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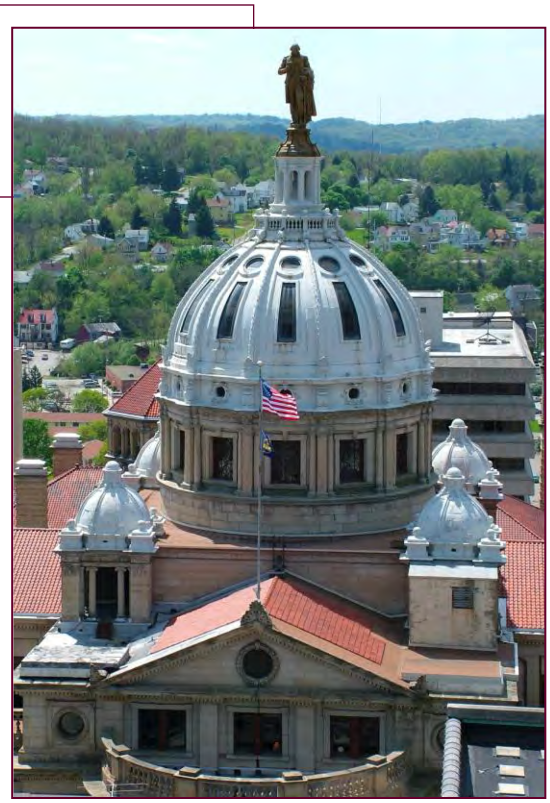
Washington County Planning Commission

Washington County
Act 167 County-Wide
Stormwater Management Plan
Phase II

June 17, 2010



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ACKNOWLEDGEMENTS

The Washington County Planning Commission would like to thank the following individuals, municipalities, and agencies for their assistance and support of this project:

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Army Corps of Engineers	

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Section I – Introduction

This Stormwater Management Plan (Plan) is the product of a collaborative effort between the varied stakeholders located in the Act 167 Designated Watersheds in Washington County, Pennsylvania. The Plan has been developed based on the requirements of the *Pennsylvania Stormwater Management Act*, Act 167 of 1978 and guidelines established by the Pennsylvania Department of Environmental Protection (DEP). The intent of this document is to present the findings of a two-phased, multi-year study of the watersheds in the county. Generally, the study was undertaken to develop recommendations for improved stormwater management practices, to mitigate potential negative impacts by future land uses, and to improve conditions of impaired waters. The specific goals of this plan are discussed in detail in the following section. This section introduces some basic concepts relating the physical elements of stormwater management, the hydrologic concepts, and the planning approach used throughout this study.

RAINFALL AND STORMWATER RUNOFF

Precipitation that falls on a natural landscape flows through a complex system of vegetation, soil, groundwater, surface waterways, and other elements as it moves through the hydrologic cycle. Natural events have shaped these components over time to create a system that can efficiently handle stormwater through evaporation, infiltration, and runoff. The natural system often sustains a dynamic equilibrium, where this hydrologic system evolves due to various ranges of flow, sediment movement, temperature, and other variables. Alterations to the natural landscape change the way the system responds to precipitation events. These changes often involve increasing impervious area, which results in decreased evaporation and infiltration and increased runoff. The increase in stormwater runoff is manifested in runoff quantity, or volume, and runoff rate. These two factors cause the natural system to change beyond its natural dynamic equilibrium, resulting in negative environmental responses, such as accelerated erosion, greater or more frequent flooding, increased nonpoint source pollution, and degradation of surface waters. Decreased infiltration means less groundwater recharge, which in turn leads to altered dry weather stream flow.

Some level of stormwater runoff occurs as the infiltrative capacity of the surface is exceeded. This occurs even in undisturbed watersheds. The volume and rate of runoff are substantially increased as land development occurs. Stormwater management is a general term for practices used to reduce the impacts of this accelerated stormwater runoff. Stormwater management practices, such as detention ponds and infiltration areas, are designed to mitigate the negative impacts of increased runoff. Volume of runoff and rate of runoff are often referred to by the term "water quantity". Water quantity controls have been a mainstream part of stormwater management for years. Another aspect of runoff is water quality. This refers to the physical characteristics of the runoff water. Common water quality traits include temperature, total suspended solids, salts, and dissolved nutrients. Water quality is an emerging topic in stormwater management and the general water resources field. Both water quantity and water quality can contribute to degradation of surface waters.

Section I – Introduction

As development has increased, so has the problem of managing the increased quantity of stormwater runoff. Individual land development projects are frequently viewed as separate incidents and not necessarily as an interconnected hydrologic and hydraulic system. This school of thought is exacerbated when the individual land development projects are scattered throughout a watershed (and in many different municipalities). It is has been observed and verified, that the cumulative nature of individual land surface changes dramatically influences flooding conditions. This cumulative effect of development in some areas has resulted in flooding of both small and large streams with substantial financial property damage and endangerment of the public health and welfare. Therefore, given the distributed and cumulative nature of the land alteration process, a comprehensive (i.e., watershed-level) approach must be taken if a reasonable and practical management and implementation approach or strategy is to be successful.

Watersheds are an interconnected network in which changes to any portion of the watershed carry throughout the system. There are a variety of factors that influence how runoff from a particular site will affect the overall watershed. Many of the techniques for managing stormwater in a watershed are unique to each watershed. An effective stormwater management plan must be responsive to the existing characteristics of the watershed and recognize the changing conditions resulting from planned development. In Pennsylvania, stormwater management is generally regulated on the municipal level with varying degrees of coordination on types and levels of stormwater management required between adjoining municipalities. A watershed-based stormwater management plan can minimize inconsistencies to more effectively address the issues that contribute to a watershed's degradation. While land use regulation remains at the municipal level, the framework established in a watershed plan enables municipalities to see the impact of their regulations on the overall system and coordinate their efforts with other stakeholders in the watershed.

WATERSHED HYDROLOGY

Under natural conditions, watershed hydrology is in dynamic equilibrium. That is, the watershed, its ground and surface water supplies, and resulting stream morphology and water quality evolve and change with the existing rainfall and runoff patterns. This natural state is displayed by stable channels with minimal erosion, relatively infrequent flooding, adequate groundwater recharge, adequate baseflow, and relatively high water quality. When all of these conditions are present, streams support healthy, diverse and stable in-stream biological communities. The following is a brief discussion of the impact of development on these steam characteristics:

1. Channel Stability – In an undisturbed watershed, the channels of the stream network have reached an equilibrium over time to convey the runoff from its contributing area within the channels banks. Typically, the channel will be large enough to accommodate the runoff from a storm with a magnitude that will occur approximately every 18-24 months. Disturbances such as development in the watershed disrupt this equilibrium. As development occurs, additional runoff reaches the streams more frequently. This results in the channel becoming instable as it attempts to resize itself. The resizing occurs through bed and bank erosion, altered flow patterns, and shifting sediment deposits.
2. Flooding – When a watershed is disturbed and channel instability occurs, it results in increased localized flooding and other associated problems. Overbank flows will occur more frequently until the channel reaches a new equilibrium. It is important to realize that this equilibrium may take many years to be attained once the new runoff patterns are in place. In watersheds with continuous development, a new equilibrium may not be reached. Additionally, floodplain encroachment and in-stream sediment deposits from channel erosion may exacerbate flooding.

3. Groundwater Recharge – In an undisturbed watershed, runoff is minimal. Natural ground cover, undisturbed soils, and uneven terrain provide the most advantageous conditions for maximum infiltration to occur. When development occurs, these favorable conditions are diminished or removed, causing more rainfall to become runoff that flows to receiving streams instead of infiltrating. Less water is retained in the watershed to replenish groundwater supplies.
4. Baseflow – Loss of groundwater recharge, as described above, leads to insufficient groundwater available to replenish stream flow during dry weather. As a result, streams that may have an adequate baseflow during dry weather under natural conditions may experience reduced flow or become completely dry during periods of low precipitation in developed watersheds. Thermal degradation of the waterbody often accompanies the reduction of baseflow originating from groundwater. This source of baseflow is generally much cooler than surface water sources. The increase in water temperature can be detrimental to many ecological communities.
5. Water Quality – Stormwater from developed surfaces carries a wide variety of contaminants. Pesticides, herbicides, fertilizers, automotive fluids, hydrocarbons, sediment, detergents, bacteria, increased water temperatures, and other contaminants that are found on land surfaces are carried into streams by runoff. These contaminants affect the receiving streams in different ways, but they all have an adverse impact on the quality of the water in the stream.
6. Stream Biology – Biological communities reflect the overall ecological integrity of a stream. The composition and density of organisms in aquatic communities responds proportionately to stressors placed on their habitat. Communities integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions. The adverse impacts of improperly managed runoff and increased pollution are evident in the biological changes in impacted streams. When biological communities within a waterbody degrade, the overall ecological integrity of the stream is also diminishing.

It is important to understand that watershed hydrology, rainfall, stormwater runoff, and all of the above characteristics are interconnected. The implications of this concept are far reaching. How we manage our watersheds has a direct impact on the water resources of the watershed. Any decision that affects land use has implications on stormwater management and, in turn, impacts the quality of the available water resources. The quality of water resources has an economic consequence as well as an effect on the quality of life in the surrounding areas. This understanding is at the core of current stormwater management approaches.

The stormwater management philosophy of this plan is reflected in the required standards: peak flow management, water quality management, infiltration requirements, and channel protection requirements. The philosophy, and standards, reflect an attempt to manage stormwater in such a way as to maintain the watershed hydrology as near to existing or historical conditions as possible. Maintaining watershed hydrology is essential to maintaining the water resources of the watershed.

STORMWATER MANAGEMENT PLANNING

Historically, the approach to stormwater management was to collect the runoff and deliver it via a system of inlets and pipes as quickly as possible to the nearest receiving waters. The increased volume of stormwater delivered quickly to receiving waters had a detrimental effect on channel morphology. Negative impacts have resulted, such as severe channel erosion and significant in-stream sediment deposits resulted. These impacts lead to unstable, deepened and widened channels, nuisance flooding, infrastructure damage, increased culvert and bridge maintenance requirements, and have a detrimental affect on the stream quality in terms of habitat for aquatic organisms. In addition, large amounts of rainfall are lost to the watershed and become unavailable for infiltration. Groundwater recharge and contaminants on the land surface enter the stream untreated. This approach cannot be considered stormwater management in any meaningful terms.

This approach was later replaced with the stormwater management standards that are currently in place in most municipalities. This more-recent approach requires that peak flows from development sites be managed, usually through detention ponds, such that the peak discharge from the site is no greater than 100% of the peak discharge rate from the site prior to development. While this may have helped reduce some stormwater problems, there were two (2) significant failings with this approach.

The first failing of this approach is that it does not consider the watershed as a single interrelated hydrologic unit. An integrated watershed management approach is needed to overcome this situation. Two (2) points are emphasized regarding the need for an overall watershed management approach:

1. Stormwater regulatory responsibility mainly rests with the municipal governments in Pennsylvania. Therefore, stormwater management regulations, if applied at all, are implemented by a municipality only inside the boundaries of its own jurisdiction. There is no guarantee that all municipalities in a given watershed have comparable standards. When standards are implemented by individual municipalities the problems caused by unmanaged stormwater in an area with poor, or no, regulations are conveyed to municipalities downstream. Upstream municipalities often cause stormwater problems for downstream neighbors. In these situations, downstream municipalities are forced to deal with problems associated with increased water volume, increased sediment loads, and increased pollutants that originate in areas over which they have no control.
2. Each area of a watershed is unique in terms of its contribution to the overall watershed hydrology. When the same standards are implemented throughout a municipality, and the overall watershed hydrology is not considered, these standards can result in over-management in some areas and under-management in other areas. In some cases, this type of management could actually exacerbate stormwater problems. Further, this "one-size-fits-all" approach does not take into account conditions such as soil infiltration rates, slopes, or channel conditions, which vary throughout a watershed and municipality.

The second key failing is that this approach does not consider the aspects of water quality, channel protection, or the importance of infiltration in the hydrologic cycle. Simply managing the rate at which stormwater leaves a development site does not maintain the overall watershed hydrology. When implementing a peak rate control strategy as the sole method of controlling stormwater runoff, pollutants are still delivered to surface waters, rainfall is still unavailable to the watershed for recharge, and channel erosion and sedimentation still occur.

LOW-IMPACT DEVELOPMENT AND STORMWATER MANAGEMENT

Low-Impact Development (LID) is an approach to land development that uses various land planning and design practices and technologies to simultaneously conserve and protect natural resource systems and reduce infrastructure costs (HUD, 2003). As the term applies to stormwater management, LID is an approach to managing stormwater in a manner that mimics the natural hydrologic regime by managing rainfall at the source using uniformly distributed, decentralized, micro-scale controls (Low Impact Development Center, 2007). These concepts are the origin of many of the strategies identified to achieve the goals presented in this Plan.

As a comprehensive technology-based approach to managing stormwater, LID has developed significantly since its inception in terms of policy implementation and technical knowledge. The goals and principles of LID, as described in *Low-Impact Development Design Strategies* (Prince Georges County, 2000) are defined as follows:

- Provide an improved technology for environmental protection of receiving waters.
- Provide economic incentives that encourage environmentally sensitive development.
- Develop the full potential of environmentally sensitive site planning and design.
- Encourage public education and participation in environmental protection.
- Help build communities based on environmental stewardship.
- Reduce construction and maintenance costs of the stormwater infrastructure.
- Introduce new concepts, technologies, and objectives for stormwater management such as micromanagement and multifunctional landscape features (bioretention areas, swales, and conservation areas); mimic or replicate hydrologic functions; and maintain the ecological/biological integrity of receiving streams.
- Encourage flexibility in regulations that allows innovative engineering and site planning to promote smart growth principles.
- Encourage debate on the economic, environmental, and technical viability and applicability of current stormwater practices and alternative approaches.

The overall design concepts and specific design measures for BMPs are derived from the following conceptual framework (Prince Georges County, 2000):

1. The site design should be built around and integrate a site's pre-development hydrology;
2. The design focus should be on the smaller magnitude, higher frequency storm events and should employ a variety of relatively small Best Management Practices (BMPs);
3. These smaller BMPs should be distributed throughout a site so that stormwater is mitigated at its source;
4. An emphasis should be given to non-structural BMPs; and
5. Landscape features and infrastructure should be multifunctional so that any feature (e.g., roof) incorporates detention, retention, filtration, or runoff use.

The LID process is meant to provide an alternative approach to traditional stormwater management. *Table 1.1* highlights the difference between the two (2) approaches. These concepts, as they apply to stormwater, are the basis for the stormwater management approach presented in this Plan.

LID Approach		**Traditional Approach**	
Approach	Examples	Approach	Examples
1. Integration of Pre-Development Hydrology	A development built around a drainage way outside of functional floodplain	Elimination of all water features from project site	Redirection and conveyance of drainage; alteration of floodplain to meet site design
2. Emphasis on smaller magnitude, higher frequency storm events	Several small BMPs	Large stormwater ponds and facilities that focuses on 10 and 100-year events	A single stormwater pond
3. Stormwater to be mitigated at source	BMPs located near buildings, within parking lot islands	Stormwater to be conveyed to low point in site	A single stormwater pond
4. Use simple, non-structural BMPs	Narrower drive ways, conservation easements, impervious disconnection	Use of pipe and stormwater ponds	A single stormwater pond
5. Use of multifunctional landscape and infrastructure	Green roofs, rain gardens in parking lot islands	Stormwater and site feature kept as separate as possible	No consideration given

Table 1.1. Comparison of LID Versus Traditional Stormwater Management Approach

When implemented at the site level, LID has been found to have a beneficial impact on water quality and in reducing peak flows for more frequent storm events (Bedan and Clausen, 2009; Hood et. al., 2007). There are numerous case studies and pilot projects that emphasize similar findings about the benefits of site level development and of specific LID BMPs (EPA, 2000; DEP, 2006; Low Impact Development Center, 2009).

When implemented at the watershed level, as proposed in this Plan, there are quantifiable benefits in terms of reduced peak discharges coming from future developments (as discussed in *Section VI*). The approach of considering water quality and existing condition hydrology will help address documented stream impairments (as discussed in *Section IX*). Additionally, adopting a LID approach will help alleviate the economic impact of the additional regulations proposed in the model ordinance (as discussed in *Section VIII*). Several other Act 167 Plans that have been recently prepared or are being prepared concurrently with this Plan further support these findings.

Section II – Goals and Objectives of the Act 167 Stormwater Management Plan

This Plan was developed to present the findings of a two-phased multi-year study of the watersheds within the County. Watershed-based planning addresses the full range of hydrologic and hydraulic impacts from cumulative land developments within a watershed rather than simply considering and addressing site-specific peak flows. Although this plan represents many things to many people, the principal purposes of the Plan are to protect human health and safety by addressing the impacts of future land use on the current levels of stormwater runoff and to recommend measures to control accelerated runoff to prevent increased flood damages or additional water quality degradation.

The overall objective of this Plan is to provide a plan for comprehensive watershed stormwater management throughout Washington County. The Plan is intended to enable every municipality in the County to meet the intent of Act 167 through the following goals:

1. Manage stormwater runoff created by new development activities by taking into account the cumulative basin-wide stormwater impacts from peak runoff rates and runoff volume.

2. Meet the legal water quality requirements under Federal and State laws.

3. Provide uniform stormwater management standards throughout Washington County.

4. Encourage the management of stormwater to maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to protect water resources.

5. Preserve the existing natural drainageways and watercourses consistent with County Greenways Plan.

6. Ensure that existing stormwater problem areas are not exacerbated by future development and provide recommendations for improving existing problem areas.

These goals provided the focus for the entire planning process. A scope of work was developed in Phase 1 that focused efforts on gathering the necessary data and developing strategies that address the goals. With the general focus of the Plan determined, Phase II further researched county-specific information, provided in-depth technical analysis, and developed a model ordinance to achieve these goals. On the following page, *Table 2.1* shows the preferred strategies to address the goals and where these strategies are addressed in the Plan:

1. Manage stormwater runoff created by new development activities by taking into account the cumulative basin-wide stormwater impacts from peak runoff rates and runoff volume	
Develop models of selected watersheds to determine their response to rainfall	*Section 6, Appendix C*
Determine appropriate stormwater management controls for these basins	*Section 6, Appendix A*
2. Meet the legal water quality requirements under Federal and State laws	
Provide recommendations for improving impaired waters within the county	*Section 9*
Encourage the use of particularly effective stormwater management BMPs	*Section 7*
3. Provide uniform standards throughout Washington County	
Develop a Model Stormwater Management Ordinance with regulations specific to the watersheds within the county	*Model Ordinance*
Adopt and implement the Model Ordinance in every municipality in Washington County	*Model Ordinance*
3. Encourage the management of stormwater to maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to protect water resources	
Provide education on the correlation between stormwater and other water resources	*Section 1, Section 10*
Require use of the Design Storm Method or the Simplified Method	*Model Ordinance*
4. Preserve the existing natural drainageways and watercourses	
Provide education on the function and importance of natural drainageways	*Section 1, Section 10*
Protect these features through provisions in the Model Ordinance	*Model Ordinance*
5. Ensure that existing stormwater problem areas are not exacerbated by future development, and provide recommendations for improving existing problem areas	
Develop an inventory of existing stormwater problem areas	*Section 5, Appendix B*
Analyze problem areas and provide conceptual solutions to the problems	*Section 5, Appendix B*

Table 2.1. Preferred Strategies to Address Plan Goals

STORMWATER PLANNING AND THE ACT 167 PROCESS

Recognizing the increasing need for improved stormwater management, the Pennsylvania legislature enacted the *Stormwater Management Act* (Act 167 of 1978). Act 167, as it is commonly referred to, enables the regulation of development and activities causing accelerated runoff. It encourages watershed based planning and management of stormwater runoff that is consistent with sound water and land use practices, and authorizes a comprehensive program of stormwater management intended to preserve and restore the Commonwealth's water resources.

The Act designates the Department of Environmental Resources as the public agency empowered to oversee implementation of the regulations and defines specific duties required of the Department. The Department of Environmental Resources was abolished by Act 18 of 1995. Its functions were transferred to the Pennsylvania Department of Conservation and Natural Resources (DCNR) and the Department of Environmental Protection (DEP). Duties related to stormwater management became the responsibility of DEP (Act 18 of 1995).

As described in Act 167, each county must prepare and adopt a watershed stormwater management plan for each watershed located in the county, as designated by DEP, in consultation with the municipalities located within each watershed, and shall periodically review and revise such plan at least every five (5) years. Within six (6) months following adoption, and approval of the watershed stormwater plan, each municipality must adopt or amend, and must implement such ordinances and regulations, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development within the municipality in a manner consistent with the applicable watershed stormwater plan and the provisions of the Act.

Section 5 of Act 167 sets forth the Plan contents required for each Stormwater Management Plan. Section 5.b lists thirteen (13) elements to include in the Plan, and Section 5.c lists an additional two (2) elements for inclusion. The following table addresses these elements in Section 5 of Act 167, and present the necessary information to inventory and address issues with stormwater management in the County.

SECTION 5b
(1) A survey of existing runoff characteristics in small as well as large storms, including the impact of soils, slopes, vegetation and existing development;
Section 3 identifies and analyzes factors that impact the hydrologic response of the identified watershed for including existing and future land use conditions. Section 6 discusses the technical analysis performed on the on focused watersheds. The other watersheds within the County should be considered in future Plans. Appendix A details the modeling completed to perform the technical analysis. In addition, relevant details of the factors and elements impacting the hydrologic response of the watersheds are shown graphically in the Plates.
(2) A survey of existing significant obstructions and their capacities;
The municipalities, through the PAC, responded to a survey which compiled an inventory of obstructions. Section 5 provides the inventory as well as a discussion. Capacities of the obstructions were not fully developed as Budgetary impacts reduced the scope of the Plan. Plate 7 shows the identified obstructions.
(3) An assessment of projected and alternative land development patterns in the watershed, and the potential impact of runoff;
A hydrologic model was developed and used to assess the impacts future land development alternatives in order to address the potential impacts of increased runoff, as discussed in the following portions of the Plan: Section 3 (Land Use and Surface Water Quality), Section 5 (Significant Problem Areas and Obstructions) Sections 6 (Technical Analysis) and Section 7 (Technical Standards and criteria for control of stormwater runoff), Section 9 (Water Quality Impairments and Recommendations), and Section 10 (Additional Recommendations Low-Impact Development Site Design) as well as Appendix A.
(4) An analysis of present and projected development in the flood hazard areas, and its sensitivity to damages from future flooding or increased runoff;
Federal flood insurance studies have been used as reference for the location of flood plain areas as identified in Plate 8. Section 3 provides a discussion and an analysis showing damages to existing development due to flood hazard areas caused by increased runoff in the watershed. Recommendations where made with measures to mitigate future damages in Section 7.
(5) Survey of existing drainage problems and proposed solutions;
The municipalities, through the PAC, responded to a survey which compiled an inventory of existing problem areas. Section 5 provides the inventory as well as a discussion. Plate 7 shows the identified problem areas as well as Appendix C.
(6) A review of existing and proposed stormwater collection systems;
The more urbanized areas of the County contain storm sewer systems, as do the many roadways that traverse the County. Storm sewer collection systems have a significant effect on the hydrologic response of a watershed as pipe networks rapidly increase runoff rate. If stormwater control facilities do not intercept runoff from storm sewer systems, flooding often increases, as well as other stormwater problems such as streambank erosion and sedimentation. Plate 7 shows the collection systems as identified by the municipalities through the PAC.
(7) An assessment of alternative runoff control techniques and their efficiency in the particular watershed;
Section 6 of the Plan describes the detailed analysis of the Chartiers Creek watershed and recommended alternative control criteria. Section 7 of the Plan identifies a variety of runoff control

techniques are available for use in all watersheds in the County. It references and expands upon the Pennsylvania Stormwater Best Practices Manual to identify innovative methods of controlling runoff. In addition, traditional engineering solutions such as drainage structure replacement, streambank restoration, etc. were also identified in situations where alternative runoff controls are not applicable.
(8) An identification of existing and proposed state, federal and local flood control projects located in the watershed and their design capacities;
Section 3 lists the local, state, and federal flood control projects in the County which was shown on Plate 8. Where the effectiveness in mitigating flooding or design capacity data was readily available, this information was also documented.
(9) A designation of those areas to be served by stormwater collection and control facilities within a 10-year period, an estimate of the design capacity and costs of such facilities, a schedule and an identification of the existing or proposed institutional arrangements to implement and operate the facilities;
Stormwater control facilities were identified and documented by municipalities and through the completion of the Questionaire. Although data was compiled and tabulated for those municipalities which provided data, the future facilities were not fully developed as Budgetary impacts reduced the scope and intent of the Plan. Sections 7 and 9 identify recommended strategies to address runoff impacts from future development.
(10) An identification of flood plains within the watershed;
Flood insurance studies prepared under the National Flood Insurance Program were identified in Section 3 and shown on Plate 8.
(11) Criteria and standards for the control of stormwater runoff from existing and new development which are necessary to minimize dangers to property and life and carry out the purposes of this act;
Standards and criteria were developed in Section 7 which is to be implemented through the Model Ordinance. Additional recommendations are contained in Section 10.
(12) Priorities for implementation of action within each plan; and
Section 7 contains recommended BMP's and implementation of stormwater management controls. Section 11 details the preparation process completed and the County adoption of the draft Plan with submission to PADEP for approval. This will initiate the mandatory schedule of adoption of ordinances needed to implement stormwater management criteria.
(13) Provisions for periodically reviewing, revising and updating the plan.
Section 11 discusses the requirement of Section 5(a) of the Act that each plan must be reviewed and any necessary revisions made at least every five years after its initial adoption.
SECTION 5c
(1) Contain such provisions as are reasonably necessary to manage stormwater such that development or activities in each municipality within the watershed do not adversely affect health, safety and property in other municipalities within the watershed and in basins to which the watershed is tributary; and
With the adoption of the Model Stormwater Management Ordinance provided with this Plan, each municipality must enforce development, redevelopment, and other regulated activities consistent with the standards and criteria contained in the Model Ordinance. These standards and criteria have been developed to ensure regulated activities will not adversely affect health, safety, and property in the County.
(2) Consider and be consistent with other existing municipal, county, regional and State environmental and land-use plans.
Section 3 identifies several planning efforts which the County conducted in the past. These include watershed Act 167 Plans, comprehensive planning including open space planning and land use plans, and hazard mitigation planning. In addition, Section 4 contains identified existing stormwater regulations.

Table 2.2. Elements of Act 167

PLAN ADVISORY COMMITTEES (PACS)

Public participation by local stakeholders is an integral part of comprehensive stormwater management planning. Coordination amongst these various groups facilitates a more inclusive Plan that is able to better address the variety of issues experienced throughout the county. Several PAC meetings were facilitated throughout the development of this Plan.

A PAC was formed at the beginning of the planning process, as required by the Stormwater Management Act. The purpose of the PAC is to serve as an access for municipal input, assistance, voicing of concerns and questions, and to serve as a mechanism to ensure that inter-municipal coordination and cooperation is secured. The PAC consists of at least one (1) representative from each of the municipalities within the county, the County Conservation District, and other representatives as appropriate. A full list of the PAC members can be found in the Acknowledgements section at the beginning of this Plan.

As outlined in Act 167, the PAC is responsible for advising the county throughout the planning process, evaluating policy and project alternatives, coordinating the watershed stormwater plans with other municipal plans and programs, and reviewing the Plan prior to adoption. *Table 2.3* is a summary of the PAC meetings that were held throughout the planning process.

Meeting	Purpose of Meeting	Meeting Dates
PAC	Phase 2 Start-up Meeting - Introduce the Phase 2 planning process. Emphasize the importance of full municipal involvement. Present summary of the data collection questionnaire from Phase 1.	January 26, 2009
PAC MEC	General review of the draft Model Ordinance. Gather general comments and feedback prior to finalization of the Model Ordinance. (Draft Model Ordinance sent to municipalities prior to meeting).	March 29, 2010
PAC MEC	Technical review of draft PLAN: Review technical comments. (Draft PLAN sent to municipalities prior to meeting).	May 24, 2010
PAC	Review of the Draft Plan as well as comments and responses to comments. (Draft PLAN sent to municipalities prior to meeting).	June 2, 2010
Public Hearing	Conduct the hearing as required by Act 167 to present the PLAN to the public.	June 17, 2010

Table 2.3. Summary of PAC Meetings

Section III – Washington County Description

In 1780, the boundary of Pennsylvania was established and the following year, on March 28, 1781, Washington County was formed from parts of Westmoreland County. The County was named after General and President of the United States, George Washington. Washington County is situated on the Allegheny Plateau in the extreme southwest corner of Pennsylvania. The County encompasses 552,704 acres (863.6 square miles) and is approximately 30 miles wide by 30 miles long. Numerous narrow, relatively shallow valleys characterize the topography of Washington County. The northern part of the county has smooth; rolling hills while the southern portion has higher, sharper ridges and more steeply chiseled stream valleys. Elevations range from 1,523 feet on Mt. Wheeler in North Franklin Township to 760 feet in Elrama in Union Township. Washington County can be characterized as a diverse landscape with both natural and built settings. This is reflected by high-density residential, commercial and industrial areas coupled with large land tracts of open space within the County. The rural nature of Washington County is protected as approximately 60,000 acres are enrolled in the Agricultural Security Program, which accounts for eleven (11) percent of the total land area of the County.

POLITICAL JURISDICTIONS

The County is comprised of 66 municipalities. The political jurisdictions include two (2) cities, 32 boroughs, one (1) first class townships, and 31 second class townships. Washington County is classified as a fourth class county and is ranked 18th of 67 counties with a population of 203,312, according to the 2000 census. The 66 municipalities in Washington County and their associated land area are as follows:

TOWNSHIPS	AREA (mi^2)	BOROUGHS	AREA (mi^2)
Amwell Township	44.8	Allenport Borough	2.1
Blaine Township	11.9	Beallsville Borough	2.4
Buffalo Township	20.3	Bentleyville Borough	3.7
Canton Township	14.9	Burgettstown Borough	0.6
Carroll Township	13.5	California Borough	11
Cecil Township	26.3	Canonsburg Borough	2.3
Chartiers Township	24.5	Centerville Borough	13.2
Cross Creek Township	27.6	Charleroi Borough	0.8
Donegal Township	41.	Claysville Borough	0.3
East Bethlehem Township	5.1	Coal Center Borough	0.1
East Finley Township	35.1	Cokeburg Borough	0.4
Fallowfield Township	21.3	Deemston Borough	9.6
Hanover Township	47.6	Donora Borough	1.9
Hopewell Township	20.5	Dunlevy Borough	0.5
Independence Township	25.8	East Washington Borough	0.4
Jefferson Township	22.6	Elco Borough	0.3
Morris Township	28.4	Ellsworth Borough	0.7
Mt Pleasant Township	35.6	Finleyville Borough	0.2
North Bethlehem Township	22.3	Green Hills Borough	0.9

North Franklin Township	7.3	Houston Borough	0.4
North Strabane Township	27.3	Long Branch Borough	3.2
Nottingham Township	20.3	Marianna Borough	2
Peters Township	19.6	McDonald Borough	0.3
Robinson Township	21.2	Midway Borough	0.4
Smith Township	34.4	New Eagle Borough	1
Somerset Township	32.1	North Charleroi Borough	0.3
South Franklin Township	20.6	Roscoe Borough	0.2
South Strabane Township	23.1	Speers Borough	1
Union Township	15.4	Stockdale Borough	0.3
West Bethlehem Township	22.1	Twilight Borough	1.6
West Finley Township	39.1	West Brownsville Borough	1.3
West Pike Run Township	16.3	West Middletown Borough	0.4
CITIES	**AREA (mi²)**		
Monongahela City	2.9		
Washington City	1.9		

Table 3.1. Washington County Municipalities

LAND USE

GENERAL DEVELOPMENT PATTERNS

In 1999, the Urban Research and Development Corporation was commissioned to develop the Washington County Economic Development Strategy. As described in the Washington County Comprehensive Plan, the Urban Research and Development Corporation led a group of economic development, business and government agencies to develop a thorough analysis of the existing economic conditions of Washington County as well as detailed recommendations to lead the effort for economic sustainability and revitalization.

The Washington County Economic Development Strategy determined that the different attributes of the County resulted in unique economic development advantages and opportunities specific to each area. Such attributes included waterways, major highways, public water and sewerage, air and rail service, agriculture, and proximity to the City of Pittsburgh. Such characteristics were to be built upon in each of the seven (7) "growth areas" identified in Washington County in order to realize economic growth that could be sustained across the County. These areas are as follows: City of Washington/County Airport; I-70 Corridor, I-79/US-19 Corridor; Mon Valley Corridor; PA-50 Corridor; Southern Beltway Corridor; and US-22/PA-18 Corridor. The future development growth patterns should be directed in a manner that promotes greater parity by capitalizing on the strengths and minimizing negative impacts of each region.

TRANSPORTATION

The County is served by two (2) important major transportation routes. Interstate 70 (I-70) traverses the United States from Baltimore, Maryland to Salt Lake City, Utah. I-70 enters eastern Washington County in Speers and exits the County in Donegal Township. Interstate 79 (I-79), which connects Charleston, West Virginia to Erie, Pennsylvania, enters the southern edge of Washington County in Amwell Township and exits to the north in Cecil Township. Other minor transportation routes include US Route 19, US Route 22, PA Route 88, and PA Route 837, which provide access from surrounding counties to regional business and industrial centers located in Washington County.

Three (3) airports provide service for the Washington County area. These airports and locations are as follows: Washington County Airport (South Franklin Township), Finleyville Airpark (Finleyville), and Bandel Airport (North Bethlehem Township).

Two (2) Class I rail lines serve the region by connecting Washington County to the rest of the North American market. The Norfolk Southern line extends in a mostly east-west direction, connecting Chicago and points west with the New York City area. The CSX line also extends mostly east-west from Washington County, and connects the Chicago area with Washington, DC.

The County is served by three (3) regional trail networks. The Montour Trail, and associated Panhandle Trail, serves the northern part of the County. The Arrowhead Trail serves residents of Peters Township and adjoining areas. The Montour Trail forms the western link of the Great Allegheny Passage that will link Pittsburgh with Washington, DC. The trail currently is 47 miles long, linking trail systems in Allegheny County and West Virginia. The Panhandle Trail is a 29-mile trail that runs from Walker's Mill, near Carnegie through the northern portion of Washington County to Weirton, West Virginia. The Arrowhead Trail is a four-mile long trail that runs through Peters Township.

FARMLANDS

Prime farmland, as defined by the U.S. Department of Agriculture (USDA) in the National Soil Survey Handbook, is the land that is best suited to producing food, feed, forage, and fiber and oilseed crops. It has the soil quality, growing season, and water supply needed to economically produce a sustained high yield of crops when it is treated and managed using acceptable farming methods (NRCS, 2007). In 1972, the USDA assigned the Soil Conservation Service the task of inventorying the prime and unique farmlands and farmlands of state and local importance. This inventory was designed to assist planners and other officials in their decision making to avoid unnecessary, irrevocable conversion of good farmland to other uses. On the USDA's important farmland inventory map, the farmlands are categorized into four (4) classifications: prime farmland, unique farmland, additional farmland of statewide importance, and additional farmland of local importance. According to the USDA, prime farmland soils are usually classified as capability Class I or II. Of Washington County's total land area, 3,633 acres (0.7 percent) are classified as Class I soils and 59,817 acres (10.9 percent) are classified as Class II soils as identified in the *Soil Survey of Greene and Washington Counties, Pennsylvania* (SCS, 1983).

Farmland soils of statewide importance are soils that are predominantly used for agricultural purposes within a given state, but have some limitations that reduce their productivity or increase the amount of energy and economic resources necessary to obtain productivity levels similar to prime farmland soils. These soils are usually classified as capability Class II or III.

According to USDA's National Agriculture Statistic Service, there are 2,023 active farms in Washington County covering over 210,000 acres. This agricultural land accounts for 38 percent of the total land area of the county.

The importance of identifying prime farmland, and planning accordingly, is significant. The loss of good farmland is often accompanied by such environmental problems as surface water runoff and interference with the natural recharging of groundwater. Furthermore, when prime agricultural areas are no longer available, farmers will be forced to move to marginal lands, usually on steeper slopes with less fertile soils, which are more apt to erode and less likely to produce. Clearly, decision makers must be able to make informed judgments about the development of farmland. Actions that put high quality agricultural areas into irreversible uses should only be initiated if the actions are carefully considered and are clearly for the benefit of public good.

CLIMATE

Washington County is situated on the Allegheny Plateau in southwestern Pennsylvania and the climate is classified as humid continental. Most weather systems that affect the area originate in the Central Plains or Midwest and are steered eastward by the prevailing westerly flow aloft. The primary source of moisture is the Gulf of Mexico. Due to the long overland trajectory, cold Canadian high-pressure air masses are many times considerably modified by the time they reach southwestern Pennsylvania. The mean temperature for Washington County is 53° Fahrenheit (F) with a maximum mean monthly temperature of 74°F in July and mean monthly low of 30°F in January. Cloudiness is rather persistent during the winter months of December through February due to the frequent rotation of weather systems through the area. About 60 percent of the annual precipitation falls during the spring and summer. Precipitation averages approximately 38 inches per year and is fairly evenly distributed throughout the year. May, July and August are the wettest months with an average of 3.9 inches per year and February is the driest month with approximately 2.2 inches per year of precipitation. Snowfall averages 21.2 inches per year with most of it falling between December and March.

RAINFALL

Figures 3.1 and 3.2 show the rainfall statistics for Washington County. The average rainfall, shown in Figure 3.1 portrays the amount of precipitation for each year since 1931. As shown, there can be significant variation in the annual rainfall total (between 25 and 51 inches). While this variation can have a significant impact on water supply and vegetative growth, it is the quantity of rain in a relatively short time period (1-hour, 6-hour, 24-hour, or 48-hour) that receives the focus of most stormwater regulations.

Figure 3.2 shows the annual maximum rainfall events recorded over the same time period graphed and the NOAA Atlas 14 values for the 2-year and 100-year, 24-hour storm events, derived using partial series data. The annual maximum rainfall for a station is constructed by extracting the highest precipitation amount for a particular duration in each successive year of record. A partial duration series is a listing of period of record greatest observed precipitation depths for a given duration at a station, regardless of how many occurred in the same year. Thus, a partial data series accounts for various storms that may occur in a single year.

Historical focus on the annual maximum rainfall and the larger magnitude, low frequency storm events as done in previous stormwater planning efforts throughout PA has led to neglect of 1) the majority of storm events that are smaller than the annual maximum and their subsequent value to the landscape in terms of volume and water quality and 2) the fact that inclusion of every storm may increase the 24-hour rainfall total typically used in design.

The majority of rainfall volume in Washington County comes from storms of low magnitude. Only 10% of the daily rainfall values between 1939 and 2009 exceeded 0.67 inches, which is below any design standards currently being used in the County. Thus, any stormwater policy should incorporate provisions such as water quality, infiltration, or retention BMPs that account for these small events. It is important to acknowledge that many of these smaller **rainfall** events lead to larger **runoff** events as they may be saturating the soils prior to a larger storm or occurring within a short time period that still overwhelm existing conveyance facilities.

For the gage shown in Figure 3.1 and 3.2, the NOAA Atlas 24-hour, 2-year storm event total of 2.38 inches was exceeded 11 times in 78 years of data. Best management practices should incorporate the NOAA Atlas 14, partial duration data series to ensure the best available data is being used for design purposes.

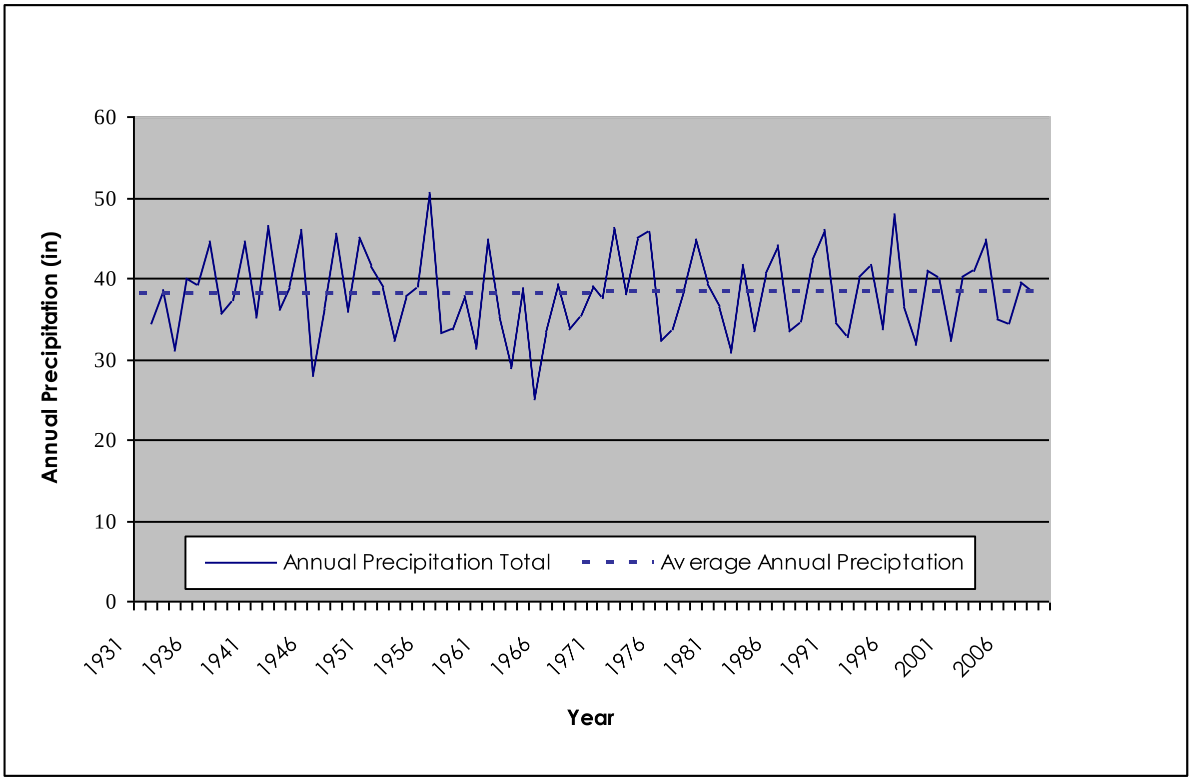


Figure 3.1. Annual Precipitation at Charleroi Lock 4, Pennsylvania (Coop ID #361377)

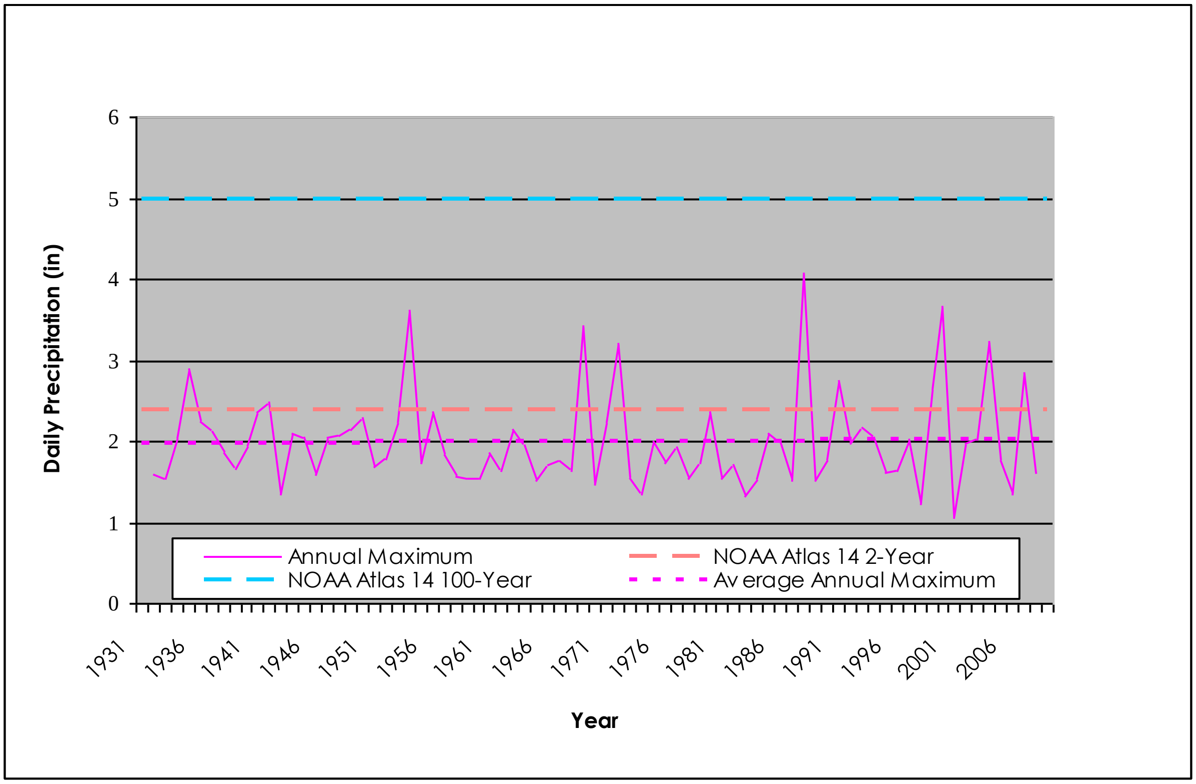


Figure 3.2. Daily Precipitation at Charleroi Lock 4, Pennsylvania (Coop ID #361377)

GEOLOGY

Washington County is located mostly within the Waynesburg Hills Section of the Appalachian Plateaus Physiographic Province. The northern part of the County is located in the Pittsburgh Low Plateau Section of the Appalachian Plateaus Physiographic Province. The present day surface forms were created through millions of year of uplifting and subsiding, geologic erosion, and stream cutting. These processes changed what had previously been a nearly level surface formed by freshwater inland seas to a highly dissected, rolling, and hilly relief. Most of the county is hilly, but some parts are only slightly dissected.

The Appalachian Plateau Province is by far the largest province in the state. It contains mostly rock that is not faulted and folded, but sits relatively flat. This province is a highland that has been eroded by streams that have created deep valleys and hilly topography. The Waynesburg Hills Section is very hilly with narrow hilltops and steep-sloped, narrow valleys. The Pittsburgh Low Plateau Section consists of a smooth undulating upland surface cut by numerous, narrow, relatively shallow valleys. The uplands are developed on rocks, containing the bulk of the significant bituminous coal in Pennsylvania. The landscape reflects this by the presence of some operating surface mines, many old stripping areas, and many reclaimed stripping areas. Some of the land surface in both of these Sections is very susceptible to landslides. Refer to Plate 6 – Geology for more information.

BEDROCK FORMATIONS

The bedrock formations in Washington County are nearly level or very gently sloping. Bedrock in the county is primarily sedimentary in origin and includes six (6) different geologic formations that range from Permian-age (248 – 290 million years ago) to Pennsylvanian-age (290 – 323 million years ago) (Barnes and Sevon, 2002). The formations consist of sandstone, siltstone, mudstone, shale, and conglomerate as well as some clay, claystone, limestone, and coal. The formation names and their relative areas are as follows (Berg et al., 1980):

Formation	Dominant Lithology	% of County
Greene Formation	Sandstone	19.5
Washington Formation	Sandstone	20.6
Waynesburg Formation	Sandstone	21.5
Monongahela Group	Limestone	29.9
Casselman Formation	Shale	8.2
Glenshaw Formation	Shale	0.3

Table 3.2. Geologic Formations

The youngest rocks present are of the Permian age and they underlie the highest elevation in the south and west of the county. These include the Greene, Washington, and Waynesburg Formations. They are primarily a cyclic sequence of shale, siltstone, sandstone, and coal. Next in age are the Pennsylvanian age rocks. Bedrock formed during this age includes the Waynesburg through Glenshaw Formations and the Huntley Mountain Formation. These formations are cyclic sequences of shale, siltstone, and sandstone and are mainly located in the valleys.

OUTSTANDING AND UNIQUE FEATURES

Pennsylvania's outstanding and unique scenic geological features have been identified by the *Outstanding Scenic Geological Features of Pennsylvania* (Geyer and Bolles, 1979). Washington County contains two (2) of these resources as identified below.

Meadowcroft Rock Shelter – Located in Jefferson Township, this feature is the oldest archaeological site in the western hemisphere and is the location of the earliest known Indian habitat in the United States. Though primarily of archaeological interest, the site does have geologic significance; over 30 radiocarbon dating tests have been performed by the Smithsonian Institute, Washington, D. C. Some of the most sophisticated techniques used at any site in the world, including computer analyses, have been employed. The rock shelter was formed by the differential weathering of massive beds of sandstone, siltstone, and shale (Casselman Formation, Conemaugh Group, Middle to Late Pennsylvanian age).

Rea Block Field – Located in Cross Creek Township, the site is characterized by massive sandstone outcrops of the Greene Formation (Permian age); 20 feet to 30 feet high; excellent examples of crossbedding. The name of C. C. Rea and the date 1854 are carved into one of the blocks. This is the only known location where this sandstone crops out in Washington County.

SLOPES

Slopes play a significant role when determining the extent and type of development that is being planned. Land with slopes in excess of fifteen (15) percent begins to cause problems for development. If these steep slopes are disturbed or vegetation is removed, the soils will become prone to erosion. Washington County's soils have high clay content. The amount of rainfall in the area causes the soil to become slip-prone. Slopes greater than fifteen (15) percent are prevalent throughout Washington County, as shown in the Comprehensive Plan. Of the county's total land area, approximately 56% is classified as having slopes of fifteen percent (15%) or greater (NRCS, 2008). Slope values are broken into four (4) categories and shown in *Table 3.3* below. Also shown is the total area in Washington County within each category, the total area as a percentage of all land in the county, and the general slope restrictions associated with each category.

Slope Classification	Slope Range	Land Area (mi^2)	Portion of Total Area	Slope Restrictions
Flat to Moderate	0-8%	168.97	19.63%	Capable of all normal development for residential, commercial, and industrial uses; involves minimum amount of earth moving; suited to row crop agriculture, provided that terracing, contour planting, and other conservation practices are followed
Rolling Terrain and Moderate Slopes	8 - 15%	211.37	24.56%	Generally suited only for residential development; site planning requires considerable skill; care is required in street layout to avoid long sustained gradients; drainage structures must be properly designed and installed to avoid erosion damage; generally suited to growing of perennial forage crops and pastures with occasional small grain plantings
Steep slopes	15 - 25%	289.69	33.66%	Generally unsuited for most urban development; individual residences may be possible on large lot areas, uneconomical to provide improved streets and utilities; overly expensive to provide public services; foundation problems and erosion usually present; agricultural uses should be limited to pastures and tree farms
Severe and Precipitous Slopes	> 25%	190.51	22.14%	No development of an intensive nature should be attempted; land not to be cultivated; permanent tree cover should be established & maintained; adaptable to open space uses (recreation, game farms, & watershed protection)

Table 3.3. Summary of Slopes in Washington County

SOILS

The behavior of a soil's response to rainfall and infiltration is a critical input to the hydrologic cycle and in the formation of a coherent stormwater policy. The soils in Washington County have variable drainage characteristics and have various restrictions on their ability to drain, promote vegetative growth, and allow infiltration. They are generally moderately- to poor-drained and have a high runoff potential. The following describes the predominant soil series that occupy greater than 1% of land cover in Washington County (SCS, 1981).

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Allegheny	AgB, AgC	B	0.1	
Brooke	BoB, BoC, BoD	D	1.6	Lithic bedrock (20-40in.)
Culleoka	CaB, CaC, CaD, CkB, CkC, CkD	B	12.8	Lithic bedrock (20-40in.)
Dekalb	DaB, DaD, DaF, DbD	C	0.2	Lithic bedrock (20-40in.)
Dormont	DoB, DoC, DoD	C	18.5	Lithic bedrock (40-150in.)
Culleoka	DtD	B	16.1	Lithic bedrock (20-40in.)
Dormont	DtF	C	20.3	Lithic bedrock (40-150in.)
Wet spots	Du	D	0.5	Fragipan (15-30in.)
Fluvaquents	Fa	D	2.4	
Glenford	GdA, GdB, GdC	C	2.4	

Guernsey	GeB, GeC, GeD	C	7.9	Lithic bedrock (50-75in.)
Huntington	Hu	B	0.7	
Library	LbA, LbB, LbC	C/D	0.3	Lithic bedrock (40-72in.)
Newark	Nw	C	3.1	
Purdy	Py	D	0.1	
Udorthents	UdB, UdD, UdF	B/D	0.7	Lithic bedrock (40-72in.)
Fairpoint	UkB, UkD, UkF	C	3.3	
Weikert	WeB, WeC, WeD	C	7.4	Lithic bedrock (10-20in.)
Other	W, Ur, DAM	--	1.7	Water, Urban land, dams

Table 3.4. Soil Characteristics of Washington County (NRCS, 2008)

One (1) of the impediments to drainage throughout Washington County is the presence of lithic bedrock. This solid rock layer is relatively shallow (10 to 75 inches beneath the surface). It is a relatively homogeneous layer of rock containing few fractures and it does not readily facilitate infiltration into the water table. Thus, higher runoff rates and reduced infiltration capacity typically exist in these soils. Additional impediments to subsurface drainage include dense material and fragipans (a loamy, brittle soil layer that has minimal porosity and organic content and low or moderate clay content but a high amount of silt or very fine sand). *Table 3.5* shows the proportion of various soil restrictions in Washington County.

Restrictions	% of County
Lithic bedrock	85.7
Fragipan	0.5
Dense material	1
None Defined	12.7

Table 3.5. Soil Restrictions in Washington County

An additional indicator of the response to rainfall of the soils in Washington County is the hydrologic soil group assigned to each soil. This classification varies between "A" which has very low runoff potential and high permeability and "D" which typically has very high runoff potential and low permeability. *Table 3.6* show a summary of the hydrologic soil groups for Washington County. Some soils have variable runoff potential depending on whether or not they are drained or undrained. For example, agricultural field with tile drainage may decrease the runoff potential from hydrologic soil group D to hydrologic soil group A. Over two-thirds of the soils in Washington County are hydrologic soil group C or D, indicating a moderate to high runoff potential (Refer to *Plate 4 – Hydrologic Soils*).

Hydrologic Soil Group	Runoff Potential	% of County
A	Low	0
B	Low to moderate	29.6
B/D		0.7
C	Moderate to high	63.1
C/D		0.3
D	High	4.6
Unidentified		1.7

Table 3.6. Hydrologic Soil Groups in Washington County

HYDRIC SOILS

The analysis of hydric soils has recently become an important consideration when performing almost any kind of development review. These soils are important to identify and locate because they provide an approximate location where wetlands may be found. Wetland areas are lands where water resources are the primary controlling environmental factor as reflected in hydrology, vegetation, and soils. Thus, the location of hydric soils is one (1) indication of the potential existence of a wetland area. Wetland areas are now protected by DEP and should be examined before deciding on any type of development activity. According to NRCS, the following table lists the hydric soils found in Washington County:

Glenford silt loam
Huntington silt loam
Library silty clay loam
Newark silt loam
Purdy silt loam
Udorthents

Table 3.7. Hydric Soils

WATERSHEDS

Surface waters include rivers, streams and ponds, which provide aquatic habitat, carry or hold runoff from storms, and provide recreation and scenic opportunities. Surface water resources are a dynamic and important component of the natural environment, however, ever-present threats such as pollution, construction, clear-cutting, mining, and overuse have required the protection of these valuable resources.

Watersheds are delineated and subdivided for the sake of management and analysis. The physical boundaries of a watershed depend on the purpose of the delineation. Often, a watershed is called a "basin", but is also a "subbasin" to an even larger watershed. This indistinct nature often leads to confusion when trying to categorize watersheds. As show in *Figure 3.4*, DEP has divided Pennsylvania into seven (7) different major river basins based upon the major waterbody to which they are tributary. These include: Lake Erie Basin, Ohio River Basin, Genesee River Basin, Susquehanna River Basin, Potomac River Basin, Elk & Northeast / Gunpowder Rivers Basin, and Delaware River Basin.

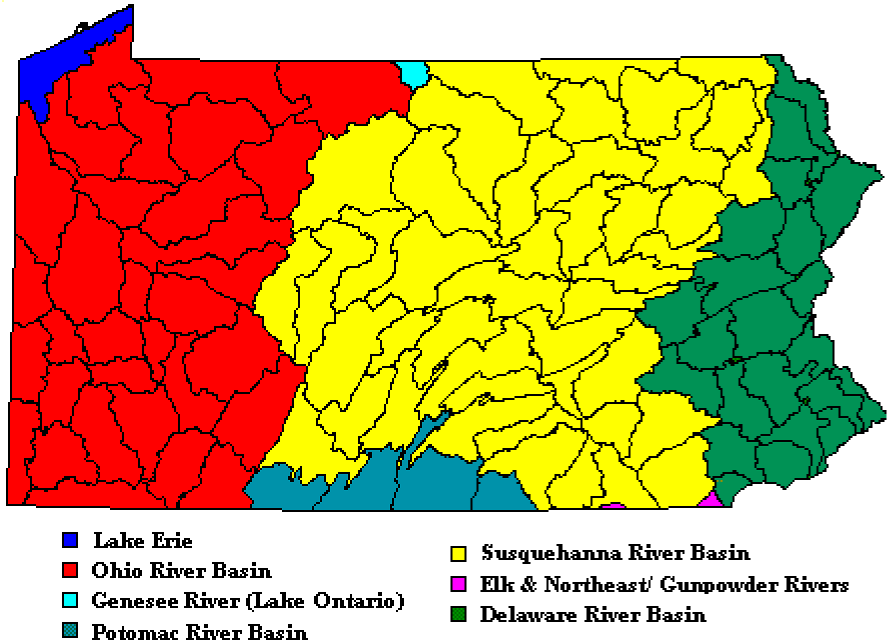


Figure 3.3. Pennsylvania's Major River Basins as Delineated by DEP (DEP, 2009)

For the purpose of this Plan, these are the largest basins within the Commonwealth. The major river basins are further divided into "subbasins" and "Act167 Designated Watersheds" for stormwater management purposes. Act 167 divided the Commonwealth into 29 subbasins and 357 designated watersheds. Washington County lies completely within the Ohio River Basin, but is tributary to two (2) different subbasins: Ohio River (From Confluence with Allegheny River to Ohio State Line) and Monongahela River (From West Virginia State Line to Confluence with Ohio River). Washington County contains at least a portion of eleven different Act 167 Designated Watersheds. This classification of the county's watersheds is summarized in the following table:

Major River Basin	Subbasin	Act 167 Designated Watershed
Ohio River	Ohio River	Ohio River
		Robinson Run
		Chartiers Creek
		Raccoon Creek
		Wheeling Creek
		Cross Creek
	Monongahela River	Monongahela River
		Tenmile Creek
		South Fork Ten Mile Creek
		Pike Run
		Pigeon Creek
		Peters Creek

Table 3.8. Classification of Washington County Watersheds

ACT 167 DESIGNATED WATERSHEDS

Most of Washington County is in the Ohio River subbasin, with the western portion of the county draining to the Monongahela River subbasin. The Monongahela River forms a portion of the county's border with Fayette, Westmoreland, and Washington Counties. No previous Act 167 Stormwater Management Plans have been completed for any of the eleven (11) Act 167 Designated Watersheds in the county. *Figure 3.4* shows the Act 167 Designated Watersheds.

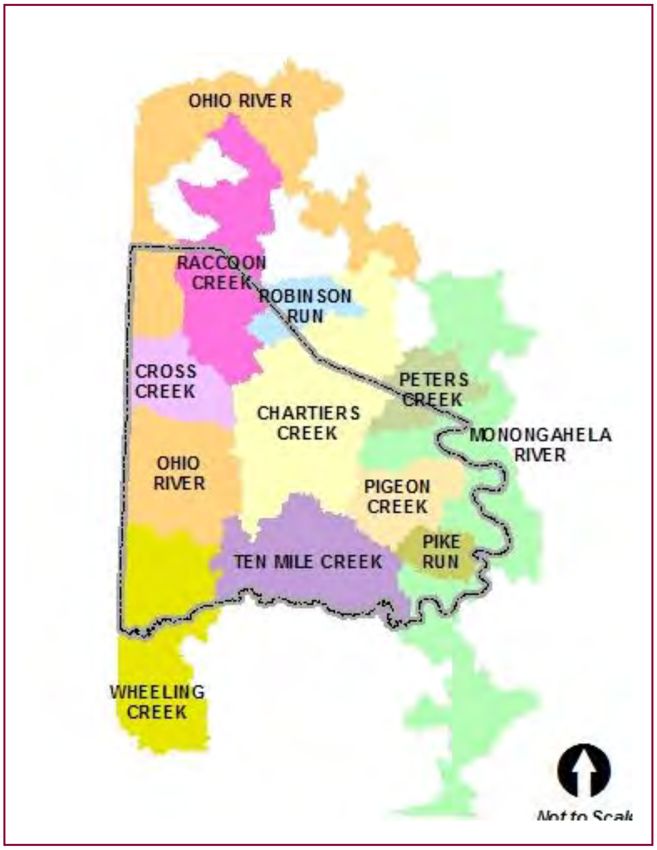


Figure 3.4. Act 167 Watersheds in Washington County

<u>Chartiers Creek Watershed</u>

This watershed is located in the northcentral region of Washington County. Chartiers Creek flows north into Allegheny County where it discharges into the Ohio River. The watershed drains an area of approximately 277 square miles, of which 186 square miles are located in Washington County. *Table 3.9* details the municipalities at least partially located in the watershed, and their contributing area:

Watershed	Municipality	Area (mi^2)
Chartiers Creek	Amwell Township	1.0
	Buffalo Township	< 0.1
	Canonsburg Borough	2.2
	Canton Township	13.8
	Cecil Township	25.9
	Chartiers Township	24.5
	City Of Washington	2.9
	East Washington Borough	0.5
	Green Hills Borough	0.9
	Hopewell Township	< 0.1
	Houston Borough	0.2
	Mount Pleasant Township	17.0

North Bethlehem Township	0.9
North Franklin Township	7.4
North Strabane Township	27.4
Nottingham Township	0.1
Peters Township	13.1
Somerset Township	3.6
South Franklin Township	6.6
South Strabane Township	23.0

Table 3.9. Chartiers Creek Watershed

The Chartiers Creek Watershed was studied in detail as part of this Plan. One result of that study was the establishment of Stormwater Management Districts across the watershed. Each Stormwater Management District has a release rate to be applied whenever a new construction project adds impervious area. The decision to incorporate release rates was based on the following factors:

1. Numerous problem areas exist in a pattern that indicate systemic stormwater problems;

2. Historic, repeated flooding has been observed;

3. Future planning projections indicate growth patterns that have historically contributed to documented problems; and

4. The size of the watercourse - Release rates are to be designated on higher order watersheds only. Larger downstream areas with well established bed-and-bank streams are not as affected by relatively small scale development and therefore do not benefit from release rates.

The hydrologic study of the Chartiers Creek Watershed is reviewed in detail in *Section VI – Technical Analysis – Modeling.*

A River Conservation Plan (RCP) was prepared for the Upper Chartiers Creek Watershed, which is located in the Washington County portion of the Chartiers Creek watershed (WCWA, 2003). The RCP was placed on DCNR's River Registry in May 2003.

IMPOUNDMENTS

There are numerous dams and impoundments scattered throughout Washington County. *Figure 3.5* shows their locations and whether or not they have any flood control potential.

Dams with small storage volumes (less than 100 acre-feet) and dams that are completely filled during minor runoff events (0.3 inches of runoff) were considered generally "run-of-the-river dams" that would only affect the immediate area near the dam. Their impacts to the overall watershed hydrology would be negligible. Any impoundments that exceed the above parameters can be considered "flood control dams" for the purpose of this Plan.

There are six (6) major water impoundments in the Chartiers Creek watershed. Their flood control properties have been incorporated into the release rate analysis that was performed for Chartiers Creek. Details of the hydraulic modeling are presented *Section VI – Technical Analysis – Modeling.*

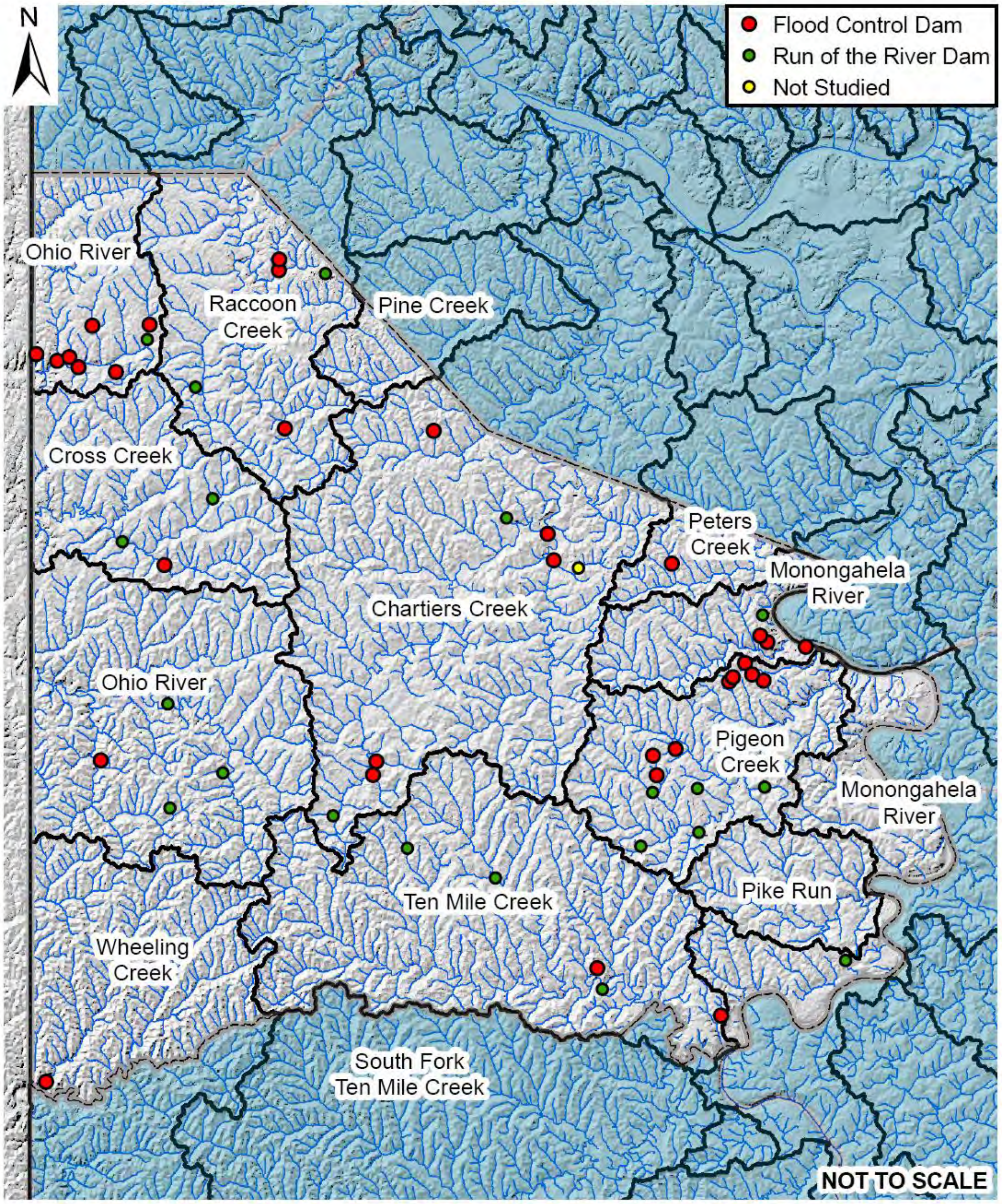


Figure 3.5. Washington County Impoundments

SURFACE WATER QUALITY

Water Quality Standards for the Commonwealth are addressed in *The Pennsylvania Code, Title 25, Chapter 93*. Within Chapter 93, all surface waters are classified according to their water quality criteria and protected water uses. According to the antidegradation requirements of §93.4a, "Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected." Certain waterbodies which exhibit exceptional water quality and other environmental features, as established in §93.4b, are referred to as "Special Protection Waters." These waters are classified as High Quality (HQ) or Exceptional Value (EV) waters and are among the most valuable surface waters within the Commonwealth.

Activities that could adversely affect surface water are more stringently regulated in those watersheds than waters of lower protected use classifications. The existing water quality regulations are discussed in more detail in *Section IV – Existing Stormwater Regulations and Related Plans*.

Washington County streams are shown with their Chapter 93 protected use classification in *Figure 3.6* below. (This figure is provided for reference only; the official classification may change and should be checked at: http://www.pacode.com/index.html) An explanation of the protected use classifications can be found in *Section IV*.

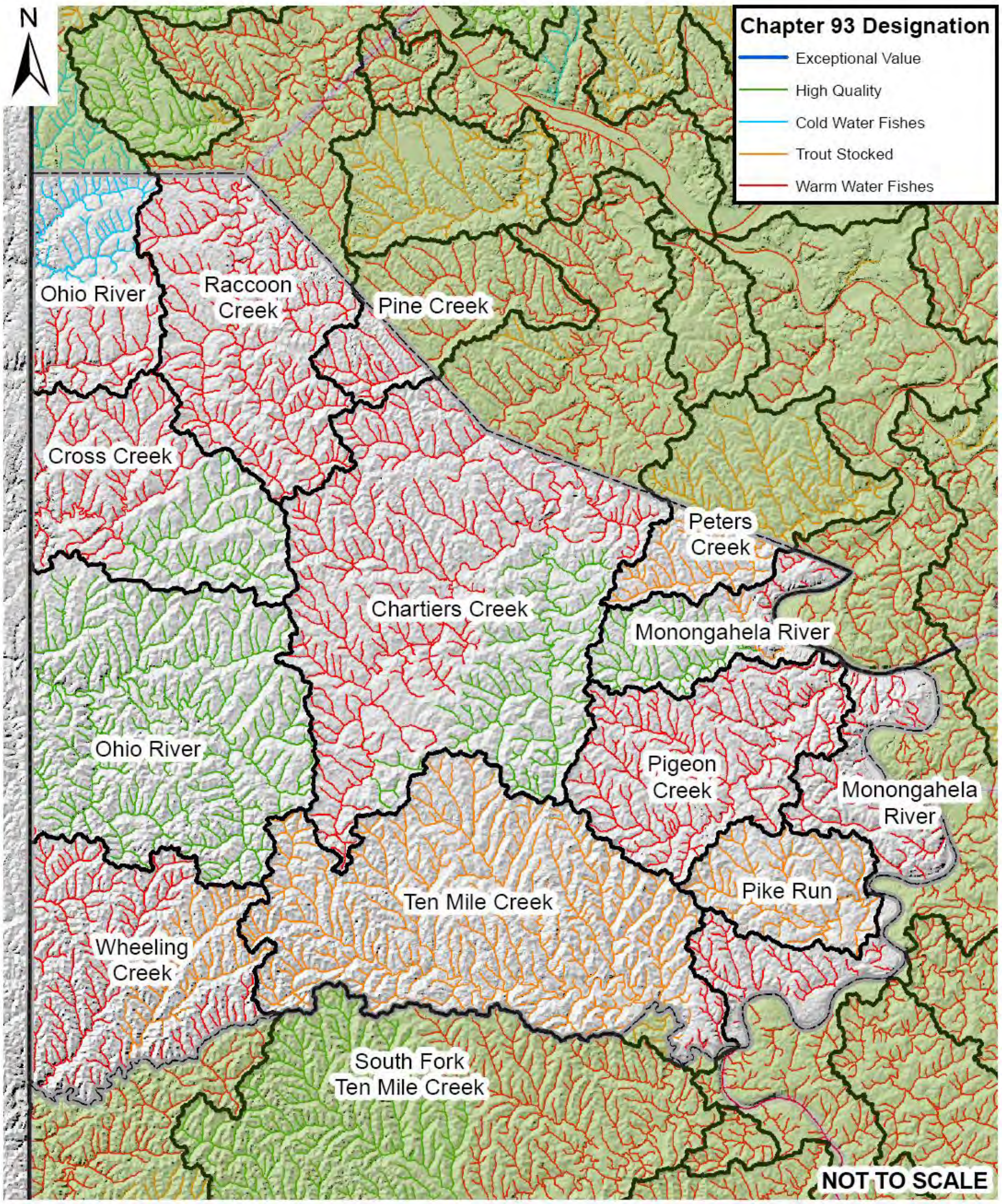


Figure 3.6. Chapter 93 Classification of Washington County Streams

In Pennsylvania, bodies of water that are not attaining designated and existing uses are classified as "impaired". Water quality impairments are addressed in *Section IX* of this Plan.

FLOODPLAIN DATA

A flood occurs when the capacity of a stream channel to convey flow within its banks is exceeded and water flows out of the main channel onto and over adjacent land. This adjacent land is known as the floodplain. For convenience in communication and regulation, floods are characterized in terms of return periods, e.g., the 50-year flood event. In regulating floodplains, the standard is the 100-year floodplain, the flood that is defined as having a one percent (1%) chance of being equaled or exceeded during any given year. These floodplain maps, or Flood Insurance Rate Maps (FIRMs), are provided to the public (http://msc.fema.gov/) for floodplain management and insurance purposes.

In 2007, the Pennsylvania Emergency Management Agency (PEMA) completed a statewide study of each county to determine damage estimates for all major flood events. The study computed damages in dollars for total economic loss, building and content damage, and also estimated the number of damaged structures (PEMA, 2009). *Table 3.12* summarizes the findings from this study for Washington County.

Storm Event	Number of Buildings at Least Moderately Damaged	Total Economic Loss
10	189	$61 million
100	238	$80 million
500	349	$115 million

Table 3.12. Potential Impact Due to Flooding (PEMA, 2009)

<u>Detailed Studies</u>

There are various levels of detail in floodplain mapping. Detailed studies (Zone AE) are conducted at locations where FEMA and communities have invested in engineering studies that define the base flood elevation and often distinguish sections of the floodplain between the floodway and flood fringe. See *Figure 3.7* below for a graphical representation of these terms. For a proposed development, most ordinances state that there shall be no increase in flood elevation anywhere within the floodway. The flood fringe is defined so that any development will not cumulatively raise that water surface elevation by more than a designated height (set at a maximum of 1'). Development in the flood fringe is usually allowed but most new construction is required to be designed for flooding (floodproofing, adequate ventilation, etc).

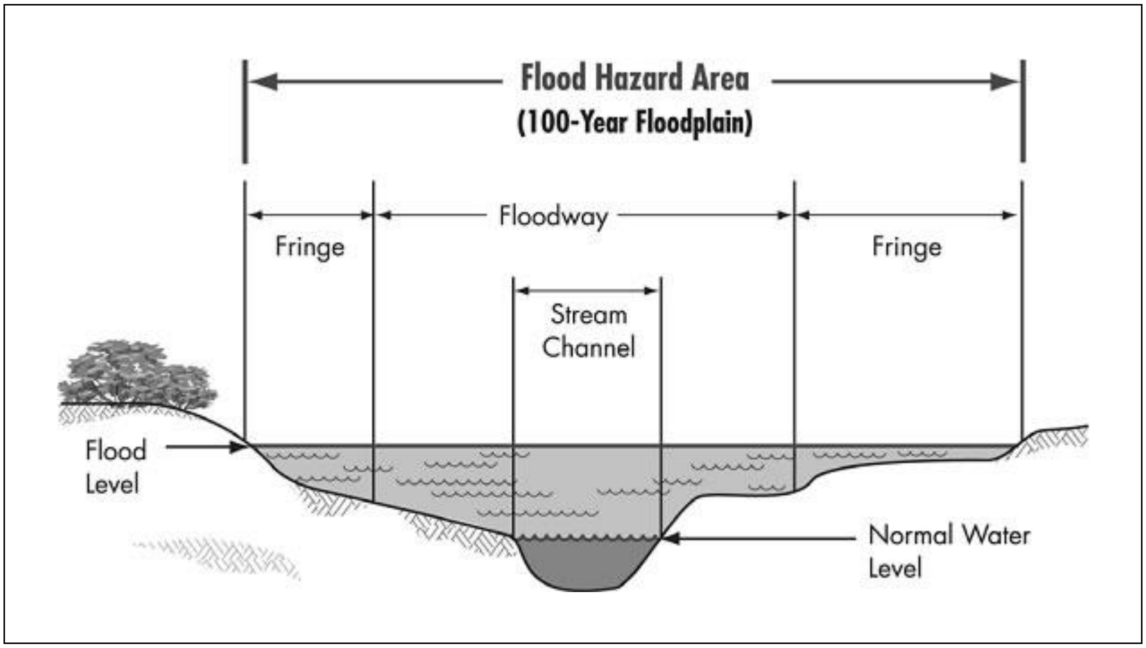


Figure 3.7. Floodplain Cross Section and Flood Fringe (NH Floodplain, 2007)

A review of the Preliminary Flood Insurance Study for Washington County revealed that Washington County contains several 100-year floodplains for the main streams draining the county. Detailed studies that clearly define the 100-year flood elevation and the floodway are provided in the streams indicated in *Table 3.13*.

Waterbody	Location
Brush Run	From approximately 25 feet downstream of Valley Brook Road to just upstream of Bebout Road.
Brush Run to Chartiers Creek	From the confluence with Chartiers Creek to approximately 20 feet upstream of Valley View Road.
Brush Run to Little Tenmile Creek	From the confluence with Little Tenmile Creek to approximately 0.7 mile upstream of Dynamite Road.
Catfish Creek	From the confluence with Chartiers Creek to approximately 240 feet upstream of Shrontz Lane.
Chartiers Creek	From approximately 100 feet downstream of I-79 to just downstream of State Route 18.
Chartiers Run	From the confluence with Chartiers Creek to approximately 0.5 mile upstream of Farm Road.
Georges Run	From the confluence with Chartiers Creek to approximately 0.3 mile upstream of Farm Road.
Little Chartiers Creek	From approximately 50 feet downstream of U.S. Route 19 to approximately 50 feet upstream of U.S. Route 40.
Little Tenmile Creek	From approximately 0.2 mile downstream of Lone Pine Road to approximately 2.8 miles upstream of Lone Pine Road.
Log Pile Run	From the confluence with Chartiers Creek to approximately 0.6 mile upstream of Prigg Road.
Monongahela River	From the downstream county boundary to approximately 60 feet upstream of the confluence of Tenmile Creek.
Montgomery Run	From the confluence with Tenmile Creek to approximately 0.3 mile upstream of I-79.
Peters Creek	From approximately 525 feet downstream of Venetia Road to

	approximately 0.9 mile upstream of Lutes Road.
Pigeon Creek	From the confluence with the Monongahela River to approximately 0.3 mile upstream of Oliver Avenue.
Raccoon Creek	From approximately 0.2 mile downstream of State Route 18 to approximately 0.2 mile upstream of West Pittsburgh Street.
Robinson Run	From approximately 0.4 mile downstream of St. John Street to just downstream of Dilly Street. From the downstream county boundary to approximately 0.3 mile upstream of McDonald Street.
Tenmile Creek	From the confluence with the Monongahela River to approximately 1.6 miles upstream of Cracraft Road.
Tributary 4	From the confluence with Little Chartiers Creek to approximately 1.5 miles upstream of Clokey Road.
Wolfdale Run	From the confluence with Chartiers Creek to approximately 0.3 mile upstream of Jefferson Avenue.

Table 3.13. Detailed Method Study

Approximate Studies and Non-delineated Floodplains

Approximate studies (Zone A on the DFIRM) delineate the flood hazard area, but are prepared using approximate methods that result in the delineation of a floodplain without providing base flood elevations or a distinction between floodway and flood fringe. If no detailed study information is available, some ordinances allow the base flood elevation to be determined based on the location of the proposed development relative to the approximated floodplain; at times, a municipality may find it necessary to have the developer pay for a detailed study at the location in question.

Approximated floodplains were delineated based mainly on the size of the contributory watershed. The U.S. Geological Survey (USGS) used a regional regression analysis consisting of basin areas compared to the flood depth observed in similar gaged streams for the one-percent-annual-chance (100-year) flood. Then the backwater due to bridges and culverts was approximated.

One (1) limitation of FIRMs and older Flood Insurance Rate Maps is the false sense of security provided to homeowners or developers who are technically not in the floodplain, but are still within an area that has a potential for flooding. Headwater streams or smaller tributaries located in undeveloped areas do not normally have FEMA delineated floodplains. This leaves these areas unregulated at the municipal level and somewhat susceptible to uncontrolled development. Flooding due to natural phenomena as well as increased stormwater runoff generated by land development is not restricted only to main channels and large tributaries. In fact, small streams and tributaries may be more susceptible to flooding from increased stormwater runoff due to their limited channel capacities.

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

Levees and other flood control structures

As administrator of the National Flood Insurance Program (NFIP), FEMA has a series of policies and guidelines concerning the protection of life and property behind levees. Periodically, FEMA updates the effective FIRMs as new hydrologic and hydraulic data become available and to reflect changes within the community. In the ongoing map update process, FEMA issued Procedure Memorandum 43 (PM 43) – Guidelines for Identifying Provisionally Accredited Levees (PALs) (FEMA, 2007). For communities with levees, PM 43 has potential to substantially impact the communities protected by levees. A PAL is a levee that has previously been accredited with providing 1-percent-annual-chance flood protection on an effective FIRM. After being designated as a PAL, levee owners will have up to 24 months to obtain and submit documentation that the levee will provide adequate protection against a one-percent-annual-chance flood. If the levee cannot be certified as providing protection from the one-percent-annual-chance flood, the areas currently being protected by the levees will be mapped and managed as if they were within the floodplain (i.e., in most cases, the residents and businesses currently being protected by the levees would be forced to purchase flood insurance in accordance with the NFIP).

There are 3 levee projects in Washington County:

Project (Year Constructed)	Owner	Waterbody	PAL Levee Status
Cecil (unknown)	**Conrail**	**Chartiers Creek**	**N/A**
South Strabane (unknown)	**Washington-East Washington Joint Authority**	**Chartiers Creek**	**Pre-PAL**
Washington (1962)	**Washington County**	**Chartiers Creek**	**Pre-PAL**

Table 3.14. Levee Systems in Washington County

Community Rating System (CRS)

To reduce flood risk beyond what is accomplished through the minimum federal standards, the NFIP employs the CRS to give a credit to communities that reduce their community's risk through prudent floodplain management measures. Several of these measures coincide with the goals and objectives of this plan: regulation of stormwater management, preservation of open space, and community outreach for the reduction of flood-related damages.

Flood insurance premiums can be reduced by as much as 45% for communities that obtain the highest rating. Only 28 of the Commonwealth's 2500+ municipalities participate in the CRS. Currently, none of Washington County's municipalities participate in the CRS.

FIRM Updates

As new information becomes available, FEMA periodically updates the FIRMs to reflect the best available data and to address any new problem areas. Washington County is scheduled to have a preliminary FIRM update available by April 2010. This will correspond to an effort by DCED to have all municipalities adopt and implement a new floodplain model ordinance that conforms to federal and state requirements.

Section IV – Existing Stormwater Regulations and Related Plans

It is often helpful to assess the current regulations when undertaking a comprehensive planning effort. An understanding of current and past regulations, what has worked in the past, and what has failed, is a key component of developing a sound plan for the future. Regulations affecting stormwater management exist at the federal, state, and local level. At the federal level the regulations are generally broad in scope and aimed at protecting health and human welfare, protecting existing water resources and improving impaired waters. Regulations generally become more specific as their jurisdiction becomes smaller. This system enables specific regulations to be developed, which are consistent with national policy, yet meet the needs of the local community.

EXISTING FEDERAL REGULATIONS

Existing federal regulations affecting stormwater management are very broad in scope and provide a national framework within which all other stormwater management regulations are developed. An overview of these regulations is provided below in *Table 4.1*.

Clean Water Act	Section 303	Requires states to establish Total Maximum Daily Loads for point sources of pollution that are allowable to maintain water quality and protect stream flora and fauna. Other water quality standards (e.g., thermal) are also regulated.
Clean Water Act	Section 404	Regulates permitting of discharge of dredged or fill material into the waters of the United States. Includes regulation of discharge of material into lakes, navigable streams and rivers, and wetlands.
Clean Water Act	Section 401/402	Authorizes the Commonwealth to grant, deny, or condition Water Quality Certification for any licensed activity that may result in a discharge into navigable waters. Established the National Pollutant Discharge Elimination System (NPDES) that regulates any earth disturbance activity of 5 acres (or more) or 1 acre (or more) with a point source discharge.
Rivers and Harbors Act of 1899	Section 10	Regulates activities that obstruct or alter any navigable waters of the United States.
Federal Emergency Management Act		Requires that any proposed structure within the floodplain boundaries of a stream cannot cause a significant increase in the 100-year flood height of the stream.

Table 4.1. Existing Federal Regulations

EXISTING STATE REGULATIONS

PA has developed stormwater regulations that meet the federal standards and provide a statewide system for stormwater regulation. State regulations are much more specific than federal regulations. Statewide standards include design criteria and state issued permits. State regulations cover a variety of stormwater related topics. A brief review of the existing state regulations is provided below in *Table 4.2*.

Chapter 92	Discharge Elimination	Regulates permitting of point source discharges of pollution under NPDES. Storm runoff discharges at a point source draining five (5) or more acres of land or one (1) or more acres with a point source discharge are regulated under this provision.
Chapter 93	Water Quality Standards	Establishes the Water Use Protection classification (i.e., water quality standards) for all streams in the state. Stipulates anti-degradation criteria for all streams.
Chapter 96	Water Quality Implementation Standards	Establishes the process for achieving and maintaining water quality standards applicable to point source discharges of pollutants. Authorizes DEP to establish TMDLs and Water Quality Based Effluent Limitations (WQBELs) for all point source discharges to waters of the Commonwealth.
Chapter 102	Erosion and Sediment Control	Requires persons proposing or conducting earth disturbance activities to develop, implement and maintain Best Management Practices to minimize the potential for accelerated erosion and sedimentation. Current DEP policy requires preparation and implementation of a post-construction stormwater management (PCSM) plan for development areas of five (5) acres or more or for areas of one (1) acre or more with a point source discharge.
Chapter 105	Dam Safety and Waterway Management	Regulates the construction, operation, and maintenance of dams on streams in the Commonwealth. Also regulates water obstructions and encroachments (e.g., road crossings, walls, etc.) that are located in, along, across or projecting into a watercourse, floodway, wetland, or body of water.
Chapter 106	Floodplain Management	Manages the construction, operation, and maintenance of structures located within the floodplain of a stream if owned by the State, a political subdivision, or a public utility.

Table 4.2. Existing State Regulations

STATE WATER QUALITY STANDARDS

Water Quality Standards for the Commonwealth are addressed in *The Pennsylvania Code, Title 25, Chapter 93*. Within Chapter 93, all surface waters are classified according to their water quality criteria and protected water uses. The following is an abbreviated explanation of these standards and their respective implications to this Act 167 Plan.

General Provisions (§93.1 - §93.4)

The general provisions of Chapter 93 provide definitions, citation of legislative authority (scope), and the definition of protected and statewide water uses. DEP's implementation of Chapter 93 is authorized by the Clean Streams Law, originally passed in 1937 to "preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation," and subsequently amended. *Table 4.3* is a summary of the protected water uses under Chapter 93 that are applicable to Washington County.

Protected Use	Relative Level of Protection	Description
Aquatic Life		
Warm Water Fishes (WWF)	Lowest	Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
Trout Socking (TSF)	↓	Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
Cold Water Fishes (CWF)	↓	Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.
Special Protection		
High Quality Waters (HQ)	↓	A surface water that meets at least one of chemical or biological criteria defined in §93.4b
Exceptional Value Waters (EV)	Highest	A surface water that meets at least one of chemical or biological criteria defined in §93.4b and additional criteria defined in §93.4b.(b)

Table 4.3. Chapter 93 Designations in Washington County

Antidegradation Requirements (§93.4a - §93.4d)

According to the antidegradation requirements of §93.4a, "Existing in-stream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected." Certain waterbodies which exhibit exceptional water quality and other environmental features, as established in §93.4b and summarized in *Table 4.3*, are referred to as "Special Protection Waters." Activities that could adversely affect surface water are more stringently regulated in those watersheds than waters of lower protected use classifications. For WWF, TSF, or CWF waterbodies, many of the antidegradation requirements can be addressed using guidance provided in this plan and the DEP BMP Manual; for HQ or EV watersheds, the current regulations follow DEP's antidegradation policy.

For new or additional, point source discharges with a peak flow increase to an HQ or EV water, the developer is required to use a non-discharge alternative that is cost-effective and environmentally sound compared with the costs of the proposed discharge. If a non-discharge alternative is not cost-effective and environmentally sound, the developer must use the best available combination of treatment, pollution prevention, and wastewater reuse technologies and assure that any discharge is non-degrading. In the case where allowing lower water quality discharge is necessary to accommodate important economic or social development in an area, DEP may approve a degrading discharge after satisfying a multitude of intergovernmental coordination and public participation requirements.

Water Quality Criteria (§93.6 - §93.8c)

In general, the water discharged form either a point source or a nonpoint source discharge may contain substances in a concentration that would be inimical or harmful to a protected water use. The specific limits for toxic substances, metals, and other chemicals are listed in this section.

Designated Water Uses and Water Quality Criteria (§93.9)

The designated use and water quality criteria for each stream reach or watershed is specified. On the following page, *Table 4.4* shows the Chapter 93 designated uses for Washington County as defined by §93.9. The majority of watersheds within Washington County have watersheds designated as warm water fisheries.

Water Quality Impairments and Recommendations

Additional to the Chapter 93 regulations, DEP has an ongoing program to assess the qualities of water in PA and identify stream and other bodies of water that are not attaining the required water quality standards. These "impaired" streams, their respective designations, and the subsequent recommendations are discussed in *Section IX*.

Drainage List V – Monongahela River Basin in Pennsylvania	
Barneys Run	WWF
Dry Run	WWF
Fishpot Run	WWF
Froman Run	TSF
Hooders Run	WWF
Huston Run	WWF
Lilly Run	WWF
Maple Creek	WWF
Mingo Creek (Froman Run to mouth)	TSF
Mingo Creek (source to Froman Run)	HQ-TSF
Pigeon Creek	WWF
Pike Run	TSF
South Fork Tenmile Creek (Browns Creek to mouth)	WWF
Tenmile Creek (source to South Fork Tenmile Creek)	TSF
Tenmile Creek (South Fork Tenmile Creek to mouth)	WWF
Twomile Run	WWF
UNT to Monongahela River (all sections in PA; PA-WV state border to Mingo Creek)	WWF
UNT to Monongahela River (Mingo Creek to Youghiogheny River)	WWF
Drainage List W – Ohio River Basin in Pennsylvania	
Brush Run	WWF
Brush Run	WWF
Buffalo Creek (all sections in PA)	HQ-WWF
Catfish Creek	WWF
Chartiers Run	WWF
Cross Creek (all sections in PA; Avella water intake to PA-WV state border)	WWF
Cross Creek (source to Avella water intake)	HQ-WWF
Enlow Fork (main stem; source to PA-WV state border)	TSF
Georges Run	WWF
Harmon Creek (all sections in PA)	WWF
Kings Creek (all sections in PA)	CWF
Little Chartiers Creek (Alcoa Dam to mouth)	WWF
Little Chartiers Creek (source to Alcoa Dam)	HQ-WWF
Long Run	WWF
McPherson Creek	WWF
Middle Wheeling Creek (all sections in PA)	WWF
Reservoir No. 2	HQ-WWF
Reservoir No. 3	HQ-WWF
Reservoir No. 4	HQ-WWF
Robinson Fork	WWF
Spottedtail Run (all sections in PA)	WWF
Templeton Fork	TSF
Turkey Run (all sections in PA)	WWF
UNT to Chartiers Creek	WWF
UNT to Enlow Fork (all sections in PA; PA-WV border to confluence with Dunkard Fork)	WWF
UNT to Enlow Fork (all sections in PA; PA-WV state border to confluence with Dunkard Fork)	WWF
UNT to Enlow Fork (source to PA-WV state border)	WWF
UNT to Wheeling Creek (all sections in PA; confluence of Enlow and Dunkard Forks to mouth)	WWF

Table 4.4. Washington County Designated Water Uses

EXISTING MUNICIPAL REGULATIONS

In Pennsylvania, stormwater management regulations usually exist at the municipal level. A review of the existing municipal regulations helps us unravel the complex system of local regulation and develop watershed-wide policy that both fits local needs and provides regional benefits. *Table 4.5* provides a summary of existing regulations for the 66 municipalities in Washington County.

WASHINGTON COUNTY MUNICIPAL ORDINANCES

MUNICIPALITY	STORMWATER MANAGEMENT		SUBDIVISION & LAND DEVELOPMENT (SALDO)		ZONING		FLOODPLAIN MANAGEMENT	
Allenport Boro			Yes		Yes			
Amwell Twp	No		Yes		Yes		Yes	1989
Beallsville Boro			No	County	No			
Bentleyville Boro			Yes		Yes			
Blaine Twp			Yes	County	Yes			
Buffalo Twp			Yes		Yes			
Burgettstown Boro			No		Yes			
California Boro	Yes	1996	Yes	2006	Yes			
Canonsburg Boro			Yes		Yes			
Canton Twp			Yes		Yes			
Carroll Twp	Yes	2007	Yes		Yes		No	SALDO
Cecil Twp			Yes		Yes			
Centerville Boro	No		Yes		Yes	2000		
Charleroi Boro	Yes	2002	Yes		Yes			
Chartiers Twp			Yes	1996	Yes			
Claysville Boro			Yes		Yes			
Coal Center Boro			No		Yes			
Cokeburg Boro			Yes		Yes			
Cross Creek Twp	Yes	2003	Yes	2003	Yes	2006	No	SALDO
Deemston Boro			Yes	2005	No			
Donegal Twp			Yes		No			
Donora Boro			Yes		Yes			
Dunlevy Boro			No	unknown	No			
East Bethlehem Twp			No	unknown	Yes			
East Finley Twp			No	unknown	Yes			
East Washington Boro			Yes		Yes			
Elco Boro			Yes		Yes			
Ellsworth Boro			No	unknown	Yes			
Fallowfield Twp	Yes	2007	Yes		Yes			
Finleyville Boro			No		No			
Green Hills Boro			No		No			
Hanover Twp			Yes	1991	Yes	2005		
Hopewell Twp			Yes		Yes			

Houston Boro			Yes		Yes			
Independence Twp			No		Yes			
Jefferson Twp			Yes		Yes			
Long Branch Boro			Yes		No			
Marianna Boro			Yes		No			
McDonald Boro			No		Yes			
Midway Boro			No		Yes			
Monongahela City			Yes		Yes			
Morris Twp			Yes		Yes			
Mount Pleasant Twp	No		Yes		Yes		Yes	
New Eagle Boro	Yes	2004	Yes	1973	No			
North Bethlehem Twp			Yes		No		Yes	1985
North Charleroi Boro			No		Yes			
North Franklin Twp			Yes		Yes			
North Strabane Twp			Yes		Yes	2006		
Nottingham Twp			Yes	1991	Yes	1990	Yes	1991
Peters Twp	Yes		Yes		Yes		No	Zoning
Robinson Twp			Yes		Yes			
Roscoe Boro			Yes	unknown	Yes			
Smith Twp	No		Yes	2001	Yes		Yes	2009
Somerset Twp			Yes		Yes			
South Franklin Twp			Yes		Yes			
South Strabane Twp			Yes		Yes	2009		
Speers Boro			Yes		Yes		Yes	1995
Stockdale Boro			No	unknown	No			
Twilight Boro			Yes	1961	Yes	1984	No	Zoning
Union Twp	Yes	2008	Yes		Yes			
Washington City			Yes		Yes			
Washington County			No		No			
West Bethlehem Twp	No		No	unknown	No		Yes	1990
West Brownsville Boro			No		No			
West Finley Twp			Yes		No			
West Middletown Boro			Yes		Yes		No	Zoning
West Pike Run Twp			Yes		Yes			

Table 4.5. Washington County Municipal Ordinance Matrix

It is noted that although Washington County had a SALDO in the 1970's, it has since been dissolved/retracted. Some Municipalities continue to use or reference this County SALDO even though it no longer is in effect at the County level.

Table 4.6 shown on the following pages is a brief summary of the results of an ordinance review of the existing municipal regulations and the stormwater management provisions contained within each Ordinance. Not all municipalities submitted ordinances for our review, so we only present the ordinances of those municipalities that did respond to our request.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
Amwell Township	No separate ordinance.	None Submitted.	None Submitted.	Ordinance No. 2 (1989) References FEMA FIRM. No construction in Floodway that would cause an increase to the 100-year flood.
California Borough	Ordinance No. 435 (1996) and 440 (1997) Rational Method, TR-55, and PSU-IV Method. Design Drainage structures for 25-year storm. Rate control standards not defined.	Chapter 187 (2006) Specifies 100% Rate Control of 10-year storm.	Chapter 205 No references to stormwater or flood control submitted.	None Submitted.
Carroll Township	Ordinance No. 2007-4 References future Act 167 Plan. TR-55 Method – 80% release rates for 2, 10, 25, and 100-year storms. Release rates in an Act 167 Plan adopted by the Township will supersede the ordinance.	None Submitted.	Article X Establishes various floodplain districts in the Township. References the FEMA FIRM. No construction in the floodway that causes 100-year flood rise. Limits certain structures in floodplain.	Addressed in zoning.
Centerville Borough	Do not have.	Ordinance No. 138-76 (1976) Restricts development within 50 feet of the banks of a watercourse. 24-foot minimum street width. Does not specify stormwater management, only the safe and healthful disposal of stormwater.	Ordinance No. 01-00 No references to flooding or stormwater management.	None submitted. SALDO restricts development within 50 feet of the banks of a watercourse.
Charleroi Borough	Ordinance No. 937 (2002) Rational Method, TR-55, or PSU-IV. Design Drainage structures for 25-year storm. Rate control standards not defined.	None Submitted.	None Submitted.	None Submitted.
Chartiers Township	None Submitted.	(1996) Specifies easements for water courses. Design of drainage structures using Rational Method or TR-55. Design for 50-year or 10-year storms. Calls for rate and volume control, but no design storms or specific volumes are specified.	None Submitted.	None Submitted.
Cross Creek Township	Ordinance No 3-03 (Online-2003) Rational Method or method approved by Twp Engineer. 90% release rate for 10, 25, 50, & 100-year storms. No volume control.	Ordinance No. 2-03 (Online) References SWM Ordinance. References the Infrastructure Improvement and Development Specifications for street widths.	Ordinance No. 4-06 (Online) References FEMA flood maps.	SALDO references FEMA maps.
Deemston Borough	None Submitted.	Ordinance No. 05-02 (2005) References Storm Water Management Act for drainage. Specifies rate control of stormwater – no standards presented.	No separate ordinance.	None Submitted.
Fallowfield Township	2007 – Rational Method or NRCS. Specifies 100% release rate and 80% removal of TSS (25-year storm). Requires use of SWM BMPs and provides examples and design methodologies.	None Submitted.	None Submitted.	None Submitted.
Hanover Township	None Submitted.	Ordinance No. 82 (1991) Minimal drainage requirements.	Passed in 2005, but the document emailed to the County may be a draft. References a Floodplain Management Ordinance. References the SALDO for stormwater management.	None Submitted.
Mount Pleasant Township	Addressed in SALDO.	Chapter 178 (Online) SCS, TR-55, HEC-1, or PSRM analysis methods. Specifies 100% release rates for 2, 10, 25, and 100-year storms. Allows more-restrictive release rates if a watershed has an adopted plan.	Chapter 200 (Online) References Chapter 97 for flood-prone properties.	Chapter 97 (Online) References FEMA FHBM and FIRM for floodplain identification. Regulates construction in the floodplain, and further regulates construction in the floodway.
New Eagle Borough	Ordinance No. 476 (2004) Allows stormwater credits for LID. 100% release rate for 2, 5, 10, 25, 50, and 100-year storms. Storage and treatment of the "90%" storm is required for water	Ordinance No. 317 (1973) 20' Minimum pavement width. Minimal drainage requirements.	None Submitted.	None Submitted.

	quality. The 90% storm is to be infiltrated or released over a minimum of a 24-hour period.			
North Bethlehem Township	None Submitted.	None Submitted.	None Submitted.	Ordinance No. 54 (1985) References FEMA FIS. Compliance is a requirement for issuance of a building permit.
North Strabane Township	None Submitted.	None Submitted.	Ordinance No. 314 (2006) Located ordinance on the Twp's website (northstrabanetwp.com) Regulates floodplains to some degree. References SALDO for stormwater management.	Not Submitted.
Nottingham Township	None Submitted.	Ordinance No. 32 (1991) Specifies 100% release rates for 10, 25, or 100-year storms. Ponds are required to dewater in 12 hours. Rational or SCS Methods.	Ordinance No. 50 (1990) No provisions for flooding or stormwater.	Ordinance No. 36 (1984) and Ordinance No. 36A (1991) References most recent FEMA FIRM.
Peters Township	The Storm Water Management Plan of Peters Township is a map of the Township, which is based on a hydrologic and hydraulic study prepared by Gateway Engineers. The map specifies release rates throughout the Township. Referenced in the SALDO.	Chapter 22 (Online) – www.peterstownship.com Establishes SWM districts and subareas (defined in the SWM Plan of Peters Township). Specifies release rates from 50% to 100 %. TR-55 and HEC-1 are required for SWM analysis for developments larger than 3 Ac.	Chapter 27 (Online) – www.peterstownship.com Floodplain provisions included. References FEMA FIRM.	Addressed in Zoning.
Smith Township	Addressed in SALDO.	Ordinance No. 2001-03 (2001) TR-55, Rational Method, & PSU Runoff Model allowed. 100% release rates for 2, 5, 10, 25, and 100-year storms.	None Submitted.	Municipal Code, Chapter 8 (updated 2009) References FEMA Flood Hazard Boundary Map
South Strabane Township	None Submitted.	None Submitted.	Ordinance No. 3-2009 (2009) Establishes a floodplain overlay district, in which development is regulated. References a Stormwater Management Ordinance.	None Submitted.
Speers Borough	None submitted.	None submitted.	None submitted.	Ordinance No. 388 (1995) Defines floodplain. Many pages of ordinance missing.
Twilight Borough	None submitted.	Ordinance No. 71 (1961) (Some pages missing) No references to stormwater or floodplain management in the pages received.	Ordinance No. 119 (1984) Establishes a Flood Plain District, FP. Restricts certain forms of development within the FP district and further restricts development inside the floodway.	Addressed in zoning.
Union Township	Ordinance No. 2008-12 (2008) TR-55, HEC-1, PSRM, Rational Method, or as approved by eng. Release rate map has been prepared, but not submitted. Release rates range from 90% to 100% throughout the Township. 80% TSS removal for storage basins over 1000 cu. Ft.	None submitted.	None submitted.	None submitted.
West Bethlehem Township	Does not have.	Does not have.	Does not have.	Ordinance No. 01-1990 (1990) References federal flood maps (FEMA)
West Middleton Borough	None submitted.	None submitted.	Ordinance No. 001-92 Restricts development in and near waterways. Provides standards for conveyance of stormwater. No rate or volume control.	Addressed in zoning.

Table 4.6. Municipal Ordinance Review

EXISTING RELATED PLANS

Review of previous planning efforts is another important component of regional planning. An analysis of previous plans, and the results achieved through implementation of recommendations within those plans, provides invaluable information for current and future planning efforts. The following table is a summary of related plans which includes a listing of pertinent plan goals:

Plan Title	Date	Author
River Conservation Plan for the Upper Chartiers Creek Watershed	January 2003	Washington County Watershed Alliance and Chartiers Creek Watershed Association
Washington County Comprehensive Plan	November 2005	Washington County Planning Commission
Storm Water Management Plan of Peters Township	September 1997	The Gateway Engineers, Inc.

Table 4.7. Related Plans Review

Section V – Significant Problem Areas and Obstructions

One (1) of the stated goals of this Plan is to "ensure that existing stormwater problem areas are not exacerbated by future development and provide recommendations for improving existing problem areas." The strategy for achieving this goal required identification of the existing significant stormwater problem areas and obstructions and then evaluation of the identified problem areas and obstructions.

The first task was to identify the location and nature of existing drainage problems in the study area and, where appropriate, gather field data to be used for further analysis of the problem. The geographical location data was used to plot all of the problem areas and obstructions on a single map (Reference Plate 9 – Problem Areas & Obstructions). Mapping the location of the sites in this manner enables you to identify isolated problems and determine which problems are part of more systemic problems. Systemic problems are often an indication that larger stormwater management problems exist, which may warrant more restrictive stormwater regulations. This information was used when modeling the watersheds and determining appropriate stormwater management controls.

The second part of this task was to analyze individual problem areas and obstructions, determine potential solutions for the most significant problems, and provide recommendations that can be implemented through the Washington County Stormwater Management Plan. All of the problem areas and obstructions were evaluated and potential solutions were developed. A preliminary prioritization assessment was conducted to give a countywide overview of the severity of the existing problems. The priority assessment also provides general guidance on the relative order in which the problems should be addressed when considered at a countywide level.

IDENTIFICATION OF PROBLEM AREAS AND OBSTRUCTIONS

Identification and review of existing information concerning the County's stormwater systems, streams, and tributary drainage basins within the project limits was conducted during Phase I and Phase II of this Plan. During Phase I, questionnaires were distributed to all of the municipalities in Washington County. The questionnaire enabled the municipalities to report all of the known problem areas and obstructions in their municipality. Of the 66 municipalities in Washington County, 50 participated in the assessment process by returning completed questionnaires. West Alexander also completed a questionnaire, but the borough subsequently merged with Donegal Township. The responses were summarized and reported in the Phase I Scope of Study. The responses were reviewed during Phase II of the Act 167 planning process. Field reconnaissance was subsequently conducted to confirm problem area locations, assess existing conditions, identify the general drainage patterns and gather data to complete a planning level analysis.

All of the reported problem areas and obstructions are listed in *Table 5.1* on the following pages.

ID	Municipality	Location	Description
P1	Robinson Township	Creek Road	Bank erosion undercutting guide rails
P2	Robinson Township	Robinson Church Road	Sediment buildup
P3	Robinson Township	Beagle Club Road	Sediment buildup
P4	Robinson Township	Valley Street	Flooding
P5	Robinson Township	Noblestown Road	Inadequate storm sewer
P6	Robinson Township	North Branch Road	Flooding and Pooling
P7	West Pike Run Township	Whitehall Road	Bridge abutment weakening
P8	West Pike Run Township	Deems Park Rd near Spring RD	Undersized pipe
P9	East Finley Township	Rocky Run	Ponding
P10	East Finley Township	Templeton Avenue	Ponding
P11	East Finley Township	Buffalo Creek	Ponding
P12	Peters Township	Bower Hill Road	Stream bank erosion
P13	Burgettstown Borough	Center Avenue	Stream bank erosion
P14	Burgettstown Borough	Bridge Street	Obstruction
P15	Burgettstown Borough	Shady Avenue Bridge	Undercut by stream
P16	Burgettstown Borough	Burgetts Fork	Stream bank erosion
P17	Burgettstown Borough	Shady Avenue Bridge	Undercut by stream
P18	Burgettstown Borough	?	Stream bank erosion
P19	Burgettstown Borough	Smith Twp border	Storm runoff
P20	Burgettstown Borough	?	Mine runoff
P21	Burgettstown Borough	Adjacent Township	Runoff
P22	Burgettstown Borough	?	Mine runoff
P23	Burgettstown Borough	Adjacent Township	Storm runoff
P24	Cross Creek Township	Parker Rd near Sugar Camp	Bank Erosion
P25	Cross Creek Township	Cooke Road	Bank Erosion
P26	Cross Creek Township	Sugar Camp Road	Bank Erosion
P27	Cross Creek Township	Cross Creek Road	Sediment buildup/Debris
P28	Cross Creek Township	Clark Avenue Intersection	Flooding

ID	Municipality	Location	Description
P29	West Brownsville Borough	400 Mainstreet & Woodlawn	Drains blocked by railroad
P30	West Brownsville Borough	Route 40/88	Sediment buildup, flooding and ponding
P31	California Borough	Second Street & Peach Alley	Undersized pipe
P32	Speers Borough	Oak St at Charles & Elizabeth	Drainage issue
P33	Washington City	Catfish Creek	Stream remediation
P34	Washington City	S Main St & Park Ave	Stream debris
P35	Washington City	Ford Avenue	Debris, flooding
P36	South Strabane Township	Country Club at Enterprise St	Flooding
P37	South Strabane Township	Country Club at Locust Ave	Flooding
P38	South Strabane Township	Manifold Rd near Pine Valley Rd	Flooding
P39	South Strabane Township	Lakeview Dr at Hilltop Rd & Quarry Rd	Flooding
P40	South Strabane Township	Mitchell Rd. between Rt 136 & bridge	Flooding
P41	Claysville Township	Main Street	Undersized pipe, flooding
P42	Claysville Township	Throughout Township	Undersized pipe, poor quality pipes
P43	Hanover Township	South Township border	Flooding
P44	Mount Pleasant Township	Agape Rd at Caldwell Rd	Flooding
P45	Roscoe Borough	Route 88 and Mount Tabor	Sediment buildup
P46	Roscoe Borough	Latta Hollow and Route 88	Sediment buildup
P47	Roscoe Borough	Corwin Street	Flooding
P48	Roscoe Borough	High Road and Howard Road	Flooding
P49	Roscoe Borough	High Road	Flooding
P50	Roscoe Borough	High Road to Eiver's Edge	Flooding
P51	Bentleyville Borough	Wash. St at 7th to Pigeon Creek	Debris, flooding
P52	Bentleyville Borough	Pittsburgh Rd below Smith St	Flooding
P53	Somerset Township	SR 2019	Ponding
P54	Canonsburg Borough	North Jefferson & West Pike St	Flooding
P55	Canonsburg Borough	Walter's Alley at Craig Head St	Flooding
P56	Canonsburg Borough	Chartiers Creek at West Pike St	Flooding
P57	Houston Borough	Plum Run & Chartiers Run	Erosion & Flooding

ID	Municipality	Location	Description
P58	South Franklin Township	Bedillion Rd & Vista Valley Rd	Flooding
P59	South Franklin Township	Vista Valley Rd	Flooding
P60	South Franklin Township	Crestmont Rd	Flooding
P61	Independence Township	Run Road & S.R. 531	Debris in Stream Channel
P62	Cecil Township	Park Road	Bank Erosion
P63	Cecil Township	Georgetown Road	Flooding of Roadway
P64	Marianna Borough	Main Street	Stream Bank Erosion
P65	Somerset Township	Unknown	Erosion
O1	Robinson Township	Washington Road	Beaver dam causing ponding
O2	Robinson Township	Robinson Church Road	Sediment Buildup
O3	Robinson Township	Maple Grove Road	Sediment Buildup
O4	Robinson Township	Valley View	Pooling
O5	Robinson Township	Beagle Club Road	Sediment Buildup
O6	Robinson Township	Valley Street	Flooding
O7	Robinson Township	Noblestown Road	Inadequate storm sewer
O8	Robinson Township	North Branch Road	Flooding and pooling
O9	West Pike Run Township	Deems Park Rd near S. California Dr	Ponding
O10	Chartiers Township	Pike Street and Country Club Road	Undersized pipe
O11	Chartiers Township	East Indiana Ave & North Shady Ave	Undersized pipe
O12	Peters Township	Greenbriar Drive	Obstruction
O13	Peters Township	Lutes Road	Undersized pipe
O14	Burgettstown Borough	Bridge Street	Obstruction
O15	Burgettstown Borough	Shady Avenue Bridge	Undercut by stream
O16	Cross Creek Township	Parker Road	Undersized pipe
O17	Cross Creek Township	Browntown Bridge	Sediment Buildup
O18	Cross Creek Township	Clark Avenue Bridge	Sediment Buildup
O19	Amwell Township	Big Ten Mile Creek	Sediment Buildup
O20	Amwell Township	Little Ten Mile Creek	Sediment Buildup
O21	Donegal Township	Buck Run	Sediment Buildup

ID	Municipality	Location	Description
O22	Donegal Township	Valley Road & Lake Road	Sediment Buildup
O23	West Brownsville Borough	Main St at 400 Block & Woodlawn Ave	Debris buildup from railroad property
O24	Washington City	Fairhill Drive	Undersized pipe, flooding
O25	Washington City	Houston Street	Undersized pipe, flooding
O26	Washington City	Sammy Angoit Way & East Wylie Avenue	Debris, flooding
O27	Buffalo Township	State Route 221	Debris
O28	Buffalo Township	North Sunset Beach Road	Debris
O29	Mount Pleasant Township	Sabo Road	Flooding
O30	Mount Pleasant Township	Zuk Lane	Flooding
O31	Mount Pleasant Township	Skyline Drive	Flooding
O32	Mount Pleasant Township	Skyline Drive	Flooding
O33	Deemston Borough	Hull Road at Plum Run	Flooding
O34	Donora Borough	Third Street and Meldon Street	Flooding
O35	Somerset Township	Chartiers Creek	Debris
O36	Somerset Township	Pigeon Creek	Sediment Buildup
O37	North Bethlehem Township	?	Runoff
O38	North Bethlehem Township	?	Sediment Buildup
O39	North Bethlehem Township	?	Debris
O40	North Bethlehem Township	Roberts Road	Undersized pipe
O41	Canonsburg Borough	Chartiers Ck. behind West Pike Street	Flooding
O42	Morris Township	Ten Mile Creek	Debris
O43	Houston Borough	Chartiers Creek	RR Pier
O44	Beallsville Borough	Stream	Undersized pipe
O45	Smith Township	Burgett-Forke	Sediment Buildup
O46	Smith Township	Burgett-Forke	Sediment Buildup
O47	Elco Borough	Hollow Road	Undersized Pipe/Catch Basin
O48	Independence Township	Run Road & S.R. 531	Debris in Stream Channel
O49	Cecil Township	Hahn Road	Undersized 24" CMP

Table 5.1. Reported Problem Areas and Obstructions

HYDRAULIC MODELING

Potential solutions were initially offered by the municipality or the project engineer for every identified problem based on a field view of the area. The locations of these problem areas were a factor in determining that Chartiers Creek encounters systemic flooding and that release rates should be investigated. The analysis of the Chartiers Creek watershed is presented in *Section 6.*

PROBLEM AREA ASSESSMENT

The reported stormwater problems within the study area were assessed and broken into several categories associated with the attributed principal causes:

ID	Municipality
P1	Robinson Township
P12	Peters Township
P13	Burgettstown Borough
P16	Burgettstown Borough
P18	Burgettstown Borough
P24	Cross Creek Township
P25	Cross Creek Township
P26	Cross Creek Township
P33	Washington City
P39	South Strabane Township
P55	Canonsburg Borough
P56	Canonsburg Borough
P57	Houston Borough
P62	Cecil Township
P64	Marianna Borough
P65	Somerset Township
O7	Robinson Township
O41	Canonsburg Borough

Table 5.4. Bank Erosion

ID	Municipality
P2	Robinson Township
P3	Robinson Township
P27	Cross Creek Township
P30	West Brownsville Borough
P33	Washington City
P34	Washington City
P35	Washington City
P45	Roscoe Borough
P46	Roscoe Borough
P51	Bentleyville Borough
P56	Canonsburg Borough
P61	South Franklin Township
O2	Robinson Township
O3	Robinson Township
O5	Robinson Township
O7	Robinson Township
O17	Cross Creek Township
O18	Cross Creek Township
O19	Amwell Township
O20	Amwell Township
O21	Donegal Township
O22	Donegal Township
O23	West Brownsville Borough
O26	Washington City
O27	Buffalo Township
O28	Buffalo Township
O35	Somerset Township
O36	Somerset Township
O38	North Bethlehem Township
O39	North Bethlehem Township
O41	Canonsburg Borough
O42	Morris Township
O45	Smith Township
O46	Smith Township
O48	Independence Township
O49	Cecil Township

Table 5.5. Sediment Buildup/Debris

ID	Problem
P4	Robinson Township
P5	Robinson Township
P6	Robinson Township
P9	East Finley Township
P10	East Finley Township
P11	East Finley Township
P19	Burgettstown Borough
P21	Burgettstown Borough
P23	Burgettstown Borough
P28	Cross Creek Township
P29	West Brownsville Borough
P31	California Borough
P32	Speers Borough
P36	South Strabane Township
P37	South Strabane Township
P38	South Strabane Township
P40	South Strabane Township
P41	Claysville Borough
P42	Claysville Borough
P44	Mount Pleasant Township
P47	Roscoe Borough
P48	Roscoe Borough
P49	Roscoe Borough
P50	Roscoe Borough
P52	Bentleyville Borough
P53	Somerset Township
P54	Canonsburg Borough
P55	Canonsburg Borough
P58	South Franklin Township
P59	South Franklin Township
P60	South Franklin Township
P63	Cecil Township
O4	Robinson Township
O6	Robinson Township
O7	Robinson Township
O8	Robinson Township
O9	West Pike Run Township
O10	Chartiers Township
O24	Washington City
O25	Washington City
O30	Mount Pleasant Township
O31	Mount Pleasant Township
O34	Deemston Borough
O37	North Bethlehem Township
O47	Elco Borough

Table 5.6. Flooding – Inadequate/No Drainage System

ID	Municipality
P8	West Pike Run Township
O7	Robinson Township
O11	Chartiers Township
O13	Peters Township
O16	Cross Creek Township
O29	Mount Pleasant Township
O33	Deemston Borough
O40	North Bethlehem Township
O44	Beallsville Borough
O49	Cecil Township

Table 5.7. Flooding – Inadequately Sized Bridge/Culvert

ID	Municipality
P4	Robinson Township
P14	Burgettstown Borough
P33	Washington City
P39	South Strabane Township
P43	Hanover Township
P55	Canonsburg Borough
P56	Canonsburg Borough
O1	Robinson Township
O6	Robinson Township
O12	Peters Township
O14	Burgettstown Borough
O32	Mount Pleasant Township
O41	Canonsburg Borough
O43	Houston Borough

Table 5.8. Flooding – Stream/Floodplain Obstruction

ID	Municipality
P7	West Pike Run Township
P15	Burgettstown Borough
P17	Burgettstown Borough
O15	Burgettstown Borough

Table 5.9. Bridge Scour

ID	Municipality
P4	Robinson Township
P20	Burgettstown Borough
P22	Burgettstown Borough
O6	Robinson Township

Table 5.10. Mine Drainage

RECOMMENDATIONS

The following recommendations were developed to help address the different problem area categories:

BANK EROSION

Streambank erosion is the removal of soil material from the land area adjacent to a stream, causing steep slopes and the transport of sediment downstream. This condition can be improved at its source through streambank remediation, which is the excavation of the steep streambank to a gentle slope and armoring the streambank with riprap and woody plantings.

There are many causes of streambank erosion, including stream migration and increased frequency of flooding. In part, it is a natural process, but it is accelerated by upstream development in the stream's watershed, so should be addressed on a watershed scale. The riparian buffers required by the *Model Ordinance* help avoid bank erosion by allowing native vegetation to grow on the streambanks. Also, the trees and woody plants in the buffer slow the flowrate of floodwaters, which reduces the amount of soil lost to erosion.

A Conceptual Solution sheet for a typical bank erosion problem area (P24) can be found in *Appendix C*.

SEDIMENT BUILDUP/DEBRIS

Sediment and debris can build up in a stream for a variety of reasons, including a heavy upstream sediment load or an undersized stream crossing or obstruction. When sediment-laden water is forced to slow abruptly at a stream obstruction, the sediment and debris has a chance to settle to the streambed. Over the course of a few storms, this aggradation further slows the flow of water and exacerbates the problem.

A typical solution to this problem is to simply clean the debris out of the channel upstream of bridge crossings. This work can be done by the bridge owner with minimal regulatory permits in PA. If the problem recurs frequently, the bridge crossing may be undersized and need to be replaced.

The overall health of the watershed plays a role in sediment and debris buildup. In healthy watersheds, the stream is stable and the sediment load is low. A goal of this Plan is to encourage development that mimics the natural stormwater cycle. A Conceptual Solution sheet for a typical sedimentation/debris problem area (O21) can be found in *Appendix C*.

FLOODING – INADEQUATE/NO DRAINAGE SYSTEM

Local flooding due to surface runoff during storms can largely be addressed by the construction of typical on-site drainage structures (swales, pipes, catch basins, etc.). Flooding along streams and rivers requires the construction of more expensive, regional facilities to protect property in the floodplain. Regional solutions include levees, stormwater impoundment facilities, or public acquisition of flood-prone properties.

Two (2) goals of this Plan are to protect riparian buffers and reduce the amount of runoff during future storms. These will reduce flooding along streams by lowering flood peaks to some degree and discouraging development in the floodplain.

A Conceptual Solution sheet for a typical problem area (P55) can be found in *Appendix C*.

FLOODING – INADEQUATELY SIZED BRIDGE/CULVERT

Flooding due to inadequately-sized structures, such as bridges and culverts, occurs frequently due to a number of reasons. This includes natural siltation and sedimentation of streams and drainageways, lack of maintenance of existing structures, and additional upstream development with inadequate stormwater management or controls.

Methods used to address flooding of this type include: regularly inspection of structures for capacity and general structural condition; ensuring that stormwater created by new development does not exceed downstream pipe or structure capacity; and regular maintenance of streams, ponds, and creeks through removal of debris and obstructions.

A Conceptual Solution sheet for a typical problem of this type (area O29) can be found in *Appendix C*.

FLOODING – STREAM/FLOODPLAIN OBSTRUCTION

Flooding due to stream and floodplain obstructions may occur naturally or in conjunction with (or as a result of) other types of problems. Some of the same reasons apply as explained in the above section (flooding due to inadequately sized structures).

Methods used to address flooding of this type may include: adopting more stringent floodplain ordinances; enforcing current ordinances regarding construction within the floodplain; regular maintenance of streams, ponds, and creeks through removal of debris and obstructions; and addressing increased incidence of flooding by construction of flood control structures.

A Conceptual Solution sheet for a typical floodplain obstruction problem area (P33) can be found in *Appendix C*.

BRIDGE SCOUR

Bridge scour may occur naturally or in conjunction with (or as a result of) other types of problems as well. Some of the reasons for bridge scour consist of increased flow in a defined stream channel, which may undermine an existing bridge foundation, inadequate maintenance of the bridge structure, and natural stream migration (meandering).

Methods used to address bridge scour include: more frequent maintenance of the bridge structure; removal of debris and obstructions from the stream; and construction of a new bridge structure with a foundation constructed below the depth of expected scour.

A Conceptual Solution sheet for a typical bridge scour problem area (P07) can be found in *Appendix C*.

MINE DRAINAGE

Abandoned Mine drainage (AMD) is prevalent in western Pennsylvania. The effects of AMD include loss of biodiversity due to chemical pollutants and degradation of existing structures due to acidity of the drainage. See *Section 9 - Impairments* for further effects of AMD.

Resolution to AMD problems are varied. Solutions may be a simple as closing off an AMD stream to providing specific facilities for dealing with the acidity and mineral pollutants.

A Conceptual Solution sheet for a typical mine drainage problem area (P14/O14) can be found in *Appendix C*.

Section V – Significant Problem Areas and Obstructions

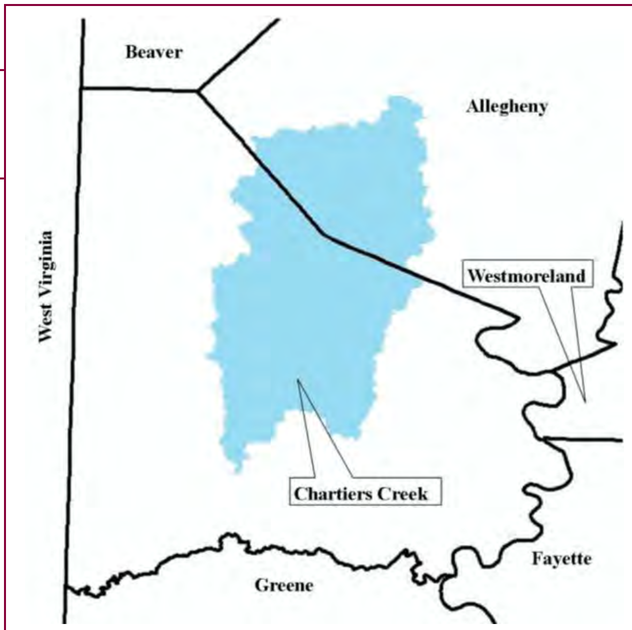
It is noted that the problem areas mentioned in this section are more pronounced in the more populated/developed areas. This is most likely due to encroachments into floodplain areas and undersized culverts or bridges. Also, a large number of these stormwater related problems have been traced back to uncontrolled runoff from local and upstream areas, inadequate culverts or bridges, and obstructions in the system that are blocking the natural flow of stormwater.

This Plan has identified some drainage problems that occur on a yearly basis. While a certain amount of flooding is natural in streams during heavy rain, periodic maintenance can prevent some of the identified problems with flooding and erosion. A stormwater facility maintenance program should be developed and implemented as part of the strategy to correct existing problems and alleviate future problem areas. The repair and upgrade of the existing drainage facilities will need capital expenditures.

Continued improper development within the county will amplify these problems. Remedial actions will be necessary to correct existing drainage problems. In the long term, a comprehensive approach is needed to tackle these problems. This approach will have to incorporate regulations and development standards into local zoning, consider both on-site and off-site drainage, provide a consistent approach between communities, use natural elements for the transport and storage of stormwater, consider both quantity and quality of water, and treat the watershed as a whole.

Stormwater master planning is one (1) way to address all of the needs and potential threats to a watershed. Implementation of these practices can be difficult and may not be economically feasible for many communities. The County is taking the lead to develop economical solutions that address stormwater runoff issues that lead the industry and provide the regulatory community with solutions that meet EPA and DEP standards. Looking ahead, it is expected that the status of the current stormwater infrastructure will keep deteriorating with time. In addition to imposing stronger regulations to control new development, increased expenditures for maintenance and other improvements is necessary, or the systems will continue to deteriorate faster than the ability to fix and maintain them.

Section VI – Technical Analysis - Modeling



TECHNICAL APPROACH

To provide technical guidance in the Act 167 planning process, hydrologic models were prepared for specific watersheds identified by the municipalities, the county and DEP. The results from these models increase the overall understanding of watershed response to rainfall and help guide policy. Through the development and analysis of a hydrologic model, effective and fair regulations can be applied on a county-wide basis, while addressing specific issues identified by the individual communities in Washington County. The hydrologic methodology used in the technical approach is based on unit hydrograph theory and the runoff Curve Number (CN) method described in various NRCS publications (NRCS, 2008a). This method was chosen since it is the most common method used by designers in PA and has widely available data (NRCS, 2008b). Additionally, this method is the basis for which many of the guidelines were developed in the PA BMP Manual. The calculations for this methodology were performed with HEC-HMS, the US Army Corps of Engineers' Hydrologic Modeling System.

The modeling approach in this study was to:

1. Establish a reasonable estimate of rainfall-runoff response under existing conditions,

2. Establish a reasonable estimate or rainfall-runoff response under an assumed future condition land development,

3. Provide an examination of the impact with the implementation of guidelines from the PA BMP Manual (i.e., Design Storm Method and Simplified Method), and finally

4. Develop stormwater management districts where it is determined necessary to do so.

Information from PAC meetings has been incorporated to direct the focus of this modeling effort and to ensure the most current DEP regulations are successfully incorporated throughout the entire county.

HYDROLOGIC MODEL PREPARATION

One (1) watershed within the county was selected for hydrologic modeling: Chartiers Creek. This watershed was delineated into subwatersheds based on problem areas, significant obstructions, and natural subwatershed divides. The delineation of these subwatershed areas created points of interest at junctions where the subwatersheds were hydraulically connected in the HEC-HMS model.

CHARTIERS CREEK MODEL

The Chartiers Creek watershed has a total drainage area of 276.6 square miles. A large portion (about 91 mi^2) of this watershed including the confluence of Chartiers Creek with the Ohio River lies within Allegheny County. The watershed was divided into 222 subwatersheds for the HEC-

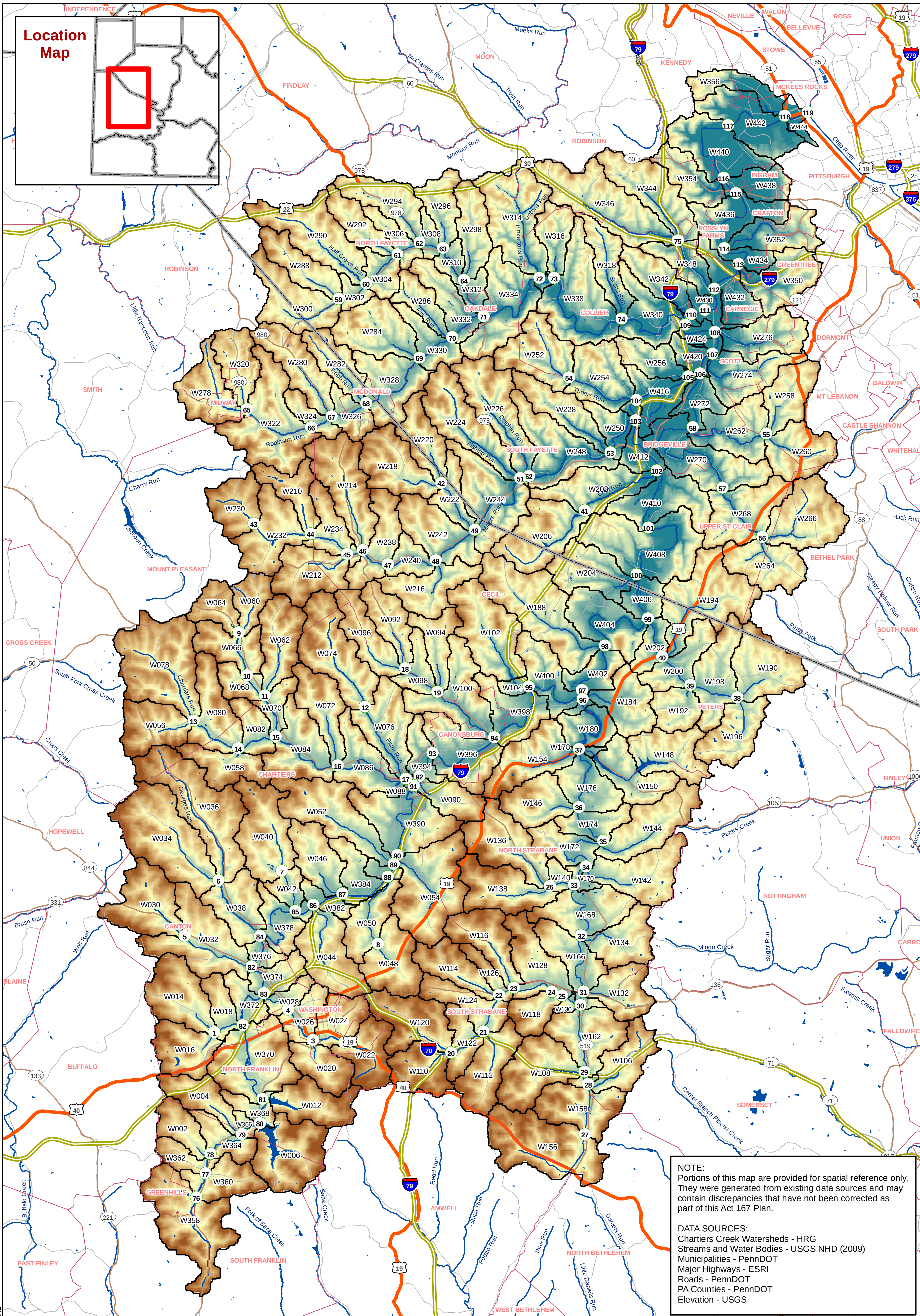
HMS model. Figure 6.1 shows the Chartiers Creek subwatersheds and cumulative discharge points.

This watershed contains six (6) dams that were considered to have a significant impact on the hydrology of the watershed. Dams with small storage volumes (less than 100 acre-feet) and dams that are completely filled during minor runoff events (0.3 inches of runoff) were considered generally "run-of-the-river dams" that would only affect the immediate area near the dam. Their impacts to the overall watershed hydrology within Washington County would be negligible and were not included in this study.

The six (6) dams listed in Table 6.1 are included in the HEC-HMS Model for Chartiers Creek. The tributary drainage area to of these dams ranges from 1.4 mi^2 to 45.1 mi^2. Outflow data for the dam was provided by DEP in the form of HEC-1 output files or design documentation filed by DEP. The same assumptions used in DEP dam safety analyses were used in this study. This information was used to model the flows from the dam within the HEC-HMS model. The following table summarizes the impoundments within the watershed. It is noted that the Owner listed may have been succeeded by another entity.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
Boone Reservoir	Speers Run	North Strabane Twp.	County Citizens Water Co.	384
Canonsburg Lake	Little Chartiers Creek	North Strabane Twp.	Pa. Fish Commission	822
Morganza Dam	Morganza Run	Cecil Twp.	Pa. Training School	61
Washington No. 2	Johnstown Run	North Strabane Twp.	County Citizens Water Co.	1,040
Washington No. 3	Br. Chartiers Creek	North Franklin Twp.	County Citizens Water Co.	325
Washington No. 4	Br. Chartiers Creek	North Franklin Twp.	County Citizens Water Co.	2,839

Table 6.1. Impoundments within the Chartiers Creek Watershed



NOTE:
Portions of this map are provided for spatial reference only. They were generated from existing data sources and may contain discrepancies that have not been corrected as part of this Act 167 Plan.

DATA SOURCES:
Chartiers Creek Watersheds - HRG
Streams and Water Bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI
Roads - PennDOT
PA Counties - PennDOT
Elevation - USGS

2 0 2 Miles

Discharge Points
Streams
Water bodies
Limited Access
Highway
Major Road
Local Road
Municipalities
Counties

Elevation

Value

High : 1480 Feet

Low : 700 Feet

04/07/2010 R002071.0425

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[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure 6.1
Chartiers Creek HEC-HMS Model
Washington County, Pennsylvania

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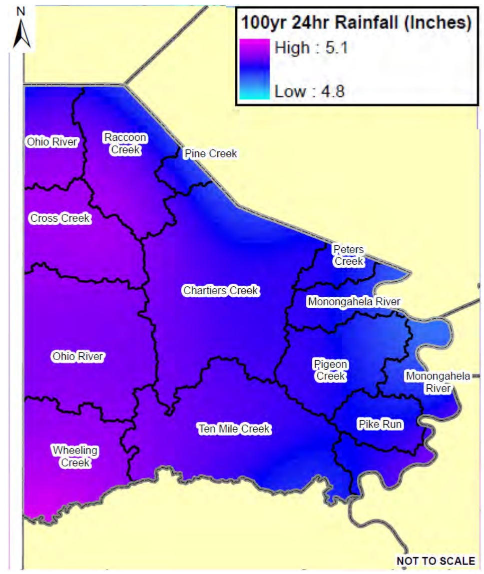
HYDROLOGIC MODEL PARAMETERS

The various parameters entered into the hydrologic models include subwatershed area, soil-type, land cover, lag time, reach lengths and slopes, reach cross-sectional dimensions, and design rainfall depths. These parameters are discussed in further detail in the technical appendix. A brief description of these components follows.

RAINFALL DATA

Rainfall data used in this modeling effort incorporates rainfall runoff data from the NOAA Atlas 14. NOAA Atlas 14 provides the most up-to-date precipitation frequency estimates, with associated confidence limits, for the US and is accompanied by additional information, such as temporal distributions and seasonality. Rainfall depths were obtained from a single point at the approximate geographic center of the county. The following table provides the rainfall estimates used for various design storm frequencies for Washington County (NOAA, 2008):



NOAA Atlas 14 100-year, 24-hour Rainfall

Design Storm (years)	24-hr Rainfall Depth (in)
2	2.38
10	3.34
25	3.95
50	4.45
100	4.98

Table 6.2. Rainfall Values for Washington County

It was assumed in all of the following analyses that these single rainfall quantities could be applied uniformly over the entire watershed area. Additionally, the rainfall quantities were applied to the NRCS Type II storm distribution. Although this combination of Atlas 14 data with the NRCS Type II storm distribution results in a relatively conservative rainfall pattern, this approach is consistent with the guidelines in *PA BMP Manual* (DEP,2006).

SUBWATERSHED AREA

Generally, the subwatershed area for the modeled watersheds was 1-3 mi^2. The drainage areas may be slightly larger or smaller depending on hydrologic characteristics and location of problem areas. Subwatersheds with an area less than one (1) square mile were included in the model if they formed a junction between two (2) larger basins or were tributary to a defined problem area.

Basins with drainage area outside of Washington County were beyond the scope of study, so they were not studied at the same level of detail as portions of the watershed within the county. Approximately 91 mi^2 of Chartiers Creek is in Allegheny County. The land use for the subbasins within Allegheny County was assumed to be constant for existing and future conditions.

SOILS

Soil properties, specifically infiltration rate and subsurface permeability, are an important factor in runoff estimates. Runoff potential of different soils can vary considerably. Soils are classified into four (4) Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate (NRCS

1986). HSG A refers to soils with relatively high permeability and favorable drainage characteristics; HSG D soils have relatively low permeability and poor drainage characteristics. The runoff potential increases dramatically in order of group A (lowest), B, C, and D (highest). Soil cover data was used in conjunction with land use cover data within GIS to develop composite curve numbers for each subwatershed in the models.

Table 3.5 shows the relative percentage of hydrologic soil groups in Washington County. Generally, the runoff potential of soils in the northwestern portion of the county is very high; the location of these soil types corresponds to the location of many of the counties' identified problem areas.

LAND USE

Existing land use was derived from the Land Use provided by the Washington County Planning Department. This data was converted to land uses that correspond to NRCS curve number tables (NRCS, 1986). The land use categories that were used are listed in *Table 6.3*.

Future land uses for the year 2020 were also provided by the Washington County Planning Department and were later digitized for the purposes of this study. The future land use data reflects an estimate of future land use considering current trends and policies. The future land use categories listed shows a mixed urban land use change of almost 7% replacing other land use categories as shown by the corresponding decreases.

Land Use	Existing Land Use		Proposed Land Use		Change Future - Existing
	Acres	%	Acres	%	%
Brush[1]	3.7	0.0%	3.7	0.0%	0.0
Commercial and Business	5516.1	3.1%	5204.1	2.9%	-0.2
Contoured Row Crops[1]	13449.6	7.6%	12573.1	7.1%	-0.5
Industrial	2641.1	1.5%	2311.9	1.3%	-0.2
Institutional (assumed 50% impervious)	522.3	0.3%	519.9	0.3%	0.0
Meadow[1]	4944.0	2.8%	4141.3	2.3%	-0.5
Mixed Urban (assumed 65% impervious)	44.8	0.0%	12247.0	6.9%	6.9
Newly graded areas	1961.2	1.1%	1607.0	0.9%	-0.2
Open space[1]	16750.3	9.5%	16623.3	9.4%	-0.1
Pasture[1]	23192.2	13.1%	21205.5	12.0%	-1.1
Residential - 1 acre	13371.8	7.6%	13055.4	7.4%	-0.2
Residential - 1/2 acre	28623.3	16.2%	26680.8	15.1%	-1.1
Residential - 1/8 acre or less	386.7	0.2%	333.5	0.2%	0.0
Water	780.0	0.4%	696.3695	0.4%	0.0
Woods[1]	64738.3	36.6%	59722.06	33.8%	0.2
Total	**176925.1**	**100.0%**	**176925.1**	**100.0%**	**n/a**

Notes: [1] In Good Condition

Table 6.3. Existing and Future Land Use for the Chartiers Creek Watershed

LAG TIME

Lag time is the transform routine when using the NRCS Curve Number Runoff Method. Lag can be related to T_c using the empirical relation:

$$T_{Lag} = 0.6 * T_C$$

Lag time values for the subwatersheds were based on NRCS Lag Equation and altered as described in *Appendix A*:

$$T_{Lag} = L^{0.8} \frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where: T_{lag} = Lag time (hours)

L = Hydraulic length of watershed (feet)

Y = Average overland slope of watershed (percent)

S = Maximum retention in watershed as defined by: S = [(1000/CN) – 10]

CN = Curve Number (as defined by the NRCS Rainfall-Runoff Method)

For comparison purposes, a lag time was also calculated for each subwatershed using the TR-55 segmental method. Generally the best estimate for rural areas (less than 20% imperviousness) is provided by the NRCS lag equation. For urban areas (greater than 20% imperviousness), the TR-55 segmental method is the preferred method (PHRC, 2007).

INFILTRATION AND HYDROLOGIC LOSS ESTIMATES

Infiltration and all other hydrologic loss estimates (e.g., evapotranspiration, percolation, depression storage, etc.) were modeled using the standard initial abstraction in the NRCS CN Method (i.e., Ia = 0.2S) for the existing conditions and future conditions models. For the future conditions with stormwater controls model, these losses were taken into account using a modified initial abstraction value. This modified value was developed to be consistent with, and account for, the volume removal criteria under the Design Storm Method and the Simplified Method (CG-1 and CG-2). A detailed explanation of this modeling effort is described in *Appendix A*.

REACH LENGTHS, SLOPES, AND CROSS SECTION DIMENSIONS

Reach lengths and slopes were determined within GIS. Channel baseflow widths and depths for each river reach were estimated based on drainage area and percent carbonate using the methodology outlined in *Development of Regional Curves Relating Bankfull-Channel Geometry and Discharge to Drainage Area for Streams in Pennsylvania and Selected Areas of Maryland* (USGS, 2005). Dimensions for the overbank area were visually determined from FEMA floodplains or visual inspection of topographic data. *Figure 6.3* shows the dimensions as they are approximated.

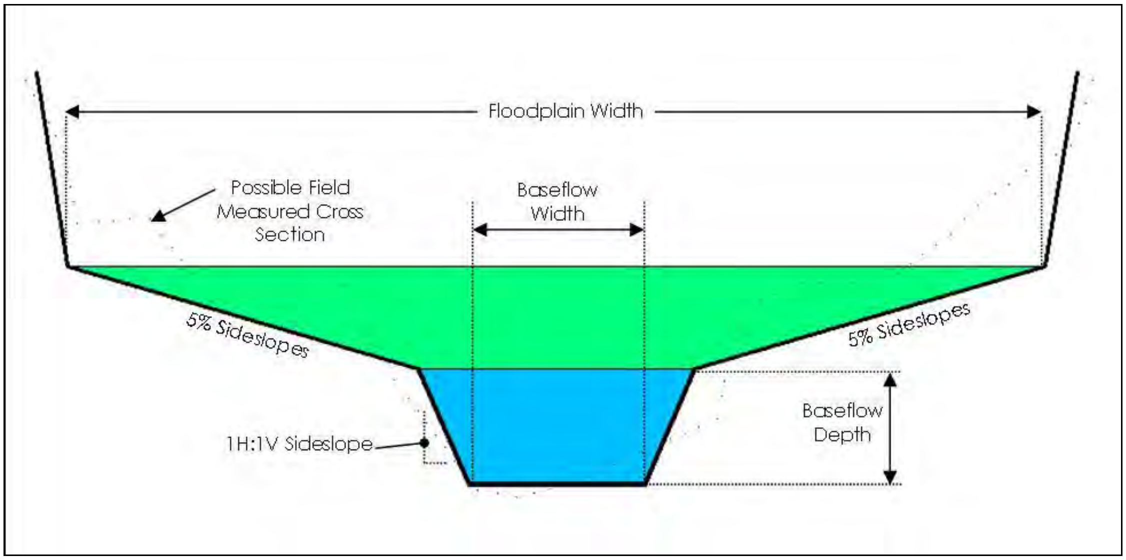


Figure 6.2. Cross Sections Used for Reaches in HEC-HMS Model

The reaches were modeled using the Muskingum-Cunge routing procedure. This procedure is based on the continuity equation and the diffusion form of the momentum equation. Manning's Roughness Coefficient *n* values were assumed to be 0.055 in channel; overbank channel values were assumed to be 0.08. When necessary for calibration, Manning's *n* values and the overbank sideslopes were altered so that realistic discharge values could be obtained. The data used for each specific reach is available within the HEC-HMS Model.

MODEL CALIBRATION

The HEC-HMS models incorporate a number of user-defined variables to generate runoff hydrographs. The accuracy of the model remains unknown, unless it is calibrated to another source of runoff information. Possible sources of information include stream gage data, high water marks (where detailed survey is available to facilitate hydraulic analysis), and other hydrologic models. The most desirable source of calibration information is stream gage data as this provides an actual measure of the runoff response of the watershed during real rain events.

USGS Gage 03085500 Chartiers Creek at Carnegie, PA
Source: USGS, 2010

There are six (6) USGS stream gages located within the Chartiers Creek Watershed. The following table lists these gages and their respective statistics. Five of these gages are in Washington County and one gage is in Allegheny County.

USGS Stream Gage No.	Site Name	Drainage Area mi²	Number of Gage Years at Gage	Used in HEC-HMS Model
03072818	Daniels Run near West Zollarsville, PA	8.47	2	Not Used
03085217	Chartiers Creek at Lagonda, PA	3.97	2	Not Used
03085219	Unn Trib 2 to Chartiers Creek at Lagonda, PA	0.37	2	Not Used
03111150	Brush Run near Buffalo, PA	10.30	21	Not used
03111585	Enlow Fork near West Finley, PA	38.10	6	Not Used
03085500	Chartiers Creek at Carnegie, PA	257	86	Used

Table 6.4. USGS Stream Gages in Washington County

The only gage within the watersheds being analyzed for this study is USGS Gage 03085500 located in Allegheny County. All gages have Bulletin 17b estimates that are higher than predictions from the USGS Regression Equations. This reflects the County's relatively intense response to rainfall. Flow estimates were derived at this gage using the *Bulletin 17B* methodology outlined in USGS (1982). This method produces estimates for storms of all of the frequencies desired in this study (between the 1- and 100-year storm events) for any gage that has more than ten (10) years of data.

When no stream gage data is available, the next most desirable source of data for purposes of comparison is other hydrologic studies prepared by local, state, or federal agencies. FEMA Flood Insurance Studies (FIS) often provide discharge estimates at specific locations within FEMA floodplains. The estimates provided in FEMA FISs are valid sources for comparison, but should be carefully considered when used for calibration since they are sometimes dependent on outdated methodology or focus exclusively on the 100-year storm event for flood insurance purposes.

The third available source of information that may be used for calibration is regression equation estimates. The regression equations were developed on the basis of peak flow data collected at numerous stream gages throughout PA. This procedure is the most up-to-date method and takes into account watershed average elevation, carbonate (limestone) area, and minor surface water storage features such as small ponds and wetlands. The methodology for developing regression equation estimates within Pennsylvania is outlined in USGS Scientific Investigations Report 2008-5102 (USGS, 2008). Mean Elevation, Percent Carbonate Rock, and Percent Storage, the applicable parameters within Washington County, were calculated using GIS from layers supplied from USGS Digital Elevation Model (DEM) data, Environmental Resources Research Institute (1996), and USGS (2008).

The target flow rates were determined from one (1) of these three(3) sources. The HEC-HMS models were then calibrated to the target flow rates at the overall watershed level, at subwatersheds where significant hydrologic features were identified (e.g., confluences, dams, USGS Gages), and at each individual subbasin. This approach was used so that a flow value anywhere in the model would compare favorably to the best available data source. The parameters of calibration for the entire overall watershed were the antecedent runoff condition, lag time, and reach routing coefficients. Detailed calibration results are provided in *Appendix A*.

The following figures (*Figures 6.3-6.8*) show the overall watershed calibration results at junctions throughout Chartiers Creek. As can be shown, the calibration results are in general agreement with the range of values for other hydrologic studies. The HEC-HMS model was within four percent (4%) of the USGS gage values; at other calibrations points, the HEC-HMS model was within the standard error for the USGS Regression values (31-36%). Detailed calibration results and model input are provided in *Appendix A*.

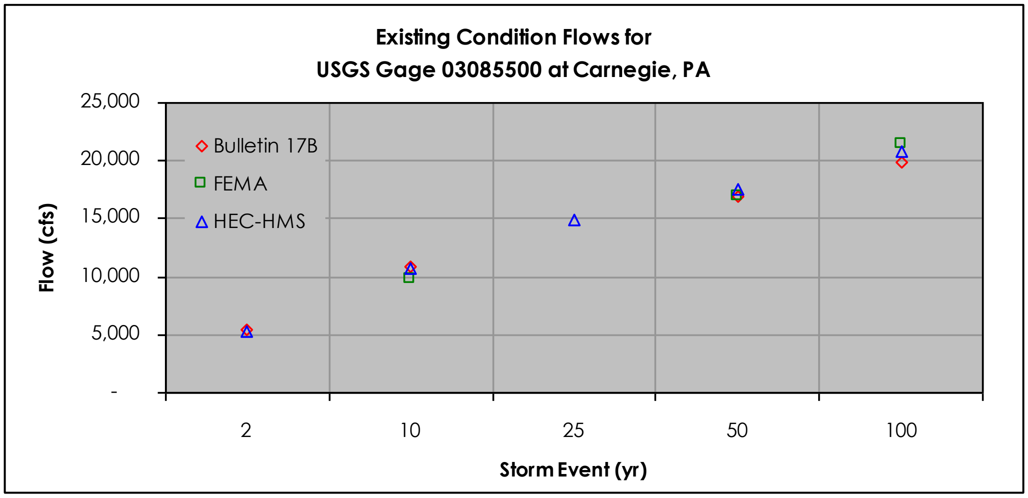


Figure 6.3

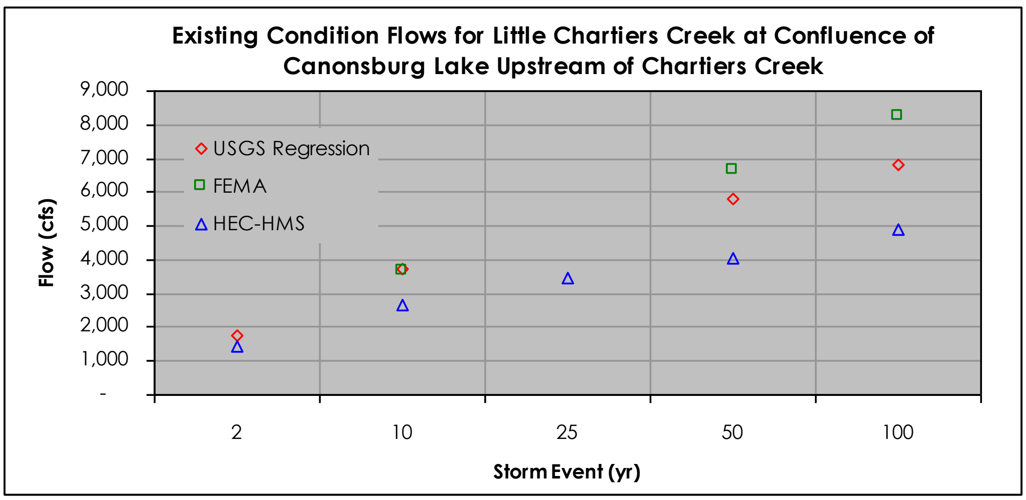


Figure 6.4

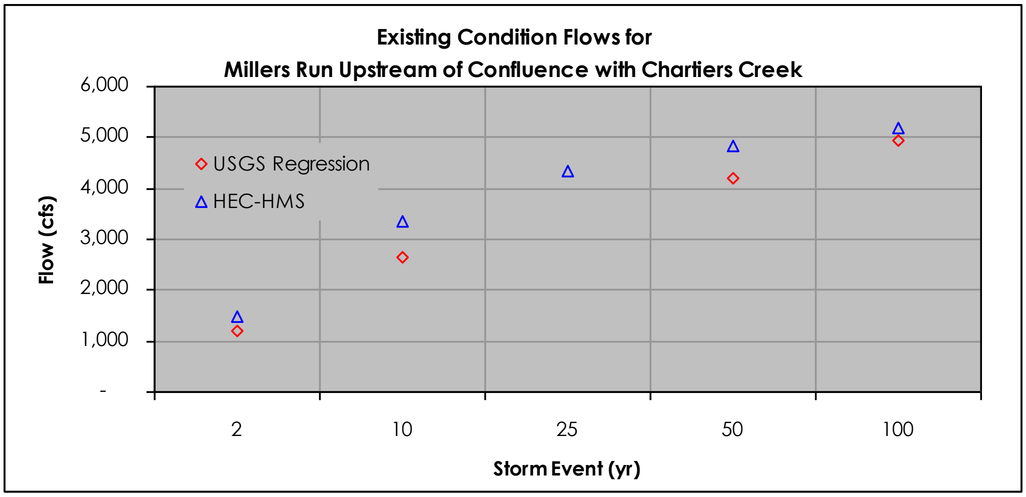


Figure 6.5

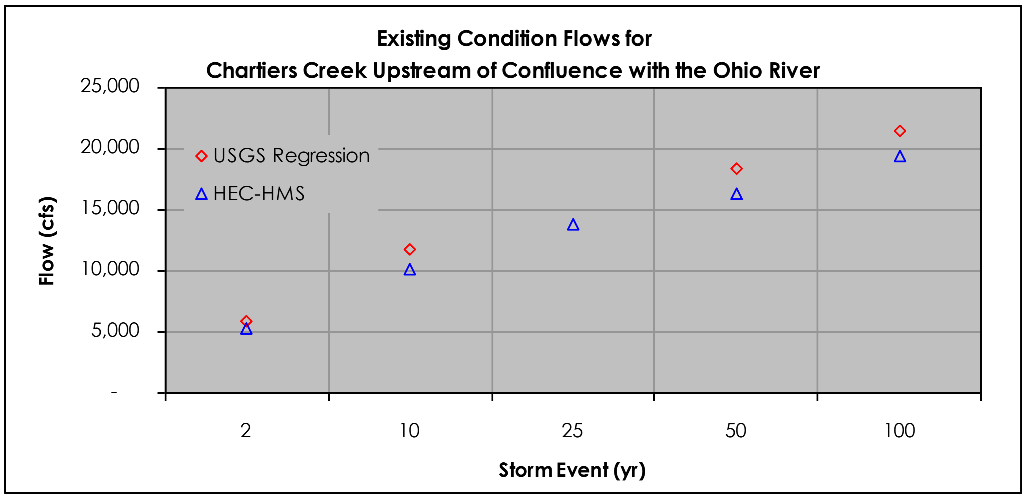


Figure 6.6

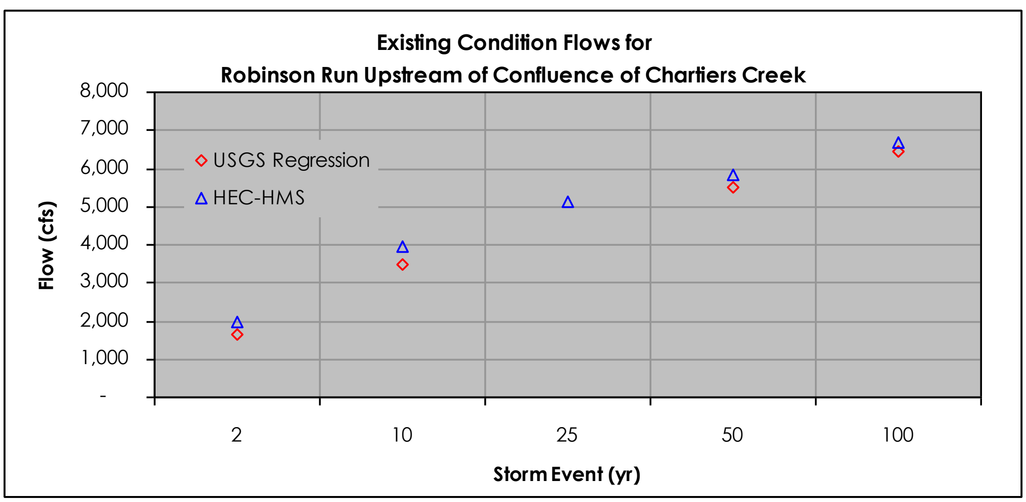


Figure 6.7

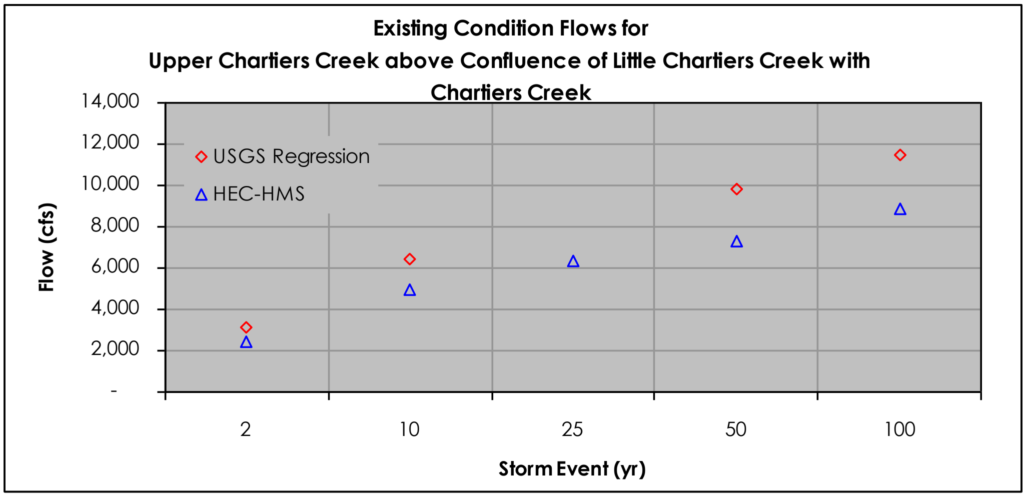


Figure 6.8

MODELING RESULTS

Once the existing conditions model was calibrated and the existing conditions peak flows were established, additional models were developed to assist in determining appropriate stormwater management controls for the watersheds. Based on a comparison of existing and future land use, most subbasins will experience varying degrees of development through the full build-out future condition.

The following simulations were performed with HEC-HMS (2, 10, 25, 50 and 100-year, 24-hour storm events) for Chartiers Creek:

Existing Conditions (Ex)
An existing conditions model was developed and analyzed using the using the calibration procedures described above. Results from the existing conditions model reflect the estimated land uses from 2010. The existing condition flows are provided in *Appendix A* for both watersheds.

Future Conditions with No Stormwater Controls (F-1)
A future conditions model was developed and analyzed using the projected future land use coverage for the year 2020 provided by Washington County. The revised land use resulted in an increased CN and a decreased T_c for several subbasins. It was assumed that there was no required detention or any other stormwater controls in this simulation.

Future Conditions with Design Storm Method and Release Rates as Stormwater Controls (CG-1R)
A future conditions model with Stormwater Controls was developed by modifying the future conditions model to include the effects of peak rate controls and the volume removal requirements of the Design Storm Method.

The effects of peak rate controls, through detention of post-development flows, was estimated by routing the post-development flow for each subbasin through a simulated reservoir. The reservoirs were designed so that they could release no more than the pre-development flow estimate. This approach was assumed to simulate the additive effect of all of the individual detention facilities within a sub-basin. The volume removal requirements of the Design Storm Method were simulated using modified initial abstraction values as described above and in *Appendix A*.

The approach in this Act 167 Plan was to 1) estimate the effects of detention of post-development flows and 2) apply release rates to subwatershed wherever there is a significant increases in peak flow at the points of interest. The results for each watershed are presented below; detailed results of the modeling are provided in *Appendix A*.

CHARTIERS CREEK

The increases in the Chartiers Creek watershed are depicted in *Figure 6.9*.

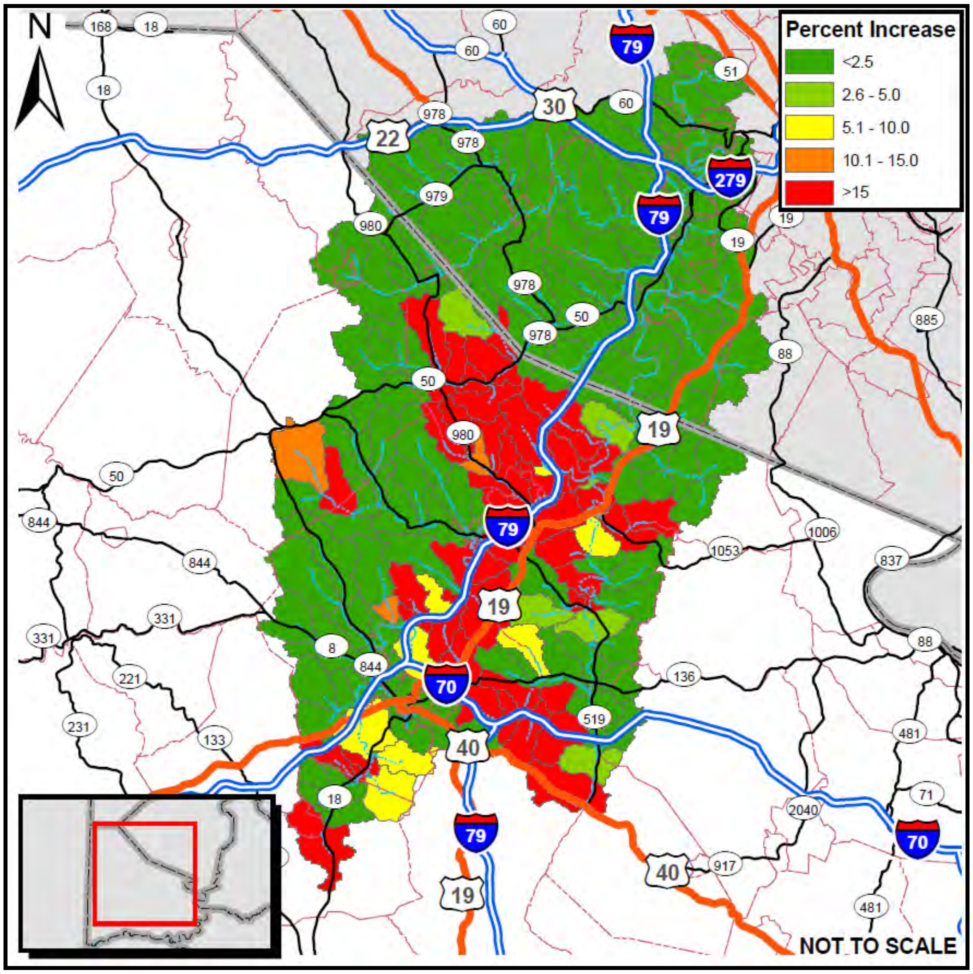


Figure 6.9 Increase in Flow for 2-Year Storm Event with No SWM Controls for Modeled Watershed within Washington County

Table 6.5 shows the effects of future condition discharges with no peak rate or volume controls.

Storm Event (year)	Effects of Future Condition on Discharges		
	Maximum % Increase in Future Conditions	Average % Increase in Future Conditions[1]	Portion of subbasins with Increase (%)
2	464.5	21.3	27.9
10	263.0	15.1	27.5
25	217.2	13.7	27.5
50	198.4	13.5	27.5
100	180.7	12.7	27.5

Notes: [1] Area weighted averages

Table 6.5. Future Condition Flows with No Stormwater Management Controls for Chartiers Creek

Table 6.6 shows the reduction in peak flows that would occur if only the Design Storm Method were implemented without any peak rate controls. The flows for the lower magnitude events are substantially reduced compared to future conditions with no stormwater management controls with the implementation of the Design Storm Method. The flows for the higher magnitude events are moderately reduced with implementation of the Design Storm Method, but significant increases still occur.

Storm Event (year)	Effects of CG1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	2.5	0.2	18.0
10	45.1	3.6	27.5
25	65.7	5.1	26.1
50	80.1	6.0	26.6
100	88.1	6.6	25.7

Notes: [1]Area weighted averages

Table 6.6 Future Subbasin Flows with Design Storm Method Only – No peak control for Chartiers Creek

If there was a significant increase at a point of interest, the allowable release rate was reduced until the increase in peak flow at the points of interest was reduced to acceptable values. Table 6.7 reflects the future condition flows with peak rate control and uniform Design Storm Method implementation.

Storm Event (year)	Release Rates with the Design Storm Method
	Release Rates (%)[1]
2	100
10	50-70-100
25	50-70-100
50	50-70-100
100	50-70-100

Notes: [1] For the 10, 25, 50, and 100 year storms.

Table 6.7. Release Rates for Chartiers Creek

STORMWATER MANAGEMENT DISTRICTS

When substantial increases are found in the HEC-HMS model due to additive effects of future development, it may be necessary to restrict post-development discharges to a fraction of pre-development flow. The fraction has historically ranged between 50 and 100 percent of the pre-development flow in previous Act 167 efforts. A 75% release rate district would indicate that any future development within the district be required to restrict post-development flows to 75% of pre-development flows.

Release rate theory and the designation of stormwater management districts is not substantially supported in stormwater literature. The calculation of release rates is heavily dependent on timing and growth projections, both of which involve a high degree of uncertainty. Additionally, it has been observed that localized stormwater measures do not typically capture and detain entire tributary areas (Emerson, 2003). Given these limitations with release rates, the following criteria were examined before applying release rates to the modeled watersheds:

1. Numerous problem areas exist in a pattern that indicate systemic stormwater problems;

2. Historic, repeated flooding has been observed;

3. Future planning projections indicate growth patterns that have historically contributed to documented problems; and

4. Release rates are to be designated on higher order watersheds only; larger downstream areas with well-established bed-and-bank streams are not as affected by relatively small-scale development and therefore do not benefit from release rates.

When the above criteria indicate a need for additional stormwater management controls, release rates are considered. The results from hydrologic models are used as guidance to establish appropriate release rates. Ultimately, reasonable hydrologic judgment is used in the final designation of release rates.

CHARTIERS CREEK

Evaluation of the Chartiers Creek watershed indicates a need for stormwater management districts. The watershed has had numerous problem areas in patterns indicative of systemic problems. Additionally future growth is projected throughout the watershed. Stormwater management districts have been developed for portions of the watershed with release rates ranging between 50 and 100%.

The location of the stormwater management districts is shown on *Plate 10 - Stormwater Management Districts*, which also identifies the location for potential regional stormwater facilities.

RECOMMENDATIONS

The modeling results discussed in this and previous sections provide technical guidance on provisions that should be included in the model ordinance. The following recommendations follow from the technical analysis and data collection efforts in preparing this Plan.

CN and T_c methodologies should be restricted to reflect the observed runoff response in the hydrologic models. The runoff response to NOAA Atlas 14 rainfall in Washington County was lower than standard NRCS methods predict for the 10-year, 24-hour storm event and above. This has the potential to allow designers to undersize their stormwater facilities and to increase peak discharges for the higher magnitude events. It is recommended for CN calculations to assume 'good conditions' when using any CN table, which is consistent with proposed control guidance. It is recommended for T_c computations to use the maximum value provided by 1) the TR-55 segmental method and 2) the NRCS Lag Equation.

Implement a volume control guideline in addition to a traditional peak rate methodology. The modeling results show a definite reduction in peak discharge in all storm events with the implementation of the control guideline criteria. The control guideline criteria will provide a direct benefit with volume reduction and also an indirect benefit of channel protection.

Implement and enforce a flexible yet clearly documented release rate policy for specified watershed. The stormwater management districts are provided on Plate 10. These should be used to determine the allowable post-development peak flow rate. The use of strategically placed regional facilities and watershed-scale conservation, drainage way, and critical recharge area easements should also be considered as an alternative to release rate implementation.

Provide a clear alternative volume control and peak rate control strategy for areas with poorly-drained soils or areas with geologic restrictions. Washington County has a substantial number of potential limitations to infiltration facilities: shallow bedrock, hydric soils, floodplains, and documented problem areas. Section 7 provides a recommended procedure for sites with these limitations.

Section VII – Technical Standards and Criteria for Control of Stormwater Runoff

TECHNICAL STANDARDS FOR STORMWATER MANAGEMENT

The field of stormwater management has evolved rapidly in recent years as additional research has increased our comprehension of how stormwater runoff is interrelated with the rest of our natural environment. Even now, this relationship is not completely understood. Stormwater management practices will continue to evolve as additional knowledge becomes available. Effective resource management involves balancing the positive and negative effects of all potential actions. These actions are considered and the individual management techniques that provide the best known balance are chosen for implementation. The goal of this Plan is to manage stormwater as a valuable resource and to manage all aspects of this resource as effectively as possible. This Plan contains technical standards that seek to achieve this goal through four (4) different methods. These standards are summarized as follows:

1. Peak Discharge Rate Standards – Peak discharge rate standards are implemented primarily to protect areas directly downstream of a given discharge by attenuating peak discharges from large storm events. These standards are also intended to attenuate peak flows throughout the watershed during large storm events. Peak discharge rate controls are applied at individual development sites. Controlling peak discharge rates from the sites entails collection, detention, and discharge of the runoff at a prescribed rate. This is an important standard for achieving stable watersheds.

2. Volume Control Standards – The standards in this Plan that address increased stormwater volume are intended to benefit the overall hydrology of the watershed. The increased volume of runoff generated by development is the primary cause of stormwater related problems. Increased on-site runoff volume commonly results in a sustained discharge at the designed peak discharge rate as well as an increased volume and duration of flows experienced after the peak discharge rate. Permanently removing a portion of the increased volume from a developed site is key in mitigating these problems and maintaining groundwater recharge levels. Meeting this standard generally involves providing and utilizing infiltration capacity at the development site, although alternative methods may be used.

3. Channel Protection Standards – Channel protection standards are designed to reduce the erosion potential from stormwater discharges to the channels immediately downstream. Even though peak discharge rate controls are implemented for larger design storms, they do not provide controls for the smaller storms. These storms account for the vast majority of the annual precipitation volume. Past research has shown that channel formation in developed watersheds is largely controlled by these small storm events. The increased volume and rate of stormwater runoff during small storms forces stream channels to change in order to accommodate the increased flows. Channel protection standards will be achieved through implementation of permanent removal of increased volume from discharges during low flow storm events.

4. Water Quality Standards – The water quality standards contained in this Plan are meant to provide a level of pollutant removal from runoff prior to discharge to receiving streams. Stormwater runoff can deliver a wide range of contaminants to the receiving stream,

which leads to a variety of negative impacts. Water quality standards can be achieved through reducing the source of pollutants and utilizing natural and engineered systems that are capable of removing the pollutants.

Beyond the standards discussed above, other measures may be taken to ensure that stormwater is properly managed. Some of these measures are discussed later in *Section X, Additional Recommendations*. These measures are included as recommendations because they are beyond the regulatory scope of this Plan. Municipalities should consider these recommendations seriously.

Stormwater management is an issue that is entwined with land use decisions and has social and economic implications. To maximize the effectiveness of a stormwater management program, a holistic approach is needed. Stormwater management should be a consideration in any ordinance decisions that affect how land is used.

CRITERIA FOR CONTROL OF STORMWATER RUNOFF

The principal purpose of this Plan was to develop criteria for control of stormwater runoff that are specific to the watersheds in Washington County. Mathematical modeling techniques, as discussed in the previous chapter, were used to simulate the existing conditions throughout the county and to determine the effects anticipated future development will have on stormwater runoff within these watersheds. The models were used to determine the outcome of a variety of different stormwater control scenarios. These results were then used to determine a group of control criteria that provides the best results on a watershed-wide basis. The outcome of each analysis is stormwater control criteria that are appropriate and applicable to that watershed.

The process of developing unique controls for individual watersheds is complicated by the reality that regulations must be implemented and enforced across varying jurisdictions. The more site-specific and complicated a regulatory structure is, the more difficult it becomes to implement the regulations. For this reason it is most advantageous to develop a system of controls that are similar in structure but can also be adjusted as necessary to meet the specific needs of each watershed. The need for balance between these two (2) important concepts has lead to the system of stormwater control criteria contained within this Plan.

A broad and uniform approach has been developed for implementation of water quality, volume control, and channel protection controls. These criteria have been developed with adequate latitude in implementation to be applicable to most watersheds statewide. Peak discharge rate control standards, which are unique to each watershed, have been developed to achieve watershed-specific controls.

PEAK DISCHARGE RATE CONTROLS

Peak discharge rate controls have been the primary method of implementing stormwater management controls for many years. Peak rate controls are generally applied to individual sites with little to no consideration given to how the site discharge impacts overall stream flows. It is necessary to consider the cumulative effects of site level peak rate controls and their contribution to the overall watershed hydrology in order to control regional peak flows. This is accomplished through mathematical modeling of the watershed. The intent of the modeling is to analyze the flow patterns of the watershed, the impact of development on those patterns, and, if necessary, develop a release rate for various subwatersheds such that the rate of release of the increased volumes of runoff generated is not detrimental to downstream areas.

In some subbasins, it is necessary to implement strict release rates that require sites to discharge at flows much lower than those calculated for pre-development flows. This is due to the timing of the peak flows from all of the subbasins and how flows from the subbasin in question impact the overall stream flows. Variable release rates for subbasins throughout a watershed are an important part of achieving regional peak flow controls. The proposed release rates calculate no peak flow increase above the existing condition peak flows at any point throughout the county watersheds. Strict release rates for the more frequent design storms are necessary to meet this criterion in some subwatersheds. The proposed release rates for this Plan fall into two (2) categories:

1. Areas not covered by a Release Rate Map:

   Post-development discharge rates shall not exceed the predevelopment discharge rates for the 2-, 10-, 25-, 50-, and 100-year, 24-hour storm events. If it is shown that the peak rates of discharge indicated by the post-development analysis are less than or equal to the peak rates of discharge indicated by the pre-development analysis for 2-, 10-, 25-, 50-, and 100-year, 24-hour storm events, the requirements of this section have been met. Otherwise, the applicant shall provide additional controls as necessary to satisfy the peak rate of discharge requirement.

2. Areas covered by a Release Rate Map:

   For the 2-, 10-, 25-, 50-, and 100-year, 24-hour storm events, the post-development peak discharge rates will follow the applicable approved release rate maps. For any areas not shown on the release rate maps, the post-development discharge rates shall not exceed the predevelopment discharge rates.

VOLUME CONTROLS

Developed sites experience an increased volume of runoff during all precipitation events. The increased volume of stormwater is the cause of several related problems such as increased channel erosion, increased main channel flows, and reduced water available for groundwater recharge. Reducing the total volume of runoff is key in minimizing the impacts of development. Volume reduction can be achieved through reuse, infiltration, transpiration, and evaporation. When infiltration is used as a stormwater management technique, multiple goals are achieved through implementation of a single practice. Infiltrating runoff reduces release rates, reduces release volumes, increases groundwater recharge, and provides a level of water quality improvement. These opportunities will be provided by use of BMPs, such as infiltration structures, replacement of pipes with swales, and disconnecting roof drains. Other methods that may be used are decreased impervious cover, maximizing open space, and preservation of soils with high infiltration rates.

The proposed volume controls for this Plan include two (2) pieces:

1. Reduction of runoff generated through utilization of Low Impact Development (LID) practices to the maximum extent practicable.

2. Permanent removal of a portion of the runoff volume generated from the total runoff flow.

The permanent removal of runoff volume is to be achieved through one (1) of three (3) available methods:

1. *The Design Storm Method* (CG-1 in the PA BMP Manual) is applicable to any size of Regulated Activity. This method requires detailed modeling based on site conditions.

A. Do not increase the post-development total runoff volume for all storms equal to or less than the 2-year 24-hour storm event.

B. For modeling purposes:

i) Existing (pre-development) non-forested pervious areas must be considered meadow or its equivalent.

ii) Twenty (20) percent of existing impervious area, when present, shall be considered meadow in the model for existing conditions.

2. *The Simplified Method* (CG-2 in the SWM Manual[1]) provided below is independent of site conditions and should be used if the Design Storm Method is not followed. This method is not applicable to Regulated Activities greater than one (1) acre or for projects that require design of stormwater storage facilities. For new impervious surfaces:

A. Stormwater facilities shall capture at least the first two inches (2") of runoff from all new impervious surfaces.

B. At least the first one inch (1.0") of runoff from new impervious surfaces shall be permanently removed from the runoff flow -- i.e. it shall not be released into the surface waters of this Commonwealth. Removal options include reuse, evaporation, transpiration, and infiltration.

C. Wherever possible, infiltration facilities should be designed to accommodate infiltration of the entire permanently removed runoff; however, in all cases at least the first one-half inch (0.5") of the permanently removed runoff should be infiltrated.

D. This method is exempt from the requirements of Section 304, Rate Controls.

3. Alternatively, in cases where it is not possible, or desirable, to use infiltration-based BMPs to partially fulfill the volume control requirements, the following procedure shall be used:

A. The following water quality pollutant load reductions will be required for all disturbed areas within the proposed development:

Pollutant Load	Units	Required Reduction (%)
Total Suspended Solids (TSS)	Pounds	85
Total Phosphorous (TP)	Pounds	85
Total Nitrate (NO_3)	Pounds	50

B. The performance criteria for water quality BMPs shall be determined from the *PA BMP Manual*, most current version.

WATER QUALITY CONTROLS

Urban runoff is one (1) of the primary contributors to water pollution in developed areas. The most effective method for controlling nonpoint source pollution is through reduction, or elimination, of the sources. It is not reasonable to assume that all sources of pollution can be reduced or eliminated. For this reason, implementation of natural and engineered systems must be used to achieve the desired results. The water quality control standards will be achieved through the use of various BMPs to reduce the sources of water pollution and treat those that cannot be eliminated.

A combination of source reduction measures through non-structural BMPs and water quality treatment through use of structural BMPs is the proposed water quality control strategy of this Plan. Reducing the amount of runoff to be treated is the preferred strategy to meet this goal:

- Minimize disturbance to floodplains, wetlands, natural slopes over 8%, and existing native vegetation.
- Preserve and maintain trees and woodlands. Maintain or extend riparian buffers and protect existing forested buffer. Provide trees and woodlands adjacent to impervious areas whenever feasible.
- Establish and maintain non-erosive flow conditions in natural flow pathways.
- Minimize soil disturbance and soil compaction. Over disturbed areas, replace topsoil to a minimum depth equal to the original depth or four (4) inches, whichever is greater. Use tracked equipment for grading when feasible.
- Disconnect impervious surfaces by directing runoff to pervious areas, wherever possible.

Treating the runoff that cannot be eliminated is the secondary strategy for attaining the water quality standards. By directing runoff through one (1) or more BMPs, runoff will receive some treatment for water quality, thereby reducing the adverse impact of contaminants on the receiving body of water.

CONTROLS FOR ROADWAY PROJECTS

For purposes of Act 167 Plans, design policy pertaining to stormwater management facilities for Pennsylvania Department of Transportation (PennDOT) and Pennsylvania Turnpike Commission (PTC) roadways and associated facilities are provided in Sections 13.7 (Antidegradation and Post Construction Stormwater Management Policy) of PennDOT Publication No. 13M, Design Manual Part 2 (August 2009), as developed, updated, and amended in consultation with PADEP. As stated in DM-2.13.7.D (Act 167 and Municipal Ordinances), PennDOT and PTC roadways and associated facilities shall be consistent with Act 167 Plans. DM-2.13.7.B (Policy on Antidegradation and Post Construction Stormwater Management) was developed as a cooperative effort between PennDOT and PADEP. DM-2.13.7.C (Project Categories) discusses the anticipated impact on the quality, volume, and rate of stormwater runoff.

Where standards in Act 167 Plans are impracticable, PennDOT or PTC may request assistance from DEP, in consultation with the County, to develop an alternative strategy for meeting state water quality requirements and the goals and objectives of the Act 167 Plans.

Municipal roadway projects are regulated by municipal stormwater ordinances but Municipalities are exempt from the requirement to file an Operations and Maintenance (O&M) agreement with themselves.

For purposes of this Act 167 Plan, road maintenance activities are regulated under 25 Pa Code Chapter 102.

RECOMMENDED BMPS

As previously stated, the preferred strategy for achieving the goals of this Plan is to reduce, or eliminate, the sources of nonpoint source pollution. "The treatment of runoff is not as effective as the removal of runoff needing treatment" (Reese, 2009). This is an important concept, in that the most effective way to reduce the number of stormwater runoff problems is to reduce the amount of runoff generated. There are a wide variety of non-structural practices that are used to reduce the amount of runoff generated and to minimize the potential negative impacts of runoff that is generated. All of these BMPs are intended to minimize the interruption of the natural hydrologic cycle caused by development. The relative effectiveness of each non-structural BMP listed in the *PA BMP Manual* in *Table 7.1* below. These BMPs should be used where applicable to decrease the need for less cost effective structural BMPs.

Non-Structural BMP	**Stormwater Functions[1]**			
	Peak Rate Control	**Volume Reduction**	**Recharge**	**Water Quality**
Protect Sensitive / Special Value Features	Very High	Very High	Very High	Very High
Protect / Conserve / Enhance Riparian Areas	Low/Med.	Medium	Medium	Very High
Protect / Utilize Natural Flow Pathways in Overall Stormwater Planning and Design	Med./High	Low/Med.	Low	Medium
Cluster Uses at Each Site; Build on the Smallest Area Possible	Very High	Very High	Very High	Very High
Concentrate Uses Area-Wide through Smart Growth Practices	Very High	Very High	Very High	Very High
Minimize Total Disturbed Area - Grading	High	High	High	High
Minimize Soil Compaction in Disturbed Areas	High	Very High	Very High	Very High
Re-Vegetate and Re-Forest Disturbed Areas using Native Species	Low/Med.	Low/Med.	Low/Med.	Very High
Reduce Street Imperviousness	Very High	Very High	Very High	Medium
Reduce Parking Imperviousness	Very High	Very High	Very High	High
Rooftop Disconnection	High	High	High	Low
Disconnection from Storm Sewers	High	High	High	Low
Streetsweeping	Low/None	Low/None	Low/None	High

NOTES:
[1] All Stormwater function values from *PA Stormwater BMP Manual*

Table 7.1. Stormwater Functions of Structural BMPs

When non-structural practices are unable to achieve the stormwater standards, it may be necessary to employ structural practices. Generally, structural BMPs are chosen to address specific stormwater functions. Some BMPs are better suited for particular stormwater functions than others. The relative effectiveness of structural BMPs at addressing individual stormwater functions varies, as shown in *Table 7.2*. This table contains all of the structural BMPs listed in the *PA BMP Manual* and their stated effectiveness for each stormwater function. Additional information on each practice can be found in the *PA BMP Manual*.

Structural BMP	Stormwater Functions[1]			
	Peak Rate Control	Volume Reduction	Recharge	Water Quality
Porous Pavement with Infiltration Bed	Medium	Medium	Medium	Medium
Infiltration Basin	Med./High	High	High	High
Subsurface Infiltration Bed	Med./High	High	High	High
Infiltration Trench	Medium	Medium	High	High
Rain Garden / Bioretention	Low/Med.	Medium	Med./High	Med./High
Dry Well / Seepage Pit	Medium	Medium	High	Medium
Constructed Filter	Low-High[2]	Low-High[2]	Low-High[2]	High
Vegetated Swale	Med./High	Low/Med.	Low/Med.	Med./High
Vegetated Filter Strip	Low	Low/Med.	Low/Med.	High
Infiltration Berm and Retentive Grading	Medium	Low/Med.	Low	Med./High
Vegetated Roof	Low	Med./High	None	Medium
Rooftop Runoff - Capture and Reuse	Low	Med./High	Low	Medium
Constructed Wetland	High	Low	Low	High
Wet Pond / Retention Basin	High	Low	Low	Medium
Dry Extended Detention Basin	High	Low	None	Low
Water Quality Filter	None	None	None	Medium
Riparian Buffer Restoration	Low/Med.	Medium	Medium	Med./High
Landscape Restoration	Low/Med.	Low/Med.	Low/Med.	Very High
Soils Amendment and Restoration	Medium	Low/Med.	Low/Med.	Medium

NOTES:
[1] All Stormwater function values from *PA Stormwater BMP Manual*
[2] Depends on if infiltration is used

Table 7.2. Stormwater Functions of Structural BMPs

The table above shows the qualitative effect of individual BMPs when used as standalone treatment practices. The overall effectiveness of a stormwater system can be improved when several, smaller BMPs are dispersed throughout a given site. The combination of different BMPs enables each BMP to complement each other by providing a particular stormwater function than allowing the runoff to pass downstream to another BMP that is used to address different criteria. This allows designers to better mimic the site's existing hydrologic features, which are not typically isolated to one (1) area of the site. The "treatment train" system of utilizing multiple BMPs on a single site is an effective technique that, in some cases, may be used to meet all of the stormwater criteria.

Several of the structural BMPs are particularly effective at achieving the criteria for control of stormwater presented in this Plan. The following practices should be considered where appropriate:

RAIN GARDENS & BIORETENTION

A rain garden, also referred to as bioretention, is an excavated shallow surface depression planted with native, water-resistant, drought and salt tolerant plants with high pollutant removal potential that is used to capture and treat stormwater runoff. Rain gardens treat stormwater by collecting and pooling water on the surface and allowing filtering and settling of suspended solids and sediment prior to infiltrating the water. Rain gardens are generally constructed to provide twelve (12) inches or less of ponding depth with shallow side slopes (3:1 max). They are designed to reduce runoff volume, filter pollutants and sediments through the plant material and soil particles, promote groundwater recharge through infiltration, reduce stormwater thermal impacts, and enhance evapotranspiration. Their versatility has proved extremely successful in most applications including urban and suburban areas (Pennsylvania Stormwater Best Management Practices Manual, 2006).

Construction of rain gardens varies depending on site-specific conditions. Rain gardens contain the same general components: appropriate native vegetation, a layer of high organic content mulch, a layer of planting soil, and an overflow structure. Often times, an infiltration bed is added under the planting soil to provide additional storage and infiltration volume. Also, perforated pipe can be installed under the rain garden to collect water that has filtered through the soil matrix and convey it to other stormwater facilities. Rain gardens can be integrated into a site with a high degree of flexibility and can be used in coordination with a variety of other structural BMPs. They can also enhance the aesthetic value of a site through the selection of appropriate native vegetation.

DRY WELL / ROOF SUMP

A dry well, sometime referred to as a roof sump, is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from the roofs of structures. Roof runoff is generally considered "clean" runoff, meaning that it contains few or no pollutants. Roofs are one (1) of the primary sources of increased runoff volume from developed areas. This runoff is ideal for infiltration and replenishment of groundwater sources due to the relatively low concentration of pollutants. By decreasing the volume of stormwater runoff, dry wells can also reduce runoff rate thereby improving water quality.

Roof drains are connected directly into the dry well, which can be an excavated pit filled with uniformly graded aggregate wrapped in geotextile or a prefabricated storage chamber. Runoff is collected during rain events and slowly infiltrated into the surrounding soils. An overflow mechanism, such as an overflow outlet pipe, or connection to an additional infiltration area, is provided as a safety measure in the event that the facility is overwhelmed by extreme storm events or other surcharges (Pennsylvania Stormwater Best Management Practices Manual, 2006). Dry wells are not recommended within a specified distance to structures or subsurface sewage disposal systems.

VEGETATED SWALES

Vegetated swales are broad, shallow channels, densely planted with a diverse selection of native, close-growing, water-resistant, drought and salt tolerant plants with high pollutant removal potential. Plant selection can include grasses, shrubs, or even trees. These swales are designed to slow runoff, promote infiltration, and filter pollutants and sediments while conveying runoff to additional stormwater management facilities. Swales can be trapezoidal or parabolic, but should have broad bottoms, shallow side slopes (3:1 to 5:1 ratio), and relatively flat longitudinal slopes (1-6%). Check-dams can be utilized on steeper slopes to reduce flow velocities. Check-dams can also provide limited detention storage and increase infiltration volume. Vegetated swales provide many benefits over conventional curb and gutter conveyance systems. They reduce flow velocities, provide some flow attenuation, provide increased opportunity for infiltration, and providing some level of pretreatment by removing sediment, nutrients and other pollutants from runoff. A key feature of vegetated swales is that they can be integrated into the landscape character of the surrounding area. They can often enhance the aesthetic value of a site through the selection of appropriate native vegetation.

A vegetated swale typically consists of a band of dense vegetation underlain by at least 24 inches of permeable soil. Swales constructed with an underlying 12- to 24-inch aggregate layer provide significant volume reduction and reduce the stormwater conveyance rate. The permeable soil media should have a minimum infiltration rate of 0.5 inches per hour (in/hr) and contain a high level of organic material to enhance pollutant removal. A nonwoven geotextile should completely wrap the aggregate trench (DEP, 2006). There are several variations of the vegetated swale that include installing perforated pipe under the swale to collect water that has filtered through the soil matrix and convey it to other stormwater facilities or combining the swale with an infiltration bed to provide additional infiltration volume.

INFILTRATION FACILITIES

Infiltration beds are created by placing storage facilities that collect stormwater, provide temporary storage, and allows water to slowly infiltrate. Infiltration facilities are designed to provide significant volume reduction through temporary storage and infiltration, which also benefits peak rate control and water quality.

An infiltration bed usually consists of a layer of highly pervious planting soil and vegetation at the base of a storage facility. The facility is formed by excavating an area or placing an embankment to create a shallow pond. An overflow structure should be included to provide protection in case of extreme storm events or system failure. The bottom of the infiltration bed must be level and consideration for distribution systems to larger facilities to ensure that water is infiltrated evenly over the entire surface area. The soil layer and vegetation provide water quality through filtration and increase evapotranspiration. A popular variation of this facility is an infiltration trench, which is the same concept applied as a linear facility. Infiltration trenches are often more shallow than infiltration beds and are designed for smaller flows than infiltration beds.

EXTENDED DETENTION BASINS

Extended detention basins are created by constructed an earthen impoundment for temporary storage of runoff hydraulically attenuating peak rates. Detention basins are widely used to control the peak rates and have some water quality mitigation through settlement of suspended solids.

The basin outlet structure must be designed to detain runoff from the stormwater quality design storm for extended periods. A sediment foerbay consisting of a separate cell should be incorporated into the design to provide upstream pretreatment. The use of micro-pool storage is recommended for the water quality design storm. Flow paths from inflow points to outlets should be maximized.

IMPLEMENTATION OF STORMWATER MANAGEMENT CONTROLS

From a regulatory perspective, the standards and criteria developed in this Plan will be implemented through municipal adoption of the Model Stormwater Management Ordinance (Model Ordinance) developed as part of the Plan. The Model Ordinance contains provisions to realize the standards and criteria outlined in this section. Providing uniform stormwater management standards throughout the county is one (1) of the stated goals of this Plan. This goal will be achieved through adoption of the Model Ordinance by all of the municipalities in Washington County.

From the pragmatic development viewpoint, the stormwater management controls will be put into practice through use of comprehensive stormwater management site planning and various stormwater BMPs. Site designs that integrate a combination of source-reducing, non-structural BMPs and runoff control structural BMPs will be able to achieve the proposed standards. A design example has been included in *Section VIII* and *Appendix B* to demonstrate how to incorporate the various aspects of the Model Ordinance into the stormwater management design process.

Section VIII – Economic Impact of Stormwater Management Planning

IMPLEMENTATION OF STORMWATER STANDARDS

The economic impact of managing urban stormwater runoff is a major concern. For example, the U.S. EPA has estimated the costs of controlling combined sewer overflows (CSO) throughout the U.S. at approximately $56 billion (MacMullan and Reich, 2007). Developing and implementing stormwater management programs and urban-runoff controls will cost an additional $11 to $22 billion (Kloss and Calarusse, 2006). There are direct economic impacts associated with implementation of stormwater management regulations, regardless of the type of stormwater control standards that are proposed. The design example provided in this section has been developed to highlight a site design approach that can reduce the costs of employing the proposed stormwater management control measures and, at the same time, maximize the benefits they are intended to provide. The design example is compared to a similar site design that uses traditional peak rate stormwater controls in order to provide an illustration of the direct economic impact of the proposed regulations using initial construction costs.

Site planning that integrates comprehensive stormwater management into the development process from the initial stages often results in efficiencies and cost savings. Examples of efficiencies include: reduction in area necessary for traditional detention basins; less redesign to retrofit water quality and infiltration measures into a plan; and reduced costs for site grading and preparation. Planning for stormwater management early in the development process may decrease the size and cost of structural solutions since nonstructural alternatives are more feasible early in the process. In the vast majority of cases, the U.S. EPA has found that implementing well-chosen LID practices, like the proposed stormwater management methods, saves money for developers, property owners, and communities while protecting and restoring water quality (EPA, 2007).

DESIGN EXAMPLE 1

The following design example illustrates the methods used to design stormwater management facilities and structural BMPs in accordance with the volume and peak rate control strategies developed within this Plan. The design process encouraged by the *PA BMP Manual* is used to determine non-structural BMP credits and perform the calculations necessary to determine if the requirements of the *Model Ordinance* have been met. The 2-year, 24-hour storm event is utilized to illustrate the methods used to meet the volume requirements of the Ordinance. The SCS Runoff Curve Number Method is used for runoff volume calculations as suggested by the *PA BMP Manual.* Refer to this document for additional guidance, rules and limitations applicable to these methods, and the design of structural and non-structural BMPs.

For the following example, LID techniques are utilized to address the volume control and rate control requirements of the *Model Ordinance*. The example addresses these requirements for the entire development, not any single lot, thereby superseding the requirements of the *Small Project Stormwater Management Application*.

PRE-DEVELOPMENT CONDITIONS

The design example is a 10-lot single family residential subdivision on an 8.1 acre parcel with a total drainage area of 9.78 acres. The existing land use is partially wooded (2.29 acres) with a fallow agricultural field covering the remaining acreage. The entire site is tributary to Mill Run, which flows near the back of the property. All on-site soils are classified in hydrologic soil group B.

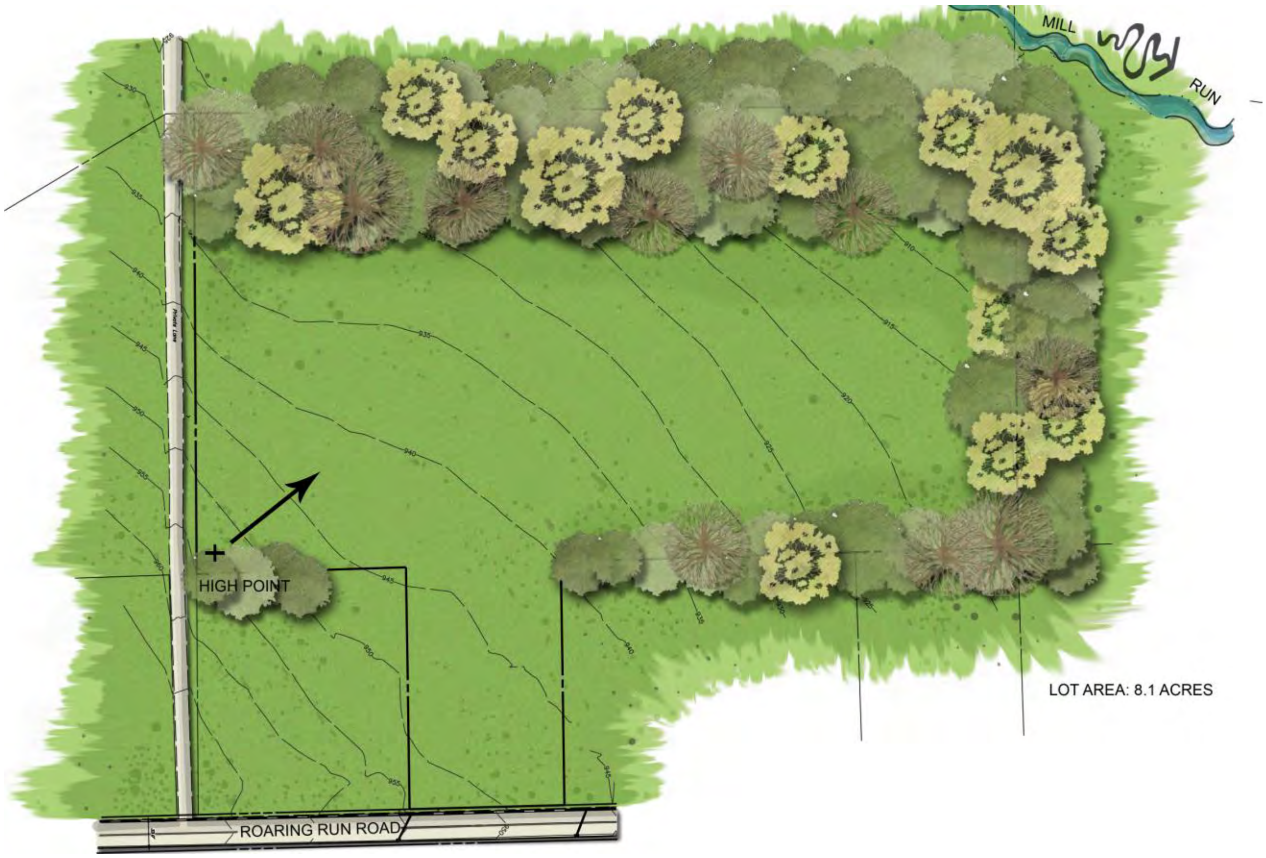


Figure 8.1. Design Example 1 – Pre-Development Conditions

Watershed:	Mill Run
Total Drainage Area:	9.78 acres
Existing Land Use:	Meadow = 7.49 acres
	Woods = 2.29 acres
Hydrologic Soil Group:	'B' – Entire Site
Parcel Size:	8.1 acres
On-Site Sensitive Natural Resources:	Woods (2.18 acres)
Pre-Development Drainage Area:	Meadow = 7.12 acres
	Woods = 0.98 acres
	Total = 8.10 acres

Table 8.1. Pre-Development Data

POST-DEVELOPMENT CONDITIONS

All of the lots will be accessed by a single cul-de-sac road to be constructed for the subdivision. Each house has an assumed 2,150-sf impervious footprint. Various LID techniques were used in the site design. A large portion of the existing woodlands (1.31 acres) was preserved during construction and will remain wooded through a permanent easement on lots 6-9, the back portion of lots 9-10 were protected from compaction during construction and will remain protected through an easement, roof drains are disconnected from the storm sewer system and directed to dry wells, and rain gardens will be installed on each lot. Runoff from the roadway is collected by swales and conveyed to a bioretention area.

Figure 8.2. Design Example 1 – Post-Development Conditions

Proposed Land Use:	Meadow = 1.61 acres
	Woods = 1.32 acre
	Open Space = 5.43 acres
	Impervious = 1.13 acres
	Ponds as Impervious = 0.31 acres
Protected Sensitive Natural Resources:	Woods (1.31 acre)
Other Protected Areas:	Minimum Disturbance (0.37 acre)
Post-Development Drainage Area:	SWM Area = 7.74 acres
	Undetained = 0.36 acres
	Total = 8.10 acres
Proposed Lot Impervious Areas:	2,150 ft^2 / house
	1,000 ft^2 / lot

Table 8.2. Post-Development Data

DESIGN PROCESS FOR VOLUME CONTROLS

The following is a summary of the design process used for implementation of the volume control and rate control requirements of the *Model Ordinance*. This is an outline of the sequence of steps that are used to implement the *Design Storm Method* through a combination of Non-Structural BMP Credits and Structural BMPs that remove volume through infiltration. Detailed calculations and example Worksheets are provided in *Appendix B* for additional clarification of the design process.

Step 1

The first task of the design process is to gather the pertinent site information as it relates to stormwater management. This general information determines which Model Ordinance provisions are applicable to the stormwater management design for the project. *Worksheet 1* is used for this task.

Step 2

The next step is to determine the sensitive natural resources that are present on the site. *Worksheet 2* is used to inventory these resources. These areas should be considered as the site layout is determined, and should be protected to the maximum extent practicable (MEP).

Step 3

As the site layout is being completed, thought should be given to which non-structural BMPs are appropriate for the site in order to reduce the need for stormwater management through structural BMPs. Once the site layout has been finalized and non-structural BMPs have been determined, the designer can begin the stormwater management calculations. The first calculation is to determine the "Stormwater Management Area". This is the land area that must be evaluated for volume of runoff in both pre-development and post-development conditions. Sensitive natural resources that have been protected are not used in the ensuing pre- or post-development volume calculations, just as one would not incorporate offsite areas into volume calculations. The top of *Worksheet 3* shows this information. In the example, the acre of protected woodland is removed from the Stormwater Management Area. This will reduce cost by reducing the total volume needed in the peak-rate management facility.

Step 4

The next step is to calculate the volume "credits" for the non-structural BMPs that have been incorporated into the design. This reduces the total volume that is required to be infiltrated by structural BMPs. There are three (3) practices used in the example: a meadow area and a lawn area have been protected from soil compaction and roof drains have been disconnected from the storm sewer system. The areas protected from compaction facilitate higher infiltration rates and disconnecting the roof leaders for the storm sewer system allows infiltration of some stormwater as it flows across the pervious surface. These calculations are completed on *Worksheet 3*.

The total non-structural credits are limited to 25% of the total required infiltration volume. This does not limit the amount of practices that can be implemented, only the amount of credit that can be used to reduce the total required infiltration volume. The total credits calculated must be checked to ensure the 25% threshold has not been exceeded.

Step 5

Worksheet 4 is completed to calculate the difference in the 2-year, 24-hour storm event runoff volume from pre-development conditions to post-development conditions. The 2-year, 24-hour storm event volume increase, minus the volume credits for non-structural BMPs, represents the volume that must be managed through structural BMPs.

Step 6

Determine the type of structural BMPs that may be appropriate for the site and decide which practices will be used. Use *Worksheet 5.A* to calculate the volume of water that will be infiltrated by each BMP. *Worksheet 5* is used to summarize the volume that will be infiltrated through structural practices. If the total structural volume is greater than (or equal to) the required volume, the volume control requirements of the *Model Ordinance* have been met.

Summary of Results

The design process outlined above was followed to design the facilities necessary to meet the volume control and peak rate control requirements of the *Model Ordinance*. The total required permanently removed volume is 12,599 ft^3. A summary of the results for Design Example 1 is provided in the table below:

Description of Stormwater Best Management Practice	Size (ft^3)	Volume Credit (ft^3)
Minimum Soil Compaction	16,200	337
Disconnect Non-Roof Impervious to Vegetated Areas	10,000	278
Total Non-Structural Volume:		615
On-Lot Rain Gardens (10)	6,740	5,049
On-Lot Dry Wells (10)	4,400	5,787
Bioretention	5,175	3,778
Total Structural Volume:		14,613
Total Volume Removed:		**15,228**

Table 8.3. Summary of BMP Credits

DESIGN OF PEAK RATE CONTROLS

In this example, additional stormwater control facilities are necessary to manage the increase in peak rate flows that would otherwise result from the development activities. Peak rate control facilities are designed to reduce post-development peak flows to, or below, pre-development peak flows. In release rate districts, post-development flows are further reduced to a given percentage of the pre-development peak flows. Design of peak rate controls necessitates flood routing, for which a flood hydrograph is required (PennDOT, 2008). A suitable hydrologic method is needed to generate runoff hydrographs for flood routing.

The Rational Equation (i.e., Q = C x I x A) was originally developed to estimate peak runoff flows. The Modified Rational Method is an adaptation of the Rational Method which is used to estimate runoff hydrographs and volumes. While this method is useful for estimating peak flows from relatively small, highly developed drainage areas, various sources document the shortcomings of this method in developing hydrographs and estimating volume (PennDOT, 2008; DEP 2006). For this reason, use of the Rational Method is strongly discouraged for the volume-sensitive routing calculations necessary tor design detention facilities and outlet controls.

The SCS Unit Hydrograph Method was developed to be used in conjunction with the Curve Number Runoff Method of generating runoff depths to estimate peak runoff rates and runoff hydrographs. While these methods have numerous limitations, the principle application of this method is in estimating runoff volume in flood hydrographs, or in relation to flood peak rates (NRCS, 2008). Therefore, the NRCS Rainfall-Runoff Method (i.e. using the Curve Number Runoff Method and SCS Unit Hydrograph Method together to produce rainfall-runoff response estimates) is the preferred method to calculate runoff peak rates and for rate control facility design calculations.

Various computer software programs are available for modeling rainfall-runoff simulations to perform peak rate control analyses for development projects. Most of the available computer modeling software is based on the NRCS Rainfall-Runoff Method. These models include the U.S. Army Corps of Engineers' Hydrologic Modeling System (HEC-HMS), SCS/NRCS Technical Release No. 20: Computer Program for Project Formulation Hydrology (TR-20) and Technical Release 55 (TR-55), NRCS National Engineering Handbook 650, Engineering Field Handbook, Chapter 2 (EFH2), and U.S. Environmental Protection Agency's Storm Water Management Model (SWMM). These modeling packages are further described in the *Pennsylvania Stormwater BMP Manual* (2006). There are also a variety of other commercially available software packages that complete many of the same functions. Designers should be careful when determining which software should be used to model a particular project to ensure that appropriate methods are being used (i.e., review the modeling method restrictions contained in the *Model Ordinance*).

DESIGN PROCESS FOR PEAK RATE CONTROLS

The peak rate analysis is carried out by completing a comparison of the post-development runoff peak rate to the pre-development runoff peak rate to determine if the rate controls of the *Model Ordinance* have been satisfied. Additional stormwater facilities, such as a detention basin and outlet structure, may be necessary to reduce post-development peak flow rates to the required peak flow rates. The volume of runoff removed by BMPs should be removed from the total runoff volume when completing peak rate calculations. This is necessary in order to size peak rate control facilities appropriately.

<u>Step 1</u>

The first step is to delineate the pre-development drainage area. This area should include all areas that will be tributary to any proposed stormwater facilities, including any off-site area. Any areas on site that have no proposed land-use changes, and are not tributary to the proposed stormwater facilities, can be removed from the drainage areas. Once the drainage area has been delineated, determine the soil-cover complex and the corresponding curve number for each subarea. If the drainage area contains multiple soil-cover complexes, the designer must determine the appropriate runoff estimation method. (A comparison of the two most prevalent methods is covered in *Appendix B*).

<u>Step 2</u>

The next step is to determine a time of concentration for the pre-development drainage area(s). The *Model Ordinance* requires use of the NRCS Lag Equation for all pre-development time of concentration calculations unless another method is pre-approved by the Municipal Engineer. The average watershed land slope of the pre-development drainage area(s) must be calculated for use in the Lag Equation.

<u>Step 3</u>

Use the information from the previous two steps to calculate the pre-development peak runoff rates for each design storm. Use design storm rainfall depths from NOAA Atlas 14 specific to the area of interest, or the values provided in the *Model Ordinance*. Any appropriate method of estimating peak runoff rates and runoff hydrographs can be used, however use of hydrologic modeling software is the most common method.

Step 4

Delineate the post-development drainage area(s) and any sub-areas. Post-development sites generally have several drainage sub-areas with multiple soil-cover complex groups in each subarea. The designer must determine a suitable level of detail to be included in the post-development model based on the site design and site conditions. The runoff estimation method chosen for multiple soil-cover complexes should be appropriate for the level of detail that is modeled.

Step 5

Determine T_c values for the post-development drainage area(s). The NRCS Segmental Method is the preferred method for all post-development T_c calculations. The Segmental Method is used to calculate travel times for individual segments of sheet flow, shallow concentrated flow, and open channel flow which are summed to calculate the T_c. The *Model Ordinance* allows the NRCS Lag Equation to be used for residential, cluster, or other low impact designs less than or equal to 20% impervious area.

Step 6

Use the information from the previous two (2) steps and relevant stormwater facility information (e.g. BMP size and outlet configuration, detention facility stage-discharge data, etc.) to calculate the post-development peak runoff rates for each design storm. This is most often done by using hydrologic modeling software to develop a model of the post-development site, which is used to estimate peak runoff rates and runoff hydrographs.

The hydrologic model is used to finalize the design of the peak rate control facilities such as the detention basin and the outlet control structure. Steps 4-6 must be revisited whenever additional BMPs are added or moved or any change to the site design alters drainage areas.

Summary of Results

For this example, the peak rate control analysis was completed with hydrologic modeling software that is based on TR-20 modeling procedures. Every component of the stormwater design (including each structural BMP) was included in the model. This helped account for peak flow attenuation and permanent volume removal that was provided by the BMPs. The runoff volume removed by the BMPs was removed from the total runoff volume by using an option within the software. A detention basin providing 8,600 ft^3 of storage (plus the required freeboard depth) and associated outlet controls was necessary to reduce the 100-year post-development peak rate flows to the pre-development flow rate. If the effects of the individual BMPs had been ignored in the post-development model, the design would have needed a basin that provided 23,850 ft^3 of storage (plus the required freeboard depth) to achieve the required flow reduction for the 100-year storm. As shown in *Table 8.4* the peak rate control requirements of the *Model Ordinance* have been achieved.

	Design Storm					
	1-year	2-year	10-year	25-year	50-year	100-year
Pre-Development	0.1	0.6	4.1	7.6	11.1	15.3
Post-Development with No SWM	2.5	5.2	14.5	21.9	28.8	36.6
Post-Development	0.1	0.4	4.1	7.4	10.6	15.3

Table 8.4. Summary of Peak Rate Flows

ECONOMIC IMPACT OF STORMWATER MANAGEMENT STANDARDS

Stormwater management standards are necessary to mitigate the adverse affects of increased stormwater runoff from developing areas. Implementation of these standards comes at a cost to regulators and developers alike. These costs are only a fraction of the costs associated with mitigating mismanaged or unmanaged runoff. Since activities within a watershed do not always exhibit a direct and measurable cause and effect relationship, identifying some of the costs associated with stormwater management can be difficult and somewhat subjective. It can be similarly difficult to quantify certain costs and altogether impossible to assign an economic value to outcomes such as environmental benefits.

There are three (3) principle methods available to assess the economics of implementing the proposed stormwater management regulations:

1. Cost Comparison – This is the most basic type of analysis. It is completed by comparing initial construction costs and other direct costs, such as land value. This type of analysis is incomplete in scope in that it captures the benefits of improved stormwater management or variances in life-cycle costs, such as O&M and life expectancy.

2. Life-Cycle Cost Analysis – A life-cycle cost analysis includes all costs throughout the projects period of service. This includes: planning; design; installation; O&M; and life expectancy. A life-cycle analysis gives a more complete financial comparison than a cost comparison, but again excludes the environmental and other benefits of improved stormwater management.

3. Cost-Benefit Analysis – This is the most thorough method of analysis and considers the full range of costs and benefits for each alternative. A cost-benefit analysis considers the same project costs as a life-cycle analysis, but includes the environmental and other benefits of improved stormwater management practices in the assessment. This method of analysis is very difficult because it requires valuation of costs and benefits not easily measured in monetary terms (i.e. environmental goods and services such as clean air, reduced erosion, or improved aquatic habitat). It is difficult to quantify the value of these non-market goods and services.

The amount of information required to perform a life-cycle cost or cost-benefit analysis makes use of these two (2) methods impractical for this discussion. These methods are also complicated by the fact that costs and benefits are often realized by different parties. As an example, a developer/owner pays for initial construction costs, the owner can benefit from potential life-cycle cost savings, and the general public benefits from potential environmental benefits like improved water quality. The flexibility, availability of data, and simplicity of cost comparisons make this the most commonly used method of comparison. A cost comparison will give a relatively accurate representation of the economic impact of the initial cost of implementing the proposed stormwater management controls.

A cost comparison has been completed for two (2) conceptual stormwater management designs to provide an example of the direct costs associated with implementation of the standards contained within this Plan. The stormwater designs are based on the site used in the Design Example. The site layout is similar for both designs to reduce the number of variables. The first plan was designed to meet traditional peak-rate stormwater management standards of reducing the post-development peak flow rates to those present in pre-development conditions for all design storms. The second plan follows the design procedures found in this Plan and meets the volume control requirements of the *Model Ordinance*.

TRADITIONAL SUBDIVISION LAYOUT WITH PEAK RATE CONTROL DESIGN

The layout for this example is typical of conventional subdivision designs. All of the existing woodlands were converted to lawns and no measures were taken to reduce impervious area (e.g. front yard setbacks were not reduced to decrease driveway lengths). The roadway has a 24' cartway with concrete curbs and there is a sidewalk on one (1) side of the street. The traditional cul-de-sac is entirely paved. The stormwater design utilizes a conventional stormwater collection and conveyance system that uses the concrete curb to direct runoff towards inlets. An HDPE pipe network carries runoff to a detention basin which is located at the low point on the property. A swale is placed near the downstream edge of the property to collect runoff that is not tributary to the storm sewer network and convey it to the detention basin. In the detention basin, a concrete outlet structure is designed to reduce peak flow rates before discharging to an outlet pipe. A rock rip-rap apron energy dissipater is installed at the pipe outfall.

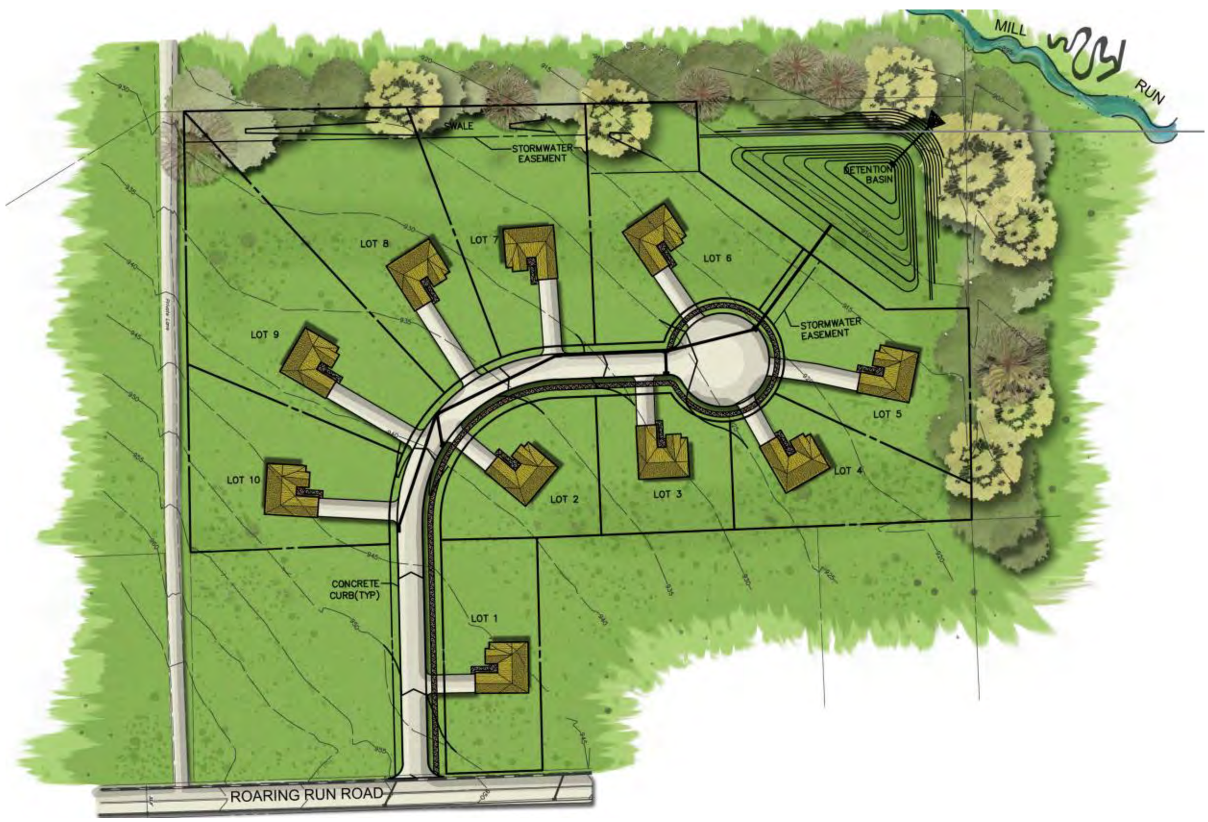


Figure 8.3. Traditional Subdivision Layout (Designed for Peak Rate Control)

LID SUBDIVISION LAYOUT WITH VOLUME CONTROL DESIGN

This design is the post-construction layout that was presented in the Design Example (see *Figure 8.2*). Several LID techniques were used to reduce runoff. This includes: reducing impervious area; preserving existing woodlands where possible; and protecting areas from soil compaction. The roadway is reduced to an 18' cartway with 3' gravel shoulders and swales are employed to collect and convey roadway runoff. Roof runoff is directed to dry wells on each lot, rain gardens are installed on each lot to collect the runoff from on-lot impervious areas as well as part of the lawn runoff. A larger bioretention facility is used to treat runoff from common areas, such as the roadway, and remove additional runoff volume. A detention basin and concrete outlet structure is used to control the peak discharge rates. A level spreader installed at the end of the outfall serves as an energy dissipater and distributes flow.

COST COMPARISON

A cost comparison was completed for the two (2) designs described above. This comparison consists of two (2) components: 1) initial construction costs for the developer, and 2) land value in the form of sale price. Construction costs were calculated for only the design elements which differ between the two (2) examples (i.e. earthwork, paving, and stormwater management facilities). Other construction costs were considered to be similar for both layouts and were omitted from the analysis. An itemized estimate of the initial construction cost is included in *Appendix* B. The results are summarized in *Table 8.5*.

Description	Traditional Layout	LID Layout
Earthwork	$ 23,950	$ 14,925
Storm Drainage	$ 102,769	$ 114,172
Paving & Curbing	$ 138,657	$ 53,790
Initial Construction Cost:	$ 265,376	$ 182,887
Cost / Sellable Acre:	$ 42,734	$ 28,355

Table 8.5. Results of Cost Comparison for Initial Construction Costs

The cost analysis performed for this example shows a cost savings of $14,379 per sellable acre in initial construction cost for the developer. These results must be combined with a land value comparison to provide a more accurate comparison.

The value of land is highly variable depending on various influencing factors. A value of $50,000/acre was assumed for this example as the cost per acre of developed land. This assumed value was used in the cost comparison to provide a more complete cost comparison. For this example, we have also assumed that some of the cost of constructing the stormwater BMPs will result in a dollar for dollar reduction in the market value of the sellable land. *Table 8.6* shows the total land sale value for each layout after subtracting the cost of BMP construction from market value.

Description	Traditional Layout	LID Layout
Total Acres For Sale	6.21	6.45
2009 Market Value / Acre	$ 50,000	$ 50,000
BMP Cost / Acre	$ 0	$ 12,682
Calculated Market Value / Acre	$ 50,000	$ 37,318
Total Land Sale Value:	$ 310,500	$ 240,701

Table B.6. Land Sale Value

A final cost comparison is completed by subtracting the initial construction cost from the land sale value to determine the cost difference between the two (2) layouts. For this example, the developer realizes an increase in total profit of $12,690 by using the LID layout with no additional cost to individual homeowners.

Description	Traditional Layout	LID Layout
Land Sale Value	$ 310,500	$ 240,701
Initial Construction Cost	$ 265,376	$ 182,887
Total Profit for Project:	$ 45,124	$ 57,814

Table B.7. Project Profit

Discussion of Costs

The cost comparison completed for the design example resulted in similar initial construction costs for each design, with a small final cost advantage for the volume control design. The proposed methods for implementing the proposed stormwater standards can cost less to install, have lower operations and maintenance (O&M) costs, and provide more cost-effective stormwater management and water quality services than conventional stormwater management controls (MacMullan and Reich, 2007). The costs and benefits of implementing the proposed stormwater management standards can be site-specific and will vary based on the BMPs used to meet the standards and site characteristics, such as topography, soils, and intensity of the proposed development. In a 2007 report summarizing seventeen (17) case studies of developments that include LID practices, U.S. EPA concludes that "applying LID techniques can reduce project costs and improve environmental performance". The report shows total capital cost savings ranged from fifteen (15) to 80 percent when LID methods were used. There were a few exceptions in which LID project costs were higher than conventional stormwater management costs. All benefits and costs associated with each option must be considered to find the true cost of implementation on a particular site.

Section IX – Water Quality Impairments and Recommendations

The Clean Water Act is a series of federal legislative acts that form the foundation for protection of U.S. water resources. These include the Water Quality Act of 1965, Federal Water Pollution Control Act of 1972, Clean Water Act of 1977, and Water Quality Act of 1987. The goal of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters". Section 305(b) of the Federal Clean Water Act requires each state to prepare a Watershed Assessment Report for submission to the United States Environmental Protection Agency (EPA). The reports include a description of the water quality of all waterbodies in the state and an analysis of the extent to which they are meeting their water quality standards. The report must also recommend any additional action necessary to achieve the water quality standards and for which waters that action is necessary.

Section 303(d) of the Act requires states to list all impaired waters not meeting water quality standards set by the state, even after appropriate and required water pollution control technologies have been applied (EPA, 2008). The law also requires that states establish priority rankings for waters on the list and develop TMDLs for these waters. A TMDL is the maximum amount of pollutant that a waterbody can receive and still safely meet the state's water quality standards for that pollutant. TMDLs are a regulatory tool used by states to meet water quality standards in impaired waterbodies where other water quality restoration strategies have not achieved the necessary corrective results.

IMPAIRED STREAMS

Pursuant to the provisions of the Clean Water Act, DEP has an ongoing program to assess the quality of waters in PA and identify streams, and other bodies of water, that are not attaining designated and existing uses as "impaired". Water quality standards are comprised of the uses that waters can support, and goals established to protect those uses. Each waterbody must be assessed for four (4) different uses, as defined in DEP's rules and regulations:

1. Aquatic life,
2. Fish consumption,
3. Potable water supply, and
4. Recreation

The established goals are numerical, or narrative, water quality criteria that express the in-stream levels of substances that must be achieved to support the uses. This assessment effort is used to support water quality reporting required by the Clean Water Act. DEP uses an integrated format for the Clean Water Act Section 305(b) reporting and Section 303(d) listing in a biennial report called the "Pennsylvania Integrated Water Quality Monitoring and Assessment Report". The narrative report contains summaries of various water quality management programs including water quality standards, point source control and nonpoint source control. In addition to the narrative, the water quality status of Pennsylvania's waters is presented using a five-part characterization of use attainment status (DEP, 2008). The listing categories are:

Category 1: Waters attaining all designated uses.

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

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

Category 4: Waters impaired for one (1) or more designated use but not needing a TMDL. These waters are placed in one of the following three subcategories:

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

Category 5: Waters impaired for one (1) or more designated uses by any pollutant. Category 5 includes waters shown to be impaired as the result of biological assessments used to evaluate aquatic life use. Category 5 constitutes the Section 303(d) list submitted to EPA for final approval

WASHINGTON COUNTY IMPAIRMENTS

If a stream segment is not attaining any one (1) of its designated uses, it is considered to be "impaired". In Washington County, all of the non-attaining streams were for Aquatic Life use attainment, which is reflective of any component of the biological community (i.e. fish or fish food organisms). The source-cause of impairment varies from stream to stream. Oftentimes, there are multiple source-causes attributed for impairment of a particular stream segment. *Table 9.1* shows a summary of the primary source of impairment in each Act 167 Designated Watershed within the county. This table does not reflect streams that have multiple source-causes of impairment. *Table 9.2* lists the non-attaining streams in Washington County and the source-cause of the pollution. *Figure 9.1* shows a map of the impaired streams.

		Act 167 Watersheds (stream miles)												
Classification	Category	Chartiers Creek	Cross Creek	Monongahela River	Ohio River	Peters Creek	Pigeon Creek	Pike Run	Raccoon Creek	Robinson Run	Ten Mile Creek	Wheeling Creek	Entire County	Percent of County (%)
Impaired (stream miles)	Abandoned Mine Drainage	23.4	10.3	11.6	18.4	9.2	1.8	--	60.2	26.0	--	25.6	186.5	29.7
	Agriculture	92.5	--	8.5	4.3	5.1	--	--	23.6	--	25.7	6.0	165.8	26.4
	Atmospheric Deposition	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0
	Forestry	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0
	Hydro-modification	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0
	Industrial or Municipal Point Source	35.8	--	--	0.8	0.7	--	--	--	1.2	2.9	--	41.4	6.6
	Urbanization	71.7	--	21.8	2.1	--	4.2	--	--	1.7	--	--	101.5	16.2
	Source Unknown	24.0	--	38.7	1.9	--	--	--	--	--	--	--	64.6	10.3
	Other	57.2	--	1.0	1.3	--	--	--	7.4	--	1.5	--	68.4	10.9
	Total Impaired	304.4	10.3	81.6	28.8	14.9	6.0	0.0	91.3	28.9	30.2	31.7	628.0	100.0
	Percent of Total (%)	48.5	1.6	13.0	4.6	2.4	1.0	0.0	14.5	4.6	4.8	5.0	100.0	

Table 9.1. Summary of Impaired Segments by Watershed

Stream Name	Source - Cause	Act 167 Watershed	Length (miles)
UNT "Allison Hollow"	Agriculture	Chartiers Cr.	0.70
UNT "Allison Hollow"	Other	Chartiers Cr.	4.37
UNT Arnold Hollow	Industrial or Municipal Point Source	Chartiers Cr.	0.83
UNT Brush Run	Agriculture	Chartiers Cr.	8.26
UNT Brush Run	Other	Chartiers Cr.	12.90
UNT Brush Run	Urbanization	Chartiers Cr.	7.32
Catfish Creek	Abandoned Mine Drainage	Chartiers Cr.	1.68
Catfish Creek	Other	Chartiers Cr.	2.29
UNT Catfish Creek	Industrial or Municipal Point Source	Chartiers Cr.	0.60
UNT Catfish Creek	Other	Chartiers Cr.	1.16
Chartiers Creek	Abandoned Mine Drainage	Chartiers Cr.	10.69
Chartiers Creek	Agriculture	Chartiers Cr.	7.75
Chartiers Creek	Industrial or Municipal Point Source	Chartiers Cr.	15.21
Chartiers Creek	Other	Chartiers Cr.	5.12
Chartiers Creek	Source Unknown	Chartiers Cr.	13.97
UNT Chartiers Creek	Abandoned Mine Drainage	Chartiers Cr.	0.26
UNT Chartiers Creek	Agriculture	Chartiers Cr.	30.27

Stream Name	Source - Cause	Act 167 Watershed	Length (miles)
UNT Chartiers Creek	Industrial or Municipal Point Source	Chartiers Cr.	11.76
UNT Chartiers Creek	Other	Chartiers Cr.	16.04
UNT Chartiers Creek	Source Unknown	Chartiers Cr.	9.61
UNT Chartiers Creek	Urbanization	Chartiers Cr.	4.32
Chartiers Run	Agriculture	Chartiers Cr.	4.50
Chartiers Run	Industrial or Municipal Point Source	Chartiers Cr.	1.29
Chartiers Run	Urbanization	Chartiers Cr.	3.09
UNT Chartiers Run	Abandoned Mine Drainage	Chartiers Cr.	2.06
UNT Chartiers Run	Agriculture	Chartiers Cr.	15.51
UNT Chartiers Run	Industrial or Municipal Point Source	Chartiers Cr.	2.76
UNT Chartiers Run	Other	Chartiers Cr.	4.20
UNT Chartiers Run	Urbanization	Chartiers Cr.	1.86
Coal Run	Agriculture	Chartiers Cr.	1.23
UNT Cross Creek	Urbanization	Chartiers Cr.	1.93
Georges Run	Urbanization	Chartiers Cr.	1.86
UNT Little Chartiers Creek	Abandoned Mine Drainage	Chartiers Cr.	5.17
UNT Little Chartiers Creek	Agriculture	Chartiers Cr.	1.34
UNT Little Chartiers Creek	Industrial or Municipal Point Source	Chartiers Cr.	2.04
UNT Little Chartiers Creek	Source Unknown	Chartiers Cr.	0.38
UNT Little Chartiers Creek	Urbanization	Chartiers Cr.	46.64
UNT McPherson Creek	Other	Chartiers Cr.	2.56
Millers Run	Abandoned Mine Drainage	Chartiers Cr.	1.05
Millers Run	Agriculture	Chartiers Cr.	6.04
Millers Run	Other	Chartiers Cr.	0.49
Millers Run	Urbanization	Chartiers Cr.	0.58
UNT Millers Run	Abandoned Mine Drainage	Chartiers Cr.	0.62
UNT Millers Run	Agriculture	Chartiers Cr.	16.33
UNT Millers Run	Other	Chartiers Cr.	2.29
UNT Millers Run	Urbanization	Chartiers Cr.	2.42
Plum Run	Industrial or Municipal Point Source	Chartiers Cr.	1.28
Plum Run	Other	Chartiers Cr.	3.63
UNT Plum Run	Other	Chartiers Cr.	2.11
Westland Run	Abandoned Mine Drainage	Chartiers Cr.	1.82
Westland Run	Agriculture	Chartiers Cr.	0.59
Westland Run	Urbanization	Chartiers Cr.	1.66
UNT “Coal Hollow”	Abandoned Mine Drainage	Cross Creek	3.11
UNT Cross Creek	Abandoned Mine Drainage	Cross Creek	6.66
UNT North Fork Cross Creek	Abandoned Mine Drainage	Cross Creek	0.53
UNT "Wood Run Hollow	Agriculture	Mon. River	1.30
Barneys Run	Agriculture	Mon. River	2.68
UNT Barneys Run	Agriculture	Mon. River	1.38
Beckets Run	Abandoned Mine Drainage	Mon. River	0.09
Downers Run	Agriculture	Mon. River	0.10
Huston Run	Abandoned Mine Drainage	Mon. River	1.30
UNT Huston Run	Abandoned Mine Drainage	Mon. River	0.93
Kelley Run	Abandoned Mine Drainage	Mon. River	0.11
Lamb Lick Run	Abandoned Mine Drainage	Mon. River	0.11
Lilly Run	Urbanization	Mon. River	1.96
UNT Lilly Run	Urbanization	Mon. River	1.17

Stream Name	Source - Cause	Act 167 Watershed	Length (miles)
Little Redstone Creek	Abandoned Mine Drainage	Mon. River	0.08
Maple Creek	Urbanization	Mon. River	4.62
UNT Maple Creek	Urbanization	Mon. River	4.36
Meadow Run	Abandoned Mine Drainage	Mon. River	0.10
Monongahela River	Source Unknown	Mon. River	38.73
UNT Monongahela River	Abandoned Mine Drainage	Mon. River	8.06
UNT Monongahela River	Agriculture	Mon. River	2.99
UNT Monongahela River	Other	Mon. River	0.98
UNT Monongahela River	Urbanization	Mon. River	5.81
Redstone Creek	Abandoned Mine Drainage	Mon. River	0.66
South Branch Maple Creek	Urbanization	Mon. River	1.78
Speers Run	Urbanization	Mon. River	0.27
Sunfish Run	Abandoned Mine Drainage	Mon. River	0.20
Twomile Run	Urbanization	Mon. River	1.54
UNT Twomile Run	Urbanization	Mon. River	0.24
UNT Bonar Creek	Industrial or Municipal Point Source	Ohio River	0.84
UNT Buffalo Creek	Agriculture	Ohio River	4.33
UNT Buffalo Creek	Other	Ohio River	1.30
Dutch Fork	Source Unknown	Ohio River	1.87
Harmon Creek	Abandoned Mine Drainage	Ohio River	5.77
UNT Harmon Creek	Abandoned Mine Drainage	Ohio River	10.16
UNT Harmon Creek	Urbanization	Ohio River	2.10
UNT Ward Run	Abandoned Mine Drainage	Ohio River	2.45
Peters Creek	Abandoned Mine Drainage	Peters Creek	3.84
UNT Peters Creek	Abandoned Mine Drainage	Peters Creek	5.32
UNT Peters Creek	Agriculture	Peters Creek	5.10
UNT Peters Creek	Industrial or Municipal Point Source	Peters Creek	0.67
Pigeon Creek	Urbanization	Pigeon Cr.	1.55
UNT Pigeon Creek	Abandoned Mine Drainage	Pigeon Cr.	1.76
UNT Pigeon Creek	Urbanization	Pigeon Cr.	2.68
UNT Burgetts Fork	Abandoned Mine Drainage	Raccoon Cr.	20.61
UNT Burgetts Fork	Agriculture	Raccoon Cr.	8.99
UNT Burgetts Fork	Other	Raccoon Cr.	4.18
UNT Dilloe Run	Abandoned Mine Drainage	Raccoon Cr.	5.74
Raccoon Creek	Abandoned Mine Drainage	Raccoon Cr.	22.79
Raccoon Creek	Agriculture	Raccoon Cr.	0.63
UNT Raccoon Creek	Abandoned Mine Drainage	Raccoon Cr.	9.41
UNT Raccoon Creek	Agriculture	Raccoon Cr.	14.01
UNT Raccoon Creek	Other	Raccoon Cr.	3.26
UNT St Patrick Run	Abandoned Mine Drainage	Raccoon Cr.	1.67
UNT North Branch Robinson Run	Abandoned Mine Drainage	Robinson Run	2.83
Robb Run	Abandoned Mine Drainage	Robinson Run	4.00
Robinson Run	Abandoned Mine Drainage	Robinson Run	6.81
Robinson Run	Industrial or Municipal Point Source	Robinson Run	0.25
UNT Robinson Run	Abandoned Mine Drainage	Robinson Run	12.38
UNT Robinson Run	Industrial or Municipal Point Source	Robinson Run	0.92
UNT Robinson Run	Urbanization	Robinson Run	1.69
Little Tenmile Creek	Agriculture	Ten Mile Cr.	2.01
UNT Little Tenmile Creek	Agriculture	Ten Mile Cr.	1.50

Stream Name	Source - Cause	Act 167 Watershed	Length (miles)
Plum Run	Agriculture	Ten Mile Cr.	2.97
UNT Plum Run	Agriculture	Ten Mile Cr.	5.74
Tenmile Creek	Agriculture	Ten Mile Cr.	3.49
UNT Tenmile Creek	Agriculture	Ten Mile Cr.	10.02
UNT Tenmile Creek	Industrial or Municipal Point Source	Ten Mile Cr.	2.91
UNT Tenmile Creek	Other	Ten Mile Cr.	1.52
Enlow Fork	Abandoned Mine Drainage	Wheeling Cr.	13.97
Robinson Fork	Abandoned Mine Drainage	Wheeling Cr.	7.63
Robinson Fork	Agriculture	Wheeling Cr.	4.18
UNT Robinson Fork	Agriculture	Wheeling Cr.	1.86
Rocky Run	Abandoned Mine Drainage	Wheeling Cr.	1.44
Templeton Fork	Abandoned Mine Drainage	Wheeling Cr.	2.59

Table 9.2. Non-Attaining Streams in Washington County

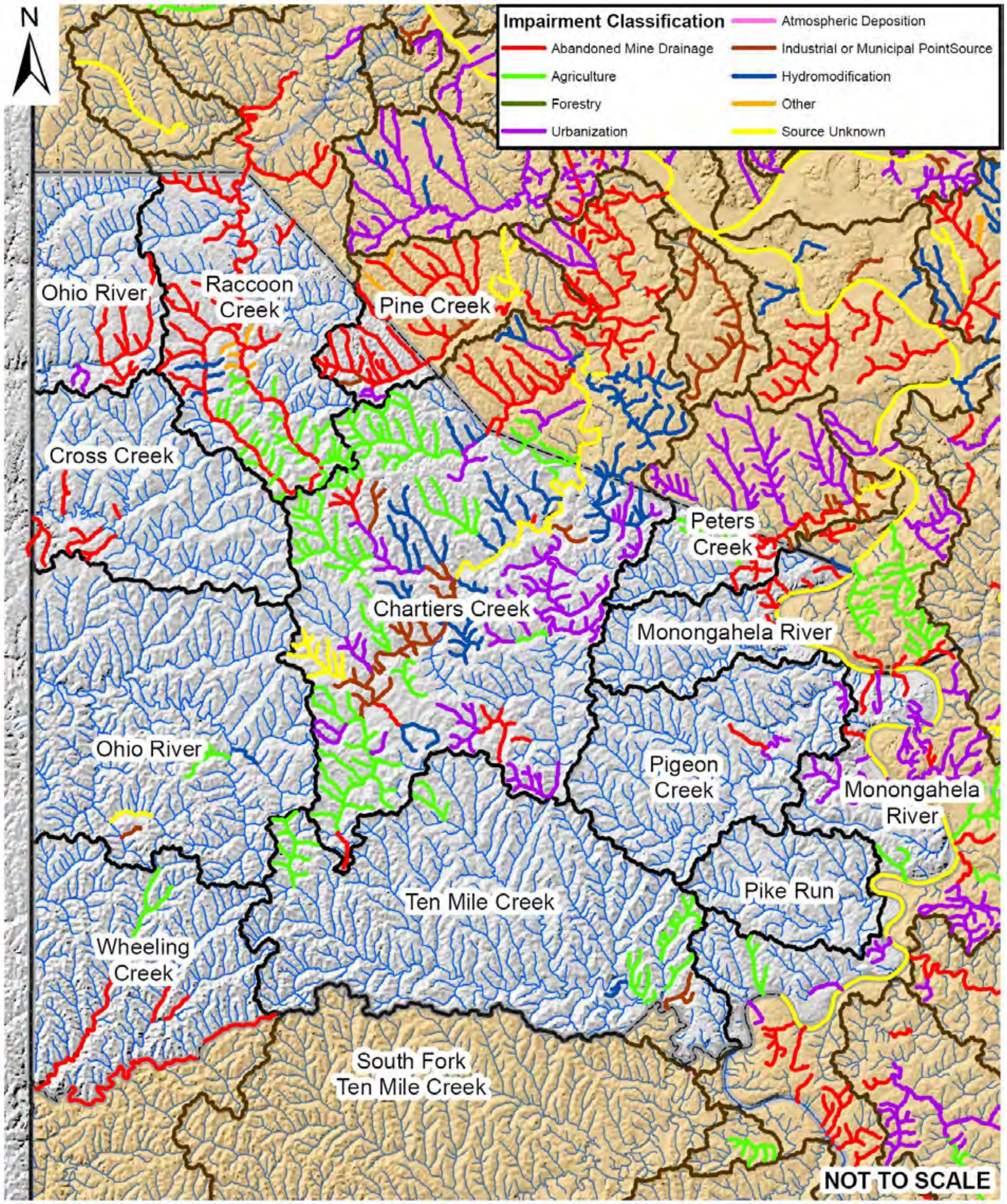


Figure 9.1. Impaired Streams in Washington County

TMDL DISCUSSION

Once a waterbody is listed on the EPA-approved 303(d) list, it is required to be scheduled for development of a TMDL. TMDLs are expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a water quality standard. They can be developed to address individual pollutants or groups of pollutants if it is appropriate for the source of impairment.

A TMDL must identify the link between the use impairment, the cause of the impairment, and the load reductions needed to achieve the applicable water quality standards. A precise implementation plan is not part of the approved TMDL. A TMDL is developed by determining how much of the pollutant causing the impairment can enter the waterbody without exceeding the water quality standard for that particular pollutant. The calculated pollutant load is then distributed among all the pollutant sources as follows:

$$TMDL = WLA + LA + MOS$$

Where: TMDL = Total Maximum Daily Load

WLA = Waste Load Allocation; from point sources such as industrial discharges and wastewater treatment plants

LA = Load Allocation; from nonpoint sources such as stormwater, agricultural runoff and natural background levels

MOS = Margin of Safety

TMDLs are developed by the State and submitted to EPA for review and approval. Once a TMDL has been approved, it becomes a tool to implement pollution controls. It does not provide for any new implementation authority. The point source component of the TMDL must be implemented through existing federal programs with enforcement capabilities (e.g. NPDES). Implementation of the Load Allocations for nonpoint sources can happen through a voluntary approach or by means of existing state or local regulations. *Table 9.2* lists all the TMDLs in Washington County.

Waterbody	TMDL Category	Cause	Status
Brush Run	Nonpoint Source	Nutrients, Organic Enrichment/Low DO, Turbidity, Siltation, Suspended Solids	EPA Approved 4-9-2003
Canonsburg Lake	Lake, Nonpoint Source	Nutrients	EPA Approved 8-9-2003
Chartiers Creek Watershed	Unknown	Metals, pH, Suspended Solids	EPA Approved 4-9-2003
Harmon Creek	AMD	Metals, pH, Siltation, Suspended Solids	EPA Approved 4-4-2007
Ohio River	Fish Consumption	Chlordane, PCB	EPA Approved 4-9-2001
Peters Creek Watershed	AMD	Metals	EPA Approved 4-7-2009
Plum Run	Nonpoint Source	Nutrients, Organic Enrichment/Low DO, Turbidity, Siltation, Suspended Solids	EPA Approved 4-9-2003
Raccoon Creek Watershed	AMD	Metals, pH, Siltation	EPA Approved 4-7-2005
Redstone Creek Watershed	AMD, Nonpoint Source	Metals, pH, Siltation, Suspended Solids	EPA Approved 4-9-2009

Table 9.2. TMDLs in Washington County

CRITICAL SOURCES OF IMPAIRMENT

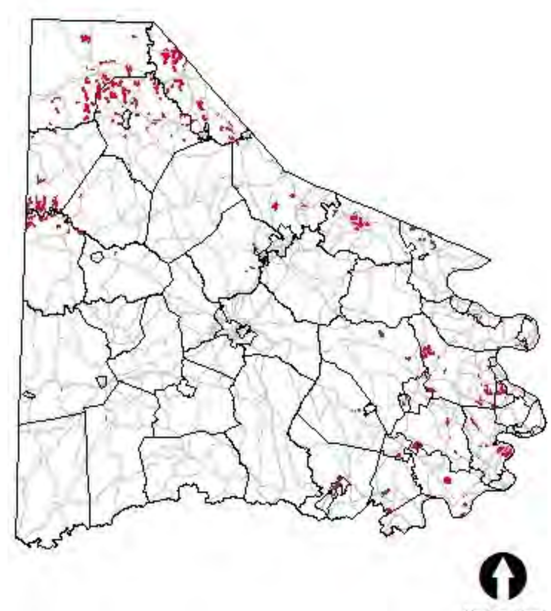
The primary causes of water quality impairment are sediment/siltation, nutrients, metals, and pathogens. Nonpoint source (NPS) pollution is a general term for water pollution generated by diffuse land use activities rather than from an identifiable or discrete facility. In PA, the leading nonpoint sources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

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

Some of these sources are regulated by stormwater ordinances and have been covered in a previous section. Several of these categories are more appropriately addressed by other regulations. Although these activities cannot be regulated by the provisions in the Model Ordinance of this Plan, they play a major role in the water quality of surface waters. The following is a summary of the nonpoint sources and causes for impairment that affect Washington County waters:

ABANDONED MINE DRAINAGE (AMD)

Contaminated water seeping from abandoned coal mine areas (commonly known as abandoned mine drainage, or AMD) is the most prevalent and severe water pollution problem in PA. AMD, impairing nearly 179 miles of surface waters within the county, is the primary cause of impairment in Washington County. Impacting 77.7% of the impaired waters within the county, AMD is, by far, the principal impairment concern. There are many different potential contaminants found in and around abandoned mines



Washington County Abandoned Mine Lands

Vast bituminous coal deposits underlie western and northcentral PA, including Washington County. Indeed, bituminous coal mining and coke making dominated much of western Pennsylvania's economy during the late nineteenth and early twentieth century. The PA bituminous industry peaked in 1918 when the industry started to encounter rising competition from other states and shrinking markets due to competing fuel sources such as petroleum and natural gas. This began a long-term decline in PA's coal industry that continues today. Bituminous coal was primarily mined through surface mining techniques or "strip mining". Through this process, the overburden (soils and other bedrock layers) is removed and relocated to expose the coal for extraction. Although this method was usually cheaper, it caused severe environmental problems that went unregulated until state law required land restoration in 1963. This process has drastically changed the county's landscape, negatively influencing the hydrologic process.

Years of coal mining conducted before the regulation of the industry and a sharp decline in production have left behind a multitude of abandoned mine sites that host a variety of environmental and safety issues. Abandoned mine sites have left dangerous highwalls, open pits, coal refuse spoil piles, old mine openings, and miles of streams polluted by AMD. Past coal mining practices have led to erosion, landslides, polluted water supplies, destruction of fish and wildlife habitat, and an overall reduction in natural beauty. Abandoned mines leak acidic, metal-contaminated waters into nearby waterways and the groundwater.

Many strip mines were not backfilled or re-vegetated, allowing water to infiltrate through acidic spoil, settle into impoundments, and contaminate groundwater supplies. Strip mine activities often removed the outcrop barrier, allowing groundwater to flow unimpeded to the surface over the old strip pit. The refuse produced from mining activities (consisting of high sulfur material) was usually just stockpiled, another source of pollution. The problems caused by AMD Sites can be classified in several categories:

SAFETY PROBLEMS - Abandoned mine land (AML) sites have contributed to deaths in several states. Highwalls, open shafts, dilapidated mine structures, and water-filled pits present serious health and safety threats.

ECONOMIC PROBLEMS - These lands are often located in the most economically depressed areas of our nation. All that remains in many once-populated mining communities are scarred lands and a few residents who are willing to commute to larger cities for employment. The AML sites make it difficult to compete for industry and tourism.

AESTHETIC PROBLEMS - The sparse vegetation (if any), stagnant water, and illegal trash dumps characterize AML sites and have a negative effect on everyone. The appearance of the site tends to depress land value and detract from the tax base. The environmental scars contribute to an apathetic attitude toward the condition of these areas.

WATER PROBLEMS - Acid run-off and sedimentation from abandoned mine sites contaminate thousands of miles of streams nationwide. This contaminated water eventually serves as potable water supply; therefore, an increase in water treatment costs is needed. AMD also leads to increased road maintenance costs due to the corrosive effects of AMD on culverts. Streams and drainage systems are often clogged by sedimentation from AML sites, which, in turn, may cause flooding.

The Surface Mining Conservation and Reclamation Act of 1971 and the Federal Surface Mining Control and Reclamation Act of 1977 have generated regulations intended to eliminate and control adverse conditions resulting from mining operations. The county continues to live with the legacy of coal mining. According to DEP, there are 393 documented AML sites and 2,135 un-reclaimed AML Features that cover 15,227 acres in Washington County.

In Washington County, there have been many reclamation projects completed and more are in progress. According to DEP, a total of 60 reclamation projects involving 1,620 acres have been undertaken at a cost of $9,611,036 in Washington County.

URBANIZATION

This is a broad category that includes the following three (3) critical sources of impairment listed earlier in this section: 1) Urban Runoff/Storm Sewers, 2) Road Runoff, and 3) Small Residential Runoff. These sources have been grouped together because they are all types of urbanization, or human development activities. When development activities replace forests, fields, and meadows with impervious surfaces the landscape's capacity for I_a is greatly reduced and surface runoff increases. This topic has been the focus of this Plan. The quantity of runoff from urbanized areas, plus the water quality characteristics of the runoff, are the two (2) base causes of surface water impairments. These two (2) primary pollutants translate into surface water impairments in several different forms.

SEDIMENT/SILTATION

As stormwater flows over land, it collects silt and sediment and carries them to surface waters. Urbanization decreases the opportunity for natural filtration of runoff through vegetation and often concentrates flow in discharges that cause increased overland erosion. The increased rate of stormwater flow and increased sediment load delivered to the stream combine to raise the in-stream energy. This changes the physical structure of the receiving streams by causing increased streambank erosion as well as scour of the streambed and sedimentation when the water finally slows down. Increased sediment loading in a stream contributes to increased Total Suspended Solids (TSS) and turbidity, which can in turn lead to increased stream temperatures as darker particles absorb heat (EPA, 1997). As water temperature rises, Dissolved Oxygen (DO) levels decrease. These changes caused by sediment and siltation are all substantial contributors to aquatic life impairments.

HABITAT ALTERATIONS

Natural channels are composed of alternating sequences of pools, riffles, and runs. The diverse characteristics of each of these features provide unique habitats that allow various aquatic species to live, feed, and reproduce (EPA, 2007). The elevated stream power that occurs when additional runoff and sediment loading are experienced causes physical alterations to the stream channel. The increased energy carries large debris downstream, erodes streambeds and banks, creates scour holes at existing structures, and deposits excess sediment in the channel. These changes can drastically alter the structure of pools, riffles, and runs and eventually diminish the quality of the habitat to a point where the stream can long longer support aquatic life.

NUTRIENTS AND METALS

As runoff flows over impervious surfaces, it picks up various pollutants and transports them to waterbodies. Pollutants include: oil and grease from automobiles; fertilizers; herbicides and pesticides from lawns; fecal matter from pet waste and malfunctioning septic tanks; chlorides from winter road maintenance; and heavy metals from tires, shingles, paints, and metal surfaces. These pollutants degrade water quality and limit the beneficial uses of the surface waters. Beneficial uses that may be impacted include: drinking water supply; swimming; fishing; other recreation; and aquatic life support.

RECOMMENDATIONS

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

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

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

Developing an implementation strategy and determining specific BMPs to treat specific sites is the last step. Existing water quality programs should be considered as the implementation strategy is developed. These programs can be coordinated with the implementation strategy in order to achieve a common goal. Thought must also be given to potential funding sources and how they can be used to implement portions of the overall water quality improvement plans. As projects are implemented, the Plan should be reviewed and revised within a certain timelines (e.g., 5 years) to ensure that the water quality goals will be obtained.

NONPOINT SOURCE POLLUTION REDUCTION PROGRAMS

Addressing environmental resource concerns and implementing conservation practices is one of the primary focuses of the Washington CCD and the USDA Natural Resource Conservation Service (NRCS). The process of improving the county's water quality impairments has already been initiated by these two (2) groups.

RECOMMENDED AGRICULTURAL CONSERVATION PRACTICES

A variety of agricultural conservation practices are available to help achieve producer's goals while also protecting natural resources. These practices are used to reduce soil erosion and improve and protect water quality. These practices are intended to address specific resource concerns. Individual BMPs are most effective through a conservation system. A conservation system addresses all of the resource concerns on a particular farm through a combination of different management practices and BMPs that work together. Planning a conservation system ensures that the maximum benefits can be obtained from the individual components and that the overall management goals are accomplished. Conservation planning services are offered by a variety of private consultants as well as state and federal agencies, including the local CCD and USDA Natural Resource Conservation Service staff. The following BMPs have been identified as particularly well suited to address the impairments identified in Washington County:

Streambank Protection

Streambank protection provides direct water quality results by reducing the amount of sediment, animal waste and nutrients entering the stream. Protection is implemented by excluding livestock from the stream and establishing buffer zones of vegetation around the stream (see *Riparian Buffers*). The practice can be implemented with or without fencing;

however, it is much more effective when fencing is installed. This BMP usually requires installation of an alternate watering source for livestock and an animal crossing to allow animals access to pasture on both sides of the stream. According to the *Chesapeake Bay Program Best Management Practices, Agricultural BMPS – Approved for CBP Watershed Model* (DEP, 2007) the pollutant removal efficiency of this practice, with fencing and off-stream watering applied, is 60% (Nitrogen), 60% (Phosphorus), and 75% (Sediment). Without fencing, the efficiency is reduced to 30%, 30%, and 38% for nitrogen, phosphorus, and sediment, respectively. This practice is eligible for several funding programs.

Riparian Buffers

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

Additionally, wetlands and riparian areas also help decrease the need for costly stormwater and flood protection facilities. The efficiency of riparian buffers varies by hydrologic setting. This practice can be implemented with several funding programs, such as CREP.

Riparian buffers are part of a larger group of practices referred to as Conservation Buffers. This general practice is any area or strip of land maintained in permanent vegetation to help reduce erosion and filter nonpoint source pollutants. This group also includes contour buffer strips, field borders, filter strips, vegetative barriers, and windbreaks (NRCS, 1999).

Barnyard Runoff Control

Animal concentration areas (ACA) are a principal source of sediment and nutrient pollution on agricultural operations. Barnyard runoff control is used to manage stormwater runoff from animal concentration areas to reduce the sediment and nutrients that reach surface waters. Runoff control can be achieved with a variety of methods, but the principles are the same for all of the methods. These principles are keeping "clean" water away from the barnyard, collecting runoff from the barnyard, and filtering it with an appropriate BMP or storing it in a manure storage facility for field application. Clean water is diverted away from ACAs with roof runoff structures, diversions, and drainage structures. When barnyard runoff control is implemented without storage, the pollutant removal efficiency is 20% (Nitrogen), 20% (Phosphorus), and 40% (Sediment) (DEP, 2007). When the practice is implemented in conjunction with a manure storage, the nitrogen and phosphorus efficiencies are both reduced to 10% and the sediment efficiency remains the same.

Nutrient Management

Nutrient management is planning for, and implementation of, the application of organic and inorganic materials to provide sufficient nutrients for crop production in a manner that limits negative environmental impact of their use (NRCS, 1999). A nutrient management plan accounts for all nutrient sources and details the location, timing, rate, and method of nutrient application to crop fields. Implementing a nutrient management plan provides benefit to the farmer by allocating the available nutrients to where they are needed the most for crop yield. It also limits excess nutrients that would otherwise be susceptible to transport eventually contribute to NPS pollution. Pollutant delivery reductions achieved by implemented nutrient management plans are greatly varied by individual agricultural operations. There is no efficiency directly associated with this practice. Several cost-share programs are available to assist costs associated with plan development and implementation.

Animal Waste Management Systems

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

Cover Crops

Cover crops are planted in the fall after the primary crop has been harvested. The cover crop grows through the fall and provides ground cover for the field throughout the winter months and early spring when the soil is extremely susceptible to erosion. The cover crop also provides nitrogen removal benefits as it utilizes excess nitrogen in the soil. The cover crop can either be harvested as a commodity crop in the spring or it can be killed and left as ground cover prior to spring planting. Cover crops provide excellent soil erosion protection when the fields need it most. The CCD has several cost incentive programs to encourage use of cover crops. The efficiency of cover crops varies based on planting time and harvesting. The pollutant removal efficiencies and cost incentive programs are identified in the Appendix.

Conservation Tillage

Conservation tillage is a crop production system that results in minimal disturbance of the surface soil. Maintaining soil cover with crop residue is an important part of conservation tillage. Maintaining ground cover throughout the year has many benefits to crop production, but the most significant water quality benefit is reduction in soil erosion. No-till farming is one (1) form of conservation tillage in which crops are planted directly into ground cover with no disturbance of the surface soil. Minimum tillage farming is another method that involves minor disturbance of the soil, but maintains much of the ground cover on the surface. There is no efficiency associated with this practice. The effects of each tillage system can be calculated by the Revised Universal Soil Loss Equation (RUSLE), which will give an estimation of the annual soil loss estimate for each field.

POTENTIAL FUNDING SOURCES

Washington County has a variety of potential sources for funding projects and individual practices that will help improve water quality. Some of these programs are countywide and others are targeted specifically at impaired watersheds. This is a review of the major funding programs available for projects addressing water quality impairments and not an all-inclusive listing. Funding sources available throughout the county include:

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

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

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

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

Section X – Additional Recommendations and Considerations

The stormwater management standards developed in this Plan are the basis for sound stormwater management throughout the county. The measures included in Section X are additional recommendations for municipalities to consider for inclusion into their adopted and implemented stormwater management ordinances. Generally, standards for many of these activities are contained in Zoning Regulations and Subdivision and Land Development Ordinances. Some of these activities and their impact on stormwater management are discussed below.

The measures contained in Section X provide a supplement to the regulatory scope of the municipal stormwater management ordinance. It is suggested that all municipalities consider these additional recommendations and determine whether adoption of some of these policies could be beneficial to their respective communities. Municipalities with substantial stormwater problem areas could especially benefit from regulation of these activities. A holistic approach that considers all land use policies and their impact on stormwater is necessary to maximize the effectiveness of a stormwater management program.

MUNICIPAL ZONING

Municipal zoning is perhaps the single most influential factor in a stormwater management program. This is because the rainfall-runoff response of a given geographical area is directly linked to land use. In this manner, zoning regulations can help achieve the goals of a stormwater program or they can be a hindrance to successful implementation of the program. Only 34% of rural municipalities have enacted zoning ordinances. The majority of these municipalities are located in the southeast portion of the Commonwealth (Lembeck et al., 2001). Instituting new or updating existing can be very difficult. Potential obstacles may include: political backlash from a perceived overreach in municipal regulation; increased enforcement costs; and a lack of professional staffing (often related to a lack of financial resources) in the development of regulations.

Despite the difficulties associated with implementing zoning regulation changes, this is a vital element of a successful stormwater management program. The impacts of zoning regulation reach far beyond stormwater management. Zoning changes should be developed with careful consideration of all of the potential and perceived effects of the ordinance changes.

Recommendations for Improved Municipal Zoning

The following zoning tools are recommended by the Center for Watershed Protection to aid in achieving the stated goals of this Plan (Center for Watershed Protection, 1999):

- **Watershed Based Zoning** – Master planning efforts and zoning incorporate recommendations for individual watershed, with watershed specific regulations. Long-term monitoring and evaluation of the effectiveness of the regulations should be part of the program.

- **Overlay Zoning** – With this option, specific criteria can be applied to isolated areas without the limitations of underlying base zoning. Overlay zoning superimposes additional regulatory standards, specifies permitted uses, or applies specific development criteria onto existing zoning provisions. Overlay zones may take up only part of an underlying zone or may encompass several underlying zones. An example of watershed-related overlay zoning may be "Impervious Overlay Zoning" in areas with documented stormwater problems that sets a maximum impervious area cap.
- **Performance Zoning** – This technique requires a proposed development to ensure a desired level of performance within a given area. This method has been used to control traffic or noise limits, light requirements, and architectural styles. Watershed-related performance zoning might provide precise limits on stormwater quality and quantity. This may be one (1) option to address impaired waters.
- **Large Lot Zoning** – This type of zoning district requires development to occur at very low densities to disperse impervious cover. This helps disperse the stormwater impacts of future development, but may contribute to urban sprawl.
- **Urban Growth Boundaries** – Growth boundaries set dividing lines for areas designated for urban and suburban development as well as areas appropriate for traditionally rural land uses (e.g., agriculture and forest preservation). Growth boundaries are typically set for up a specific time period (e.g. 10 to 20 years) and re-evaluated at appropriate intervals.
- **Infill Community Redevelopment** – This strategy encourages use of vacant or under-used land within existing growth centers for urban redevelopment. This practice is one method used to reduce the negative impacts of urban sprawl and minimize additional impervious area by maximizing utilization of existing infrastructure.
- **Transfer of Development Rights** – This allows transfer of development rights from sensitive subwatersheds (where the potential for adverse impacts is relatively high) to other watersheds designated for growth (where the potential for adverse impacts are relatively low).

RIVER CORRIDOR PROTECTION

River corridor protection is a very broad term that encompasses several closely-related river. The term "river" is used loosely here to include all rivers, streams, creeks. River corridors provide an important spatial context for maintaining and restoring the river processes and dynamic equilibrium associated with high quality aquatic habitats (Kline and Dolan, 2008). The river corridor includes the existing channel, floodplain, and adjacent riparian zone. The basic concept behind river corridor protection is recognizing the natural functions of rivers and streams and managing them to resolve conflicts between the natural systems and human land use.

Rivers and streams adjust over time in response to the varying inputs of water, sediment, and debris due to dynamic fluvial processes. Natural adjustments to these inputs are continually occurring continually in rivers and streams. These adjustments are generally minor and occur over long time periods. The result of these processes is evidenced in streambank erosion, channel incision, meandering stream channels, and the inevitable conflict between the stream and nearby human infrastructure. Large flood events cause more significant changes, such as channel relocation. River corridor protection includes the following management strategies to complement a stormwater management program:

FLOODPLAIN MANAGEMENT

There is a direct relationship between stormwater management and floodplain management. Stormwater management focuses on future development and reduces the likelihood of increased flooding. Floodplain management focuses on preventive and corrective measures to reduce flood damage. Implementation of the Model Ordinance will reduce the probability of new flooding problems, but will have only minor impacts on existing problems. Section V – Significant Problem Areas and Obstructions provides documentation of these problems. These problems are mainly due to historic floodplain development and inadequately sized infrastructure. Floodplains are necessary to convey and attenuate the natural peak flows that occur during major hydrologic events.

As discussed in Section III, Washington County incurs a substantial economic loss in major hydrologic events (as much as $61 million in a 10-year storm event). Floodplain management policy serves to minimize anthropogenic impact to floodplains during such events. While improved stormwater management will greatly reduce the occurrence of nuisance flooding, floodplains are necessary to attenuate flood waters from events that exceed the intended scope of stormwater policy. The most effective floodplain management policy provides preventive provisions that restricts future floodplain development and mitigates existing flood problem areas.

Recommendations for Floodplain Management

- **Adopt and enforce the Pennsylvania Department of Community and Economic Development (DCED) Model Floodplain Ordinance.** When the FIRMs in Washington County were updated, it was strongly recommended by DCED that each municipality adopt the DCED model ordinance. This will ensure that the local ordinance addresses the minimum state and federal requirements of the NFIP and provide a consistent basis of floodplain management between all of municipalities in the county.
- **Participate in the Community Rating System (CRS).** The CRS gives communities credit for reducing the risk of flood hazards. By implementing many of the same principles that are discussed in this Plan, municipalities can reduce flood insurance rates for residents inside the 100-year floodplain limits by up to 45%.
- **Provide open space preservation in floodplain areas.** Open space preservation may also provide credits to future developments by reducing impervious area.
- **Acquire and relocate flood-prone buildings so they are no longer within the floodplain.** Repetitive loss properties (properties for which two (2) or more claims of at least $1000 have been paid by the NFIP within any 10-year period since 1978) constitute a large portion of the NFIP flood insurance claims. Nationally, less than 1% of all properties with flood insurance have accounted for 30% of flood insurance claims between 1978 and 2004 (U.S. General Accounting Office, 2004). Removing these and any other structure that incurs flood risk on an annual basis reduces the overall risk of the NFIP and reduces the community's exposure to flood damage. It is usually more economical to remove properties (particularly in the rural areas of Washington County) than it is to install structural alternatives like levies, diversion projects, or dams.
- **Implement a drainage system maintenance program.** As noted in *Section V*, there are numerous locations where clogged or poorly-maintained facilities result in flooding of areas not normally prone to flooding. Most engineering design calculations for stormwater detention and conveyance facilities assume full function of a bridge or culvert. A systematic inspection and maintenance program should be implemented that includes periodic inspections on all channels, conveyances, and storage facilities. Routine maintenance should be performed as necessary to remove debris.

RIVER CORRIDOR PLANNING

River corridor planning considers all aspects of the river. River-specific assessments characterize the river and identify important features susceptible to threats. Land use planning strategies that focus on land use impact of land use on the river system are also evaluated in river corridor planning.

River corridor planning is used to designate corridors along the rivers where natural river changes are most likely to occur as a result of accelerated erosion and subsequent bank failures. These areas are referred to as "fluvial erosion hazard zones" and are responsible for a large portion of the damage to human infrastructure during flood events (Dolan and Kline, 2008). Once these areas are identified and mapped, land use planning mechanisms are used to protect identified sensitive areas and limit future development within this zone. Keeping infrastructure out of the high risk areas greatly reduces the cost of protecting and maintaining it.

Recommendations for River Corridor Planning

- **Identify beneficial river corridor planning areas.** Identifying areas that could benefit from improved river corridor management can protect river resources and greatly reduce the economic impact caused by major hydrologic events. River corridor planning can be especially beneficial in areas with special value, areas that are likely to receive considerable future development near the river, floodplain areas that would provide more economic benefit by being conserved, or areas that currently experience persistent flood damage.
- **Identify and protect fluvial erosion hazard zones.** Flood damage may also occur as a stream channel changes course and meanders. The channel changes may result from either naturally occurring fluvial processes or human-induced changes to watershed hydrology or hydraulics. A geomorphological assessment can identify the areas that are most likely to experience channel changes through erosion. These areas form the overlay zoning districts or areas within specified stream buffers afforded additional protection. The State of Vermont has integrated Fluvial Erosion Zones into floodplain mapping as a tool for floodplain management in specific areas (Dolan and Kline, 2008).

RIPARIAN ZONE PROTECTION

The riparian zone is the transitional zone between the aquatic zone and adjacent uplands. It generally includes the streambanks, floodplain, and any adjacent wetlands. The riparian zone is often overlapping with the river corridor, but has a slightly different connotation. The term riparian zone does not refer to an explicit width, rather a width that varies along the length of a given stream depending on the geography of the area. Natural riparian zones are typically covered with trees, shrubs, and other types of local vegetation. Vegetation provides a natural buffer between waterways and human land use as well as providing vital and unique natural habitat.

Riparian zones provide two (2) principle stormwater benefits. First, temporary storage areas are provided as flood protection by slowing the velocity of flood waters. These storage areas provide a small amount of volume reduction through infiltration and permanent retention as the areas are often located in disconnected low lying areas. The second primary benefit of riparian zones are the improvement of water quality functions. Riparian zone vegetation provides shade, reducing water temperature, trapping and removing pollutants from stormwater, and providing protection from streambank erosion.

Recommendations for Riparian Zone Protection

- **Adopt and enforce the riparian buffer provisions of the Model Stormwater Management Ordinance.** The Model Ordinance includes provisions to require establishment of riparian buffers on all new development that occurs near watercourses. These requirements complement the recently proposed changes to the statewide E&S pollution control regulations (25 Pa. Code Chapter 102). This will provide riparian zone protection by creating buffers between stream segments and all future development.
- **Establish a riparian zoning overlay district.** Identify critical riparian areas in which existing land uses may not be achieving water quality, floodplain management, and stormwater management objectives. Use this inventory of critical riparian zones to create a riparian zoning overlay district that establishes regulations on activities inside the zoning district.
- **Adopt stream specific guidelines where appropriate.** Where numerous problems areas have been identified and a riparian buffer is identified as a potential solution, a municipality may wish to adopt a stream specific set of guidelines that consider the specific fluvial geomorphological processes of that stream. A stream corridor study may be prepared that designates varying widths along a reach of stream. An ordinance that uses a stream corridor study as it basis will establish buffer widths using the best available scientific data. Some buffer ordinances have zones that vary between 75’ and 1000’ depending on the scientific and economic justification (Wenger and Fowler, 2000).
- **Encourage voluntary establishment of riparian buffers.** A regulatory approach will limit future development within the riparian zone, but will have little effect on existing land uses in critical riparian areas. There are numerous existing incentive programs that offer technical and/or financial assistance to encourage land owners to alter existing land uses and establish riparian buffers. These include agricultural land retirement programs such as USDA’s Conservation Reserve Enhancement Program (CREP) program and cost-share programs, such as USDA’s Environmental Quality Incentives Program (EQIP). Grant and loan programs could also help to meet this objective.

WETLAND PROTECTION

Wetlands play an essential role in stormwater management and water quality protection, as well as providing other valuable ecological and cultural functions. Some of the functions wetlands provide relevant to stormwater include: storm flow modification, erosion reduction, flood control, water quality protection, sediment and nutrient retention, and groundwater replenishment. Wetlands associated with lakes and streams provide temporary storage of floodwater by spreading the water over large flat areas, essentially acting as natural detention basins. This decreases peak flows, reduces flow velocity, and increases the time period for the water to reach the watersheds outlet. Research by R.P. Novitzki found that basins with 30 percent or more areal coverage by lakes and wetlands have flood peaks that are 60 to 80 percent lower than the peaks in basins with no lake or wetland area (Carter, 1997).

Wetlands can maintain quality water and improve degraded water. Wetland vegetation also decreases water velocities causing suspended solids to drop out of suspension, thus decreasing the erosive power of the water. Sediment, nutrients, trace metals, and organic material are trapped, precipitated, transferred, recycled, and exported through wetlands. Water leaving a wetland can differ noticeably from that entering (Mitsch and Gosselink, 1993).

Recommendations for Wetland Protection

- **Identify and protect special value wetlands.** Wetlands are protected through various levels of federal and state regulations due to the benefit diversity. These regulations protect wetlands from development, however, they permit minor wetland encroachments for certain activities. Some wetlands provide specific ecological or stormwater related benefits to an area. These wetlands should be identified and further protected through municipal regulations.

LID SITE DESIGN

The basic principles and concepts of LID were covered in Section I along with some of the benefits of implementing LID stormwater management practices. These concepts have been further developed throughout this Plan. This information has primarily discussed LID concepts as they relate to stormwater management, however, there are many non-stormwater LID practices that can have a very positive impact on a stormwater management program.

Development can alter the natural landscape with human infrastructure like buildings, roads, sidewalks, parking lots, and other impervious surfaces. As previously discussed, all of these "improvements" alter the natural hydrology of a site and generate increased runoff. LID site design concepts include reducing impervious surface area, minimizing the amount of natural area disturbed during development, decentralizing stormwater management facilities, and generally attempting to minimize the effects of development on natural resources. Stormwater management can be improved by encouraging use of additional LID practices.

LIMIT IMPERVIOUS COVER

Increased impervious area within a watershed is a direct contributor to increased storm flows and decreased water quality. Research in recent years has consistently shown a strong relationship between the percentage of impervious cover in a watershed and the health of the receiving stream (EPA, 2010). Various studies have indicated that as overall watershed imperviousness approaches 10%, biological indicators of stream quality begin to show degradation. Limiting impervious cover is one (1) method of reducing the impact of development on the hydrologic cycle.

Recommendations to Limit Impervious Cover

Some alternative development approaches within the LID approach include cluster development, reduction in street widths, reduction in parking space requirements (number and/or sizes), and creating a maximum impervious percentage on individual lots. Some specific elements within the LID framework include the following:

- **Road Widths** – These are usually specified based on the anticipated road use category (e.g., major, minor, or collector). Most ordinances assume a standard 12-foot wide travel lane and add width for shoulders, parking lanes, bicycle lanes, and other considerations. Reducing the travel lane width to eleven (11) feet for minor roads (e.g., roads within a subdivision development) could reduce the impervious cover of those roadways by up to eight (8) percent.
- **On-Street Parking** – Parking lanes are often specified to be eight (8) or ten (10) feet wide. Standardizing the maximum width of these lanes to eight (8) feet would reduce runoff. Also, limiting parking to one side of a street, particularly in subdivisions, could result in a significant reduction in total runoff. Another option would be to require that

the parking lanes be constructed of pervious pavement, grid blocks or another pervious surface.

- **Sidewalks** – In instances where ordinances require sidewalks, consideration should be given to only requiring them on one (1) side of the street in order to reduce impervious cover. Also, sidewalks should be separated from the roadway surface by a "green strip" (e.g., grass or shrubs) to allow runoff from the impervious surface an opportunity to infiltrate before entering the roadway drainage system. In fact, the sidewalks could, in some instances, be laid out so that they do not parallel the roadway, providing even greater opportunity for infiltration.
- **Curb and Gutter Systems With Storm Sewers** – In heavy residential areas, many ordinances require the developer to install curb and gutters along roadways as well as to use inlets and storm sewers to remove and transport the runoff from the roads. Ordinances should be modified to allow roadside swales, providing additional infiltration opportunity and some water quality benefit through filtration. This option would have the added benefits of significantly reducing development costs and minimizing future maintenance requirements.
- **Parking Requirements and Parking Stall Dimensions** – Consideration should be given to reducing the number of parking spaces that must be provided on-street or in parking lots for residential, commercial, educational, and industrial developments. Furthermore, stall sizes in parking lots should be set to 8-feet wide by 18-feet long. In addition, consideration could be given to requiring that larger parking lots establish special areas for compact cars with stall sizes reduced to 7-feet wide by 15-feet long. Finally, the ordinances should include requirements for a minimum amount of "green space" in parking lots which should allow runoff from the impervious surfaces to flow over them so that infiltration and water quality filtration would be enhanced.
- **Lot Sizes and Total Impervious Cover** – Most ordinances establish minimum lot sizes for various types of development and the number of "units" permitted on each lot. There are times the ordinances do not limit the amount of impervious cover that can be built on a specific lot, particularly in residential developments. Limits should be established and those limits should be used in determining the "post-development" runoff condition when designing the proposed storm water management systems. In addition, requirements should be established for the minimum amount of "green space" that should be provided in commercial, educational, and industrial developments. These "green spaces" should be designed so that runoff from the impervious surfaces can flow over them to the maximum extent practical.
- **Lot Setbacks** – There are at least two (2) schools of thought regarding lot setbacks as they relate to stormwater management: 1) Minimizing lot setbacks will reduce driveway lengths and, thereby, reduce total impervious cover and 2) Maximizing lot setbacks will allow runoff from impervious surfaces (e.g., roof tops) greater opportunity to infiltrate prior to reaching roadway drainage systems. Either method could be beneficial as long as the method works in coordination with the other Ordinance requirements.

LIMIT DISTURBANCE OR COMPACTION OF TOPSOIL

Topsoil is an absorbent top layer that provides significant stormwater management functions through the initial abstraction process. During rainfall events, no runoff occurs until the topsoil becomes saturated and the initial holding capacity of the soil is exceeded. The void spaces in undisturbed topsoil can provide significant water storage. The ability for initial abstraction can alter drastically from one (1) soil type to another or because of varied site conditions. Soil compaction plays a significant role in the ability of a given soil type to hold water. As topsoil is disturbed or compacted, the holding capacity of the soil is drastically reduced, thus limiting its effectiveness in reducing runoff. Previous studies (Gregory et al., 2006) have shown that compacted pervious area effectively approaches the infiltration behavior of an impervious surface.

Recommendations for Topsoil Management

- **Adopt topsoil management ordinance language.** The area of disturbance during the construction phase of a project should be limited to the minimum area necessary to complete the project. This provides the dual benefit of limiting erosion during construction and improving PCSM.
- **Adopt ordinance provisions that limit soil compaction where possible.** Areas that are not disturbed should be protected from compaction by construction activities to the maximum extent practicable. These areas should be designated on site plans, demarcated and protected by in-field measures. This is especially important for areas intended for infiltration-based stormwater management facilities.

IMPEDIMENTS TO LID IMPLEMENTATION

The LID concept has been around for a long time, but has been slow to catch on in mainstream implementation. In an effort to assess the impediments to LID in the Chesapeake Bay portion of Virginia, Lassiter (2007) identified and ranked several impediments to LID implementation. The two (2) most important impediments identified were: 1) lack of education about the LID concept and 2) existing development rules that conflict with LID principles.

Other recent studies have found that existing municipal regulations are often a significant impediment to LID implementation (Kerns, 2002). Many existing municipal regulations were developed to provide adequate infrastructure to meet the needs of growing communities. These standards often encourage use of unnecessary impervious surfaces, such as extra-wide streets in small residential areas, parking spaces for "worst-case scenarios" that get used only a few times a year, and dead-end sidewalks. Municipalities are encouraged to review their ordinances for regulations that conflict with LID and revise them to encourage the use of LID site design. There are many direct economic, environmental, aesthetic, and social benefits for a municipality adopting LID-friendly Ordinances.

Recommendations to Remove LID Impediments

- **Provide education activities and training workshops to various stakeholder groups.** Municipal and county officials should be encouraged to obtain additional education on LID practices. Other stakeholders, such as developers, builders, and homeowners , should also have educational resources available to increase awareness and encourage implementation of LID practices. Education is the key to successful implementation of LID practices.
- **Promote guidance documents.** There are a variety of publications and internet sites that discuss LID and offer design solutions: Low Impact Development Center (2009), DEP (2006), and Prince George's County (1999). These resources, along with this Plan, should be made available through municipal offices, websites, or trainings.
- **Alter existing Subdivision and Land Development Ordinances and Zoning Ordinances to allow for successful LID implementation.** Adoption of the Model Stormwater Management Ordinance in this Plan is an important tool in accomplishing the goals of

LID. It is recommended that municipalities modify and enhance ordinances in order to provide enough flexibility to allow these innovative design methods to be employed by developers in order to advance the goals of this Plan. Potential alterations that may help create flexibility include: 1) creation of overlay zoning, 2) providing amendments to Ordinances to support LID efforts (i.e. reducing impervious cover and limiting topsoil compaction), or 3) creating an expedited waiver process for LID-specific requests.

- **Provide incentives for LID implementation.** Lassiter (2007) identifies tax credits, allowing for higher density developments, mitigation credits, and reduced land development fees for sites with LID developments as potential incentives to encourage developers to use LID.
- **Keep an inventory of LID efforts to help provide County-specific recommendations and successful BMP installation.** While considerable documentation exists on specific BMPs (e.g. National Research Council, 2008; DEP, 2006), very little scientific data exists within this region and particularly this County. A valuable part of LID, one that is too often neglected, is the component of encouraging debate and expanding the LID knowledge base. Having an agency with a central role in land development permitting, such as the CCD, would be invaluable to developers and design professionals in distinguishing between what does and does not work in Washington County.

SUMMARY

Implementation of the standards developed in this Plan are a necessary step toward developing a holistic stormwater management plan, but much more can be done to improve how we manage water resources. There are many opportunities for local governments to improve the way this resource is managed and protected. The benefits are vast for those who undertake the challenge. There is a substantial number of technical resources available to guide development of regulations for proactive thinking municipalities.

Section XI – Plan Adoption, Implementation and Update Procedures

PLAN REVIEW AND ADOPTION

The opportunity for local review of the draft Stormwater Management Plan is a prerequisite to county adoption of the Plan. Local review of the Plan is composed of several parts, namely the PAC review (with focused assistance from others, including Legal Advisor's and Municipal Engineer's review) and County review. Local review of the draft Plan is initiated with the completion of the Plan by the County and distribution to the aforementioned parties. Presented below is a chronological listing and brief narrative of the required local review steps through County adoptions.

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

    a. Municipal Engineers Review – Municipal Engineers have been invited to PAC meetings to focus on the technical aspects of the Plan and to educate the Municipal Engineers on the ordinance adoption and implementation requirements of the Plan. The group met twice to solicit input as well as to receive comments and direction in the development of the Model Ordinance. The result of this is a revised draft model ordinance for Municipal and County consideration.

    b. Legal Advisory Review – Municipal solicitors have been invited to PAC meetings to focus on the legal aspects of the Plan and to educate the Municipal solicitors on the Ordinance adoption and implementation requirements of the Plan. The group met to provide input as well as to receive comments and direction in the development of the model ordinance. The result of this effort is a revised draft Model Ordinance for Municipal and County consideration.

2. Municipal Review - Act 167 specifies that prior to adoption of the draft Plan by the County, the planning commission and governing body of each municipality in the study area must review the Plan for consistency with other plans and programs affecting the study area. The draft Model Ordinance that will implement the Plan through municipal adoption is the primary document reviewed by the PAC. The output of the municipal review will be a letter directed to the County outlining the municipal suggestions, if any, for revising the draft Plan (or Ordinance) prior to adoption by the County.

3. County Review and Adoption - Upon completion of the review by the PAC, with assistance from the Municipal Engineer, Legal Advisory Committee, and each

municipality, the draft Plan will be submitted to the County Board of Commissioners for their consideration.

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

The County will submit the Commissioner-adopted Plan to DEP for their consideration for approval. The review comments of the municipalities will accompany the submission of the Commissioner-adopted Plan to DEP.

IMPLEMENTATION OF THE PLAN

Upon final approval by DEP, each municipality within the county will become responsible for implementation of the Plan. Plan implementation encompasses the following activities:

- Adoption of municipal ordinances that enable application of the Plans provisions;
- Review of Drainage Plans for all activities regulated by the Plan and the resulting ordinances; and
- Enforcement of the municipal regulations.

Each municipality will need to determine how to best implement the provisions of this Plan within their jurisdiction. Three (3) basic models for Plan implementation are presented in *Table 11.1* below. In some cases, it may be advantageous for multiple municipalities to implement the Plan cooperatively or even on a county-wide basis.

Individual Municipal Model	Each municipality passes, implements, and enforces the SWM Ordinance individually.
Multi-Municipal Model	Several municipalities cooperate through a new or existing service-sharing agreement (COG, Sewage Association, etc.)
County Service Provider Model	County department, or office, (e.g. County Planning Entity or CCD) provides SWM ordinance implementation and enforcement services to municipalities.

Table 11.1. Models for Municipal Plan Implementation

Regardless of what model is used for implementation, each municipality will need to adopt regulations that enable the chosen implementation strategy. For municipalities that choose the Individual Municipal Model, this means municipal adoption of the Model Ordinance or integration of the Plan's provisions into existing municipal regulations. For the other two (2) models, this will require ordinance provisions that designate the regulatory authority and adoption of an inter-municipal agreement or service-sharing agreement.

It is important that the standards and criteria contained in the Plan are implemented correctly, especially if the municipality chooses to integrate the standards and criteria into existing regulations. In either case, it is recommended that the resulting regulatory framework be reviewed by the local planning commission, the municipal solicitor, and/or the Washington County Planning Commission for compliance with the provisions of the Plan and consistency among the various related regulations. Additionally, the adopted regulations may be reviewed by PADEP for compliance with this Plan.

PROCEDURE FOR UPDATING THE PLAN

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

1. Monitoring of the Plan Implementation - The Washington County Planning Commission will be responsible for monitoring the implementation of the Plan by maintaining a record of all development activities within the study area. Development activities are defined and included in the recommended Municipal Ordinance. Specifically, the WCPC will monitor the following data records:

    a. All subdivision and land developments subject to review per the Plan which have been approved within the study area.
    b. All building permits subject to review per the Plan which have been approved within the study area.
    c. All DEP permits issued under Chapter 105 (Dams and Waterway Management) and Chapter 106 (Floodplain Management), including location and design capacity (if applicable).

2. Review of Adequacy of Plan - The PAC will be convened periodically to review the Plan and determine if the Plan is adequate for minimizing the runoff impacts of new development. At a minimum, the information to be reviewed by the Committee will be as follows:

    a. Development activity data as monitored by the WCPC.
    b. Information regarding additional storm drainage problem areas as provided by the municipal representatives to the PAC.
    c. Zoning amendments within the study area.
    d. Information associated with any regional detention alternatives implemented within the study area.
    e. Adequacy of the administrative aspects of regulated activity review.

The PAC will review the above data and make recommendations to the County as to the need for revision to the Washington County Act 167 Stormwater Management Plan. Washington County will review the recommendations of the PAC and determine if revisions are to be made. A revised Plan would be subject to the same rules of adoption as the original Plan preparation. Should the County determine that no revisions to the Plan are required for a period of five (5) years, the County will adopt a resolution stating that the Plan has been reviewed by DEP and has been found to satisfactorily to meet the requirements of Act 167. The resolution will be forwarded to DEP.

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