still a fairly recent phenomena, the institutions concerned with managing stormwater quantities are not nearly as numerous and the system not nearly as complex as that required for management of water quality. Other than flood control activities performed by the Corps, there are principally two levels of government involved: (1) the state (DER) through the permitting of stream obstructions and enforcement of erosion and sedimentation regulations, and (2) the local municipalities through the application of storm drainage controls for new construction contained in their land use, development and building regulations.

Traditionally local municipalities have been the focal point for stormwater management activities. Two of the major problems that many municipalities face are the lack of adequate financial resources and skilled personnel to carry out a comprehensive and effective stormwater program. The earlier technical section demonstrated that there are many interrelated variables that must be considered in designing a stormwater control system both on a single site basis and, more importantly, for an entire watershed. These facts raise the issue of whether or not any single municipality has either the technical and financial capacity to implement an areawide Stormwater Management Plan.

Furthermore, while Act 167 mandates local municipal responsibility for administering stormwater management, it clearly intends a coordinated approach at the watershed level. The initial planning is to be done on a watershed basis, and municipalities are responsible to see that they do not cause harm anywhere within the watershed or in the watersheds to which they are tributary. As the technical discussion and release rate concept has shown, anything less than a watershed approach can indeed result in unnecessary expenditures and ultimately harm the properties in adjacent localities.

The technical measures relating to stormwater management as presented in this study focus primarily on "on-site" solutions; that is, actions that can be undertaken by the land developer to retain the increased runoff on site and thereby not increase the rate of runoff further downstream. However, there are also "off-site" solutions, which could include storm sewer system, publicly owned retention facilities to serve multiple developments, lakes, ponds, or other physical facilities.

While it was not within the scope of this study to develop a detailed plan for such stormwater control facilities, there may be a need for more off-site solutions in the future. In many instances, a public stormwater system may prove more cost effective and easier to administer and to maintain than many small, separately-owned retention facilities. Also, topography, soils, and other natural constraints may make it difficult to provide on-site retention in many locations, and development will not be possible unless other alternatives are available.

For these reasons, it is important to look at institutional alternatives that can be activated immediately to handle current functions and problems and can also adapt to future situations and new responsibilities. Given these concerns, this plan outlines essentially a two-phase approach to developing a stormwater management system for Armstrong County. The first phase describes ways to initiate actions leading to adoption of the recommended stormwater ordinances, the improvement of local administration and enforcement, and the selection of a permanent watershed management system.

The second phase foresees the organization of a coordinated watershed management system. This system would be capable of assisting constituent municipalities with development regulations (relative to stormwater), as well as developing and operating physical facilities. In proposing the options for watershed management, various criteria were considered, including technical and legal feasibility, financial resources, and political acceptability. Consideration was also given to the general applicability of the management system to other parts of the county.

- Methods to finance the administration

The county will require adequately trained inspection and enforcement personnel. Two to three site visits probably will be required for average construction projects, with more site visits required for larger projects with sophisticated stormwater control measures. Often the inspections for stormwater facilities can be combined with inspections for other items (roads, sewers, grading, etc.), and the municipality's existing building inspector(s) should be able to handle the additional stormwater-related work. In instances where the proposed stormwater facilities are beyond the scope of the local inspector (or municipal engineer), then the municipality may find it necessary to call upon outside expertise.

Another approach would be for the county to contract (or hire) professional assistance on a watershed basis for certain plan review, inspection, and enforcement functions.

As noted later in the section on the model ordinance, the county should establish a fee system which covers a substantial portion of its administrative costs. Whether the county elects to use preset fees, developer's fees, or some other approach, it is important that the fee structure accurately reflect the municipality's costs.

WATERSHED MANAGEMENT SYSTEM

An overall system will have two basic areas of interest: (1) the administration of the stormwater ordinances, and (2) the development and management of physical facilities. The major functional categories are: planning, construction, operation and maintenance, financing, regulatory (includes ordinance administration), and information and education.

Functions of the Management System

Within the five broad functional categories, there are many specific types of activities, although not all of these will be required. Table VII-2 summarizes some

TABLE VII–2

WATERSHED MANAGEMENT ACTIVITIES BY FUNCTIONAL CATEGORIES

PLANNING	CONSTRUCTION	OPERATION AND MAINTENANCE	FINANCING	REGULATORY	INFORMATION AND EDUCATION
Maintain data base on stormwater facilities/ structures in watershed.	Design and construct public stormwater control systems (e.g., public retention facilities).	Operate and maintain publicly–owned stormwater control facilities (e.g., retention basins).	Provide adequate funds (fees, grants, tec.) for ordinance preparation and continuing administration.	Adopt and enforce (i.e., plan reviews and construction inspection) municipal stormwater ordinances (zoning, subdivision and land development. etc.).	Educate developers, local officials, property owners, on provisions and importance of stormwater management plan.
Assist County with five–year plan update.	Provide standards/specifications for privately constructed stormwater fatilities.	Provide system for continuing maintenance and replacement of privately owned stormwater facilities/ structures.	Assure funding availability for maintenance/operation of private stormwater control facilities.	Enforce local floodplain ordinances.	Provide information on the application of good stormwater management techniques; provide information on new or innovative solutions to stormwater problems.
Perform detailed planning and/or feasibility studies for new or upgraded stormwater control facilities, as proposed by stormwater plan.	Coordinate with applicable public agencies on construction of stormwater related facilities/structures and flood control within watershed to assure consistency with the plan.	Coordinate with local, county, and state agencies to assure regular maintenance and/or replacement of their stormwater structures (e.g., culverts, bridges.	Privide financing for construction, operation of publicly owned facilities, as proposed by the stormwater plan.	Assure that state obstruction and erosion and sidimentation permits are obtained where required.	Provide assistance to property owners with stormwater related problems, such as proper enforcement procedures, legal remedies.
Initiate program of stream flow monitoring.		Provide maintenance service (on a contract basis) to public or private owners of stormwater facilities/ structures within the watershed.	Provide funds for continuing planning and stream monitoring system.	Assure public improvements projects (roads, shools, utilities, ets.) are completed in accordance with stormwater plan.	
Coordinate stormwater recreation, water quality).			Provide adequate administrative funds for stormwater management agency(s).		

Source: Allegheny County, Act 167 Stormwater Management Plan, 1982.

of the stormwater management activities included in each of the functional categories. While Act 167 mandates certain responsibilities for the municipalities, there are many other management activities that are necessarily implied by these mandates and the adopted stormwater plan. Therefore, the management system must take into consideration both of these types of functions.

One very important functional responsibility is the regular maintenance of stormwater facilities such as storm sewers, culverts, stream channels, and retention/detention ponds. The stormwater system can only work as well as the overall efficiency of the facilities within the system.

Therefore, it will be the responsibility of the county to determine who should be responsible for maintenance of state, county, local, and privately-owned facilities. As a part of that determination, the cost of maintaining these facilities will have to be determined as well as how funds will be provided. There are a variety of ways this could be handled.

Additionally, there may be other activities that will improve overall stormwater management in the watershed, such as conducting educational and informational programs. Although optional functions (i.e., not specifically mandated by Act 167), the watershed management agency(s) and/or municipalities may decide that certain activities will enhance their ability to implement the plan.

COUNTY ROLE IN STORMWATER MANAGEMENT

Because it enforces its own subdivision regulations, Armstrong County will be required to update this document so that it is consistent with the Stormwater Management Plan. The county is presently in the process of revising the entire S/LD package, providing an opportune time to add provisions for stormwater management.

This becomes increasingly important since many municipalities do not presently have S/LD regulations, deferring to the county for enforcement of regulations. In doing so, the county will automatically become responsible for administering the stormwater plan to the majority of the Glade Run Watershed. In addition, the county will be responsible for constructing and maintaining those stormwater management facilities built in conjunction with county-owned roads and properties.

Additional implementation involvement for Armstrong County could be the continuation of funding for municipal stormwater projects. This study identifies other activities which the county should assume, particularly during the initial implementation phase. In addition, there are those activities that the county could undertake in order to assist the municipalities in performing their assigned functions.

As a result of the adoption of this plan and modifications to the county S/LD ordinance, the county will assume full responsibility for all stormwater related activities. This approach would eliminate the concern relating to the probability that many municipalities do not have the technical and financial resources necessary to establish an effective stormwater management program and the further concern that within each watershed there may be one or more communities that are unable (or unwilling) to do their "fair share." Implementation of this approach would require legislation to enable the county to perform many of the necessary functions, although some municipalities might be reluctant to relinquish any of their authority over local land use and development.

Additionally, there are other areas in which county action may be considered:

- Technical Assistance
    - Increase staff capability of the County Conservation District to improve administration of erosion and sedimentation program and to provide greater assistance in plan reviews, inspection and enforcement of erosion regulations.
    - Institute a program of stream monitoring to provide better data for future planning.

- Maintain and update computer model for the watershed and make its use available to developers, engineers, public/private agencies undertaking projects in the watershed.

- Education and Information

  - Sponsor and assist state agencies in conducting stormwater management workshops for developers, design professionals, and municipal officials. This activity will be valuable particularly during the initial phase of implementation, but workshops should be repeated regularly.

  - Prepare training materials for local municipalities to be used by their staffs and consultants.

  - Develop a series of programs on stormwater management to increase the general public's awareness of the problems and the necessary solutions.

Undoubtedly the significant variable in what the county does or does not do will be money. However, there are possibilities for acquiring some outside grants for some of the proposed activities, and the county may be in a better position to obtain these funds than the individual municipalities. Also, the county may be able to reassign and reallocate its personnel to provide certain functions without creating additional costs.

The DER is authorized to not only administer grants to counties for costs in preparing official Stormwater Management Plans, but to also provide funding assistance or reimbursement for actual administrative and enforcement costs, implementation costs, and costs for revisions to official plans. This reimbursement is equal to 75 percent of the allowable costs for preparation of official Stormwater Management Plans, administrative, enforcement and implementation costs incurred by the municipality or county.

This means that the costs that are incurred for the review of developer stormwater plans by the county which are not covered by fees paid by the developer may be reimbursed by the DER equal to 75 percent of the allowable costs of the review. Also, the cost to modify the S/LD ordinance to include stormwater management provisions is also reimbursable.

The review of stormwater plans prepared by developers should be reviewed by a engineer with expertise in stormwater planning. A personal computer will be necessary with several software packages to facilitate the review. These include Soil Conservation Service Technical Release 55 (TR-55), the Penn State Urban Hydrology Model (PSUHM), and the Penn State Runoff Model (PSRM).

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION VIII
FINANCING STORMWATER MANAGEMENT

Who does what and when will depend primarily on the availability of the necessary funds. In the past, local revenues and private developers have contributed most of the funds for local stormwater control facilities (typically storm sewers), while state and federal agencies have financed major flood control or drainage projects. The basic philosophy has been to have new development pay the cost for its facilities (i.e., to prevent problems) and to use public funds to correct existing or major regional problems.

Although this basic approach to financing stormwater management probably will hold true in the future, it can be anticipated that there will be fewer public funds available for capital improvement projects. Consequently, the emphasis will be on preventing future problems, while at the same time taking specific steps to ensure that existing problems will not be aggravated.

In implementing a feasible stormwater management program, financing is bound to be one of the major stumbling blocks. It is extremely important that the watershed task force, municipalities, the county and DER investigate thoroughly all practical financing techniques, including any new legislation to make stormwater management more economical.

At first, it may be tempting to adopt the approach that "the one who creates the cost pays the cost," thus placing most of the financial responsibility on the local municipality and private developer. However, this approach may not be realistic -- or totally fair. Many of today's stormwater concerns are the result of years of insufficient planning and lack of attention to stormwater drainage by all levels of government, as well as the private sector. Therefore, everyone should share in the cost of the solutions, whether those solutions involve activities to prevent new problems or to correct existing ones.

Unfortunately, most people are unwilling to accept the fact that, to varying degrees, stormwater runoff is everyone's responsibility. They may be aware of flooding, landslides, and other stormwater-related problems in their community; but unless they are actually suffering the impacts, they are unwilling to assume any financial responsibility. Therefore, part of the resolution to stormwater financing will be to inform and educate the citizens on stormwater management problems, their solutions, and the need to act in a timely manner. The public should become aware of the fact that delaying stormwater programs or projects, or approaching them on a piecemeal basis, only compounds the problems or succeeds in moving them downstream.

The following paragraphs describe briefly some of the financing alternatives available for stormwater management. Most of the ones presented here are applicable to local municipalities and can be pursued under existing legal authorities, although a few may require new or changed legislation to make them useful in stormwater management. The financing alternatives include techniques to finance three important functions of a watershed management system: (1) capital improvement projects, (2) operation and maintenance activities, and (3) local ordinance administration.

MUNICIPAL BONDS

Most long-term borrowing by municipalities and authorities is done by issuing bonds. Pennsylvania local governments and authorities are governed in this area by the Local Government Unit Debt Act (Act 185 - 1972). This Act regulates the type of bonds that agencies may issue and establishes debt limitations for municipalities. In general, the limitation is 250 percent of the borrowing base for nonelectoral debt and 300 percent of the base for lease rental debt. The borrowing base is the average of certain net revenues of the municipality over the three years preceding the year in which the bonds are being issued.

The local Government Unit Debt Act authorizes four different types of bonds:

- **Electoral Debt Bonds** may be issued by a municipality after an approving election held in accordance with provisions of the Local Government Unit Debt Act. If the electorate approves bonds for a specified project, such as the construction of a storm sewer system, then the electoral bonds are not subject to any debt limitation under provisions of the Act. Thus, if a municipality wishes to go to the electorate, it is possible to issue electoral general obligation bonds in the form of electoral debt even though the amount of the bonds would otherwise exceed the municipality's debt limitation.

- **Nonelectoral General Obligation Bonds** pledge the general taxing powers of a municipality for repayment of the bonds and, as a result, do not have any coverage factor on their repayment. This type of bond is seldom used to finance larger, high-cost projects.

- **Guaranteed Revenue Bonds** presently are receiving a great deal of favor by municipal bond issuers. This bond is a revenue bond of the municipality, which pledges revenues from the project for repayment. In event of any delinquency, the municipality guarantees to make up the deficiency out of its general taxes. To the extent that taxes are used to pay any portion of the principal and interest on guaranteed revenue bonds, these bonds become a debt within the debt limitation of the municipality. Guaranteed revenue bonds also may be limited to a specific percentage of deficiencies which will be made up by a municipality out of its tax revenues. When this occurs, these bonds are designated as "limited guaranteed revenue bonds."

- **Straight Revenue Bonds** differ from guaranteed revenue bonds in that the sole basis for repayment of the principal and interest on these bonds is the revenues for services provided by the project.

For all nonelectoral bonds and revenue bonds that may be issued by a municipality, provisions under Act No. 185 can qualify these debts as "self-liquidating" out of revenues collected. Once these debts are qualified as self-liquidating, these bonds thereafter are not considered to be within the debt limit of the municipality, so long as revenues which make the bonds self-liquidating continue to pay the full amount of principal and interest on these bonds.

Although revenue bonds are widely used for sanitary sewer and water systems, they have had limited applicability to stormwater or flood control projects because such projects usually are not revenue producing. This situation reflects the difficulty in establishing a basis for assessing charges to system users.

General obligation bonds are used less frequently now by Pennsylvania municipalities because they either come under the community's debt limit or, in the case of electoral bonds, require approval of the voters. In today's economy, communities are reluctant to go to the voters with major capital expenditures. Also, as noted earlier, lack of public awareness and understanding of stormwater management has sometimes resulted in projects being defeated by voters. However, general obligation bonds probably are the least expensive method of long-term financing for municipalities.

TAX REVENUES

General and special tax revenues are probably the most frequent means of financing stormwater-related projects for local municipalities. Tax revenues cover the majority of operation and maintenance cost for publicly-owned stormwater facilities and structures. Real estate taxes are the main source of local tax of revenues, along with wage taxes and other special taxes or assessments.

State liquid fuels monies also could be used for stormwater and drainage structures related to street construction and repair. It is not clear whether liquid fuels monies can be used for stormwater projects that are not directly part of the street construction (i.e., correcting a drainage problem adjacent to, but impacting the roadway). It may be desirable for PennDOT to review its current guidelines on the eligible liquid fuels projects and allow more latitude on stormwater projects affecting local streets.

As noted earlier, most municipalities currently pay for stormwater-related projects from their general funds (i.e., tax revenues). This includes correction of localized drainage problems, as well as maintenance of any municipal stormwater facilities and structures. Thus, the level of municipal stormwater management is directly related to local tax revenues. It is often difficult for smaller or declining communities to obtain adequate financing for necessary projects, and municipalities frequently are limited in their ability to accumulate funds for larger stormwater or flood control projects.

One solution to this problem is for a municipality to establish a capital improvement reserve fund. Each year the local government can set aside an amount for the reserve fund; funds can be allowed to accumulate, if necessary, for larger projects. The principal advantage to the reserve fund is that it allows municipalities to put projects on a "pay-as-you-go" basis, thus saving the interest costs for borrowing. A capital reserve fund also enables a municipality to set up an ongoing program for improving and maintaining physical facilities.

There are various ways of generating revenues for the reserve fund. One way is to maintain a constant level of the property tax levies allocated to debt retirement. Usually existing debt drops as a percentage of property tax revenues, as annual payments for debt service decline and assessed valuation of property increases. By maintaining the tax at its current rate (if taxes are not too high), a community can earmark those "extra" funds to the capital reserve fund.

Another approach might be to allocate a portion of the funds from such sources as parking meters, amusement taxes, service charges, licensing or permitting fees. For example, a community could include a special set-aside for the "stormwater capital reserve fund" from its building permit fees. Also, any operating surplus for a fiscal year (or some portion thereof) could be transferred to the reserve fund.

SPECIAL ASSESSMENTS

Special assessments may be levied on affected property to finance specific projects, most often capital improvements. The assessment rate is set on a formula basis which relates the amount of the assessment to the value of the services or benefits provided. Special assessments are applicable to projects with one or more of these characteristics:

- Provides special benefits to property which are direct and measurable, such as storm sewers, catch basins, curbs, and gutters.
- Provides general benefits to a localized area where the whole area benefits, although not uniformly (e.g., flood control facilities).
- Provides public appurtenances to private property (e.g., sewers, streets).
- Abates a public nuisance (e.g., public retention pond).

The special assessment has not been used widely in western Pennsylvania, especially for storm drainage facilities. One of the drawbacks has been in developing an equitable formula for allocating the assessment for properties. It often is difficult to set the amount of the benefit of the stormwater facilities for properties both upstream and downstream of the facility.

However, special assessment financing certainly merits further consideration by Pennsylvania communities. It may be particularly applicable in areas where storm sewer systems are recommended (or require improvement) or where a public retention facility is proposed to serve one or more subbasins in the watershed. Also, the watershed stormwater plan provides a better basis than existed previously for assessing how properties will be affected (benefitted) by proposed stormwater facilities. Therefore, it can aid in establishing an assessment formula.

USER CHARGES

User or service charges may become more popular in the future for financing stormwater management activities. To utilize this approach though, it is necessary to have a stormwater plan to develop sound cost estimates for implementing the stormwater system. To date, user charges have been applied by areas with extensive storm sewer or combined sewer systems to finance both capital improvements and maintenance. Service charges do not seem to be used widely for other types of stormwater management facilities.

User charges have been utilized in other states where communities have established a separate stormwater utility. In this arrangement, the utility owns and operates all aspects of stormwater management and flood controls and charges a fee for property owners based on lot area and estimated runoff rates. A stormwater utility appears to be possible in Pennsylvania, but it would have to be licensed and regulated under the Pennsylvania Utility Commission, similar to some privately-owned and operated sewage treatment plants.

It is not clear whether user charges could be instituted under existing legislation, especially without local voter approval. However, user charges have one major advantage for stormwater financing. They create a steady source of revenue, which makes it possible to finance major projects with long-term securities, including revenue bonds. Such fees could be determined by considering various physical factors affecting runoff rates (e.g., amount of impervious surface, soil and slope conditions), which can be documented. A user charge could be a fairly equitable way to finance stormwater management within a watershed.

GRANT FUNDS

In the past, communities have depended heavily on federal and state grants for major capital improvements (primarily to correct existing problems) and for flood control projects. However, given the present state of flux in federal and state funding programs, it is unclear how secure a source of financing these will be in the future. For this reason, this study does not present any extensive catalogue of grant programs. If a community has a specific project, it should contact appropriate state or federal agencies to determine if any funding assistance is currently available.

On the federal level, the U.S. Corps of Engineers can provide technical assistance (for planning, design, and construction) of specific stormwater projects. The Corps will also assist in smaller improvement projects if necessary to protect a public facility. There are funds and technical assistance available from the U.S. Soil Conservation Service (SCS).

Many communities are receiving funds through the Community Development Block Grant (CDBG) program, funded by the U.S. Department of Housing and Urban Development.

The Pennsylvania Department of Community Affairs (DCA) and Environmental Resources (DER) provide technical assistance, information and education, programs and some funding for capital improvements. DCA administers the flood plain management program and assists communities with the preparation and adoption of their flood plain ordinances and other flood plain management activities. Also, under Act 167, DCA is assigned responsibility for conducting education and informational programs.

DER, of course, administers the stormwater management program established by Act 167. It also provides technical assistance (including public education) on stormwater, erosion and sedimentation problems, provides partial funding to the County Conservation District, and provides financial assistance for correcting flooding or erosion problems that are affecting public facilities.

PRIVATE FINANCING

A substantial proportion of the costs for stormwater management activities is provided by private land developers. In most communities, developers are responsible for the initial construction of any facilities required to serve their site and, in some cases, are also responsible for off-site improvements necessitated by the development, such as increasing the size of a downstream culvert. Where there is an existing public stormwater facility (or one is proposed by the plan), such as a storm sewer or retention pond, then the developers may be required to contribute to its improvement (or installation) cost. Communities sometimes may ask a developer to oversize a facility to serve areas outside the development, perhaps to correct an existing problem or to permit future development. In this situation, the community should share in the increased costs and "recapture" its costs from the benefitted property owners, possibly using the special assessment mechanism.

Developer application/permit fees provide the major source of funds for local ordinance administration, including plan reviews, inspection, and enforcement. Some municipalities use a fixed-fee system based on size of development (square footage, land area, etc.), impervious surface, or some other measure. Generally, fees are higher for commercial, industrial, and multifamily projects than for single-family developments. Other communities use the developer fee approach, which is a fee established at the time of application and based on an estimate of actual costs to the municipality for professional reviews, hearing, schedules for plan reviews, inspection, hearings, or other activities in the development approval process.

Fair and effective stormwater regulation will require increased expenditures for professional assistance (either staff or consultant) for most municipalities and developers. However, to a large degree, the issue is simply a matter of deciding when the monies are going to be spent -- in the beginning of a project to prevent problems or at the end of construction to correct them. In Armstrong County, and particularly in the study area, much of the future development will be taking place on sites with one or more natural or physical constraints (e.g., steep slopes). Therefore, the potential (and magnitude) for future stormwater problems is even greater, unless both developers and municipalities increase their investment in good stormwater management.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION IX
PRIORITIES FOR IMPLEMENTATION

The Glade Run Stormwater Management Plan preparation process for Armstrong County and the six affected municipalities of Sugar Creek, Washington, East Franklin, West Franklin, North Buffalo and Cadogan Townships is complete with the county adoption of the draft plan and submission of the final plan to the DER for approval.

Approval of the plan by the DER will set in motion the mandatory schedule of adoption of municipal ordinance provisions to implement the recommendations of the plan. Armstrong County and the six affected municipalities will have six months from the DER approval within which to adopt the necessary ordinance provisions. Failure to do so could result in the withholding of all state funds to the county and affected municipalities.

Following the adoption and approval of the plan, the location, design, and construction within the watershed of stormwater management systems, obstruction, flood control projects, subdivisions and major land developments, highways and transportation facilities, facilities for the provision of public utility services and facilities owned or financed in whole or in part by funds from the Commonwealth must be conducted consistent with the stormwater plan for the watershed.

Recognizing that effective stormwater management must be done on a watershed basis, the plan requires those who engage in the development of land, whether the developer be a private or public entity, to implement reasonable measures to prevent harm to persons or properties downstream. Such measures shall include action as are required to:

- Assure that the maximum rate of stormwater runoff is no greater after development than prior to development activities.

- Manage the quantity, velocity and direction of resulting stormwater runoff in a manner which otherwise adequately protects health and property from possible injury.

The Storm Water Management Act (Act 167) places the responsibility for implementation of the plan in the hands of the local municipalities, in this case Armstrong County and, to a lesser degree, the six affected municipalities.

Armstrong County must incorporate the Glade Run Stormwater Management Plan into their Subdivision and Land Development (S/LD) Ordinance, and the municipalities must make reference to the ordinance in their zoning, building ordinance, and plumbing codes, where applicable, in order to provide a comprehensive ordinance package covering all types of land alteration activities. A flow chart is provided in Figure IX-1 showing the steps in chronological order which are necessary for the implementation of the plan.

Several of the tasks have already been completed including the steps through submission of a draft report and receiving comments from Armstrong County, the six affected municipalities, and the DER.

The major tasks yet to be completed include the approval and adoption of the plan by the county commissioners, approval of the plan by the DER, revision of the S/LD Ordinance by the county, and administration and enforcement of the revised ordinance.

Remaining items to be addressed by the county, following the approval of the plan by the DER, will be modification of the S/LD Ordinance to include provisions for stormwater management. Since the county is in the process of revising its S/LD Ordinance, this provides an ideal opportunity to include provisions for stormwater.

Armstrong County
Stormwater Management Plan
Glade Run Watershed

Recommended Implementation Activities

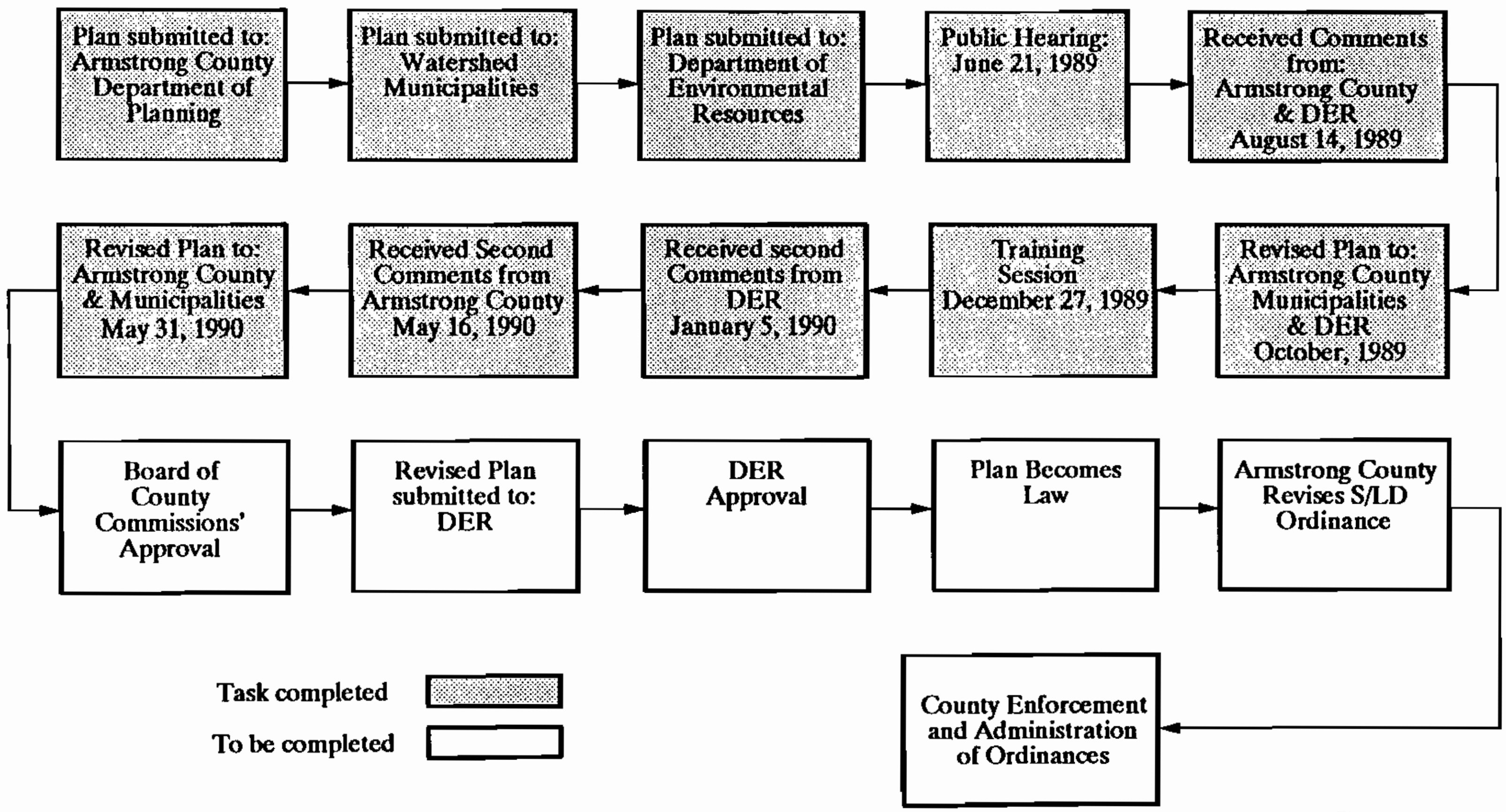

FIGURE IX-1

The overall regulatory approach recommended here is that the county include appropriate stormwater provisions to their S/LD Ordinance and that the six affected municipalities reference these provisions in their zoning and building regulations. Most land use and development activities to which stormwater management measures should be applied will fall within the scope of one or more of these three types of development ordinances. These ordinances cover different types of regulatory activities. Therefore, municipalities generally will need to utilize the powers provided by all three to ensure a comprehensive stormwater management regulatory system that applies to all types of land alterations, whether it be new development, expansion of existing facilities, or redevelopment of existing lots and structures.

As discussed previously in Section II, the municipality's planning code enables municipalities to adopt zoning and subdivision/land development regulations and to address various municipal codes (township, borough, etc.) authorizing communities to enact building regulations. These very clear enabling powers are the major rationale for recommending that the stormwater management provisions be included in the appropriate development ordinance.

Appendix A contains key sections of the stormwater management article for the S/LD Ordinance.* This sample form is not intended to be a model ordinance but rather to provide a guide to the county in preparing their regulations. Before proceeding with the adoption of any specific stormwater provisions, the changes should be reviewed within the context of the community's entire ordinance structure with legal counsel. This will help avoid conflicts which might develop within an amended ordinance, or conflicts with provisions in other ordinances.

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* Where a separate stormwater ordinance is used, then similar provisions would be included in that ordinance.

ARMSTRONG COUNTY
GLADE RUN WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION X
STORMWATER PLAN RECOMMENDATIONS

The Glade Run Stormwater Management Plan has been prepared to respond to the mandates and requirements of the Storm Water Management Act (Act 167). Act 167 establishes the basic standard for all stormwater activities. Section 13 of Act 167 requires that those engaged in the development of land, whether private or public entities, must implement reasonable measures to prevent harm to persons or property. These measures must include actions:

- To assure that the maximum rate of stormwater runoff is no greater after development than prior to development activities.

- To manage the quantity, velocity and direction of resulting stormwater runoff in a manner which otherwise adequately protects health and property from possible injury.

Act 167 further requires that this be accomplished on a watershed level to ensure that no increase in flooding occurs downstream from new development. The recommendations contained in this plan will meet this basic standard provided that those involved in the planning, reviewing, construction, and maintenance of stormwater facilities make a concerted effort to meet these goals.

The philosophy that controlled design in the past was to collect stormwater in sewers and deposit it in the nearest stream. This approach does not always meet the requirements of Act 167. As has been shown in this report, reducing impervious areas (pavement, rooftops, etc.), increasing on-site infiltration of stormwater, and slowing the flow of runoff must replace the traditional reliance on quick removal. Future engineering and design practices should concentrate on ways to improve the effectiveness of natural systems rather than to negate, replace, or ignore them.

The recommendations in this plan are designed to allow for both immediate use in responding to Act 167 and also for future modification to meet alternative institutional implementation approaches that may be selected.

The following summary of recommendations organizes the plan implementation activities by municipal and county roles. To some degree these roles are generalized, and opportunities exist for changes and adaptations to tailor the Stormwater Management Plan to specific needs and conditions.

MUNICIPALITY'S ROLES

Since the Act 167 places the responsibility for implementation in the hands of the local municipalities, the following activities should be undertaken:

- Incorporate stormwater provisions into the appropriate municipal ordinance. Zoning, subdivision and land development (including erosion and sedimentation, grading), and building ordinances should be adopted or amended to provide a comprehensive ordinance package.

  The ordinance revisions should include:

  - Incorporation of the release rate percentage as described in this plan.
  - Provision of a modified requirement for small developments. This plan recommends that developments disturbing less than 7,500 square feet of area with impervious surfaces (100 percent runoff) be considered small. These developments are required only to maximize the use of stormwater management techniques.
  - Provision for use of stormwater management techniques in new developments.

- Establishment of a more vigorous program for review of stormwater management proposals as submitted by developers and for facilities as they are being constructed in the field.

- Creation of a Watershed Task Force (WTF) whose primary purpose will be to assist in the establishment of a permanent watershed management system to implement the plan. This permanent group may consist of one or more agencies to perform the necessary functions of planning, operation, maintenance, and financing.

- Begin addressing existing stormwater problems on a watershed level. The philosophy of eliminating problems by passing them downstream must be replaced with comprehensive watershed planning. Capital reserve funds needed to resolve existing problems should be budgeted into fiscal programs.

- Establishment of maintenance programs by each municipality that schedule regular intervals for inspection and cleaning of drainage structures. In those instances where maintenance costs become excessive, consideration should be given to replacement or alteration of the structure.

COUNTY ROLE

Act 167 places the responsibility for preparation and periodic revision of the plan with the county. Roles assigned to counties are influenced by the capabilities of the county planning department. Those activities which are beyond the capacity of the county should be contracted to outside consultants. In Armstrong County, since the county planning department is capable of providing assistance in many areas, the following activities are recommended (although not necessarily in order of importance):

- Initiate the process for formal adoption of the stormwater plan.

- Assist municipalities and the WTF in modifying ordinances to incorporate stormwater management features.

- Assist municipalities and the WTF in the development of an appropriate watershed management system.

- Periodically update the plan compatible with the needs of the watershed. If minimal development is anticipated in the watershed, a greater time interval between plan updates may be possible. Considering the importance of the plan recommendations, particularly to the downstream communities, the first plan update should occur within five years of approval of this plan. Establishment of intervals for subsequent plan updates should be part of the initial plan update effort.

- Review and revise Armstrong County Subdivision Regulations to be consistent with Act 167 and the watershed Stormwater Management Plans. Assume the lead role in the review of Stormwater Management Plans for development.

- Work with appropriate county departments/agencies to assist them in implementing stormwater management control measures in county public works projects. Measures must be consistent with watershed Stormwater Management Plans and Act 167.

APPENDIX A

SUGGESTED AMENDMENTS TO THE
SUBDIVISION AND LAND DEVELOPMENT ORDINANCE

The following suggested amendments to Subdivision and Land Development (S/LD) Ordinances have been developed for use by Pennsylvania municipalities by the DER as a possible method for implementation of the provisions of their county storm water management plans. Municipal implementation of the criteria and standards contained in the county storm water management plan is required by Section 11 of the Storm Water Management Act. Modifications have been included to reflect some of the recommendations of the watershed plan.

Armstrong County is in the process of revising the present overall S/LD Ordinance. The following ordinance, which is based on the DER model ordinance will be included in the new S/LD package either in part or in total.

The alternatives listed are not to be construed as the only possible alternatives available. Municipalities (in this case, Armstrong County) must tailor their changes to suit their own needs and the provisions of their watershed storm water management plan.

ARTICLE I
GENERAL PROVISIONS

Comment: A Subdivision and Land Development Ordinance will usually contain a section under the general provisions heading which lists the purposes of the ordinance. This section can be amended to include the following purposes which apply to storm water management.

SECTION 1.0 - PURPOSE

A. To plan and manage storm water runoff in each watershed by regulating subdivisions, land development, and mobile home parks in a manner consistent with the County storm water management plan.

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

C. Encourage recharge of groundwaters.

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

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

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

ARTICLE II
DEFINITIONS

Comment: A Subdivision and Land Development Ordinance will contain a listing of definitions. The listing should be expended to include terms pertaining to storm water management such as the following.

Accelerated Erosion - The removal of the surface of the land through the combined action of man's activities and natural processes at a rate greater than would occur because of the natural processes alone.

Cistern - An underground reservoir or tank for storing rainwater.

Conservation District - The conservation district serving Armstrong County.

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

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

Detention Basin - A basin designed to retard storm water runoff by temporarily storing the runoff and releasing it at a predetermined rate. A detention basin can be designed to drain completely after a storm event, or it can be designed to contain a permanent pool of water.

Developer - A person or persons, partnership, association, corporation or other entity, or any responsible person therein or agent thereof, that undertakes the activities covered by this ordinance.

Diversion Terrace A channel and a dike constructed up slope of a project for the purpose of diverting stormwater away from the unprotected slope.

Drainage Easement - The natural process by which the surface of the land is worn away by the action of water, wind or chemical action..

Erosion - The natural process by which the surface of the land is worn away by the action of water, wind or chemicals.

Forest Management Operations - All activities connected with growing and harvesting of forest products including the site preparation, cultivation and logging of trees, and the construction and maintenance of roads.

Groundwater Recharge - Replenishment of existing natural underground water supplies.

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

Infiltration Structures - A structure designed to direct runoff into the ground, e.g., french drains, seepage pits, seepage trench.

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

Land Disturbance - Any activity involving grading, tilling, digging or filling of ground, or stripping of vegetation, or any other activity which causes land to be exposed to the danger of erosion.

Peak Discharge - The maximum rate of flow of water at a given point and time resulting from a specified storm event.

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

SCS - Soil Conservation Service, U.S. Department of Agriculture.

Sediment - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by water.

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

Semi-Pervious Surface - A surface such as stone, rock, concrete or other materials which permits some vertical transmission of water.

Soil-Cover Complex Method - A method of runoff computation developed by SCS, and found in its publication Urban Hydrology for Small Watersheds, Technical Release No. 55, January 1975.

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

Storm Water Management Plan - The plan for managing storm water runoff adopted by Armstrong county as required by the Act of October 4, 1978, P.L. 864, (Act 167), and known as the "Storm Water Management Act."

Subdivision - The division or re-division of a lot, tract or parcel of land by any means into two or more lots, tracts or parcels or other divisions of land including changes in existing lot lines for the purpose, whether immediate or future, of lease, partition by the court for distribution to heirs or devisees, transfer of ownership or building or lot development; provided, however, that the subdivision by lease or land for agricultural purposes into parcels of more than ten acres, not involving any new street or easement or access or any residential dwelling, shall be exempted.

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

ARTICLE III
PREAPPLICATION PROCEDURES

Comments: In order for the applicant to prepare the storm water management portion of his subdivision or land development plan, he must first determine the applicable storm water management criteria in his proposed project area. Some municipalities will have different areas with different sets of storm water management criteria. In this case, these sets of criteria are spelled out in Article V of this amendment. Before writing this section of your ordinance, you must have a clear understanding as to what services your county Conservation District can provide. A memo of understanding between your municipality and the conservation district can be used to spell out these services.

SECTION 3.0 - Prior to preparation of any plan, the applicant is urged to consult the County Stormwater Management Plan and the specific criteria contained in Article V of this Ordinance.

SECTION 3.1 - Applicants are urged to consult the Department of Planning and Development for assistance. The applicant is also urged to submit a sketch plan with a narrative description of these measures.

ARTICLE IV
PRELIMINARY PLAN

Comment: Preliminary plan requirements should be amended to include the following items pertaining to storm water management.

SECTION 4.0 - PRELIMINARY PLAN REQUIREMENTS

The following information shall be included in the preliminary plan.

A. Runoff calculations for the proposed project except where the watershed storm water management plan has determined no hydrologic effect will occur downstream.

B. A narrative and pictorial description of proposed storm water control measures and devices.

C. Maps showing:

1. Current boundaries, all existing and proposed easements, the location of the proposed subdivision, land development, or mobile home park within the designated watershed (consult the storm water management plan for the watershed boundaries).

2. The 100-year flood plain.

3. Streams, swales, and drainage patterns (existing and proposed).

4. Storm water management control measures and devices (temporary and permanent).

D. Recognition of applicable permit regulations ... under DER Chapter 102 and 105 Regulations; if required, the permit must be applied and obtained from appropriate State Agency. Take reference to Section 5.1 A(8)!

5. Areas subject to special deed restrictions affecting storm water management.

SECTION 4.1 - GENERAL REQUIREMENTS

Prior to the final approval of subdivision and/or land development plans, or the issuance of any permit, or the commencement of any land disturbance activity, the owner, subdivider, developer or his agent shall submit a storm water management plan to the municipality for approval.

SECTION 4.2 - EXEMPTIONS

The following activities are specifically exempt from the plan preparation provisions of this Ordinance.

A. Land disturbances affecting less than 10,000 square feet of ground surface.

B. Land disturbance associated with existing one and two family dwellings.

C. Use of land for gardening for home consumption.

D. Agriculture when operated in accordance with a conservation plan or erosion and sedimentation control plan prepared by the Conservation District.

E. Forest management operations which are following the DER's management practices contained in its publication <u>Soil Erosion and Sedimentation Control Guidelines for Forestry</u> and are operating under an erosion and sedimentation control plan.

SECTION 4.3 - PLAN CONTENTS

The following items, where appropriate, shall be included in the plan:

A. General

1. General description of the project.

2. General description of erosion and sedimentation controls.

3. General description of storm water controls both during and after development.

4. Expected project time schedule, including anticipated start and completion dates.

5. Training and experience of person(s) preparing the plan.

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

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

2. Existing contours at intervals of two feet. In areas of steep slopes (greater than 15 percent), 5-foot contour intervals may be used.

3. Streams, lakes ponds or other bodies of water within the project area or which will be affected by runoff from the project.

4. Other physical features including existing drainage swales and areas of natural vegetation to be preserved.

5. Locations of proposed underground utilities, sewers and waterlines.

6. An overlay showing soil types and boundaries.

7. Proposed changes to land surface and vegetative cover.

8. Areas to be cut or filled.

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

10. Final contours at intervals of two feet. In areas of steep slopes (greater than 15 percent), 5-foot contour intervals may be used.

C. Erosion and sedimentation controls

1. The staging of all earth moving activities must be described, including cuts and fills, streets, underground utilities, sewer and waterlines, buildings, driveways, parking areas, recreational areas, other structures, etc.

2. The type, location and extent of all erosion and sedimentation control measures must be shown on a map and described, including all calculations, assumptions and criteria used in designing the controls and a schedule for their implementation.

D. Storm water management controls

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

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

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

   c. Schedule for installation of the control measures and devices.

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

E. Maintenance Program

A maintenance program for all storm water management control facilities must be included. This program must include the proposed ownership of the control facilities and detail the financial responsibility for any required maintenance.

SECTION 4.4 - PLAN SUBMISSION

A. The plan shall be accompanied by the requisite fee, as set forth in Article VII of this Ordinance.

B. Three copies of the plan must be submitted.

SECTION 4.5 - PLAN APPROVAL

A. The municipality shall forward a copy of the plan to the county Department of Planning and Development and the Conservation District for review.

B. The municipal engineer and planning commission shall review the plan and comments from the Conservation District and county Planning Commission and shall recommend whether the plan be approved or disapproved.

C. The municipality shall notify the applicant within sixty (60) days from receipt of a complete plan submission of its decision.

D. A disapproval shall contain the reasons for disapproval and a listing of the plan deficiencies.

E. Failure of the municipality to render a decision within the sixty (60) day time limit shall be deemed an approval.

SECTION 4.6 - MODIFICATIONS OF PLANS

A modification to an approved storm water management plan which involves a change in control methods or techniques, or which involves the relocation or redesign of control measures, or which is necessary because soil or other conditions are not as stated on the approved application (as determined by the municipal engineer), shall be approved under the procedures contained in Section 4.5 of this Ordinance. The municipal engineer shall notify the applicant when such plan modification is required.

ARTICLE V
DESIGN CRITERIA

Comment: Section 5.0 contains a listing of the different storm water management areas located within the municipality. This is only necessary where the county storm water management plan stipulates different criteria for different areas within the municipality. The municipality may consider different methods of creating these storm water management areas such as:

1. By reference to the county storm water management plan

2. By use of amendments to an existing zoning ordinance

3. By the authority contained in Act 167

In the event that the municipality is faced with this problem, your municipal solicitor should advise you on the most appropriate method. Section 5.1 contains the storm water management criteria which are based on the county plan. General and specific criteria are listed by area. Listing of criteria by area is necessary only where the county plan stipulates the need for such areas.

SECTION 5.0 - STORM WATER MANAGEMENT AREAS

A. The municipality is hereby divided into storm water management areas which shall be designated as follows:

Glade Run Watershed

The location and boundaries of the storm water management areas are shown on an official map which is available for inspection from the municipal secretary and in the County storm water management plan.

B. When any proposed subdivision, land development, or mobile home park is located in more than one storm water management area, storm water may not be transferred from an area with stricter storm water management criteria to an area with less strict criteria, unless the need for such a transfer is identified in the County storm water management plan, the regional water quality management plan, or the state water plan.

SECTION 5.1 - DESIGN CRITERIA

A. General Criteria

1. The storm water management plan must consider all the storm water runoff flowing over the project site.

2. All storm water runoff detention controls shall be designed by a person qualified and/or experienced in the design of such structures.

3. Storm water roof drains and pipes shall discharge water into cisterns or french drains (where soils are suitable), sheet drains or other storm water runoff dispersion and absorption control device and not into storm sewers unless recommended in the watershed storm water plan.

4. No discharge of toxic materials into any storm water management system is permitted.

5. Flow velocities from any storm drain may not result in a deflection of the receiving channel.

6. Method of computation - Peak discharge and runoff shall be computed using the soil-cover complex method as set forth in the latest edition of Urban Hydrology for Small Watershed, Technical Release No. 55 as published by SCS.

7. Design Storms - The 2-, 10-, and 100-year design storm frequencies shall be used for analyzing stormwater runoff in predevelopment and postdevelopment conditions as well as for designing runoff control facilities in the Glade Run Watershed. The SCS 24-hour, Type II rainfall distribution shall be used for all analyses. The design storm, along with the 24-hour total rainfall for these storm frequencies for the watershed are:

Design Storm	Rainfall Depth in Inches
2-year	2.60
10-year	3.90
100-year	5.50

8. Maintenance of natural drainageways - All natural streams, channels, swales, drainage systems and/or areas of surface water concentration shall be maintained in their existing conditions unless an alteration is approved by the municipality. All encroachment activities shall comply with the requirements of Chapter 105 (Water Obstructions and Encroachments) of Title 25, Rules and Regulations of the Pennsylvania DER.

9. Methods of storm water runoff detention and control - The following is a listing of detention and control methods which may be utilized in

storm water management systems, if appropriate. The choice of control techniques is not limited to the ones appearing on this list.

1. Detention basins
2. Roof-top storage
3. Parking lot and street ponding
4. Seepage pits, seepage trenches or other infiltration structures
5. Porous pavement and concrete lattice block surfaces
6. Grassed channels and vegetated strips
7. Cisterns and underground reservoirs
8. Routed flow over grass
9. Decreased impervious area coverage

The use of other control methods which meet the criteria in this section will be permitted when approved by the municipal engineer. Various combinations of methods should be tailored to suit the particular requirements of the type of development and the topographic features of the project area.

SECTION 5.2 - STORM WATER MANAGEMENT DISTRICTS

A. In order to implement the provisions of the County storm water management plan, the Glade Run Watershed is hereby divided into storm water management districts which shall be designated as follows:

Watershed Subareas

Municipalities in Glade Run Watershed	Subareas
West Franklin Township	9
East Franklin Township	7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
Sugar Creek Township	18
Washington Township	18
North Buffalo Township	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Cadogan Township	120

The location and boundaries of the storm water management districts are shown on an official map which is available for inspection from the municipal secretary.

B. When a project or land disturbance activity is located in more than one storm water management district, storm water may not be transferred from a district with stricter storm water management criteria to a district with less strict criteria, unless the need for such a transfer is identified in the County storm water management plan, the regional water quality management plan, or the state water plan.

SECTION 5.3 - SPECIFIC CRITERIA

The following provisions shall be considered the overriding performance standards against which all proposed stormwater control measures shall be evaluated and, they shall apply to all subareas of the Glade Run Watershed in the municipality.

A. Storm Water Rate

1. Any landowner and any person engaged in the alteration or development of land which may affect stormwater runoff characteristics shall implement such measures as are reasonably necessary to prevent injury to health, safety, or other property. Such measures shall include such actions as are required:

a. To assure that the maximum rate of stormwater runoff is no greater after development than prior to development activities.

b. To manage the quantity, velocity, and direction of resulting stormwater runoff in a manner which otherwise adequately protects health and property from possible injury.

2. The Stormwater Management Plan for the development site must consider stormwater runoff flowing across the site from upgradient areas as well as the runoff originating from the site itself.

B. Release Rate Percentage

1. **Application** - All subdivisions and land development activities which result in the postdevelopment rate of stormwater runoff being greater than the predevelopment rate of stormwater runoff and which use detention/retention facilities to attenuate the flow to predevelopment conditions shall be subject to the Release Rate Percentage for the watershed subarea in which the site is located. A listing of the release rate percentage for each subarea in the Glade Run Watershed, which appears in Appendix A of this Ordinance and the subareas, are delineated on the watershed subarea map in the Glade Run Stormwater Management Plan.

2. **Definition** - The release rate percentage defines the percentage of the predevelopment peak rate of runoff that can be discharged from an outfall on the site following development. It applies uniformly to all land developments or alterations within a subarea, and the postdevelopment rate of runoff discharging from each outfall of the development site cannot exceed the release rate percentage for the subarea in which it is located.

3. **Procedure for Use** - The steps that must be followed to utilize the release rate percentage for a particular development site are:

   a. Identify the specific subarea in which the development site is located on the watershed subarea release rate map and obtain the subarea release rate percentage from the map or from Appendix A of this Ordinance.

   b. Compute the predevelopment and the postdevelopment runoff hydrographs for each development site using the soil cover complex method (SCS TR-55), for the 2-, 10-, and 100-year design storms, applying no on-site detention/retention for stormwater management, but including any techniques to minimize impervious surfaces and/or increase the time of concentration for stormwater runoff flowing over the development site. If the postdevelopment peak runoff rate is less than or equal to the predevelopment peak runoff rate, then additional stormwater control shall not be required for that development area. If the postdevelopment peak runoff rate is greater than the predevelopment rate of runoff, then stormwater detention will be required (Step c.).

   c. Multiply the subarea release rate percentage by the predevelopment rate of runoff from the development site to determine the maximum allowable release rate from any detention/retention facility for the 2-, 10-, and 100-year storm events for the Glade Run Stormwater Management Plan.

C. Erosion and Sedimentation - All land disturbance activities shall be conducted in such a way as to minimize accelerated erosion and resulting sedimentation. Measures to control erosion and sedimentation shall at a minimum meet the standards of the Conservation District and Chapter 102 (Erosion Control) of Title 25, Rules and Regulations of the Pennsylvania DER.

ARTICLE VI
FINAL PLAN

Comment: Final plan requirements can be amended to include the following items. It is important to insure that some entity be responsible for the maintenance of permanent control facilities. Municipalities can assume this responsibility or can require the applicant to set up a private arrangement for this purpose. When financial guarantees are being required, it is important to have them reviewed by your municipal solicitor before approval.

SECTION 6.0 - FINAL PLAN REQUIREMENTS

A. All information pertaining to storm water management from the preliminary plan along with any changes.

B. All required permits (or letters of intent to issue such permits pending final municipal approval) from the DER, the Pennsylvania Department of Transportation, the Public Utility Commission, or any other agency, if appropriate.

C. An accurate survey showing current conditions, boundaries, all deed restrictions, easements and rights-of-way.

D. The ownership and maintenance responsibilities for all storm water management control devices. The identity of the responsible individual, corporation, association, or other specific entity and the specific maintenance responsibility must be detailed.

Where the applicant is proposing the dedication of permanent storm water management control facilities to the municipality, such request must include:

1. Easements to all facilities.

2. A financial guarantee (acceptable to the municipality) to insure that the control facilities are properly installed and functioning satisfactorily.

ARTICLE VII
GUARANTEE OF IMPROVEMENTS

Comment: The financial guarantee section should be amended to include all temporary and permanent storm water management improvements. The applicant should not be released from all of the portions of the guarantee until all improvements or portions thereof are inspected and found to be properly installed. Your municipal engineer and solicitor should advise your municipality as to when this action should be taken.

ARTICLE VII
INSPECTION OF STORM WATER MANAGEMENT CONTROL FACILITIES

Comment: The municipality has an obligation to insure that any storm water management control measures being required under this ordinance are properly carried out. The only way this can be done is through inspection. If adequate provisions for inspection do not already exist in your subdivision and land development ordinances, an appropriate inspection schedule to insure proper installation of the control should be included.

The applicant should not be released from any guarantee until all controls are inspected and found to be properly installed.

ARTICLE IX
FEES

Comment: The fee schedule can be amended to reflect any increased costs resulting from the review of the storm water management portion of the ordinance.