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Butler County Planning Commission

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

May 14, 2010

[BUILDING RELATIONSHIPS.
DESIGNING SOLUTIONS.]

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Section I – Introduction

This stormwater management plan is the product of a collaborative effort between the varied stakeholders located in the Act 167 Designated Watersheds in Butler 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. However, 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.

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). However, 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 which contribute to a watershed's degradation. While land use regulation remains at the municipal level, the framework established within 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 base flows, and relatively high water quality. When all of these conditions are present the 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. Base Flows – 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 base flow 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 base flow originating from groundwater. This source of base flow 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 thus the standards, reflects 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 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 and 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 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 points are emphasized regarding the need for an overall watershed management approach:

1. Stormwater regulatory responsibility, absent arrangements to the contrary, rests with the municipal governments in Pennsylvania. Therefore, stormwater management regulations, if applied at all, are implemented by a municipality only within 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 which originate in areas over which they have no control.
2. Each area within 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 similar to nature 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 describe 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 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 10.1. 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 Butler 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 Butler 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 drainage ways and water courses.

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	*Appendix C*
Determine appropriate stormwater management controls for these basins	
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 Butler 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 Butler 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 drainage ways and water courses	
Provide education on the function and importance of natural drainage ways	*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 the department, in consultation with the municipalities located within each watershed, and shall periodically review and revise such plan at least every five years. Within six 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 Sections 6 and 7 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 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. The data was compiled and tabulated for those municipalities which provided data. 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 are to be implemented through the Model Ordinance.
(12) Priorities for implementation of action within each plan; and
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 5b
(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.

Table 2.2. Elements of Act 167

PLAN ADVISORY COMMITTEES

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

A Plan Advisory Committee (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 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 per Act 167, the Committee 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.	April 29, 2009
PAC MEC	Technical review of draft Model Ordinance: Review technical comments. (Draft Model Ordinance sent to municipalities prior to meeting).	March 11, 2010
PAC MEC	General review of draft PLAN: Gather general comments and feedback prior to finalization of the PLAN.	TBD
PAC	Pre-hearing meeting: Review comments and responses to comments. Summarize implementation.	TBD
Public Hearing	Conduct the hearing as required by Act 167 to present the PLAN to the public.	TBD

Table 2.3. Summary of PAC Meetings

Section III – Butler County Description

Butler County was formed from part of Allegheny County on March 12, 1800. The county was named in honor of General Richard Butler, a hero of the American Revolution. Butler County is situated on the Allegheny Plateau in Western Pennsylvania. The county encompasses 508,800 acres (795 square miles) and is approximately 23 miles wide by 34 miles long. Butler County occupies the high divide between the Allegheny and Beaver Rivers. The county is part of the Allegheny Plateau and is characterized by irregular terrain, having both sharp hills and valleys along with pockets of moderately sloped terrain. Only the extreme northwest part of the county has been glaciated. Elevations range from 1,500 feet on the summits in the Northern part of the county to 750 feet at the riverbeds in the Southern part of the county. Butler County has a diverse landscape with both rural and urban settings. This is reflected by high-density residential and commercial areas, such as the City of Butler and Cranberry Township, coupled with large land tracts of open space and agricultural land within the county.

POLITICAL JURISDICTIONS

The county is comprised of 57 municipalities. The political jurisdictions include 23 boroughs, one first class township (Butler Township), 32 second class townships, and the City of Butler (the county seat). Butler County is classified as a fourth class county and is ranked 20th of 67 counties with a population of 174,083, according to the 2000 census. The 57 municipalities in Butler County and their associated land area are as follows:

TOWNSHIPS	AREA (mi^2)	BOROUGHS	AREA (mi^2)
Adams Twp	22.6	Bruin Boro	1.7
Allegheny Twp	24.2	Callery Boro	0.5
Brady Twp	16.9	Cherry Valley Boro	2.9
Buffalo Twp	24.2	Chicora Boro	0.6
Butler Twp	21.6	Connoquenessing Boro	1.4
Center Twp	24.4	East Butler Boro	1.0
Cherry Twp	25.9	Eau Claire Boro	1.4
Clay Twp	25.2	Evans City Boro	0.8
Clearfield Twp	23.4	Fairview Boro	0.1
Clinton Twp	23.8	Harmony Boro	0.4
Concord Twp	24.9	Harrisville Boro	0.8
Connoquenessing Twp	22.5	Karns City Boro	0.4
Cranberry Twp	22.8	Mars Boro	0.4
Donegal Twp	23.0	Petrolia Boro	0.4
Fairview Twp	24.1	Portersville Boro	0.8
Forward Twp	23.3	Prospect Boro	4.8
Franklin Twp	20.8	Saxonburg Boro	0.9
Jackson Twp	21.2	Seven Fields Boro	0.8

TOWNSHIPS	AREA (mi²)	BOROUGHS	AREA (mi²)
Jefferson Twp	23.4	Slippery Rock Boro	1.7
Lancaster Twp	23.4	Valencia Boro	0.4
Marion Twp	25.5	West Liberty Boro	3.9
Mercer Twp	12.7	West Sunbury Boro	0.1
Middlesex Twp	23.0	Zelienople Boro	2.1
Muddy Creek Twp	21.8		
Oakland Twp	22.9		
Parker Twp	23.6	**CITIES**	**AREA (mi²)**
Penn Twp	24.2	Butler City	2.7
Slippery Rock Twp	25.8		
Summit Twp	22.3		
Venango Twp	20.8		
Washington Twp	25.0		
Winfield Twp	24.4		
Worth Twp	24.3		

Table 3.1. Butler County Municipalities

LAND USE

GENERAL DEVELOPMENT PATTERNS

According to the Butler County Comprehensive Plan, most of Butler County is undeveloped, wooded or agricultural land. Only about 20% of Butler's area is subject to intensive development. The Comprehensive Plan determined that different attributes resulted in opportunities for future land use potential in areas throughout the county. These attributes included natural features, access, existing development and other characteristics present in each portion of the county. They helped to identify "growth areas" in Butler County where economic growth and development could be sustained. The Comprehensive Plan identified eight (8) potential growth areas located throughout Butler County. These areas are as follows: Southern Butler County (Cranberry Township), City of Butler, Zelienople, Route 356 Corridor, Route 228 Corridor, Route 68 Corridor, Route 528 Corridor and nearly the entire Interstate 79 Corridor. Each of these areas will have a significant impact on land use and economic development in Butler County.

TRANSPORTATION

Butler County has an excellent geographic location in regard to road networks. The county is served by a number of important major transportation routes, including three interstate highways. Interstate 79 is a four-lane limited-access freeway, which traverses the county in a north/south direction. This road provides a convenient Interstate link between Pittsburgh and Erie. Interstate 80 passes through the northeast corner of the county. I-80 is an arterial highway that crosses the United States in an east/west direction from coast to coast. Interstate 76, part of the Pennsylvania Turnpike System, traverses the state and county in an east/west direction. In addition to the Interstate highways, several other road systems play roles in the county's transportation network. Other major road networks serving areas in Butler County include US Route 422, Route 8, Perry Highway (US-19) and the Allegheny Valley Expressway (Route 28). Overall Butler County has excellent transportation networks serving the most developed segments of the county.

While the Greater Pittsburgh International Airport handles most of the Tri-State's major air traffic, Butler County has four public airports to meet the needs of its residents. These airports and locations are as follows: Butler County Airport (Penn Township), Butler Farm Show Airport (City of Butler), Zelienople Municipal Airport (Borough of Zelienople) and Lakehill Airport (Mars Borough).

Rail is still an important means of transportation in Butler County and the United States. The longest active line is the CXS, which travels the P&W Subdivision from Allegheny County to Lawrence County. The Main Line of the Bessemer and Lake Erie is the second longest line traveling from Mercer County to Allegheny County. The other two railroads are part of the Buffalo and Pittsburgh lines. The Main Line, the larger of the two lines, travels from Eidenau to Armstrong County. The Northern Subdivision travels from Wadesworth to Burin. The final active line is a part of the Western Allegheny Line of the Bessemer and Lake Erie Railroad. It travels from Butler to Armstrong County.

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 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 Butler County's total land area, 327 acres (0.06 percent) are classified as Class I soils and 106,604 acres (20.98 percent) are classified as Class II soils as identified in the *Soil Survey of Butler County, Pennsylvania* (SCS, 1989).

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 1170 active farms in Butler County covering over 142,000 acres. This agricultural land accounts for 28 percent of the total land area of the county.

The importance of identifying 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

Butler County is situated on the Allegheny Plateau in Western Pennsylvania and the climate is classified as humid continental. Most weather systems that affect the area originate in Canada or the Central Plains of the United States and are moved eastward by the prevailing westerlies. The primary source of moisture is the Gulf of Mexico although minor effects of the Great Lakes, Lake Erie in particular, are sometimes experienced. The mean temperature for Butler County is

51°F with a maximum mean monthly temperature of 71°F in July and mean monthly low of 29°F in January. About 56% of the annual precipitation falls during the spring and summer. Precipitation averages approximately 40 inches per year and is fairly evenly distributed throughout the year. June is the wettest month with an average of 4.7 inches per year and February is the driest month with approximately 2.3 inches per year of precipitation. Snowfall averages 40.2 inches per year with most of it falling between January and March.

RAINFALL

Figures 3.1 and 3.2 show the rainfall statistics for Butler County. The average rainfall shown in Figure 3.1 portrays the amount of precipitation throughout each year since 1949. Note the significant variation in the annual rainfall total (between 25 and 53 inches). While this variation can have a major 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, 48-hour) that receives the focus of most stormwater regulations.

Figure 3.2 show 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 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 Pennsylvania 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 Butler County comes from storms with low magnitudes. Only 10% of the daily rainfall values between 1949 and 2009 exceeded 0.65 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 2.42 inches was exceeded 22 times in more than 61 years of data. When analyzing only the annual maximum series, the NOAA Atlas 24-hour, 2-year storm was exceeded only 16 times. Thus, viewing only the annual maximum series neglects a substantial number of significant historical rainfall events. The implication for stormwater policy in Butler County is that 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.

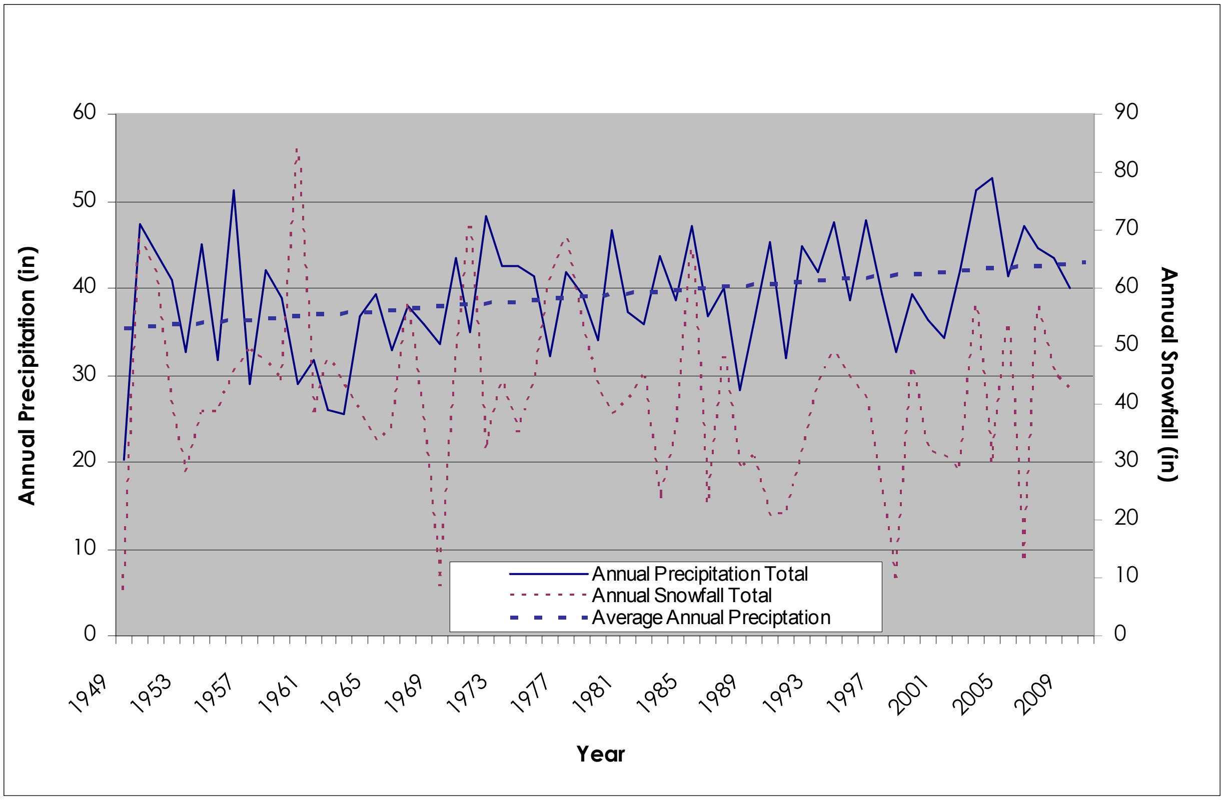


Figure 3.1. Annual Precipitation at Slippery Rock, Pennsylvania (Coop ID # 368184)

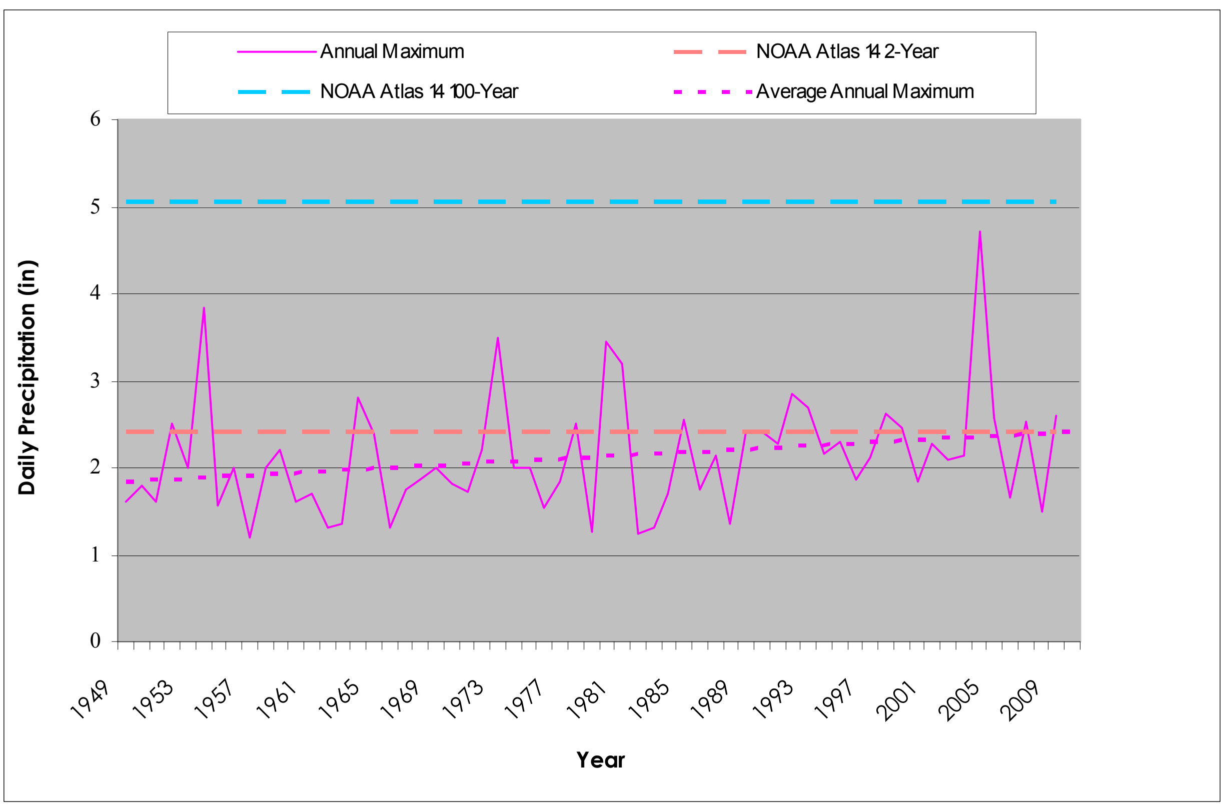


Figure 3.2. Daily Precipitation at Slippery Rock, Pennsylvania (Coop ID # 368184)

GEOLOGY

Butler County is situated in the Allegheny Plateau Province of Pennsylvania, which is characterized as a highland eroded by streams to create deep valleys and hilly topography. The smooth to irregular undulating surface, the narrow and relatively shallow valleys, strip mines and reclaimed lands of shale, sandstone, siltstone, limestone and coal are evident in this region. The bedrock of the Allegheny Plateau is nearly horizontal; therefore only one kind of rock is exposed at the surface. The dominant physiography of Butler County is rolling and hilly and consists of broad to narrow ridge tops and many steep-walled valleys. The Connoquenessing Creek has carved a deep, broad valley across the south-central part of the County. The northwest part of the county is smooth to rolling and consists of many low rounded hills and ridges. Poorly drained depressions are scattered throughout the county. The valleys occupied by Slippery Rock and Wolf Creeks are steep sided.

BEDROCK FORMATIONS

The bedrock of Butler County was formed in the Pennsylvania Period, 280 million to 310 million years ago. The bedrock is divided into three major groups based upon the age of the rocks; they are the Pottsville, Allegheny and Conemaugh groups. The county underlain by flat lying, generally thin, but locally thick limestone beds. These rocks can affect the environment in three ways: as hazards, as mineral resources and as groundwater reservoirs. This type of bedrock is also susceptible to landslides. The formation names are as follows (PA Geological Survey, 2010):

Formation	Dominant Lithology
Conemagh Group	Shale
Allegheny Formation	Sandstone
Pottsville Formation	Sandstone

Table 3.2. Geologic Formations

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). Butler County contains two of these resources as identified below.

Lake Arthur – Located in Muddycreek, Brady, Franklin, and Worth Townships, this manmade lake occupies the site of a glacial lake that existed here over 10,000 years ago, when a continental glacier covered much of northwestern Pennsylvania. The glacial ice, whose eastern edge was at Harrisville and Slippery Rock, dammed the westward-flowing Slippery Rock and Muddy Creeks, forming lakes in their valleys; in the latter, Lake Arthur was formed.

West Liberty Esker / Miller Esker / West Liberty Hogback – Located in Worth Township, this 3-mile-long esker is probably the best remaining example of this type of glacial deposit in western Pennsylvania. The esker was formed during the close of the Wisconsonian glaciation, and is also known as the Miller Esker and West Liberty "Hogback."

Eskers are ridge-shaped sand and gravel deposits formed during the melting of a glacier. The ridge form marks the trace of a glacial meltwater stream that is confined within the ice mass. Esker ridges are always associated with the stagnation phase of the glacial episodes.

The West Liberty Esker is believed to be a crevasse filling (as opposed to a sinuous shaped ice tunnel esker) for the following reasons:

- Straight-line segments of the ridge are connected by sharp bends.
- Glaciofluvial gravels are present across the whole ridge.
- Numerous normal, ice-contact faults occur along the edge of the ridge.
- No till blanket has been observed on the ridge.

SLOPES

Slopes play a significant role when determining the extent and type of development that is being planned. Land with slopes in excess of 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. Butler County's soils have high clay content and with the amount of rainfall in the area, the soils are slip prone. Slopes greater than 15 percent are prevalent throughout Butler County as shown in the Comprehensive Plan. Slope values are broken into four categories and shown in *Table 3.3* below. Also shown is the total area in Butler 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. Note that almost three-quarters of the county is comprised of slopes of 15% or less. This indicates that for the most part, slope does not preclude the development potential of the land surface.

Slope Classification	Slope Range	Land Area (mi^2)	Portion of Total Area	Slope Restrictions
Flat to Moderate	0-8%	327.00	41.18%	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%	248.32	31.28%	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%	145.25	18.29%	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%	73.46	9.25%	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 Butler 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 of Butler 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 poorly drained and have a high runoff potential. The following describes the predominant soil series in Butler County (SCS, 1989).

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Andover	AnA, AnB, AnC, AoB, AoC	D	1.7	Fragipan (16-28in.)
Arents	Ar		0.9	
Atkins	At	B/D	5.2	Lithic bedrock (60-99in.)
Braceville	BeA, BeB, BeC	C	0.5	Fragipan (15-30in.)
Brinkerton	BrA, BrB, BrC	C/D	4.2	Fragipan (15-30in.)
Buchanan	BuB, BuC, BxB, BxD	C	7.4	Fragipan (20-36in.)
Canadice	Cd	D	0.6	
Caneadea	CeA, CeB, CeC, CeD	D	0.7	
Canfield	CfB, CfC, CfD	C/D	0.5	Fragipan (15-30in.)
Cavode	ClA, ClB, ClC, ClD	C/D	6.1	Paralithic bedrock (40-72in.)
Clymer	CmB, CmC	B	0.6	Lithic bedrock (40-84in.)
Cookport	CoA, CoB, CoC, CoD	C/D	4.8	Fragipan (20-32in.)
Dams	DAM		<0.1	
Dumps	Dd, Dm		0.1	
Ernest	ErB, ErC, ErD	C/D	4.6	Fragipan (20-36in.)
Fluvaquents	Fc	D	<0.1	
Fredon	FeA, FeB	C	0.3	
Frenchtown	FrA, FrB	D	0.7	Fragipan (15-32in.)
Gilpin	GlB, GlC, GmD	C	4.2	Lithic bedrock (20-40in.)
Upshur	GnC, GnD	D	0.2	Lithic bedrock (40-70in.)
Weikert	GoB	C	1.2	Lithic bedrock (10-20in.)
Gilpin	GoC	C	1.4	Lithic bedrock (20-40in.)
Weikert	GoD	C	2.2	Lithic bedrock (10-20in.)
Gilpin	GoF, GpC, GpD	C	12.5	Lithic bedrock (20-40in.)
Gresham	GrA, GrB, GrC	C	1.5	Fragipan (15-26in.)
Hazleton	HaB, HaC, HaD, HaE, HbB, HgD, HgF	A	17.4	Lithic bedrock (40-60in.)
Monongahela	MoB, MoC	C/D	0.3	Fragipan (25-35in.)
Philo	Ph	B	0.6	
Pits	Pn	A	0.1	
Pope	Po	B	0.1	
Ravenna	RaA, RaB, RaC	D	0.6	Fragipan (14-30in.)
Riverhead	RdB, RdC	B	0.4	
Tilsit	TaA, TaB	C	1.9	Lithic bedrock (40-40in.)
Titusville	TeB, TeC, TrD	C	1.5	Fragipan (16-28in.)
Urban land	UB		<0.1	Dense material (10-10in.)
Bethesda	UaB, UaD, UaF	C	6.2	
Fairpoint	UcD, UcF	C	0.3	
Urban land	UeB, UeC, UgD	D	0.6	
Vandergrift	VcB, VcC, VcD	C	0.9	Lithic bedrock (40-72in.)
Water	W		1.1	
Wharton	WaA, WaB, WaC	C	5.6	Paralithic bedrock (40-40in.)

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Wheeling	WhA, WhB	B	0.2	
Wooster	WoB, WoC, WoD, WoF	C	0.1	Fragipan (18-36in.)

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

One of the impediments to drainage throughout Butler County is the presence of fragipan soils and lithic bedrock. A fragipan soil layer is typically composed of loamy, brittle soil that has minimal porosity and organic content and has a low to moderate amount of clay content but a high amount of silt or very fine sand. With fragipans, upwards of 60% of input water moves laterally above the fragipan layer which is typically 14-36 inches below the surface in Butler County (Ciolkosz and Waltman, 2000; NRCS, 2008). Lithic bedrock is composed of a solid rock layer that 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.

In areas of fragipan and lithic bedrock, higher runoff rates and reduced infiltration capacity can be expected. Additional impediments to subsurface drainage include paralithic bedrock (i.e., weathered or broken layers of bedrock) and dense material. *Table 3.5* displays a list of soil restrictions in Butler County.

Restrictions	% of County
Dense material	< 0.1
Fragipan	28.4
Lithic bedrock	47.6
Paralithic bedrock	11.7
None Identified	12.2

Table 3.5. Soil Restrictions in Butler County

An additional indicator of the response to rainfall of the soils in Butler 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. *Table 3.6* shows a summary of the hydrologic soil groups for Butler County. Some soils have variable runoff potential depending on whether or not they are drained or undrained. For example, an agricultural field with tile drainage may decrease the runoff potential from hydrologic soil group D to hydrologic soil group A. Approximately three quarters of the soils in Butler 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	17.5
B	Moderate to low	1.9
B/D		5.2
C	Moderate to High	47.7
C/D		20.5
D	High	5.1
Unidentified		2.1

Table 3.6. Hydrologic Soil Groups of Butler 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 wet areas 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 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 Butler County:

Andover Loam	Cookport Loam	Pope Loam
Arents-Urban Land Complex	Dumps, Industrial Waste	Ravenna Silt Loam
Atkins Silt Loam	Dumps, Mine	Tilsit Silt Loam
Braceville Loam	Ernest Silt Loam	Titusville Silt Loam
Brinkerton Silt Loam	Fluvaquents, Coal Overwash	Udorthents, Acid Material
Buchanan Loam	Fredon Loam	Urban Land – Ernest Complex
Canadice Silty Clay Loam	Frenchtown Silt Loam	Vandergrift-Cavode Silt Loams
Caneadea Silt Loam	Gresham Silt Loam	Wharton Silt Loam
Canfield Silt Loam	Hazleton Loam	
Cavode Silt Loam	Philo Loam	

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. Oftentimes 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 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.

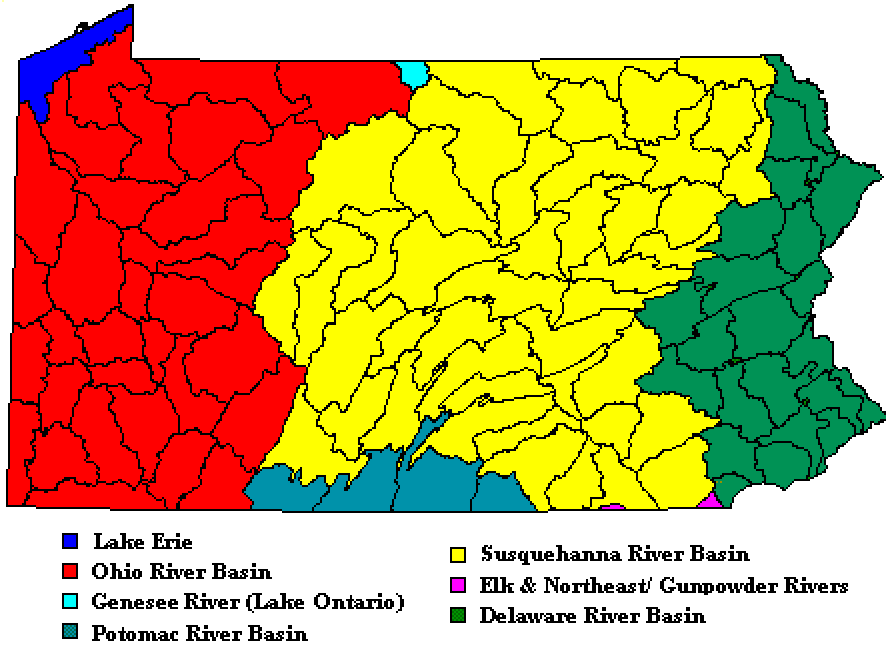


Figure 3.3. Pennsylvania's Major River Basins as Delineated by DEP (DEP, 2009)

For the purpose of this Plan, these are the largest basins in the Commonwealth. The major river basins are further divided into "subbasins" and "Act 167 Designated Watersheds" for stormwater management purposes. Act 167 divided the Commonwealth into 29 subbasins and 357 designated watersheds. Butler County lies completely in the Ohio River Basin, but is tributary to two different subbasins: Allegheny River (From Kiskiminetas River to Confluence with Ohio River) and Beaver River (From Ohio State Line to Confluence with Ohio River). Butler County contains at least a portion of nine 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	Beaver River	Sullivan Run
		Breakneck Creek
		Wolf Creek
		Slippery Rock Creek
		Connoquenessing Creek
	Allegheny River	Buffalo Creek
		Bull Creek
		Deer Creek
		Allegheny River (Direct Discharge)

Table 3.8. Classification of Butler County Watersheds

ACT 167 DESIGNATED WATERSHEDS

Most of Butler County (72.6%) is in the Beaver River Subbasin with the eastern edge of the county draining to the Allegheny River Subbasin. No previous Act 167 Stormwater Management Plans have been completed for any of the nine Act 167 Designated Watersheds in the county. *Figure 3.4* shows the Act 167 Designated Watersheds.

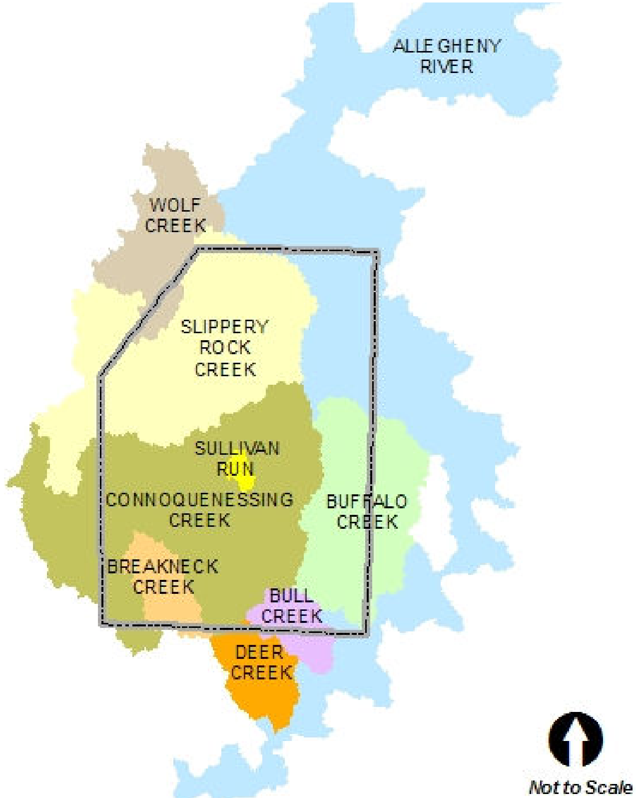


Figure 3.4. Act 167 Watersheds in Butler County

<u>Connoquenessing Creek Watershed</u>

The Connoquenessing Creek Watershed covers the southwest quadrant of Butler County. It drains an area of approximately 382 square miles, of which 296 square miles are located in Butler County. *Table* 3.9 details the municipalities at least partially in the watershed, and their contributing area:

Watershed	Municipality	Area (mi²)
Connoquenessing Creek	Adams Township	5.6
	Butler Township	18.6
	Center Township	20.6
	City of Butler	1.2
	Clay Township	1.7
	Clearfield Township	1.1
	Clinton Township	4.9
	Concord Township	10.9
	Connoquenessing Borough	1.4
	Connoquenessing Township	23.1
	Cranberry Township	17.0
	Donegal Township	1.5
	East Butler Borough	1.0
	Forward Township	19.0
	Franklin Township	7.5
	Harmony Borough	0.4
	Jackson Township	13.7

Jefferson Township	18.5
Lancaster Township	23.2
Middlesex Township	20.7
Muddycreek Township	11.0
Oakland Township	22.7
Penn Township	24.1
Portersville Borough	0.5
Prospect Borough	3.1
Saxonburg Borough	0.6
Seven Fields Borough	<0.1
Summit Township	20.1
Zelienople Borough	2.0

Table 3.9. Connoquenessing Creek Watershed

The headwaters of the Connoquenessing Creek are in Butler County, and it flows westward into Beaver County en route to its confluence with the Beaver River. The watershed encompasses the Sullivan Run Watershed and the Breakneck Creek Watershed, but they are considered separately from Connoquenessing Creek for Act 167 purposes.

The Connoquenessing Creek Watershed (including its tributary watersheds: Slippery Rock Creek, Wolf Creek, Sullivan Run, and Breakneck Creek) was studied in detail as part of this Plan. One result of that study was the establishment of Stormwater Management Districts. 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.

Only one small section of the watershed in the southern part of the county meets the above criteria for applying release rates. The hydrologic study of the Connoquenessing Creek Watershed is reviewed in detail in *Section VI – Technical Analysis – Modeling.*

<u>Buffalo Creek Watershed</u>

The Buffalo Creek Watershed is located along Butler County's eastern border. Buffalo Creek flows eastward into Armstrong County where it discharges into the Allegheny River. It drains an area of approximately 171 square miles, of which 102 square miles are located in Butler County. *Table 3.9* details the municipalities at least partially in the watershed, and their contributing area:

Watershed	Municipality	Area (mi²)
Connoquenessing Creek	Buffalo Township	16.6
	Chicora Borough	0.5
	Clearfield Township	22.4
	Clinton Township	2.7
	Concord Township	< 0.1
	Donegal Township	21.5
	Fairview Township	5.7
	Jefferson Township	4.9
	Oakland Township	0.4
	Saxonburg Borough	0.2
	Summit Township	2.2
	Winfield Township	24.5
	Buffalo Township	16.6
	Chicora Borough	0.5
	Clearfield Township	22.4
	Clinton Township	2.7

Table 3.10. Buffalo Creek Watershed

The Buffalo Creek Watershed was studied in detail as part of this Plan, but none of the subwatersheds met the criteria for applying Stormwater Management Districts. The hydrologic study of the Buffalo Creek Watershed is reviewed in detail in *Section VI – Technical Analysis – Modeling.*

IMPOUNDMENTS

There are numerous dams and impoundments scattered throughout Butler 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 are negligible. Any impoundments that exceed the above parameters can be considered "flood control dams" for the purpose of this Plan.

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

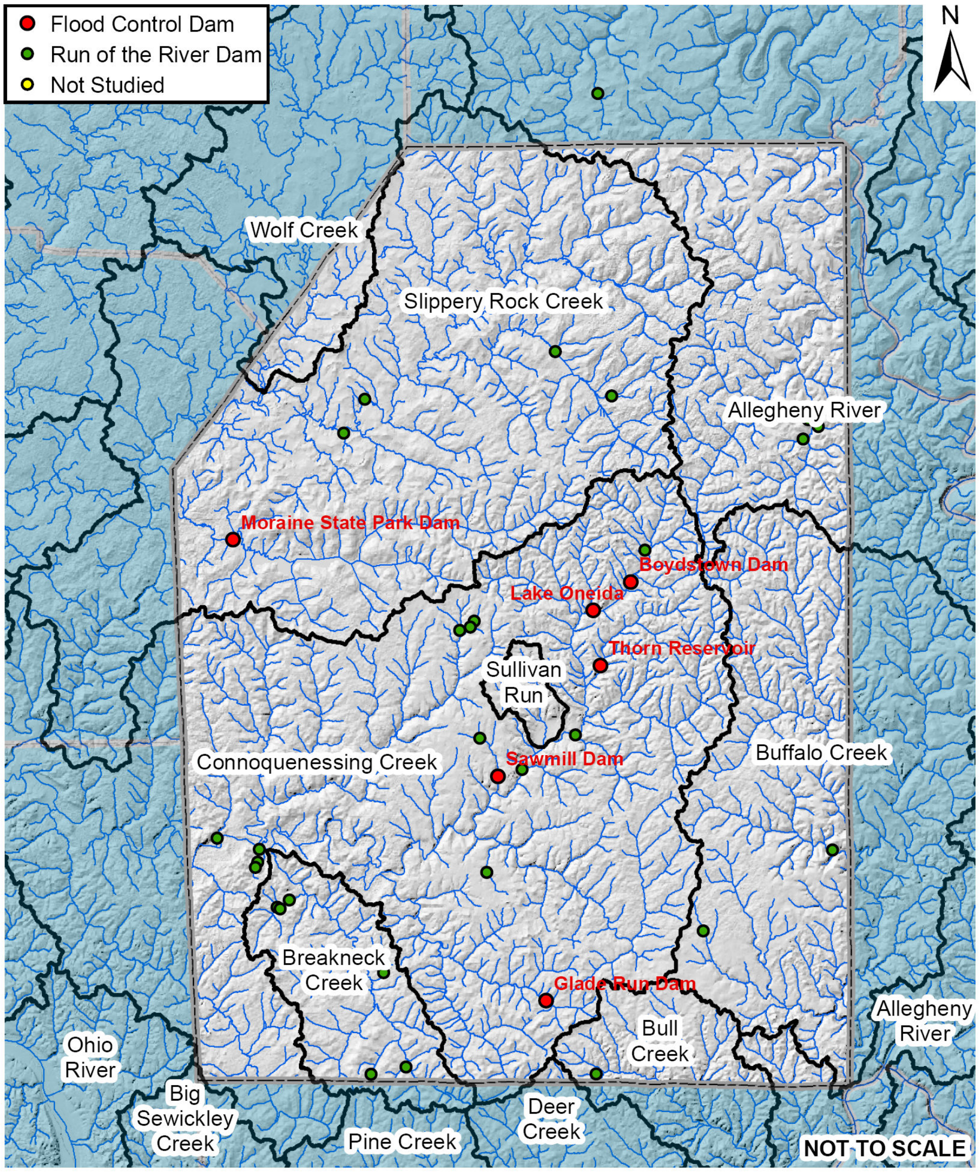


Figure 3.5. Butler County Impoundments

SURFACE WATER QUALITY

Water Quality Standards for the Commonwealth are addressed in *The Pennsylvania Code, Title 25, Chapter 93*. In 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 or Exceptional Value waters and are among the most valuable surface waters in 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*.

Butler County streams are shown with their Chapter 93 protected use classification in *Figure 3.5* 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*.

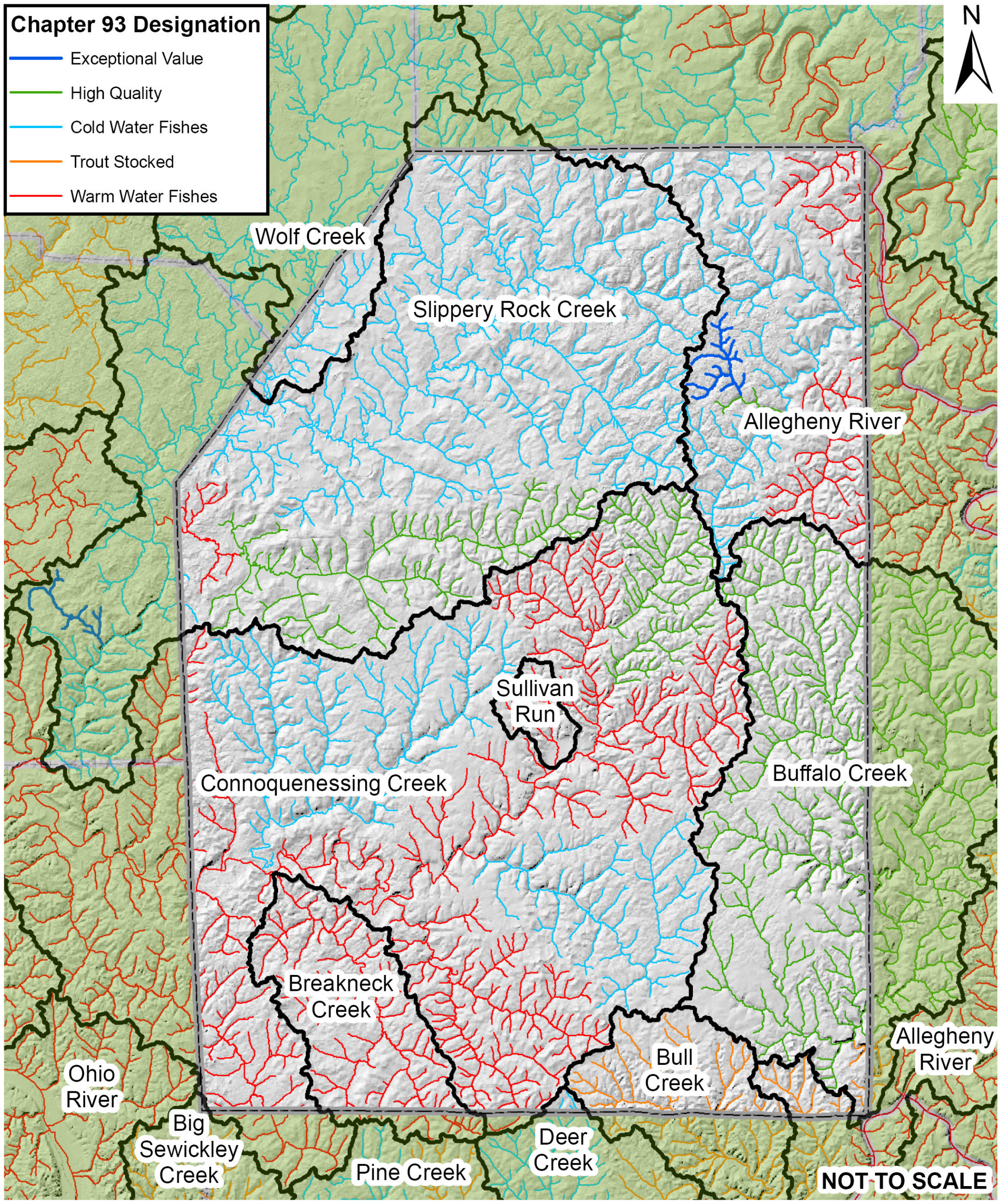


Figure 3.4. Chapter 93 Classification of Butler County Streams

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 1 percent 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 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 3.11* summarizes the findings from this study.

Storm Event	Number of Buildings at Least Moderately Damaged	Total Economic Loss
10	107	$61 million
50	127	$97 million
100	128	$113 million

Table 3.11. Potential Impact Due to Flooding (PEMA, 2009)

Detailed Studies

There are various levels of detail in floodplain mapping. Detailed studies (Zones AE and A1-A30 on the floodmaps) 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 3.5* 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 within the flood fringe is usually allowed but most new construction is required to be designed for flooding (floodproofing, adequate ventilation, etc).

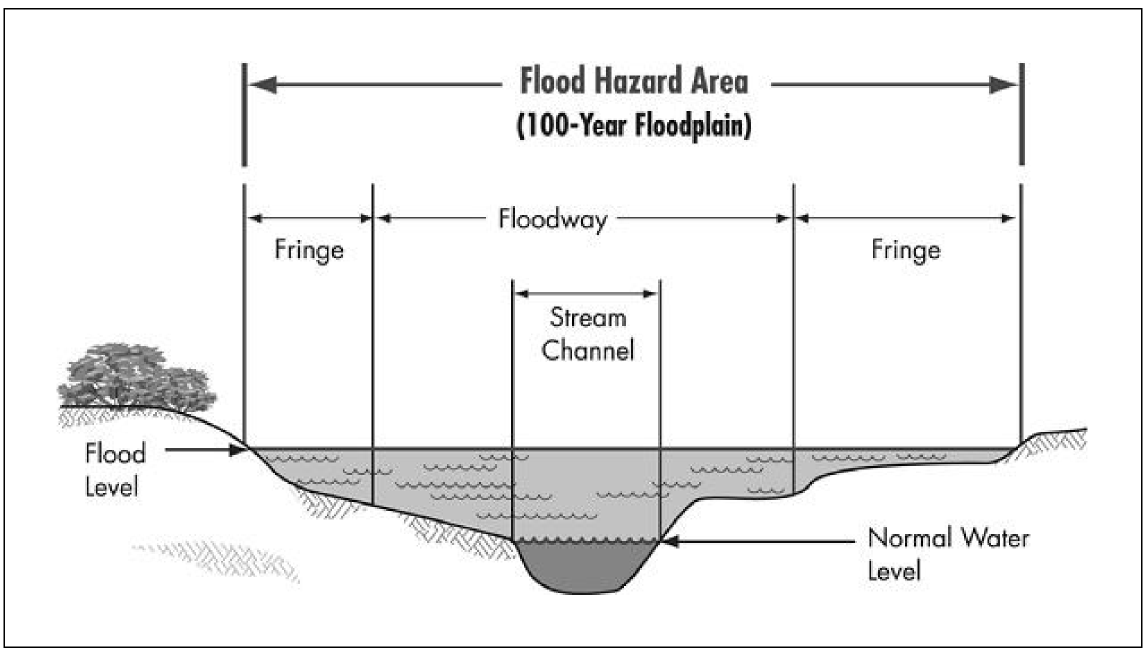


Figure 3.5. Floodplain Cross Section and Flood Fringe (NH Floodplain, 2007)

A review of the Preliminary Flood Insurance Study for Butler County revealed that Butler 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 locations indicated in *Table 3.12*.

Waterbody	Source
Bonnie Brooke	Approximately 0.3 mile downstream of East Butler Road to approximately 0.6 mile upstream of East Butler Road.
Breakneck Creek	Confluence with Connoquenessing Creek to approximately 120 feet upstream of Three Degree Road.
Brush Creek	Approximately 0.7 mile downstream of Powell Road to approximately 0.8 mile upstream of Commonwealth Drive.
Buffalo Creek	Confluence with Allegheny River to approximately 815 feet upstream of the railroad.
Butcher Run	Confluence with Connoquenessing Creek to approximately 0.4 mile upstream of William Flynn Highway.
Coal Run above Brush Creek	Confluence with Brush Creek to approximately 0.3 mile upstream of Canterbury Trail.
Coal Run above Connoquenessing Creek	Confluence with Connoquenessing Creek to approximately 700 feet upstream of Zeigler Avenue.
Connoquenessing Creek	Approximately 0.7 mile downstream of New Castle Street to approximately 0.9 mile upstream of Franklin Glass Access Road, and from just upstream of Armco Plant Road to approximately 150 feet upstream of Pine Tract Road.
Glade Run	Approximately 1.0 mile downstream of Sheldon Road to just upstream of the Glade Lake Dam.
Little Bull Creek	Approximately 0.8 mile downstream of Hranica Road to approximately 0.3 mile downstream of Hranica Road.
Little Connoquenessing Creek	Confluence with Connoquenessing Creek to approximately 0.4 mile upstream of Little Creek Road.
Scholars Run	Confluence with Connoquenessing Creek to approximately 0.7 mile upstream of Fanker Road.
Shanks Hollow Run	Confluence with Sullivan Run to approximately 400 feet upstream of Wicks Street.
Shearer Run	Confluence with Connoquenessing Creek to approximately 0.4 mile upstream of Shearer Road.
South Branch Bear Creek	Approximately 1000 feet downstream of the railroad to approximately 500 feet upstream of Nesbit Street.
Sullivan Run	Confluence with Connoquenessing Creek to approximately 0.3 mile upstream of North 6th Avenue.

Table 3.12. Detailed Method Studies

<u>Approximate Studies and Non-delineated Floodplains</u>

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 limitation of FIRMs and older Flood Insurance Rate Maps is the false sense of security provided to home owners 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.

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

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 1-percent-annual-chance flood. If the levee cannot be certified as providing protection from the 1-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 is one levee project in Butler County:

Project (Year Constructed)	Owner	Waterbody	PAL Levee Status
City of Butler (1966)	**Connoquenessing Creek Flood Control Authority**	**Connoquenessing Creek**	**N/A**

Table 3.15. Levee Systems in Butler County

Community Rating System (CRS)

To reduce flood risk beyond what is accomplished through the minimum federal standards, the NFIP employs the Community Rating System 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 Butler 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. Butler 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

Pennsylvania 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 the National Pollutant Discharge Elimination System (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 Total Mass Daily Loads (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 5 acres or more or for areas of 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 Butler 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 <u>and</u> additional criteria defined in §93.4b.(b)

Table 4.3. Chapter 93 Designations in Butler 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 a new, or additional, point discharge 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 from 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 Butler County as defined by §93.9. The majority of watersheds in Butler County have watershed designated as cold 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 Pennsylvania 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 Q – Allegheny River Basin, Tunungwant Creek to Clarion River	
Lowrey Run	WWF
Drainage List S – Allegheny River Basin, Clarion River to Kiskiminetas River	
North Branch Bear Creek	CWF
Rays Run	CWF
Silver Creek (LR 10079 Bridge at Walley Mill to Mouth)	HQ-CWF
Silver Creek (source to LR 10079 (SR 1004) Bridge at Walley Mill)	EV
South Branch Bear Creek	WWF
UNT to Bear Creek	CWF
Drainage List U – Allegheny River Basin, Kiskiminetas River to Monongahela River	
Buffalo Creek (Little Buffalo Creek to mouth)	TSF
Buffalo Creek (Little Buffalo Run to Little Buffalo Creek)	HQ-TSF
Buffalo Creek (Source to Little Buffalo Run)	HQ-CWF
Little Buffalo Creek	HQ-TSF
Drainage List W – Confl. of Monongahela and Alleg. Rivers to PA-OH State Border	
Bonnie Brook	WWF
Breakneck Creek	WWF
Brush Creek	WWF

Butcher Run	WWF
Camp Run	WWF
Coal Run	WWF
Connoquenessing Creek (source to Oneida Dam)	HQ-WWF
Doe Run	WWF
Glade Run	WWF
Hazen Run	WWF
Little Connoquenessing Creek	CWF
Muddy Creek (source to Moraine State Park Dam)	HQ-CWF
Muntz Run	WWF
Pine Run	WWF
Rocklick Run	WWF
Sawmill Run	WWF
Scholars Run	WWF
Stony Run	WWF
Sullivan Run	WWF
Thorn Creek	CWF
Thorn Creek (source to Thorn Dam)	HQ-WWF
Thorn Creek (Thorn Dam to mouth)	WWF
UNT to Connoquenessing Creek (Oneida Dam to mouth)	WWF

Table 4.4. Butler 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 4.3* provides a summary of existing regulations for Butler County's 57 municipalities.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Adams Twp	No	Yes	Yes	Yes
Allegheny Twp	No	No (County)	No	No
Brady Twp	No	Yes	Yes	No
Bruin Boro	No	No (County)	No	No
Buffalo Twp	Yes	Yes	Yes	Yes
Butler City	No	No (County)	Yes	No
Butler Twp	No	Yes	Yes	Yes
Callery Boro	No	Yes	Yes	No
Center Twp	No	Yes	Yes	Yes
Cherry Twp	No	No (County)	No	No
Cherry Valley Boro	No	No (County)	No	No
Chicora Boro	No	No (County)	No	No
Clay Twp	No	Yes	No	No
Clearfield Twp	No	Yes	No	Yes
Clinton Twp	Yes	Yes	Yes	No
Concord Twp	No	No (County)	No	No
Connoquenessing Bor	No	Yes	Yes	No
Connoquenessing Twp	Yes	Yes	No	Yes

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Cranberry Twp	Yes	Yes	Yes	Yes
Donegal Twp	No	Yes	No	No
East Butler Boro	No	No (County)	Yes	Yes
Eau Claire Boro	No	No (County)	No	No
Evans City Boro	No	No (County)	No	Yes
Fairview Boro	No	No (County)	No	No
Fairview Twp	No	No (County)	No (County)	No
Forward Twp	No	Yes	No	No
Franklin Twp	Yes	Yes	Yes	No
Harmony Boro	Yes	Yes	Yes	Yes
Harrisville Boro	No	No (County)	No (County)	No
Jackson Twp	Yes	Yes	Yes	No
Jefferson Twp	No	Yes	No	No
Karns City Boro	No	No (County)	No	No
Lancaster Twp	No	Yes	Yes	No
Marion Twp	No	Yes	No	No
Mars Boro	No	Yes	Yes	No
Mercer Twp	Yes	No (County)	No (County)	No
Middlesex Twp	No	Yes	Yes	No
Muddy Creek Twp	No	Yes	No	No
Oakland Twp	No	Yes	No	No
Parker Twp	No	No (County)	No (County)	No
Penn Twp	Yes	Yes	Yes	Yes
Petrolia Boro	No	No (County)	No	No
Portersville Boro	No	No	Yes	No
Prospect Boro	No	Yes	Yes	Yes
Saxonburg Boro	No	Yes	Yes	No
Seven Fields Boro	Yes	Yes	Yes	No
Slippery Rock Boro	No	Yes	Yes	No
Slippery Rock Twp	No	Yes	Yes	No
Summit Twp	No	Yes	Yes	Yes
Valencia Boro	No	No (County)	No	Yes
Venango Twp	No	No (County)	No	No
Washington Twp	No	No (County)	No	No
West Liberty Boro	No	Yes	No	No
West Sunbury Boro	No	No (County)	No	No
Winfield Twp	No	Yes	Yes	Yes

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Worth Twp	No	Yes	No	No
Zelienople Boro	No	Yes	Yes	No

Table 4.3. Butler County Municipal Ordinance Matrix

Table 4.4 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 in each ordinance.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
Adams Township	No separate ordinance found. Addressed in SALDO.	Article V, section 504 & 508 addresses Storm Drainage requirements, impoundments, and erosion and sedimentation control measures.	Defines floodplain, floodway & flood fringe.	Article IX defines wetlands, floodway delineation, flood plain restrictions & slope requirements.
Allegheny Township	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Brady Township	Article VII addresses roadway drainage, post < or = to pre construction runoff, compliance with Act 167, detention facilities, & compliance with PENNDOT standards.	Article VII addresses roadway drainage, post < or = to pre construction runoff, compliance with Act 167, detention facilities, & compliance with PENNDOT standards.	No SW reference found.	No separate ordinance found.
Bruin Borough	No separate ordinance found. Addressed in SALDO.	No ordinance. Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Buffalo Township	SWM Ordinance #112, is comprehensive which includes requirements for E&S control, water quality, infiltration, BMP, calculations, inspections, maintenance, easements, roof drains and enforcement.	Article IV refers to compliance with SWM ordinance #112, township grading ordinance, and DEP regulations for SW.	Article V addresses compliance with township standards, and requires plan approval by townships engineers.	FM ordinance #56 with amendments 1, 2, & 3 define floodplain, setback requirements, flood proofing, design & construction standards of SW facilities and existing conditions.
Butler City	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	Chapter 148 addresses groundwater regulations. Chapter 231 regulates SW prohibitions, E&S control, post < or = to pre construction runoff, BMP, and enforcement. Chapter 254 regulates waterway contamination & dangerous obstructions.	No separate ordinance found.
Butler Township	No separate ordinance found. Addressed in SALDO.	Article V, Chapter 252, addresses flood prone areas, E & S plan, grading drainage and SWM.	Chapter 300; definitions	Chapter 183 addresses Flood plain areas, technical provisions, existing structures,

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
				elevations, setbacks, flood proofing, design and construction standards. Chapter 188 regulates grading & excavating, maintenance, E & S, drainage facilities, and flood plain management.
Callery Borough	No separate ordinance found. Addressed in SALDO & Zoning.	Article VI addresses SW easements, natural water courses, storm drainage, SW control measures design, use of "Urban Hydrology for Small Watersheds", continuing maintenance, E & S control, submittal of an approved plan, and inspection. Appendix A-22; Roof drain sump detail.	Section 513 regulates site grading, SW handling, SW retention vessels, assistance from BC Conservation District, and post < or = to pre construction runoff.	No separate ordinance found except restriction of building in the 100 year floodplain.
Center Township	No separate ordinance found. Addressed in SALDO.	Section 14-803, addresses grading & drainage requirements, on-lot SW detention sump, SW management facilities, runoff, storm drains, natural water courses, and compliance with PA DER E & S Control Handbook.	No SW reference found.	Chapter 2, Article 5 addresses Floodplain regulations.
Cherry Township	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Cherry Valley Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Chicora Borough	Ordinance # 255 addresses SW handling as part of the building permit process, and borough Engineer approval. Post < or = to pre construction runoff.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Clay Township	No separate ordinance found. Addressed in SALDO.	Section 104.3 addresses drainage easements, E & S control DEP permitting, drainage, natural water courses, and 15' min dia pipes.	None	No separate ordinance found.
Clearfield Township	No separate ordinance found. Addressed in SALDO.	Section 500 addresses drainage easements, storm drainage, detention, plan submittal, post < or = to pre construction runoff, design stds, use of "Urban Hydrology for Small Watersheds", E & S control, wetland conservation, and future maintenance.	None	Ordinance 06-91-01 regulates flood plain requirements & resolution 77-03-01 addresses flood zone rules, delineation and management.
Clinton Township	Ordinance #90-01/95-03 requires a SW plan, and	Section 4.0 addresses drainage easements and	FN Article IX identifies 100 year floodplain	Addressed in Zoning Ordinance.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
	addresses construction stds, retention, permit procedure, review & penalties.	E&S control. Section 5.0 requires adherence to SW ordinance #95-03.	areas, flood elevations, technical requirements, dangers, MH park requirements, floodplain restrictions, existing structures, variances and definitions.	
Concord Township	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Connoquenessing Borough	No separate ordinance found. Addressed in SALDO.	Section 22-609 SW, standards of compliance w/ Act 167, plan approved by the Boro Engineer, location, materials, maintenance, fees, and provision to transfer ownership to the boro. Section 22-617 addresses E&S control. Appendix A has design specifications for SW facilities.	Section 27-1002 addresses drainage requirements, retention and collection.	No separate ordinance found.
Connoquenessing Township	Chapter 26, SWM definitions, plan submission, building permit, local standards, reduction measures, SW runoff delaying, penalties & enforcement.	Section 908, Storm Drainage & Facilities, Twp engineer specified, location & standards of construction, plan submission for approval. Section 912, E & S control.	None	Chapter 8 includes administration, identification, technical requirements, special permitting, existing structures, and definitions.
Cranberry Township	Section 87.402, SWM Public & Private, facilities, specifications & details	Section 96.614 Grading, E & S control. Section 96.617 SWM facilities, conform with Act 167, post < or = to pre construction runoff, subsurface drainage, storm sewers, minimum pipe size, roof & foundation drains, detention, fees maintenance, easements and access.	Section 108, steep slope limitations, impervious surfaces, floodplain areas, and regulations.	SALDO section 96.620, prohibited development in floodplain.
Donegal Township	No separate ordinance found. Addressed in SALDO.	Chapter 17, Storm Sewer specifications.	None	No separate ordinance found.
East Butler Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	Article 10, Site Development rules for drainage & flood prone areas.	Ordinance prohibits all new construction & development in the floodplain.
Eau Claire Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Evans City Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	Ordinance 388 restricts new construction & development in areas subject to flooding.
Fairview Borough	No separate ordinance found. Addressed in	Regulated by the County SALDO.	None	No separate ordinance found.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
	SALDO.	Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.		
Fairview Township	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None Addressed by County	No separate ordinance found.
Forward Township	No separate ordinance found. Addressed in SALDO.	Section 505, Storm Sewer specifications.	No SW reference found.	No separate ordinance found.
Franklin Township	Ordinance #38, comprehensive SWM regulations.	Section 505 Storm sewer specifications.	No SW reference found.	No separate ordinance found.
Harmony Borough	Ordinance #303, Chapter 8, codification.	Section 609 SWM compliance with Act 167, and comprehensive specifications.	Section 1001j, use of flood prone land, and compliance with ordinance # 303.	Chapters 8, codification, floodplain regulations, flood proofing measures, and building permits.
Harrisville Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None Addressed by County	No separate ordinance found.
Jackson Township	Ordinance dated 1996, general requirements, definitions, standards, BMP, maintenance and administration.	Part 6, section 22-6089, SWM & Floodplain controls, compliance with Twp SW ordinance, building on floodplain, storm drainage, and E & S controls.	Part 15, Floodplain overlay district, identification, standards, specifications, and requirements.	No separate ordinance found.
Jefferson Township	No separate ordinance found. Addressed in SALDO.	Part 4, Identification of floodplain, Part 5, technical provisions, Part 6 special permitting, Part 7 Existing structures in the floodplain, and Part 8 Variances.	None	No separate ordinance found.
Karns City Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Lancaster Township	No separate ordinance found. Addressed in SALDO.	Ordinance #86, requires plan approval and PENDOT form 408. Storm sewer, facility requirements, and standards for MH parks.	No SW reference found.	No separate ordinance found.
Marion Township	No separate ordinance found. Addressed in SALDO.	Section 700, Storm sewers, grading storm drainage, easements, SW facilities, and floodplain restrictions.	None	No separate ordinance found.
Mars Borough	No separate ordinance found. Addressed in SALDO.	Section 100, Storm drainage, county regulations, DEP regulations, and, post < or = to pre construction runoff.	No SW reference found.	No separate ordinance found.
Mercer Township	Ordinance #34, Requires building permit, SW plan, Co. Conservation District approval, and adopts "Urban Hydrology for Small Watersheds.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None Addressed by County	No separate ordinance found.
Middlesex	No separate ordinance found. Addressed in	Ordinance # 96, compliance, prohibits	Ordinance 21, sections 1100 & 1200,	No separate ordinance found.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
Township	SALDO.	construction that would increase flood height, development criteria, and MH park grading requirements.	min. area for a SW facility, prohibits mineral removal from flood prone land, grading, standing water, and plan submission.	
Muddy Creek Township	No separate ordinance found. Addressed in SALDO.	Section 500 grading, easements, storm drain lines, plan submission, and prohibits MH park in a floodplain.	None	No separate ordinance found.
Oakland Township	No separate ordinance found. Addressed in SALDO.	Section 19, plan submission, specifications, and SWM plan for MH parks.	No SW reference found.	No separate ordinance found.
Parker Township	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None Addressed by County	No separate ordinance found.
Penn Township	Ordinances #97-112, SW plan submission, requirements, standards, and review by Co. Conservation district.	Ordinance #119, prohibits MH park in a floodplain, and drainage of a MH park.	Ordinance #115, Article XII, No standing SW, post < or = to pre construction runoff, velocity, And compliance with Ord. 97-112.	Ordinance # 79, Article 3, building permits, plan submission, construction requirements, notification and approvals.
Petrolia Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Portersville Borough	No separate ordinance found. Addressed in SALDO.	No separate ordinance found.	Section 97, grading for SW drainage.	No separate ordinance found.
Prospect Borough	No separate ordinance found. Addressed in SALDO.	Chapter 22, section 500, prohibits development on flood prone land, SW requirements, construction standards, and protection of natural watercourses.	Chapter 27, part 5, drainage, facilities, and prohibits floodplain building.	Chapter 8, Part 4, prohibits floodplain development and provides variances.
Saxonburg Borough	No separate ordinance found. Addressed in SALDO.	Ordinance 405, requires SW be drained to streets, and plan review by township engineer.	Section 600, prohibits disturbance of natural drainage areas with in 100' of centerline.	No separate ordinance found.
Seven Fields Borough	Ordinance #67, Adopts DEP NPDES requirements for SW discharges.	Ordinance #30, section 602, requires flows be in accordance with sound engineering practices.	Ordinance #32, Sets requirements for floodplains & flood districts, and plan approval by borough engineer.	No separate ordinance found.
Slippery Rock Borough	No separate ordinance found. Addressed in SALDO.	Appendix B, Plan submission, calculation methods, 'No harm evaluation," and maintenance responsibilities.	No SW reference found.	No separate ordinance found.
Slippery Rock Township	Resolution 04-125, requires roadway drainage and construction standards.	Section 600 & 700, SW standards, compliance with PA SW management Act 167, drainage easements, existing watercourse drainage, and SW facilities specifications.	Section 400, Parking lot drainage, preservation of large trees for SW assistance, and compliance with SW resolution 04-125.	No separate ordinance found.
Summit Township	No separate ordinance	Chapter 22, section 103	Section 3 & 11,	Chapter 8, Permits, time

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT	ZONING	FLOODPLAIN MANAGEMENT
	found. Addressed in SALDO & Zoning.	#12, Storm drainage, approval by Twp. Engineer & Supervisors.	Building permits for SW facilities, storm drain system requirements, and performance bond requirements for SW facilities.	limits, inspections, identification of flood plain, technical requirements, standards, prohibited uses, and existing structures in the floodplain.
Valencia Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	Ordinance #203, Building permits, Co. Conservation District review, time limits, fees, floodplain management, minimization of flood damage, facility restrictions, and MH requirements,
Venango Township	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Washington Township	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
West Liberty Borough	No separate ordinance found. Addressed in SALDO.	Ordinance #91872B, Section 500 & 600, Floodplain regulations, and storm sewer construction.	None	No separate ordinance found.
West Sunbury Borough	No separate ordinance found. Addressed in SALDO.	Regulated by the County SALDO. Article VII addresses E&S control measures, storm drainage systems, storm water detention facilities, and drainage easements.	None	No separate ordinance found.
Winfield Township	Ordinance 97-03, Building permits, and plan submission requirements.	Section 1000 & 2000, Storm drainage effects, bonding, facility design, grading, easements, storm drains, and storm drain requirements.	No SW reference found.	Ordinance #982, Prohibits building in a floodplain.
Worth Township	Ordinance 04-08-98-02, Requires building permits, construction not to affect runoff, plan submission, Adhere to "Urban Hydrology for small watersheds," and standards for design.	Sections 500 to 1000, Requirements for Drainage E & S control plan, compliance with Act 167, no standing SW, easements, facilities, proper Sw devices, plan submission, and conservation buffer requirements.	None	No separate ordinance found.
Zelienople	No separate ordinance found. Addressed in SALDO & Zoning.	Section 900 & 1000, Storm sewer requirements, and detention facility requirements.	Section 609, Floodplain district identification, building permit requirement, natural watercourse preservation, new construction rules, storm drain functions, and infiltration.	No separate ordinance found.

Table 4.4. 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 of those plans, provides invaluable information for current and future planning efforts. The following table is a summary of related plans:

PLAN TITLE	*DATE*	*AUTHOR*
The County of Butler Comprehensive Plan	2002	Butler County Planning Commission
Connoquenessing Creek Watershed: Nomination for Critical Water Planning Area Under Pennsylvania State Water Plan	August 2009	Pennsylvania Department of Environmental Protection

Table 4.5. Related Plans Review

Section V – Significant Problem Areas and Obstructions

One 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 than evaluation of the identified problem areas and obstructions.

The first task was to identify the location and nature of existing drainage problems within 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 Butler County Stormwater Management Plan. This tasks was not completed as part of the Plan due to funding difficulties with Act 167 Program.

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 Butler County. The questionnaire enabled the municipalities to report all of the known problem areas and obstructions within their municipality. Of the 57 municipalities in Butler County, 36 participated in the assessment process by returning completed questionnaires. The responses were summarized and reported in the Phase I report of this Plan. 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, obstructions, and structures are listed in *Table 5.1* on the following pages. A more detailed explanation of each site can be found in *Appendix C – Significant Problem Area Modeling and Recommendations*, which contains a summary of all of the data collected for each of the problem areas and obstructions reported throughout the county.

Section V – Significant Problem Areas and Obstructions

ID	Municipality	Location	Description
P1	Clinton Twp.	Wylie Rd South of Elm Ln	Bank Erosion
P2	Clinton Twp.	Anderson Rd	Flooding Water, Erosion
P3	Clinton Twp.	Callen Rd	Erosion
P4	Clinton Twp.	Ivywood Rd at Brewer Rd	Water Ponding
P5	Clinton Twp.	Deer Creek before Jack Rd	Erosion
P6	Clinton Twp.	Tower Rd (2 Locations)	Road Surface Sinking
P7	Clinton Twp.	Westminster Rd near Rt 228	Water Ponding
P8	Clinton Twp.	Miller Rd near Brewer Rd	Water Ponding
P9	Clinton Twp.	Goldscheitter Rd near Stark Rd	2 Undersized Pipes
P10	Clinton Twp.	Victory Rd	Erosion
P11	Clinton Twp.	Lardintown Rd South of Rt 228	Flooding
P12	Clinton Twp.	Saxonburg Blvd	Unapproved Driveway Blocking Flow
P13	Concord Twp.	Manuel Rd	Low Lying Area
P14	Concord Twp.	Kuhn Rd	Excess Runoff
P15	Concord Twp.	Kauf Rd	Excess Runoff
P16	Concord Twp.	Stoops Rd	Flooding
P17	Concord Twp.	Campbell Rd	Excess Runoff
P18	Concord Twp.	Cartwright Rd	Excess Runoff
P19	Valencia Boro.	Three Degree Rd	Flow Restrictions at Bridge
P20	Valencia Boro.	Breakneck Creek	Increase in Flow
P21	Penn Twp.	Creek Rd in Village of Renfrew	Flooding
P22	Penn Twp.	Behind Houses in Village of Renfrew	Excess Runoff
P23	Penn Twp.	Village of Renfrew East of Hicks	Road Flooding
P24	Penn Twp.	McBride St at Rt 8	Excess Runoff
P25	Penn Twp.	Beacon Rd West of Meadowbrook	Excess Runoff
P26	Penn Twp.	Winters Rd	Excess Runoff
P27	Penn Twp.	Mushrush Rd at Crisswell Rd	Excess Runoff
P28	Penn Twp.	Morgan Rd	Erosion
P29	Penn Twp.	Golden City at Twp. Line	Erosion
P30	Penn Twp.	N. Dutchtown	Excess Runoff
P31	Penn Twp.	Stone Quarry	Excess Runoff, Sediment Build-up
P32	Penn Twp.	Brownsdale Rd to Orchard Rd	Flooding
P33	Penn Twp.	Hamel Rd	Erosion
P34	Penn Twp.	Meridian North of Smith	Excess Runoff
P35	Penn Twp.	Crowe Rd	Excess Runoff, Erosion
P36	Penn Twp.	Church Rd	Excess Runoff, Erosion
P37	Penn Twp.	Rockdale Rd	Erosion
P38	Penn Twp.	Royal Oak Dr	Erosion
P39	Jackson Twp.	Peters Cove / Hartman Rd	Flooding
P40	Jackson Twp.	Evergreen Mill Rd	Flooding
P41	Jackson Twp.	Village Acres	Flooding
P42	Callery Boro.	Kline Rd	Erosion
P43	Callery Boro.	Main St Extension	Undersized Pipes
P44	Callery Boro.	Kline Rd – Mars/Evans City area	Flooding, Bank Erosion
P45	Callery Boro.	Center St	Flooding, Bank Erosion
P46	Cherry Twp.		Runoff/Erosion
P47	Cherry Twp.		Ponding/Flooding
P48	Cherry Twp.		Runoff/Erosion
P49	Cherry Twp.		Runoff/Erosion
P50	Cherry Twp.		Ponding/Flooding
P51	Cherry Twp.		Undersized Culvert
P52	Cherry Twp.		Streambank Erosion
P53	Cherry Twp.		Runoff/Erosion
P54	Franklin Twp.	Grindel Rd near Miller Ln	Stream Overflows
P55	Franklin Twp.	Unionville Rd near County Club Rd	Stream Overflows
P56	Franklin Twp.	Country Club Rd near Boys Club	Stream Overflows
P57	Franklin Twp.	Swamp Run Rd near Chestnut Ridge Rd	Stream Overflows

ID	Municipality	Location	Description
P58	Franklin Twp.	Ridge Rd near Hewitt Ln	Stream Overflows
P59	Franklin Twp.	W. Old Rt 422 near Franklin Village	Stream Overflows
P60	Jefferson Twp.	Multiple Locations	Undersized Pipes
P61	Mercer Twp.	Harmony Rd	Stream Overflows
P62	Mercer Twp.	Wick Rd	Erosion
P63	Mercer Twp.	Creek	Stream Overflows
P64	Mercer Twp.	Rt 8	Erosion at Railroad Underpass
P65	Mercer Twp.		Ditch Erosion
P66	Mercer Twp.		Ditch Erosion
P67	Mercer Twp.		Property Flooding
P68	City of Butler	City Storm Sewer System	Hydraulically Overloaded
P69	City of Butler	City Storm Sewer System	Obstruction of Pipes
P70	City of Butler	City Storm Sewer System	Undersized Culvert
P71	City of Butler	City Storm Sewer System	Stream Overflow
P72	City of Butler	City Storm Sewer System	Unknown System
P73	City of Butler	City Storm Sewer System	Deep Crossovers
P74	City of Butler	City Storm Sewer System	Ponding
P75	City of Butler	City Storm Sewer System	Ponding
P76	City of Butler	City Storm Sewer System	Stream Beneath Home
P77	City of Butler	City Storm Sewer System	Stream Overflows
P78	City of Butler	City Storm Sewer System	Stream in Poor Condition
P79	City of Butler	City Storm Sewer System	Erosion
P80	City of Butler	City Storm Sewer System	Subsidence
P81	Harmony Boro.	Spring St/First St	Flooding
P82	Harmony Boro.	Jackson St/Mercer St	Flooding
P83	Harmony Boro.	Jackson St/Mercer St	Flooding
P84	Harmony Boro.	Moose Front Yard	Flooding
P85	Harmony Boro.	Seneca Dr	Undersized Pipes
P86	Harmony Boro.	Wood St	Ponding
P87	Harmony Boro.	Various Locations	Streambank Erosion
P88	Harmony Boro.	Creekside Manor	Flooding
P89	Harmony Boro.	Harmony Heights Dr	Detention Pond
P90	Harmony Boro.	Spring St	Stormwater Issues
P91	Harmony Boro.	Division St between Center/Beaver St	Flooding
P92	Harmony Boro.	Various Locations	Undersized Catch Basins
P93	Cherry Valley Boro.	Porter Rd	Flooding
P94	Cherry Valley Boro.	Oneida Valley Rd near Borchert Rd	Flooding
P95	Cherry Valley Boro.	Oneida Valley Rd near Young Ln	Flooding
P96	Brady Twp.	Beatty Rd	Undersized Culvert
P97	Brady Twp.	Various Locations in Twp.	Culvert Replacement
P98	Brady Twp.	Alexander Rd	Debris in Culvert
P99	Brady Twp.	Turk Rd	Debris in Culvert
P100	Brady Twp.	Lindey Rd	Culvert Replacement
P101	Brady Twp.	McBride Rd	Culvert Replacement
P102	Evans City Boro.	Mahan Rd near South St	Restricted Stream Flow
P103	Evans City Boro.	N. Jackson St near Harmony Al	Ponding in Streets
P104	Evans City Boro.	N. Jackson St	Ponding in Streets
P105	Evans City Boro.	N. Washington St	Restricted Stream Flow
P106	Evans City Boro.	Near Pioneer Rd	Streambed Obstruction
P107	Summit Twp.	State Route 38	Flooding
P108	Summit Twp.	Kaiser Rd	Flooding
P109	Summit Twp.	Wendelin Rd	Flooding
P110	Summit Twp.	Herman Rd	Flooding
P111	Summit Twp.	Private Driveways	Flooding
P112	Summit Twp.	Stutz Rd	Sedimentation
P113	Summit Twp.	Stutz Rd	Sedimentation
P114	Summit Twp.	Saxonburg Rd	Flooding

ID	Municipality	Location	Description
P115	Summit Twp.	Shepard Ln	Flooding
P116	Muddy Creek Twp.	Yellowcreek Rd at Stanford Rd	Flooding
P117	Muddy Creek Twp.	Fisher Rd at Book Rd	Flooding
P118	Muddy Creek Twp.	Bloomfield School Rd	Erosion
P119	Muddy Creek Twp.	Cheeseman Rd	Mine Drainage
P120	Muddy Creek Twp.	Rt 19 North	Flooding
P121	Saxonburg Boro.	Carol Dr near Dinnerbell Rd	Flooding
P122	Saxonburg Boro.	Dinnerbell Rd	Flooding
P123	Saxonburg Boro.	Cooper Cabin Parking Lot	Flooding
P124	Saxonburg Boro.	Short St near Butler St	Flooding
P125	Saxonburg Boro.	South of Water St near Butler St	Flooding
P126	Saxonburg Boro.	Water St at Butler St	Flooding
P127	Saxonburg Boro.	Thelma Dr and N Isabella St	Flooding
P128	Saxonburg Boro.	North of Water St	Flooding
P129	Saxonburg Boro.	Constitution Ave at Thelma Dr	Flooding
P130	Saxonburg Boro.	Constitution Ave near Fisher Rd	Flooding
P131	Saxonburg Boro.	Aderhold Rd	Flooding
P132	Saxonburg Boro.	Aderhold Rd near Oakwood Ln	Flooding
P133	Prospect Boro.	Bearcreek Rd	Retention Pond
P134	Prospect Boro.	Prospect Pl	Retention Pond
P135	Prospect Boro.	Commercial Development	Lack of Retention
P136	Winfield Twp.	Long Run Rd	Scouring
P137	Winfield Twp.	Little Buffalo Stream	Erosion
P138	Winfield Twp.	Winfield Rd	Erosion
P139	Winfield Twp.	Brose Rd	Erosion
P140	Winfield Twp.	Gerner Rd	Sediment Runoff
P141	Winfield Twp.	Moorehead Rd at Bauer Rd	Erosion
P142	Winfield Twp.	Cornplanter Stream	Sedimentation
P143	Winfield Twp.	Becker Rd	Sedimentation
P144	Winfield Twp.	Cabot Area of Little Buffalo Stream	Erosion
P145	Winfield Twp.	Rough Run Stream	Erosion
P146	Adams Twp.	Hespenheide Rd	High Detergents
P147	Adams Twp.	Mars/Evans City Rd near Hutchman Rd	Positive Coliform Count
P148	Adams Twp.	Naser Ln	Nitrate/Phosphate Contamination
P149	Adams Twp.	Breakneck Creek	Flooding
P150	Adams Twp.	Meredith Dr	Sedimentation
P151	Adams Twp.	Three Degree Rd	Flooding
P152	Adams Twp.	Sunset Ct	Erosion/Flooding
P153	Adams Twp.	Hespenheide Rd	Inadequate Storm Sewer System
P154	Mars Boro.	Spring Ave at Clarks Ln	Flooding
P155	Mars Boro.	Crowe Ave near Reserve Alley	Erosion
P156	Mars Boro.	Off Pittsburgh St near Gilkey Rd	Pipe Collapse
P157	Butler Twp.	Sylvan Dr to Pierce Ave	Flooding
P158	Butler Twp.	Havenhill Dr	Flooding
P159	Butler Twp.	Butler Rd from Ferguson Ave to Schaffner	Flooding
P160	Butler Twp.	Acre Ave from Whitestone to Rt 68	Flooding
P161	Butler Twp.	Valley St at E. Brady	Flooding
P162	Butler Twp.	Cupps Rd from Meredian Rd to Conn Twp	Flooding
P163	Butler Twp.	Plateau St	Flooding
P164	Butler Twp.	Clark Ave near Oliver Dr	Flooding
P165	Butler Twp.	Pittsburgh Pike Rd	Flooding
P166	Butler Twp.	Brady St near Delwood Rd	Flooding
P167	Butler Twp.	Colonial Ave to S. Duffy Rd	Flooding
P168	Butler Twp.	Willard Ave near Gregden Rd	Flooding
P169	Butler Twp.	Miller St near Highland Ave	Flooding
P170	Butler Twp.	Cecilia St near Hansen Ave	Flooding
P171	Butler Twp.	Sawmill Run Rd near Miller St	Flooding

ID	Municipality	Location	Description
P172	Butler Twp.	Bullcreek Rd near Green Manor Dr	Flooding
P173	Butler Twp.	Cottage Ave near Harrison Ave	Flooding
P174	Butler Twp.	Bellefield Rd near Beverly Rd	Flooding
P175	Butler Twp.	Evergreen St near Logan St	Flooding
P176	Butler Twp.	Meadow Ave near Evergreen St	Flooding
P177	Butler Twp.	Alameda Rd south of Rt 356	Flooding
P178	Butler Twp.	Thornwood Rd	Flooding
P179	Butler Twp.	S. Eberhary Rd	Flooding
P180	Butler Twp.	Bessermer Ave at Acton Rd	Flooding
P181	Harrisville Boro.	W. Prairie St	Flooding
P182	Forward Twp.	Horseshoe Ln at end of Wahl Rd	Flooding
P183	Forward Twp.	Needlepoint Rd	Erosion/Flooding
P184	Forward Twp.	Evans City Park Rd	Erosion/Flooding
P185	Forward Twp.	Community Park Rd at Needlepoint Rd	Insufficient Structures
P186	Forward Twp.	Ash Stop Rd	Flooding
P187	Forward Twp.	Ash Stop Rd near Spithaler Rd	Flooding
P188	Forward Twp.	Eckstein Rd	Flooding
P189	Forward Twp.	Glenwood Ave	Flooding
P190	Forward Twp.	Glade Run at Leisie Rd	Flooding
P191	Forward Twp.	John School Rd at Glade Run	Flooding
P192	Forward Twp.	Valencia Rd at Glade Run	Flooding
P193	Forward Twp.	Creek Rd near Renfrew	Flooding
P194	Forward Twp.	Old Rt 68 near Connoquenessing Ck	Flooding
P195	Middlesex Twp.	Sandy Hill Rd	Flooding
P196	Connoquenessing Boro.	Off Tulip Dr near Harmony St	Runoff
P197	Connoquenessing Boro.	Along Dogwood Ln	Runoff
P198	Center Twp.	Brewster Rd	Flooding
P199	Center Twp.	Moore Rd	Flooding
P200	Center Twp.	Rt 38 along Connoquenessing Creek	Flooding
P201	Donegal Twp.	Conerty Rd	Flooding
P202	Donegal Twp.		Flooding
P203	Donegal Twp.	Hickey Bottom Rd	Flooding
P204	Donegal Twp.	Rt 68 from Chicora to Bish Rd	Flooding
P205	Marion Twp.	Dematteis Rd along Slippery Rock Creek	Flooding
P206	Marion Twp.	Ray Rd along Slippery Rock Creek	Flooding
P207	Marion Twp.	Boyers Rd	Flooding
P208	Karns City Boro.		Acid Mine Drainage
P209	Karns City Boro.		Runoff
P210	Buffalo Twp.	Kepple Rd	Flooding
P211	Buffalo Twp.	Monroe Rd	Flooding
P212	Buffalo Twp.	Old Pike Rd	Acid Mine Drainage
P213	Parker Twp.		Flooding
P214	Parker Twp.		Flooding
P215	Parker Twp.		Flooding
P216	Parker Twp.		Acid Mine Drainage
P217	Parker Twp.		Flooding
P218	Parker Twp.		Poor Water Quality
P219	Parker Twp.		Flooding
P220	Parker Twp.		Flooding
P221	Clay Twp.		Flooding
P222	Clay Twp.		Flooding
P223	Clay Twp.		Flooding
P224	Clay Twp.		Flooding
P225	Clay Twp.		Flooding
P226	Clay Twp.		Flooding

ID	Municipality	Location	Description
P227	Clay Twp.		Flooding
P228	Washington Twp.		Flooding
P229	Washington Twp.		Flooding
P230	Washington Twp.		Flooding
P231	Washington Twp.		Flooding
P232	Washington Twp.		Flooding
P233	Slippery Rock Twp.	University Baseball Field	Overflowing Pond
P234	Bruin Boro.	Bear Creek	Flooding
P235	Bruin Boro.		Acid Mine Drainage
P236	Bruin Boro.		Runoff
P237	Bruin Boro.		Flooding
P238	Bruin Boro.	Post Office	Flooding
P239	Lancaster Twp.	Little Yellow Creek Rd	Flooding
P240	Lancaster Twp.	Yellow Creek Rd	Flooding
P241	Lancaster Twp.	Little Creek Rd	Flooding
P242	Lancaster Twp.	Little Creek Rd	Flooding
P243	Lancaster Twp.	Scott Ridge Rd at Victory Terrace Dr	Erosion
P244	Zelienople Boro.	W New Castle St near Market St	Undersized Pipe
P245	Zelienople Boro.	Fairlawn Blvd and Wayne Ave	Flooding
P246	Zelienople Boro.	Between E New Castle St and E Spring St	Flooding
P247	Zelienople Boro.	North View and Clay	Flooding
P248	Zelienople Boro.	Green Ln to New Castle St	Ponding
P249	Zelienople Boro.	Spruce St	Undersized Pipe
P250	Zelienople Boro.	Jefferson St at Beaver St	Flooding
P251	Zelienople Boro.	Beaver St between Main & Clay St	Ponding
P252	Zelienople Boro.	Hazel St	Flooding
P253	Zelienople Boro.	Pine St	Flooding
P254	Zelienople Boro.	Market St between Rt 68 & Chestnut St	Ponding
P255	Zelienople Boro.	Market St at Ziegler St	Ponding
P256	Zelienople Boro.	Peach St between McKim & Pine St	Ponding
P257	Zelienople Boro.	Park Ln between Short & Main St	Flooding
P258	Zelienople Boro.	Northview Dr between Short & Main St	Flooding
P259	Zelienople Boro.	Oliver Ave between Grandview & Maria	Erosion/Flooding
P260	Zelienople Boro.	Perry Way from Main to Boro Line	Flooding
P261	Zelienople Boro.	Division St between Beaver & Spring St	Ponding
P262	Zelienople Boro.	Spring St between Division & High St	Ponding
P263	Zelienople Boro.	New Castle St between Oliver & Main St	Ponding
P264	Zelienople Boro.	Main St between Grandview & Culvert	Flooding
P265	Zelienople Boro.	New Castle St between Main & Market St	Flooding
P266	Zelienople Boro.	Jefferson St between New Castle & Spring	Flooding
P267	Zelienople Boro.	Railroad Tracks between Rt 19 & Green Ln	Flooding
P268	Zelienople Boro.	Madison Dr between Rt 588 & Rt 288	Flooding
P269	Zelienople Boro.	Halstead Blvd between Grandview/NCastle	Undersized Ditches
P270	Zelienople Boro.	Peach St at Ziegler Ext	Ponding
P271	Zelienople Boro.	Walnut St between Green Ln & Front St	Flooding
P272	Zelienople Boro.	Rosewood Plan	Flooding
P273	Zelienople Boro.	Timberbrook Plan	Flooding
P274	Zelienople Boro.	Muntz Rd between Jackson Twp/Rt 68	Runoff/Erosion
P275	Zelienople Boro.	Benvenue Rd between Marion Twp/Rt 68	Runoff/Erosion
P276	Zelienople Boro.	Lower Areas of Boro near Conn. Creek	Flooding
P277	Slippery Rock Boro.	Intersection of Kelly Blvd & N Main St	Flooding
P278	West Sunbury Boro.	S Main St	Runoff
P279	West Sunbury Boro.	Washington St	Flooding/Runoff
P280	West Sunbury Boro.	Russell Ave at Washington St	Overflows
P281	West Sunbury Boro.	E Church St	Erosion
P282	Cranberry Twp.	Fox Run	Flooding

ID	Municipality	Location	Description
P283	Cranberry Twp.	Brookston	Flooding
P284	Cranberry Twp.	Powell & Holiday	Flooding
O1	Clinton Twp.	Wylie Rd near Elm Ln	Undersized 12" CMP
O2	Clinton Twp.	Stark Rd at Hidden Hill	Undersized 24" Concrete Pipe
O3	Clinton Twp.	Westminster Rd at Miller Rd	Undersized Concrete Pipe
O4	Clinton Twp.	Westminster Dr	Erosion
O5	Concord Twp.	Old State Rd	
O6	Penn Twp.	Dodds Rd at Rockdale Rd	Flooding
O7	Penn Twp.	McBride St at Rt 8	Undersized Facilities
O8	Penn Twp.	Rt 8	Water Ponding, Undersized Pipe
O9	Penn Twp.	Meridian Rd at Monroe	Undersized 36" Pipe
O10	Penn Twp.	N. Crisswell Rd	Stream Flooding
O11	Penn Twp.	Dodds Rd at Woodland	Undersized Pipes
O12	Penn Twp.	Anderson at Welsh	Undersized Pipes
O13	Penn Twp.	Robinson Run Rd	Driveway Runoff
O14	Penn Twp.	Plank Rd	Undersized 30" Pipe
O15	Jackson Twp.	Senns Bridge on Evergreen Mill Rd	Flooding at Bridge
O16	Callery Boro.	Elgin Ln	Undersized Pipes
O17	Callery Boro.	Breakneck St	Undersized, Deteriorating Pipes
O18	Franklin Twp.	Mt. Chestnut G.C. along Purvis Rd	Runoff, Undersized Pipe
O19	East Butler Boro.	Grant Ave	Bridge
O20	East Butler Boro.	Sherman Ave near Old E. Butler Rd	Bridge
O21	City of Butler	Sullivan Run	Flooding/Erosion
O22	City of Butler	City Storm Sewer System	Erosion
O23	City of Butler	City Storm Sewer System	Filled with Debris
O24	City of Butler	Sullivan Run	Bank Erosion
O25	City of Butler	West Penn St Bridge	Sediment Accumulation
O26	City of Butler	West Brady St Bridge	Sediment Accumulation
O27	City of Butler	West New Castle St Bridge	Sediment Accumulation
O28	City of Butler	West Cunningham St Bridge	Sediment Accumulation
O29	City of Butler	City Storm Sewer System	Undersized Pipes
O30	City of Butler	City Storm Sewer System	Undersized Pipes
O31	City of Butler	City Storm Sewer System	Siltation
O32	City of Butler	City Storm Sewer System	Siltation
O33	City of Butler	City Storm Sewer System	Clogged Pipes
O34	City of Butler	City Storm Sewer System	Clogged Pipes
O35	City of Butler	City Storm Sewer System	Obstructions
O36	Harmony Boro.	Germain St to Mercer St	Undersized 24" Pipe
O37	Clearfield Twp.	Various Locations throughout Twp.	Debris in Creek Beds
O38	Clearfield Twp.	Various Locations throughout Twp.	Maintaining Culverts
O39	Brady Twp.	Various Locations in Twp.	Obstructed Ditches
O40	Evans City Boro.	Jefferson St at S. Washington St	Bridge Obstruction
O41	Evans City Boro.	Along S. Washington St	Encroachment along Stream
O42	Summit Twp.	Osche Rd	Undersized Culverts
O43	Summit Twp.	Osche Rd	Undersized Culverts
O44	Summit Twp.	Star Grill Rd	Undersized Culverts
O45	Summit Twp.	Schnur Rd	Undersized Culverts
O46	Summit Twp.	Carbon Center Rd	Undersized Culverts
O47	Summit Twp.	McGrady Hollow Rd	Undersized Culverts
O48	Summit Twp.	Keck Rd	Sediment in Stream
O49	Summit Twp.	Keck Rd	Undersized Culverts
O50	Summit Twp.	Giebel Rd	Flooding
O51	Summit Twp.	Giebel Rd	Flooding
O52	Muddy Creek Twp.	Stanford Rd	Undersized Pipes
O53	Muddy Creek Twp.	Sawyer Rd	Undersized Pipes
O54	Muddy Creek Twp.	Baudermill Rd to Levis Rd	Undersized Pipes
O55	Muddy Creek Twp.	Stonechurch Rd	Undersized Pipes

ID	Municipality	Location	Description
O56	Muddy Creek Twp.	Hufnagel Rd at Baudermill Rd	Undersized Pipes
O57	Muddy Creek Twp.	Rt 19 at Johnson Rd	Ponding Water
O58	Saxonburg Boro.	Carol Dr near Dinnerbell Rd	Undersized Pipes
O59	Saxonburg Boro.	State St at Constitution Ave	Sediment Build Up
O60	Prospect Boro.	Wilson Ln	Stream Crossing
O61	Venango Twp.	S. Erico Rd	Beaver Dam
O62	Venango Twp.	McJunkin Rd	Undersized Pipes
O63	Middlesex Twp.	Parks Rd near Rt 228	Undersized Pipe
O64	Clay Twp.	Beaver Dam	Beaver Dam
O65	Clay Twp.	Under Bridge	Siltation
O66	Washington Twp.	Bridge	Low Bridge
O67	Lancaster Twp.	Crab Run Rd Bridge	Flooding
O68	Lancaster Twp.	Little Creek Rd Bridge	Flooding
O69	Zelienople Boro.	Community Park to Spring St	Undersized Pipes
O70	Zelienople Boro.	Walnut St Bridge	Undersized Pipes
O71	Zelienople Boro.	Linden St	Undersized Pipes
O72	Zelienople Boro.	Front St	Undersized Pipes
O73	Zelienople Boro.	Front St	Undersized Pipes
O74	Zelienople Boro.	New Castle St between Division & Oliver	Undersized Pipes
O75	West Sunbury Boro.	Along E Concord St	Runoff
O76	Cranberry Twp.	Franklin Rd	Undersized Culvert
O77	Cranberry Twp.	Rochester Rd	Undersized Culverts
O78	Cranberry Twp.	Freedom Rd	Undersized Culverts
O79	Cranberry Twp.	Rolling Rd	Undersized Culvert

Table 5.1. Reported Problem Areas and Obstructions

The following figure provides a summary of the problem area types.

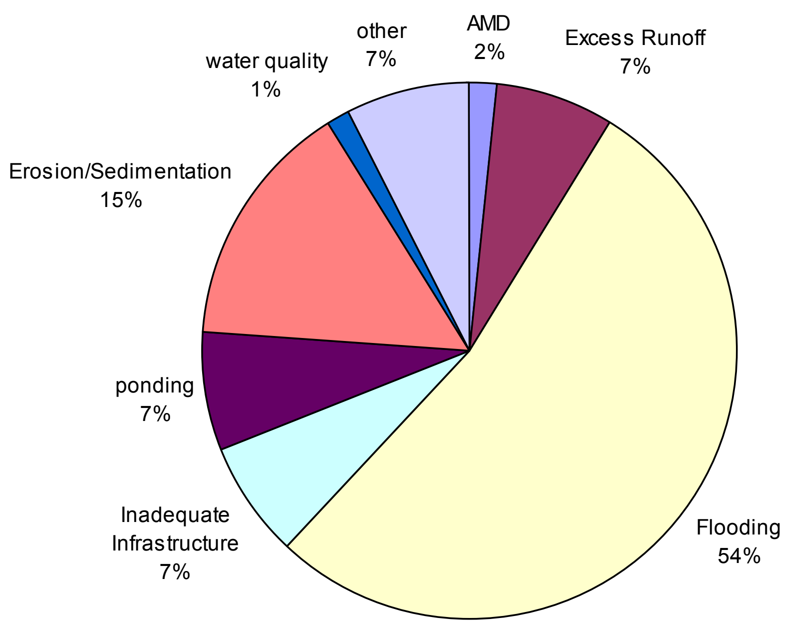


Figure 5.1. Overview of Problem Area Conveyance Capacity

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 certain portions of the Connoquenessing Creek and Buffalo Creek watersheds encounter systemic flooding, and that release rates should be investigated. The analyses of the Connoquenessing Creek and Buffalo Creek watersheds are presented in *Section 6*.

PROBLEM AREA ASSESSMENT

Due to budgetary constraints in this Act 167, no detailed technical analyses were provided for individual problem areas identified. However, upon completion of the hydraulic modeling and analysis of all of the problem areas and obstructions, an objective method would be needed to assess the order in which the proposed solutions should be implemented. The following criteria could be used to develop a more detailed set of prioritized problem areas.

Criteria from a stormwater prioritization assessment completed in Columbus, Ohio were used to establish a system for prioritization (Tickle, 2008). *Table 5.2* provides a list of criteria could be used to assess each problem area or obstruction. Each problem could be assigned a rating between 1 and 10 for each of the six criteria. The six criteria were equally weighted in order to calculate a single relative rating between 1 and 10 for each problem.

Criteria	Description	Rating
Health & Safety	To what extent will the problem endanger human life?	1 to 10
Non-health & Safety Human Impact	How will the problem affect financial aspects of the surrounding areas?	1 to 10
Environmental Impact	To what extent will the problem contribute to erosion and sediment pollution?	1 to 10
Expected Life of Existing System	When will the system associated with the problem fail?	1 to 10
Frequency of Problem	How likely will the problem occur based on a 2-yr storm event?	1 to 10
Cost of Solution	Will the solution cost thousand's, hundred's of thousands, or millions of dollars to resolve?	1 to 10

Table 5.2. Problem Area/Obstruction Rating Criteria (Adapted from Tickle, 2008)

Each of the obstructions and problem areas would be categorized in one of three categories based on their composite score: 1) Highest Priority Problem, 2) Significant Problem, or 3) General Problem. A composite rating between of 7 and 10 would classify a problem area or obstruction as a Highest Priority Problem. A composite rating between 4 and 6.9 would classify a problem area or obstruction as a Significant Problem and a rating between 1 and 3.9 would be classified as a General Problem. Because each problem was evaluated independently, each municipality can use this assessment as the basis to develop their own problem area prioritization list.

Problem areas that were categorized as Highest Priority Problems, based upon the criteria provided in Table 5.2, would ideally be analyzed in more detail. The data sheets in *Appendix C* for these problem areas include a more descriptive overviewof the problem areas.

RECOMMENDATIONS

With the data collected for the identified problem areas, the complete assessment should be completed with the rating criteria provided in the preceeding section.

A generalized analysis of the reported stormwater problems within the study area can be attributed to one, or more, of several principal causes:

1. A storm sewer, culvert or bridge has insufficient hydraulic capacity or is in poor condition.

   General Recommendation: The best method of dealing with the immense costs associated with bridge and culvert replacement it to first develop a prioritization system that highlight were the limited funds that are available can be spent. On ongoing program of inspection and maintenance is recommended so that the highest priority problem areas (i.e., the ones that endanger public health and welfare) are clearly identified and resolved as soon as funding is identified.

2. There is a severe erosion and deposition problem in a stream or man-made channel.

   General Recommendation: Each stream, channel, or obstruction that has erosion or deposition problems should be individually evaluated so the source of each problem is correctly identified. Detailed stream assessments should be performed for every action that involves moving or redirecting a stream. Blindly excavating sediment in an upstream area may remove sediment in one location, but it may lead to much more significant erosion or sedimentation upstream or downstream of a particular site. Streambank restoration either through natural design methodologies or traditional engineered armor will be needed in appropriate locations to correct adverse impacts. Re-establishment of riparian buffers will offer protection of the stream channels to help mitigate adverse impacts.

3. There is an incomplete collection and conveyance system or a lack of a formal/comprehensive maintenance program for the existing storm drain system.

   General Recommendation: As with bridge and culvert replacement, the costs associated with installing or replacing existing storm drain system are substantial. A prioritization system as discussed above for culverts and bridge is perhaps the best approach to addressing these problem areas. Another important consideration is to consider is the regional wide impact (i.e., county or watershed-wide) of a storm drain system. The inclination is to remove water immediately from a housing development or a business district, but the question should be asked of each potential solution: what about the downstream property?

4. Problem areas are located in the floodplain area.

   General Recommendation: Problem areas within the floodplain are going to flood since they are located in flood prone areas. Prudent, regional-wide floodplain management measures, as discussed further is *Section 10*, offer the best solution for mitigating problem in flood prone areas.

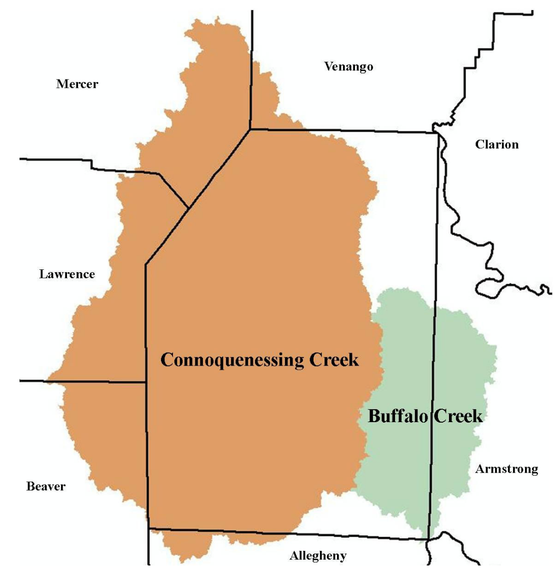
In addition, the problem areas mentioned in this section are more pronounced in the more populated/developed areas. This is most likely due to encroachments into floodplain areas and undersized culverts or bridges. Also, a large number of these stormwater related problems have been traced back to uncontrolled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

This study 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.

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 way to address all of the needs and potential threats to a watershed. However, implementation of these practices can be difficult and may not be economically feasible for many communities. 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 Pennsylvania Department of Environmental Protection. 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 Butler County. The hydrologic methodology used in the technical approach is the Natural Resource Conservation Service (NRCS) Rainfall-Runoff Method described in various NRCS publications (NRCS, 2008a). This method was chosen since it is the most common method used by designers in Pennsylvania and has widely available data (NRCS, 2008b). Additionally, this method is the basis for which many of the guidelines were developed in the PA Stormwater 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 Stormwater 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

Two watersheds within the county were selected for hydrologic modeling: Buffalo and Connoquenessing Creek. These watersheds were 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.

BUFFALO CREEK MODEL

The Buffalo Creek watershed has a drainage area of 170.6 square miles and was divided into 99 subwatersheds for the HEC-HMS model. Approximately 63.8 square miles of Buffalo Creek lies within Armstrong County. Figure 6.1 shows the Buffalo Creek subwatersheds and cumulative discharge points.

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

The only dam that was included in the hydrologic modeling effort was Saxony Dam located on Sarver Run. Outflow data for the dam was provided by DEP in the form of archived design files. This information was used to model the flows from the dam within the HEC-HMS model. The following table summarizes the impoundment within the watershed.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
Saxony Dam	Sarver Run	Jefferson Twp.	Saxony Farms	46

Table 6.1. Impoundments within the Buffalo Creek Watershed

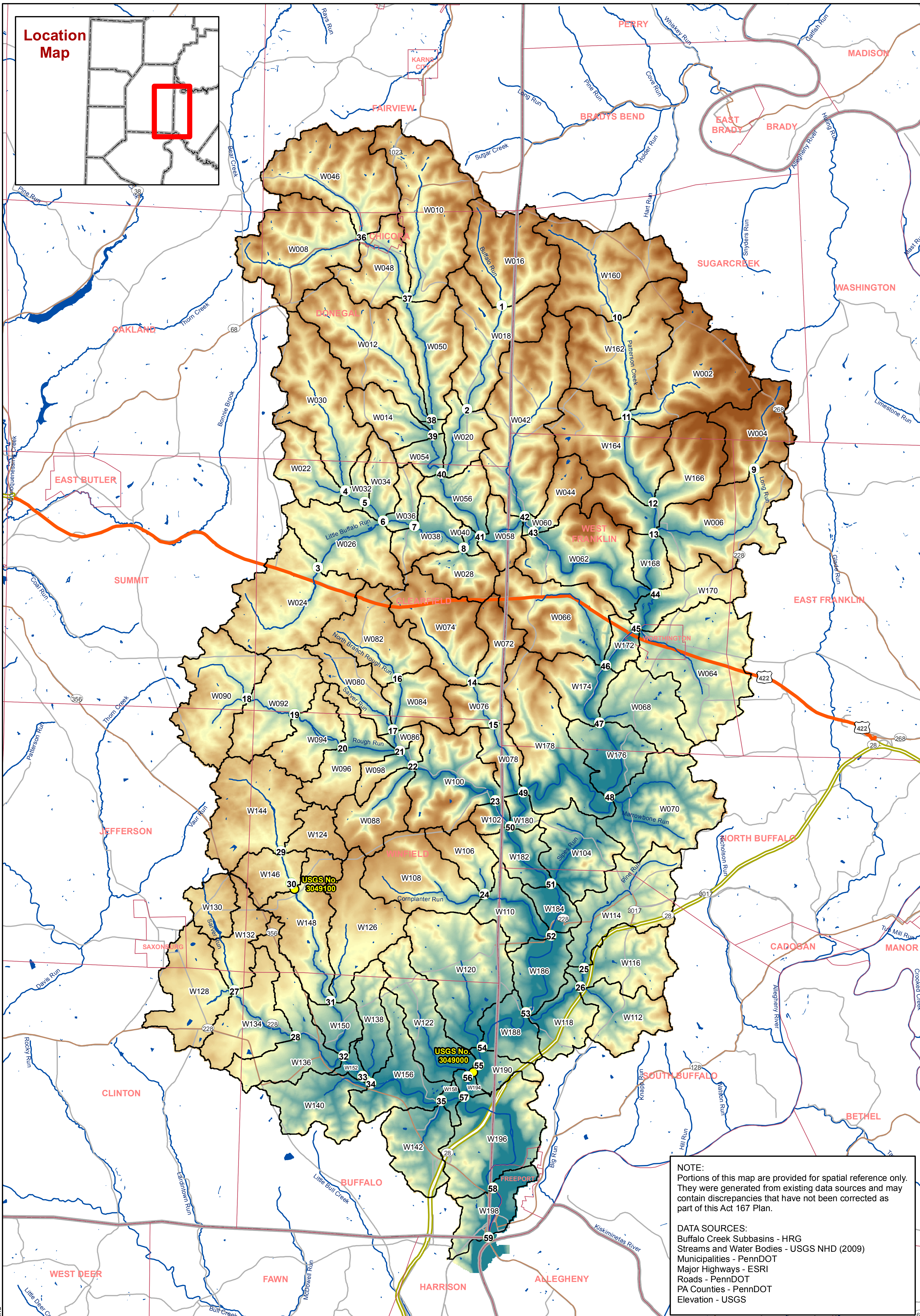
CONNOQUENESSING CREEK MODEL

The Connoquenessing Creek watershed has a total drainage area of 838.3 square miles. A large portion (about 260 mi^2) of this watershed lies outside of Butler County in Beaver, Lawrence, Mercer, and Venango Counties. The watershed was divided into 366 subwatersheds for the HEC-HMS model. Figure 6.2 shows the Connoquenessing Creek subwatersheds and cumulative discharge points.

This watershed contains five dams that were considered to have a significant enough impact on the hydrology of the watershed. The following table summarizes the impoundments within the Connoquenessing Creek watershed.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
Moraine State Park	Muddy Creek	Muddy Creek	PA Dept. of Forests and Waters	38,054
Boydstown Dam	Connoquenessing Creek	Oakland Twp.	Butler Water Company	221
Sawmill Dam	Sawmill Run	Butler Twp.	Armco Steel Corporation	144
Thorn Reservoir	Thorn Creek	Oakland Twp.	Butler Water Company	632
No. 2 Dam	Tributary Likens Run	Jackson Twp.	Evansburg Borough Municipal Authority	37

Table 6.2. Impoundments within the Connoquenessing Creek Watershed



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1.75 0 1.75 Miles

Discharge Points
USGS Gauges
Streams
Water bodies
Limited Access
Highway
Major Road
Local Road
HEC-HMS Subbasins
Municipalities
Counties

Elevation
High : 1570 Feet
Low : 740 Feet

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Figure 6.1
Buffalo Creek HEC-HMS Model
Butler County, Pennsylvania

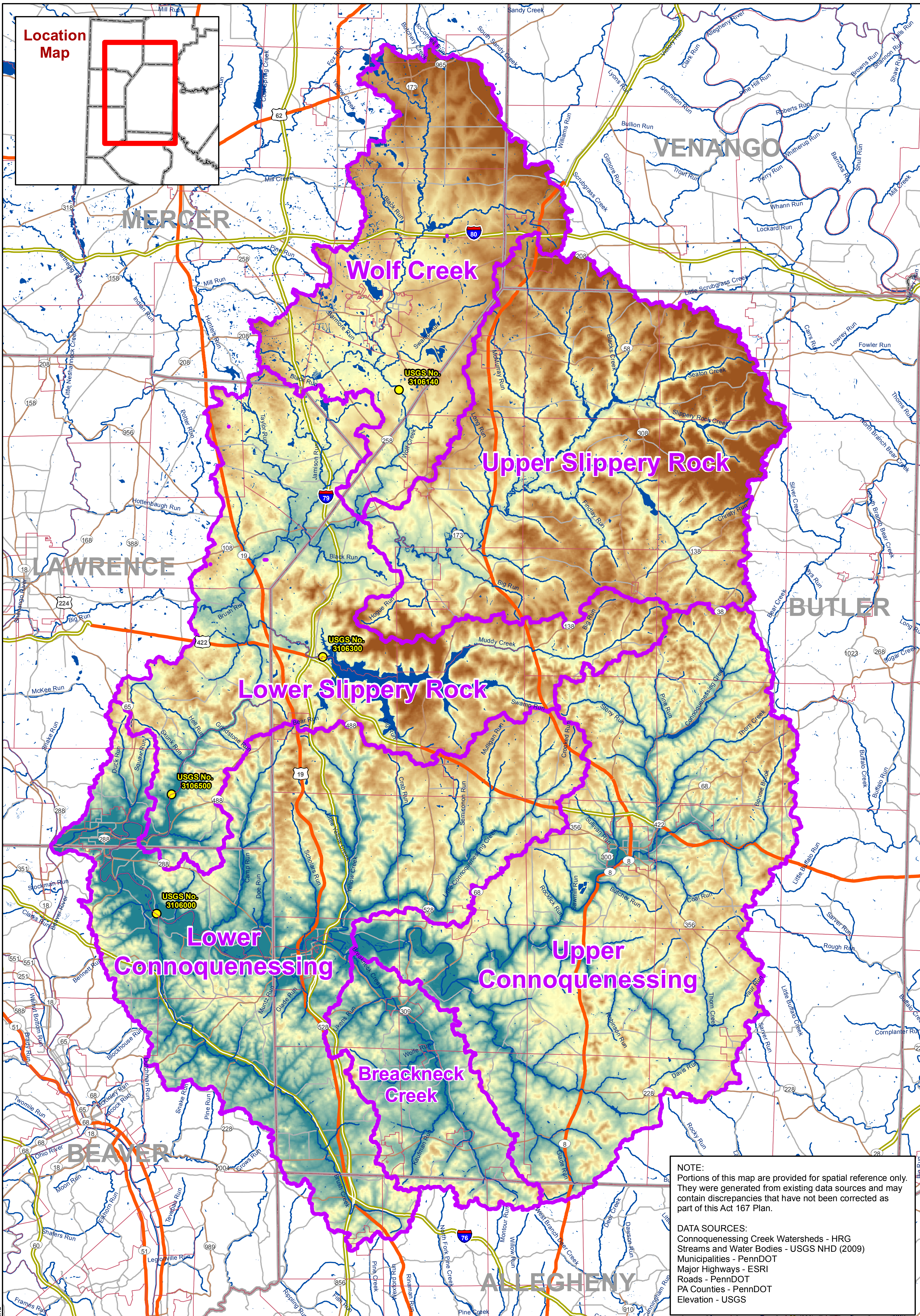

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Figure 6.2
Connoquenessing Creek HEC-HMS Models
Butler County, Pennsylvania

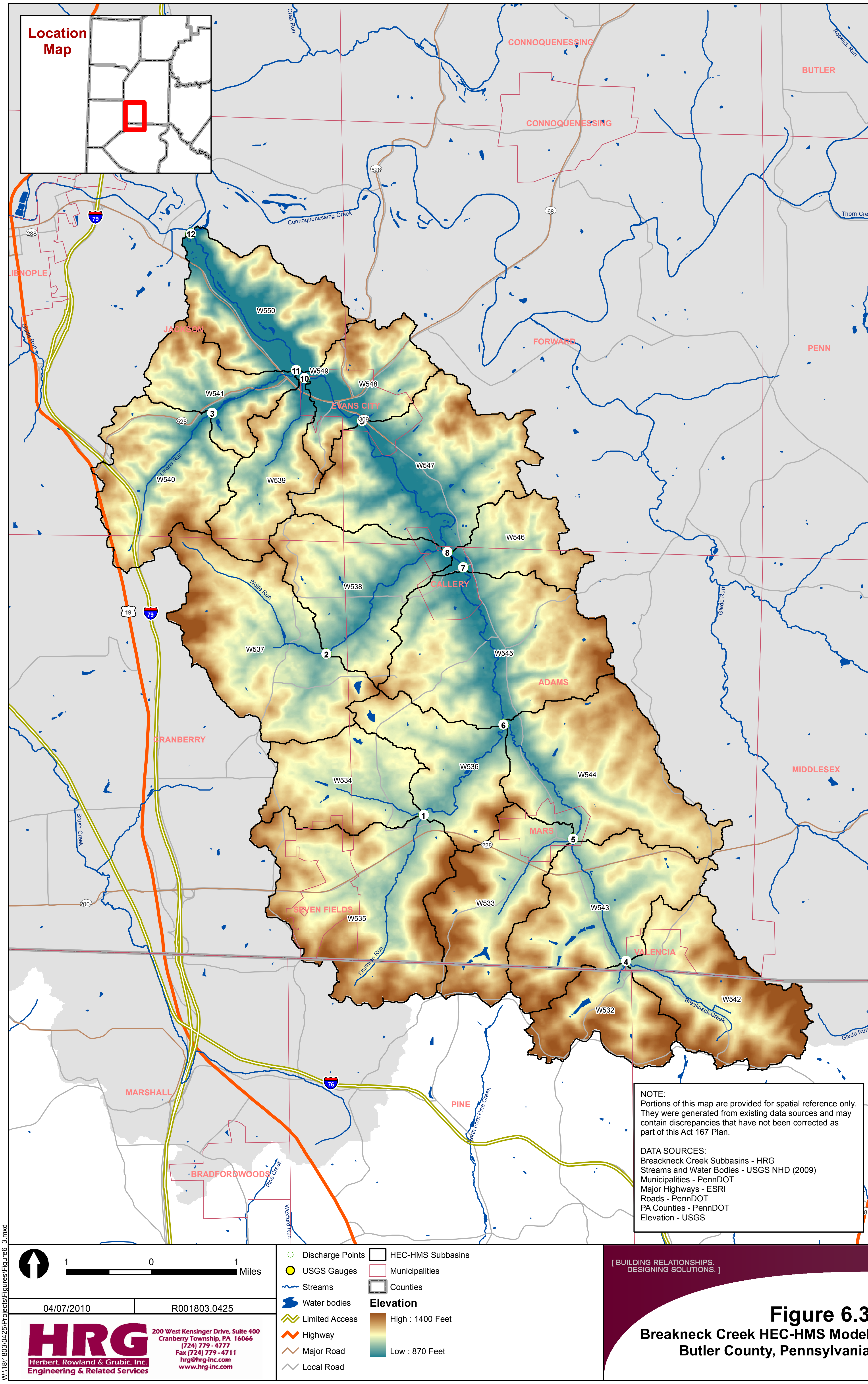

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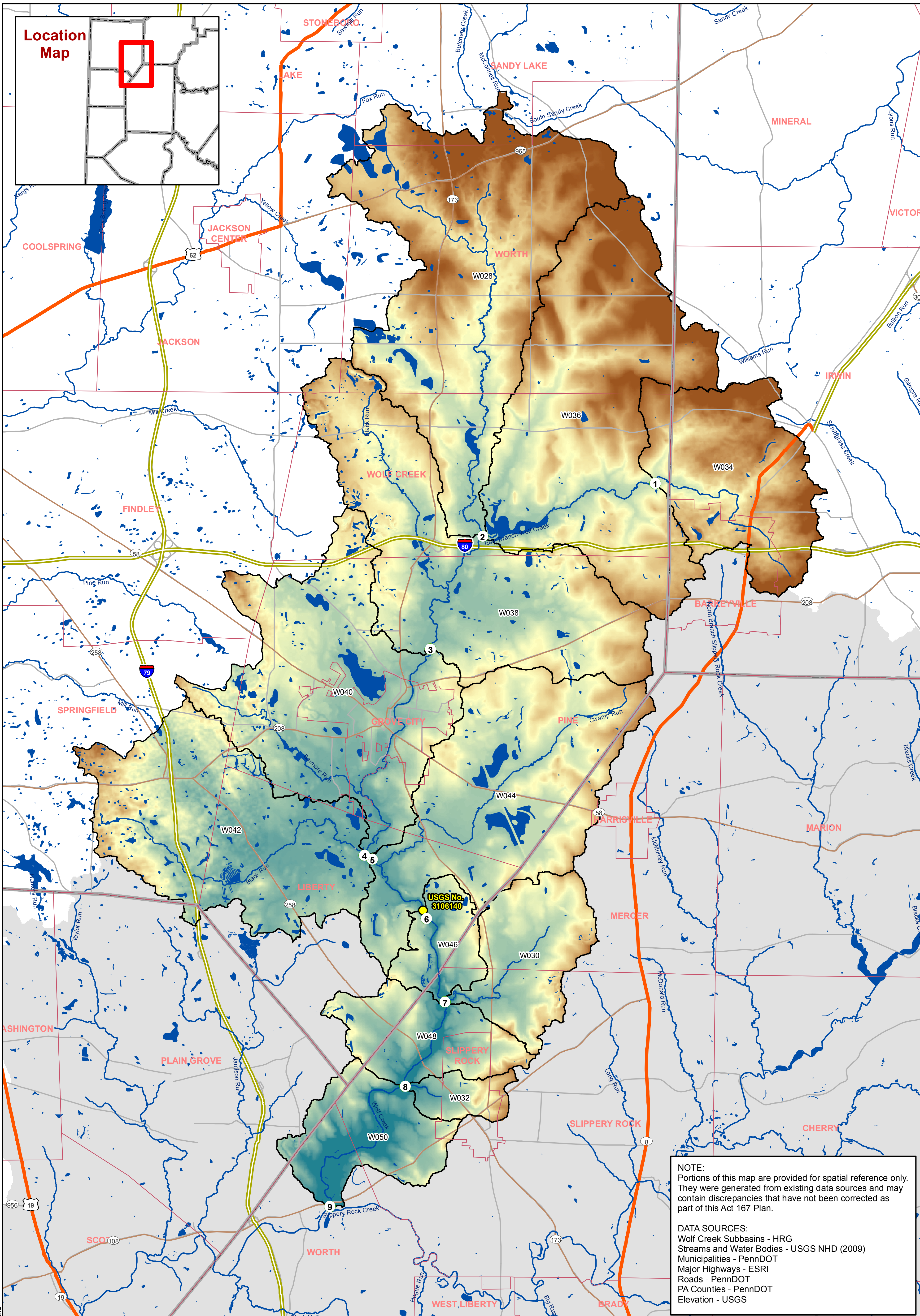
Figure 6.3
Breakneck Creek HEC-HMS Model
Butler County, Pennsylvania



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:
Wolf Creek Subbasins - HRG
Streams and Water Bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI
Roads - PennDOT
PA Counties - PennDOT
Elevation - USGS

1.5 0 1.5 Miles

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- Discharge Points
- USGS Gauges
- Streams
- Water bodies
- Limited Access
- Highway
- Major Road
- Local Road
- HEC-HMS Subbasins
- Municipalities
- Counties

Elevation
High : 1620 Feet
Low : 1090 Feet

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Figure 6.4
Wolf Creek HEC-HMS Model
Butler County, Pennsylvania

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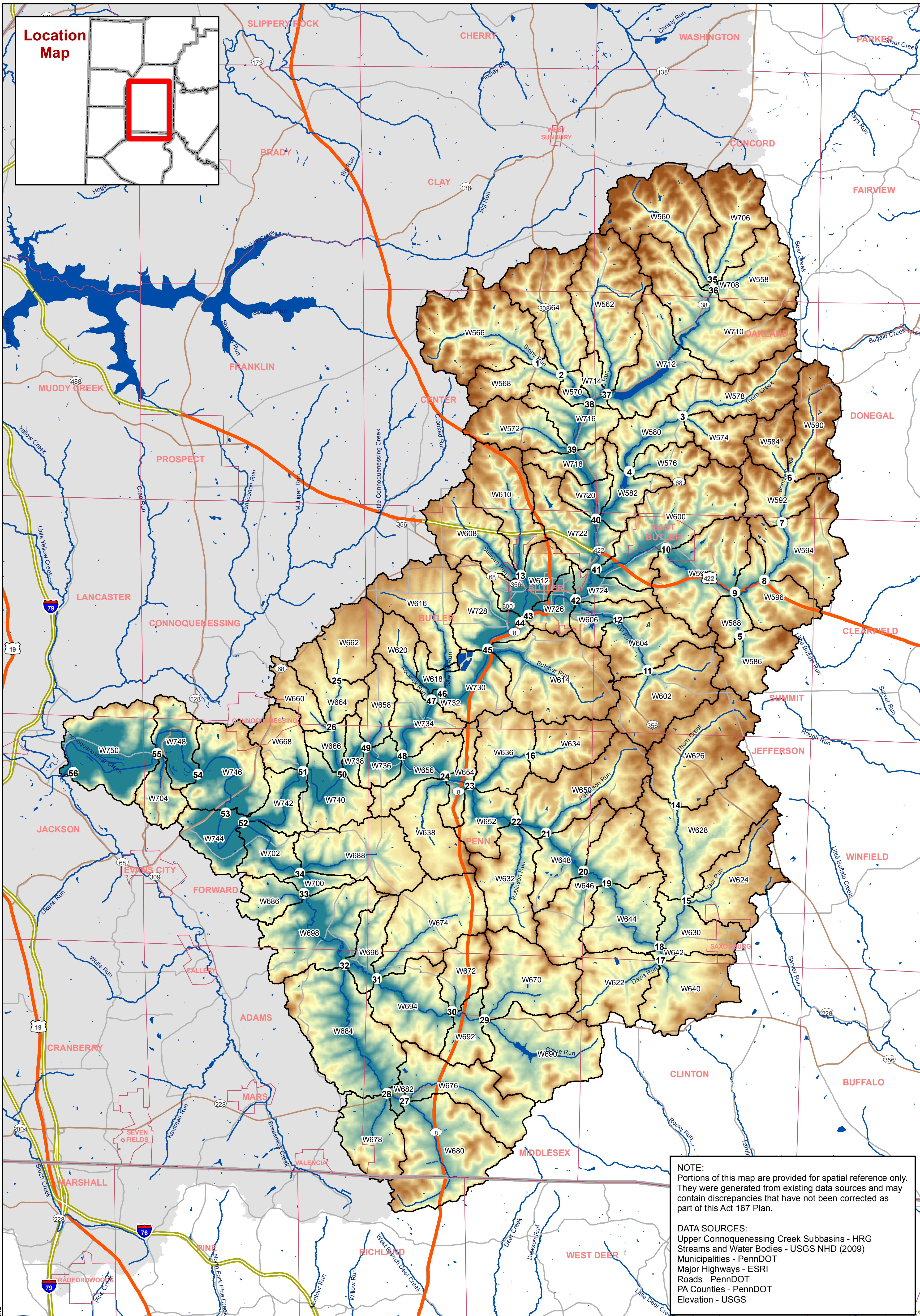

2 0 2 Miles

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Discharge Points
USGS Gauges
Streams
Water bodies
Limited Access
Highway
Major Road
Local Road
HEC-HMS Subbasins
Municipalities
Counties

Elevation

High : 1490 Feet

Low : 870 Feet

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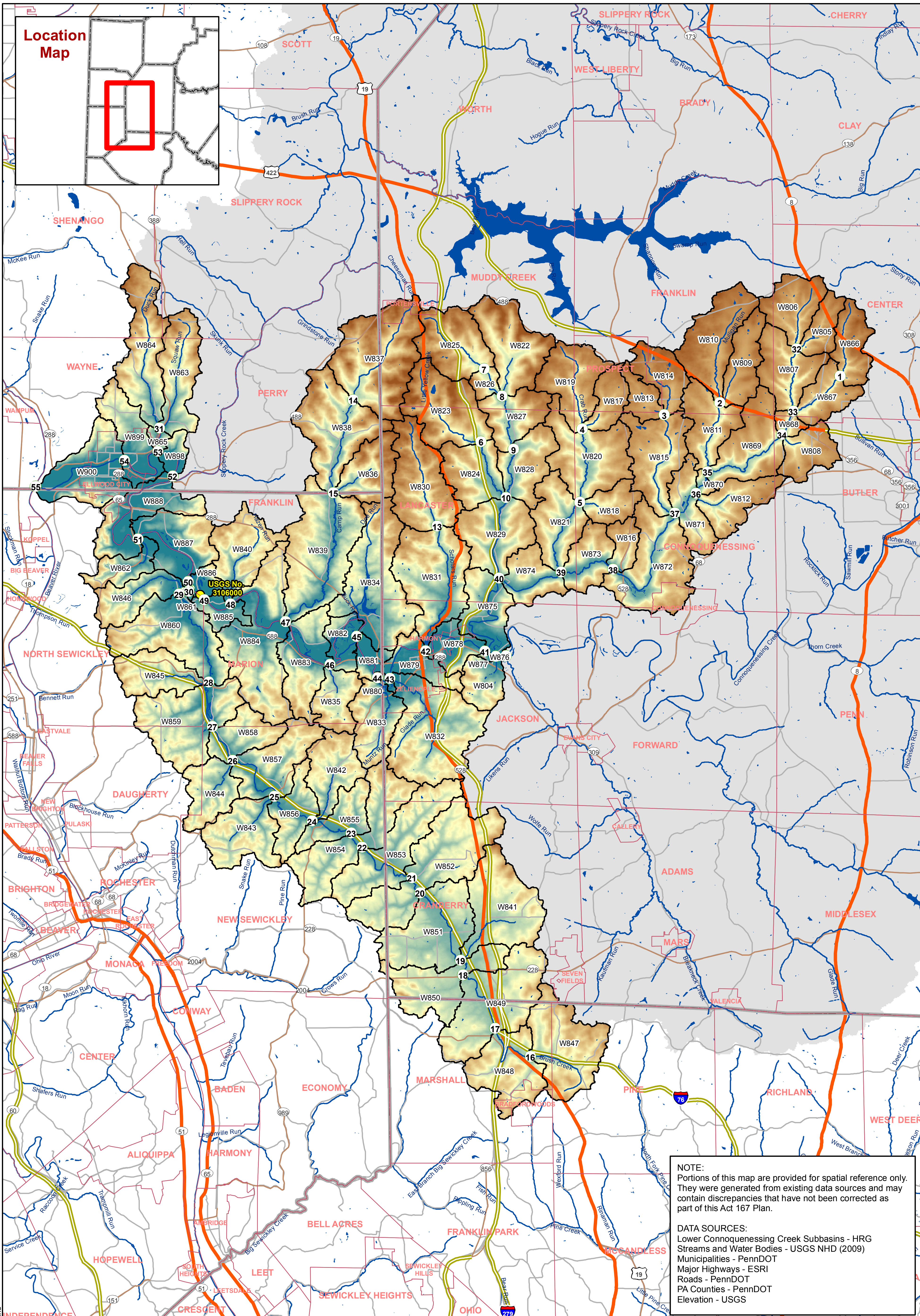
Figure 6.5

Upper Connoquenessing Creek HEC-HMS Model

Butler County, Pennsylvania



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:
Lower Connoquenessing Creek Subbasins - HRG
Streams and Water Bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI
Roads - PennDOT
PA Counties - PennDOT
Elevation - USGS

2.25 0 2.25 Miles

04/07/2010 R001803.0425

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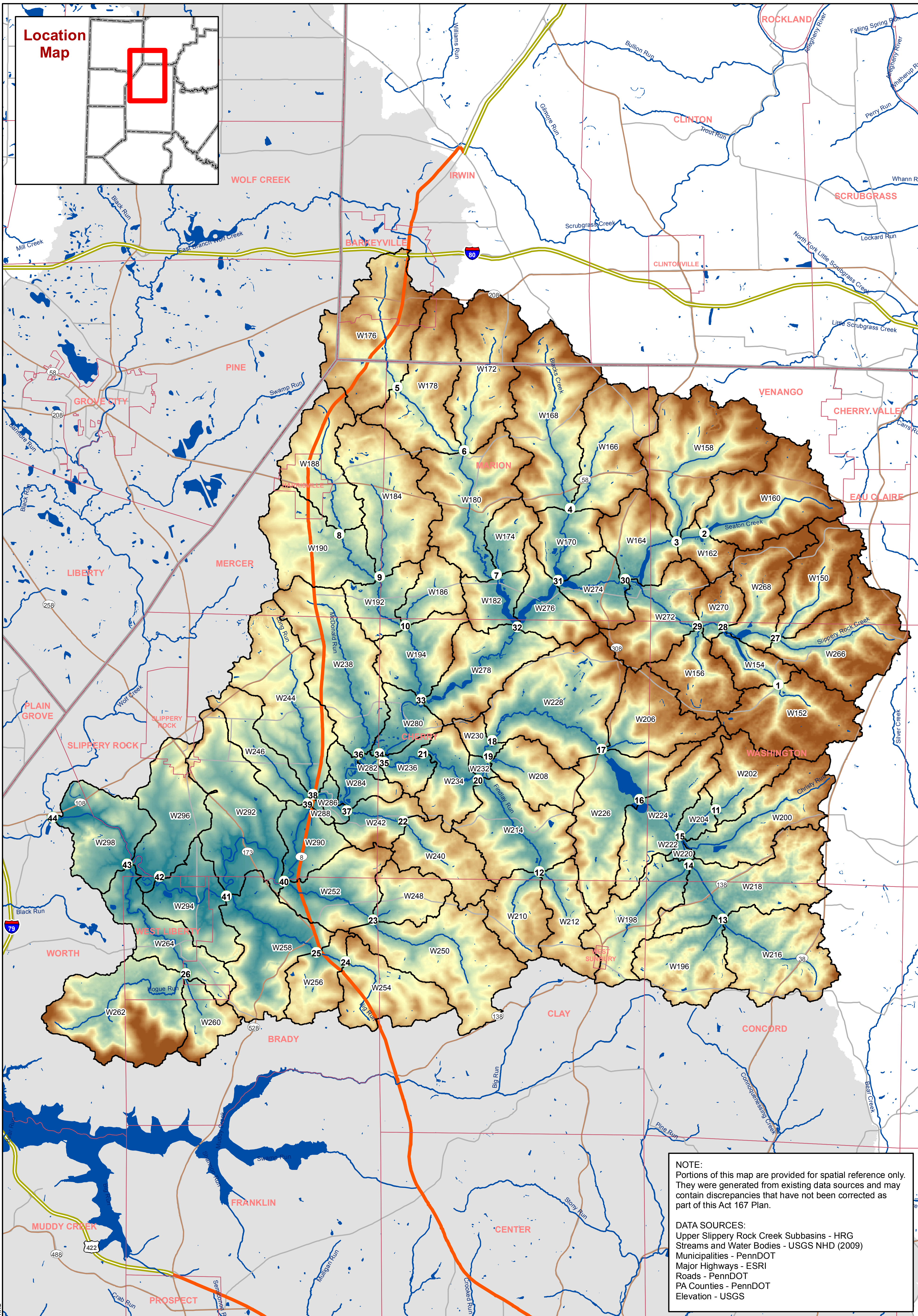
Discharge Points
USGS Gauges
Streams
Water bodies
Limited Access
Highway
Major Road
Local Road
HEC-HMS Subbasins
Municipalities
Counties

Elevation
High : 1470 Feet
Low : 730 Feet

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure 6.6
Lower Connoquenessing Creek HEC-HMS Model
Butler County, Pennsylvania



1.75 0 1.75 Miles

Discharge Points	HEC-HMS Subbasins
USGS Gauges	Municipalities
Streams	Counties
Water bodies	**Elevation**
Limited Access	High : 1620 Feet
Highway	
Major Road	Low : 1090 Feet
Local Road	

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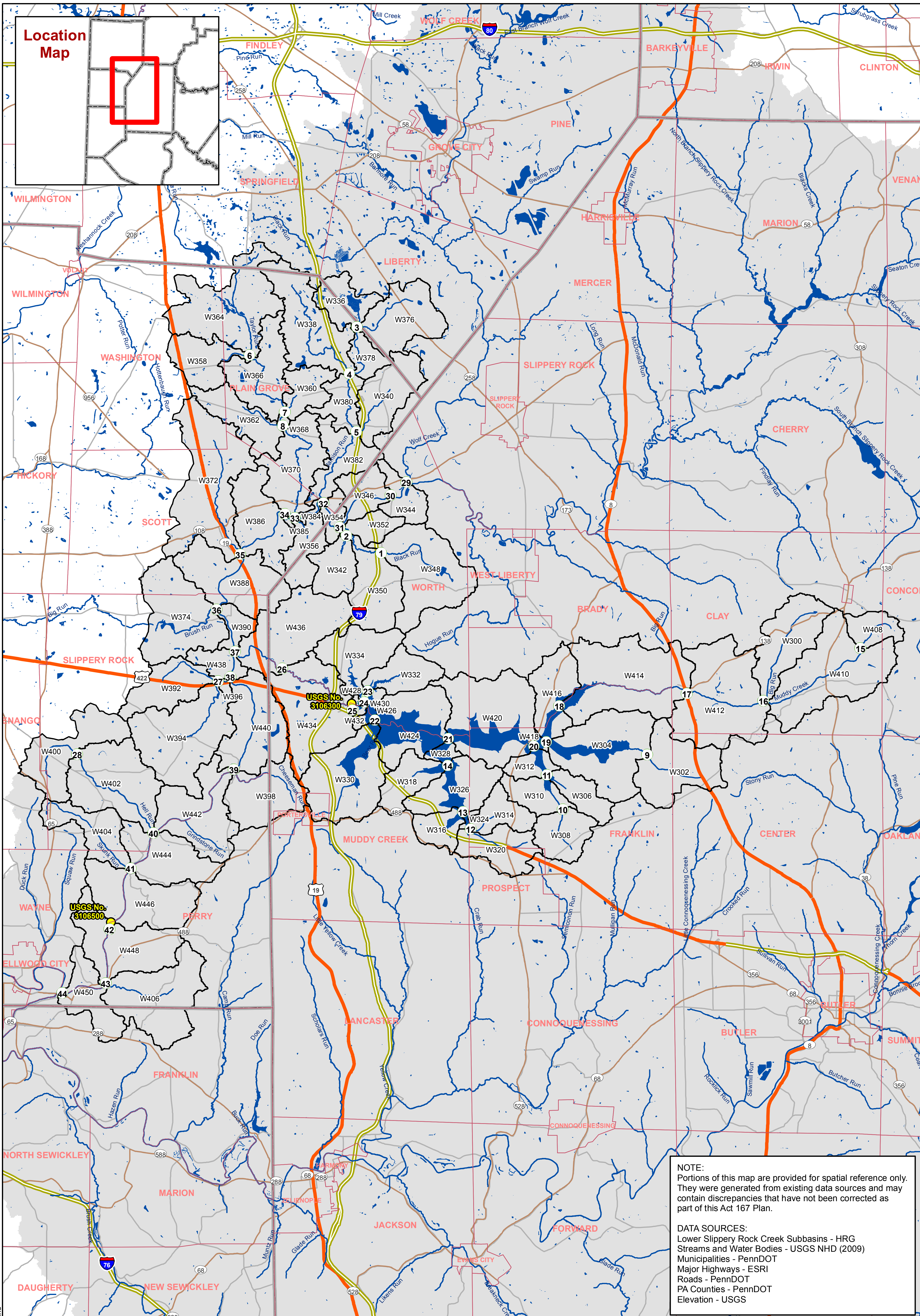
[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure 6.7
Upper Slippery Rock Creek
HEC-HMS Model
Butler County, Pennsylvania



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:
Lower Slippery Rock Creek Subbasins - HRG
Streams and Water Bodies - USGS NHD (2009)
Municipalities - PennDOT
Major Highways - ESRI
Roads - PennDOT
PA Counties - PennDOT
Elevation - USGS

2.2 0 2.2 Miles

Discharge Points	HEC-HMS Subbasins
USGS Gauges	Municipalities
Streams	Counties
Water bodies	**Elevation**
Limited Access	High : 1600 Feet
Highway	
Major Road	Low : 800 Feet
Local Road	

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[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure 6.8
Lower Slippery Rock Creek HEC-HMS Model
Butler County, Pennsylvania

HYDROLOGIC MODEL PARAMETERS

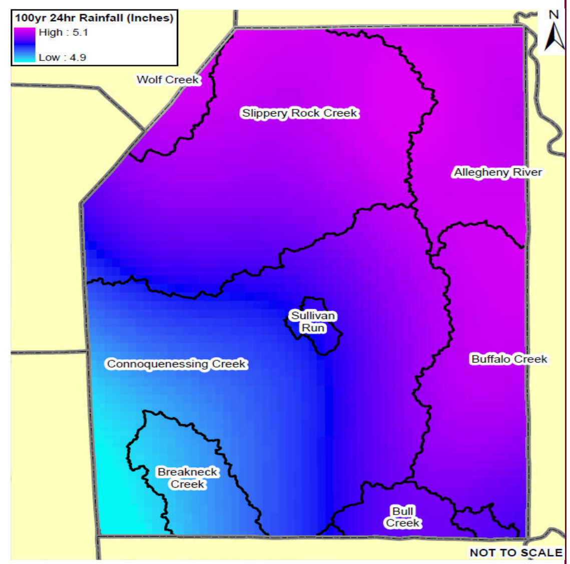
The various parameters entered into the hydrologic models include subwatershed area, soil-type, land cover, lag time, reach lengths and slopes, reach cross sectional dimensions, and design rainfall depths. These parameters are discussed in further detail in the technical appendix. A brief description 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 United States 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 Butler County (NOAA, 2008):

Design Storm (years)	24-hr Rainfall Depth (in)
2	2.42
10	3.39
25	4.01
50	4.52
100	5.05

Table 6.3. Rainfall Values for Butler County



NOAA Atlas 14 100-year, 24-hour Rainfall

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 Stormwater BMP Manual* (2006).

SUBWATERSHED AREA

Generally, the subwatershed area for the modeled watersheds was 1-5 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 larger basins or were tributary to a defined problem area.

Basins with drainage area outside of Butler 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. They were delineated into areas between 1 and 5 mi^2 and were assumed to have only negligible changes in hydrology due to future land use.

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 Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate (SCS 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 show the relative percentage of hydrologic soil groups in Butler 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 National Land Cover Dataset (USGS, 2008). 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 provided by the Butler 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.

Land Use	Existing Land Use		Proposed Land Use		Change Future - Existing
	Acres	%	Acres	%	%
Brush[1]	16.3	0.0%	16.3	0.0%	0.0
Commercial and Business	6698.2	1.0%	6698.2	1.0%	0.0
Contoured Row Crops[1]	103760.5	16.1%	101990.8	15.8%	-1.1
Industrial	5169.3	0.8%	5169.3	0.8%	0.0
Institutional (assumed 50% impervious)	1365.3	0.2%	1365.3	0.2%	0.0
Meadow[1]	24128.2	3.7%	23755.4	3.7%	0.0
Mixed Urban (assumed 65% impervious)	216.3	0.0%	2649.4	0.4%	0.4
Newly graded areas	4602.6	0.7%	4545.0	0.7%	0.0
Open space[1]	22985.2	3.6%	27646.6	4.3%	0.7
Pasture[1]	70322.6	10.9%	69671.0	10.8%	-0.1
Residential - 1 acre	10227.8	1.6%	10227.8	1.6%	0.0
Residential - 1/2 acre	66439.6	10.3%	66439.6	10.3%	0.0
Residential - 1/8 acre or less	584.0	0.1%	584.0	0.1%	0.0
Water	8189.5	1.3%	8189.461	1.3%	0.0
Woods[1]	321045.1	49.7%	316802.3	49.1%	0.0
Total	**645750.4**	**100.0%**	**645750.4**	**100.0%**	**n/a**

Notes: [1] In Good Condition

Table 6.4. Existing and Future Land Use for Modeled Watersheds within Butler County

LAG TIME

Lag time is the transform routine when using the NRCS Curve Number Runoff Method. Lag can be related to time of concentration 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. Given the rural landscape of Butler County, the best estimate for time of concentration calculation was provided by the NRCS lag equation.

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 Rainfall-Runoff 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.

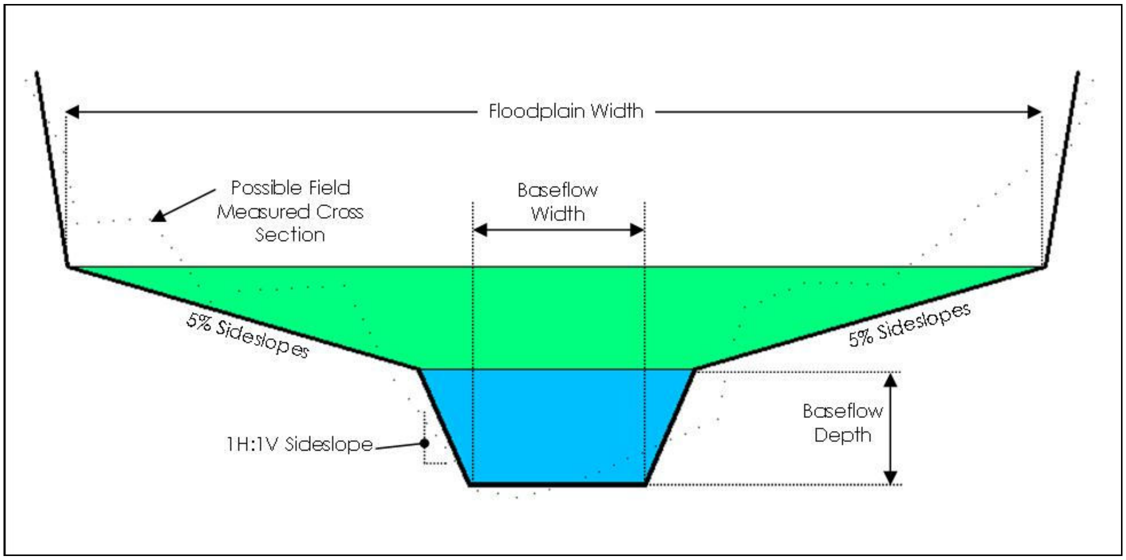


Figure 6.9. Cross Sections Used for Reaches in HEC-HMS Model

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 03106000 Connoquenessing Creek near Zelienople, PA
Source: USGS, 2010

There are five USGS stream gages with adequate record located in Butler County. The following table lists these gages and their respective statistics.

USGS Stream Gage No.	Site Name	Drainage Area mi²	Number of Gage Years at Gage	Used in HEC-HMS Model
03049000	Buffalo Creek near Freeport, PA	137.0	67	Used
03049100	Little Buffalo Creek at Cabot, PA	4.7	22	Used
03106140	Wolf Creek at Slippery Rock, PA	86.6	6	Not Used
03106300	Muddy Creek near Portersville, PA	51.2	45	Used
03106500	Slippery Rock Creek at Wurtemburg, PA	398.8	96	Used
03106000	Connoquenessing Creek near Zelienople, PA	356.0	93	Used

Table 6.5. USGS Stream Gages in Butler County

The only gage within the watersheds not being analyzed for this study is USGS Gage 03106140. 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 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 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 Pennsylvania. 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). Drainage Area, Mean Elevation, Percent Carbonate Rock, and Percent Storage, the applicable parameters within Butler 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 of these three 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 6.4-6.20*) show the overall watershed calibration results for Buffalo Creek and Connoquenessing Creek. As can be shown, the calibration results are in general agreement with the range of values for other hydrologic studies. The HEC-HMS Models were within 10% of the USGS Gage points and within the standard error for the Regression values (28-38%). USGS Gages that were affected by upstream regulation had a higher percent error. Detailed calibration results and model input are provided in *Appendix A*.

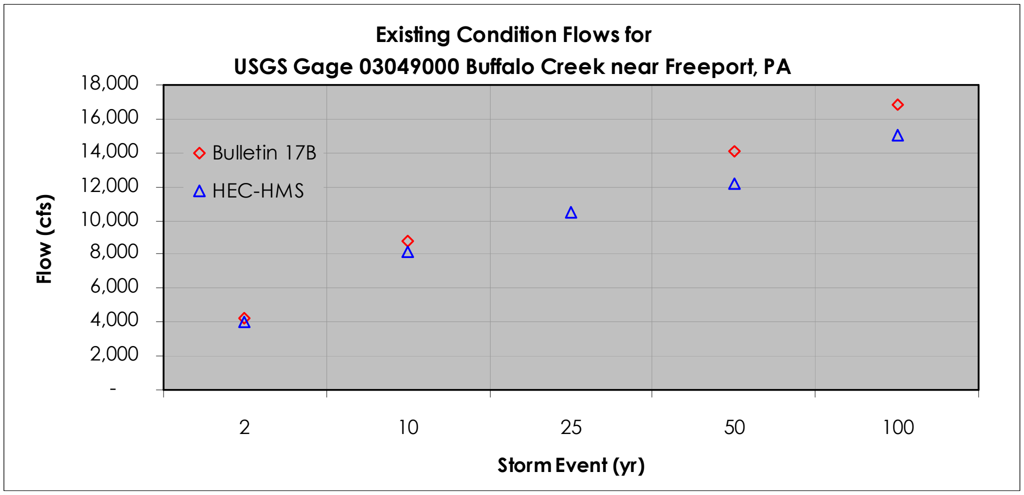


Figure 6.10

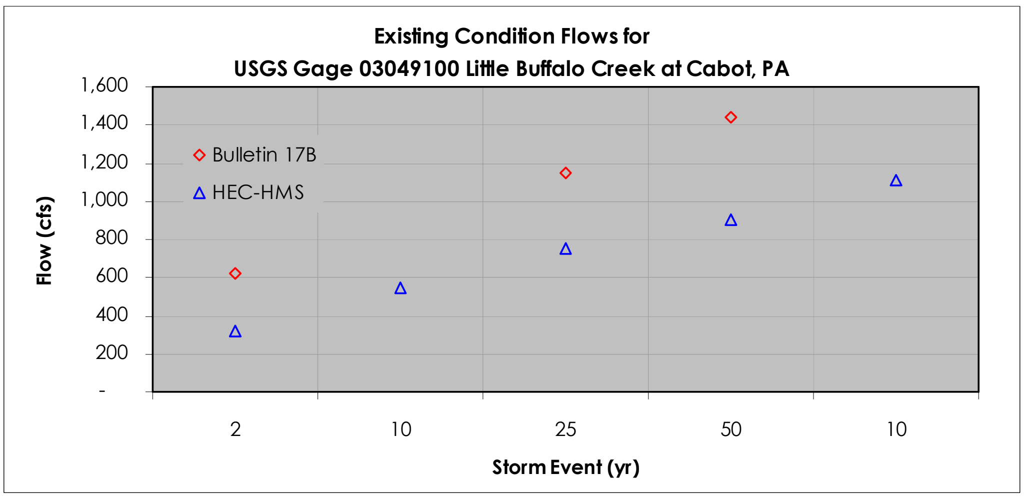


Figure 6.11

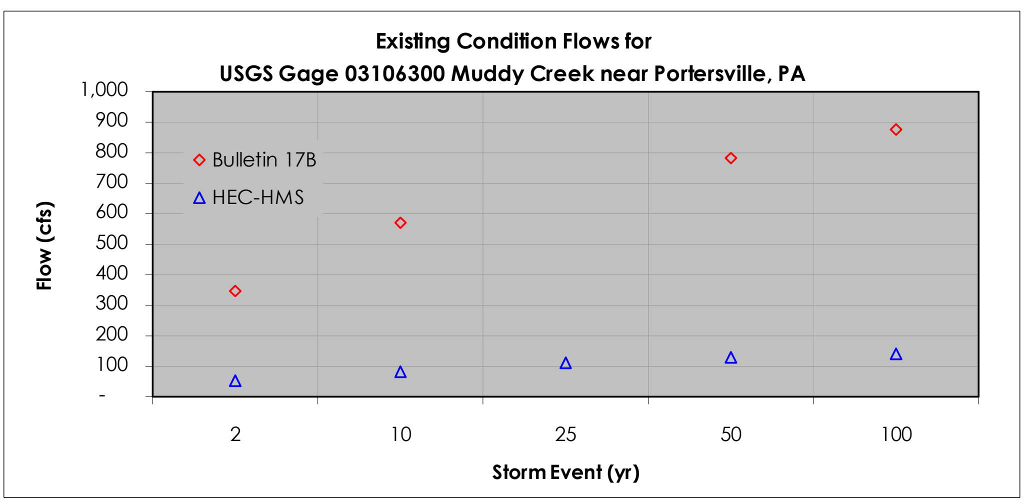


Figure 6.12

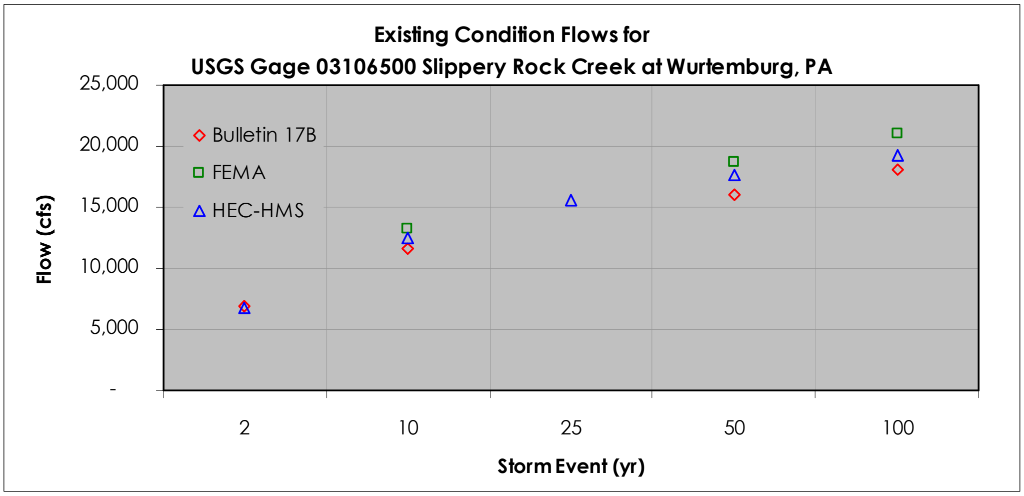


Figure 6.13

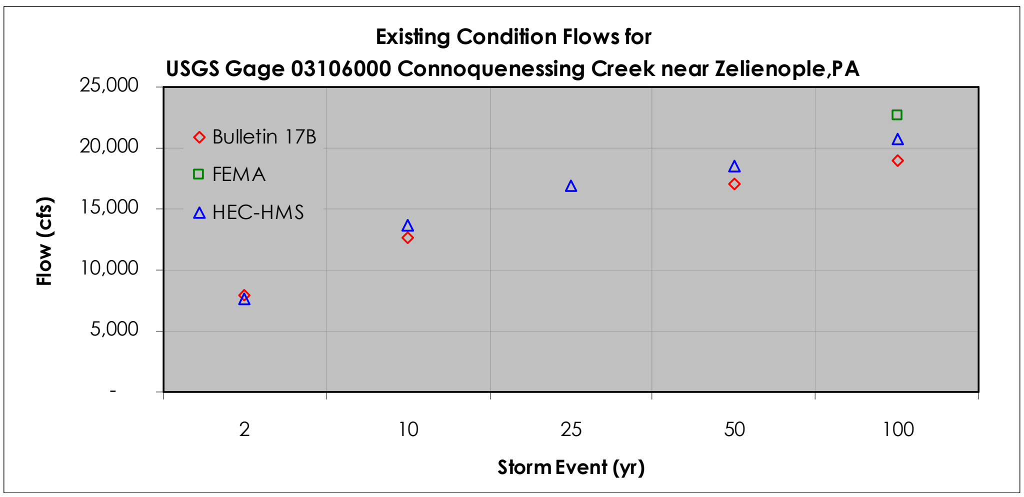


Figure 6.14

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) for Buffalo and Connoquenessing Creeks:

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 Butler County. The revised land use resulted in an increased curve number and a decreased time of concentration 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*.

BUFFALO CREEK AND CONNOQUENESSING CREEK WATERSHEDS

The flow increases within the Buffalo Creek and Connoquenessing Creek watersheds are located towards the bottom of the watersheds, as shown in *Figures 6.15 and 6.16*.

	Effects of Future Condition on Discharges		
Storm Event (year)	Maximum % Increase in Future Conditions	Average % Increase in Future Conditions[1]	Portion of subbasins with Increase (%)
2	76.7	1.3	19.8
10	60.3	1.0	19.8
25	56.5	1.0	19.6
50	57.1	1.0	19.6
100	55.6	1.0	19.4

Notes: [1] Area weighted averages

Table 6.6. Future Condition Flows with No Stormwater Management Controls for Modeled Watersheds within Butler County

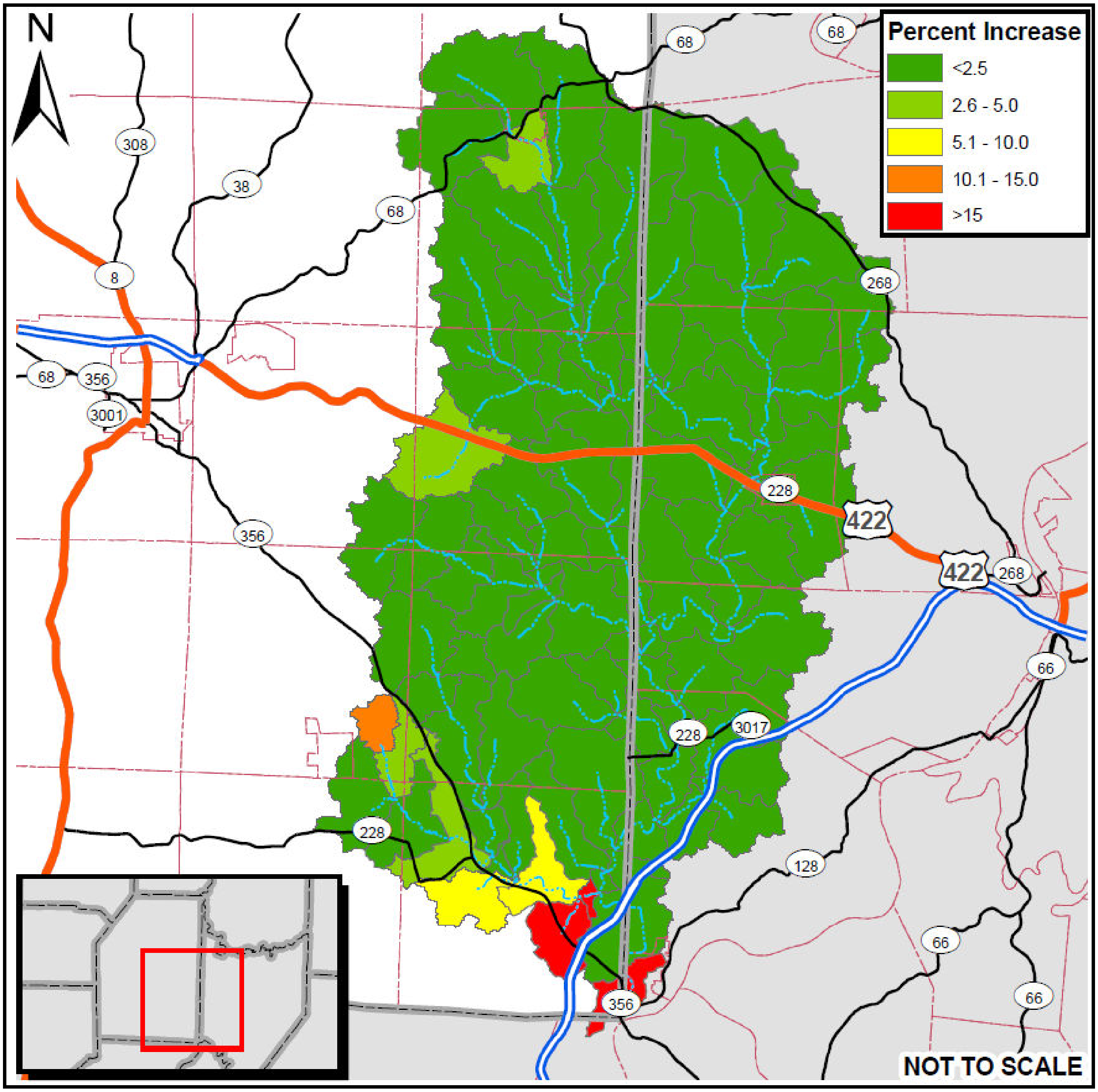


Figure 6.15 Increase in Flow for 2-Year Storm Event with No SWM Controls for Buffalo Creek

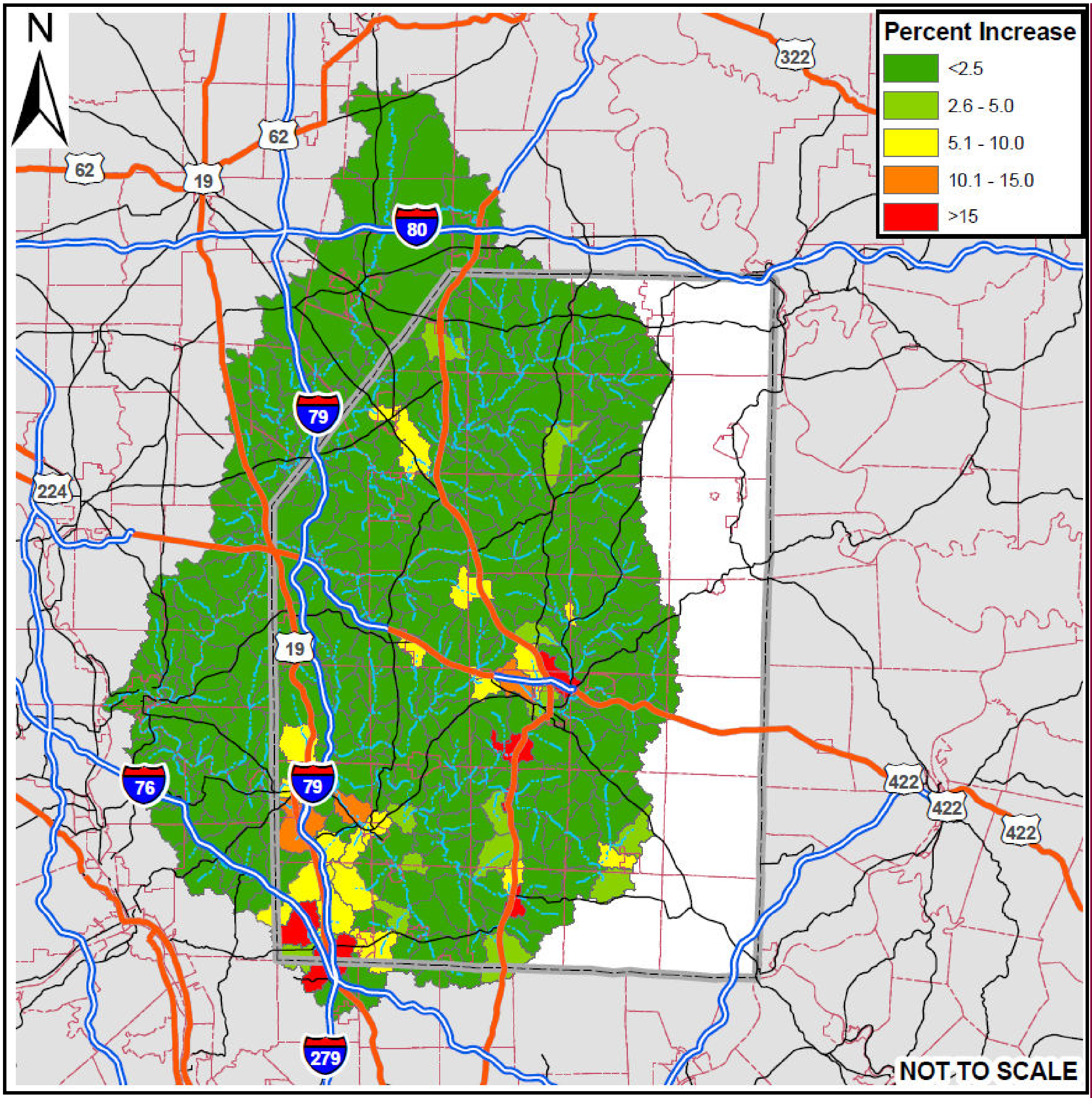


Figure 6.16 Increase in Flow for 2-Year Storm Event with No SWM Controls for Connoquenessing Creek

Table 6.7 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 CG-1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	1.6	0.3	22.4
10	17.4	0.4	16.6
25	23.7	0.4	15.3
50	27.4	0.5	15.7
100	30.1	0.6	16.8

Notes: [1]Area weighted averages

Table 6.7 Future Subbasin Flows with Design Storm Method Only – No peak control for Modeled Watershed within Butler County

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. Tables 6.8 and 6.9 reflect the allowable release rates with the implementation of the Design Storm Method.

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

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

Table 6.8. Future Subbasin Flows with Design Storm Method Implementation and Release Rates for Buffalo Creek

Storm Event (year)	Release Rates with the Design Storm Method
	Release Rates (%)[1]
2	100
10	85-90-100
25	85-90-100
50	85-90-100
100	85-90-100

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

Table 6.9. Future Subbasin Flows with Design Storm Method Implementation and Release Rates for Connoquenessing 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.

BUFFALO CREEK

The Buffalo Creek watershed was evaluated on the above criteria for implementation of stormwater management districts. The anticipated future development is concentrated in the lowest part of the watershed, near Laneville and Freeport. In this regard, there would be little benefit to restricting upstream development any more than ensuring that all post-development discharges be limited to pre-development levels. In considering the additional criteria it was determined that stormwater management districts would not be implemented.

CONNOQUENESSING CREEK

Evaluation of the Connoquenessing Creek watershed indicates a need for stormwater management districts. The watershed has had numerous problems areas in patterns indicative of systemic problems in some focused areas around Cooperstown and Glade Mills within the Glade Run Watershed. Additionally, future growth is projected throughout the watershed and in the area of the release rate districts. Sub-basins outside of Butler County within the Brush Creek watershed play a major role in future flow increases. When release rates were applied to the particular sub-basins within Brush Creek the future flow increases became higher. No problem areas were reported within the Brush Creek subbasin and release rates were not applied. Stormwater management districts have been developed for other portions of the watershed, which have potential development, with release rates ranging between 85 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.

Curve number and time of concentration methodologies should be restricted to reflect the observed runoff response in the hydrologic models. For storm events greater than the 10-year storm events, the runoff response to NOAA Atlas 14 rainfall in Butler County was lower than standard NRCS methods predict. 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 curve number calculations to assume 'good conditions' when using any curve number table, which is consistent with proposed control guidance. It is recommended for time of concentration computations to use the maximum value provided by 1) the TR-55 segmental method and 2) the NRCS Lag Equation.

Implement a volume control policy 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 guidance criteria. The control guidance 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. Butler County has a substantial number of potential limitations to infiltration facilities: fragipans, 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 which 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 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 within Butler 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 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. However, 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 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 storms. 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 storms, then 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 storms, 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 chanel 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 Best Management Practices 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 pieces:

1. Reduction of runoff generated through utilization of low impact development 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 of three available methods:

1. *The Design Storm Method* (CG-1 in the SWM Manual[1]) 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 duration precipitation.

   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 best management practices 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 best management practices shall be determined from the *Pennsylvania Stormwater Best Management Practices Manual*, most current version.

WATER QUALITY CONTROLS

Urban runoff is one of the primary contributors to water pollution in developed areas. The most effective method for controlling non-point source pollution is through reduction, or elimination, of the sources. However, 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 Best Management Practices 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 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 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 Stormwater Management Plans (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 BEST MANAGEMENT PRACTICES

As previously stated, the preferred strategy for achieving the goals of this plan is to reduce or eliminate the sources of non-point 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 *Pennsylvania Stormwater Best Management Practices Manual* in *Table 7.1* below. These practices should be used where applicable to decrease the need for less cost effective structural BMPs.

Non-Structural Best Management Practice	**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 Areawide 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 Best Management Practices

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 *Pennsylvania Stormwater Best Management Practices Manual* and their stated effectiveness for each stormwater function. Additional information on each practice can be found in the *Pennsylvania Stormwater Best Management Practices Manual*.

Structural Best Management Practice	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*	Low-High*	Low-High*	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 Best Management Practices

The table above shows the qualitative effect of individual BMPs when used as stand alone 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 then 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 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 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 12 inches or less of pending 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 temperature 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. However, they all 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 best management practices. 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. However, roofs are one 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 and contain a high level of organic material to enhance pollutant removal. A nonwoven geotextile should completely wrap the aggregate trench (Pennsylvania Stormwater Best Management Practices Manual, 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.

SUBSURFACE INFILTRATION FACILITIES

Subsurface infiltration beds are created by placing storage facilities below the proposed surface grade that collects stormwater and provides 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. Subsurface beds are ideally suited for expansive, generally flat open spaces, such as lawns, playfields, and other recreational areas (PA DEP, 2006). These systems are also well suited for cold climates as they can function year-round if constructed below the frost line.

An infiltration bed usually consists of a layer of highly pervious planting soil and vegetation, underlain by a storage facility. Storage can be provided by an excavated pit filled with uniformly graded aggregate wrapped in geotextile or a prefabricated storage chamber. An overflow structure should be included to provide protection in case of extreme storm events or system failure. Additionally, inspection ports are often added to ease monitoring and maintenance. The bottom of the infiltration bed must be level and distribution systems must be added 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. These facilities provide groundwater recharge while also preserving or creating valuable open space and recreation areas.

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 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 of the stated goals of this Plan. This goal will be achieved through adoption of the Model Ordinance by all of the municipalities in Butler 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 which they are intended to provide. The design example is then 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 non-structural 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 *Pennsylvania Stormwater 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 design storm 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 *Pennsylvania Stormwater BMP Manual* (2006). 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, Low Impact Design 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.

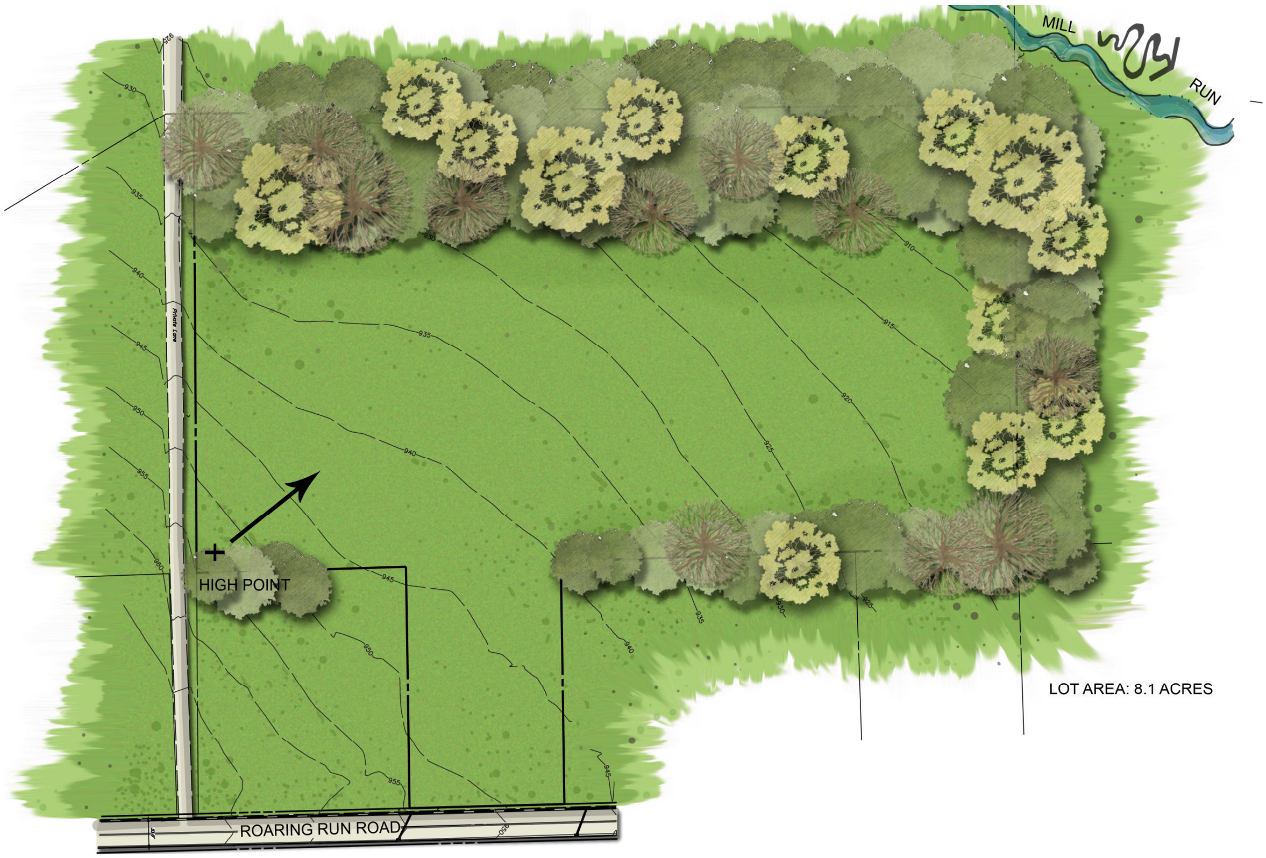


Figure 8.1. Design Example 1 – Pre-Development Conditions

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 low impact design 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 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.

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 which 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 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 design storm runoff volume from pre-development conditions to post-development conditions. The 2-year 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. Then, *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 principal 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.

Step 1

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*).

Step 2

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.

Step 3

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 time of concentration values for the post-development drainage area(s). The NRCS Segmental Method is the preferred method for all post-development time of concentration 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 time of concentration. 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 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 were 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. However, these costs are only a fraction of the costs associated with mitigating mis-managed or un-managed 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 principal 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 does to capture the benefits of improved stormwater management or variances in life-cycle costs such as operation and maintenance 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, operation and maintenance 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 which are 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 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 such as 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 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 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, and 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.

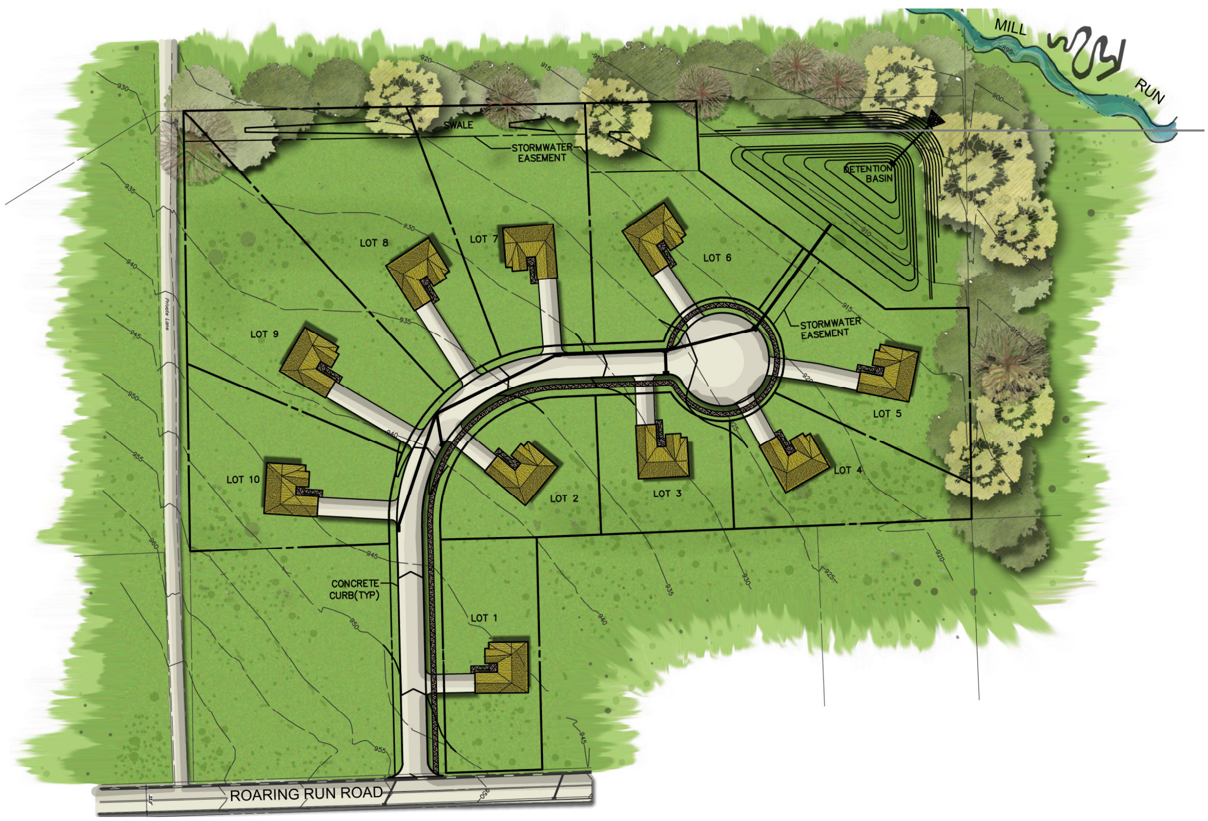


Figure 8.3. Traditional Subdivision Layout (Designed for Peak Rate Control)

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 designs described above. This comparison consists of two 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 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 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). However, the costs and benefits of implementing the proposed stormwater management standards can be very 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 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 15 to 80 percent when LID methods were used, with 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 Total Maximum Daily Loads (TMDLs) for these waters. A TMDL is the maximum amount of pollutant that a water body 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 Pennsylvania and identify streams, and other bodies of water, that are not attaining designated and existing uses as "impaired". Water quality standards are comprised of the uses that waters can support, and goals established to protect those uses. Each waterbody must be assessed for four different uses, as defined in 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 or more designated use but not needing a total maximum daily load (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 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

BUTLER COUNTY IMPAIRMENTS

If a stream segment is not attaining any one of its designated uses, it is then considered to be "impaired". *Figure 9.1* shows the non-attaining stream segments in Butler County and identifies the primary source of the impairment listing.

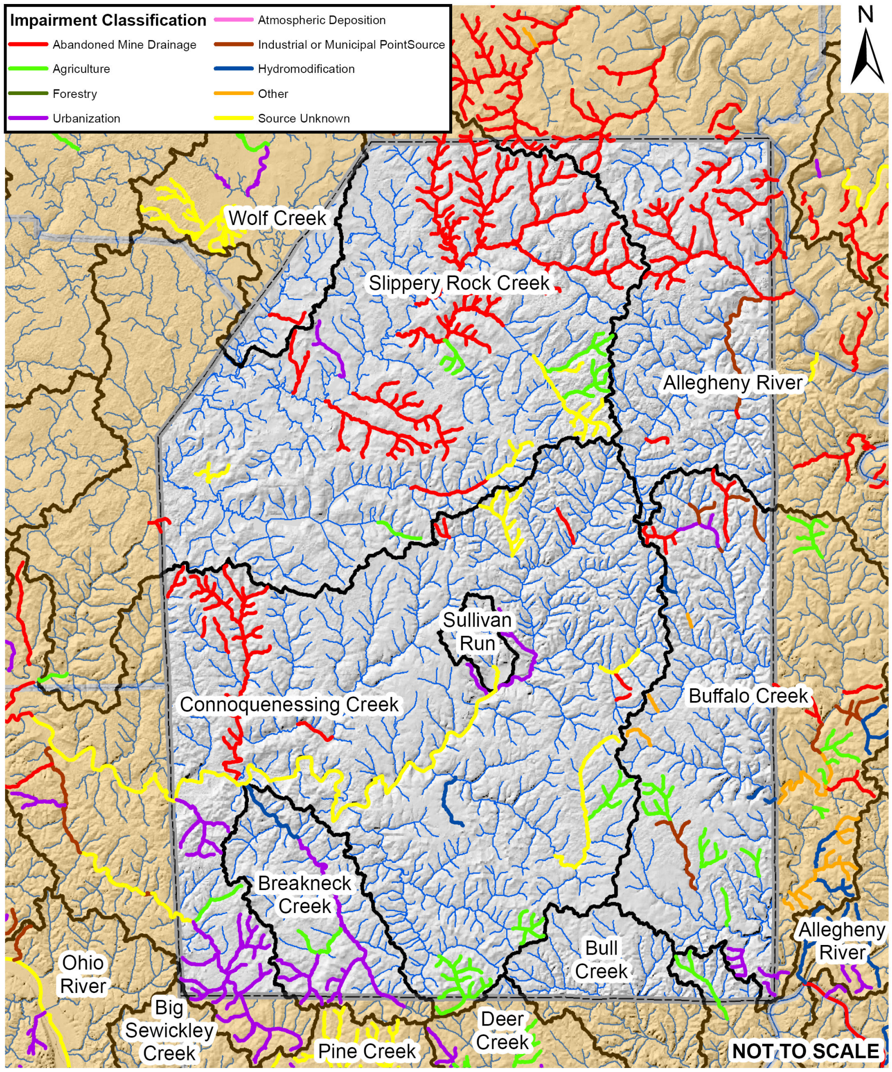


Figure 9.1. Impaired Stream Segments in Butler County

In Butler 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.

Classification	Category	Act 167 Watersheds (stream miles where not indicated) →									
		Allegheny River	Breakneck Creek	Buffalo Creek	Bull Creek	Connoquenessing Creek	Deer Creek	Slippery Rock Creek	Wolf Creek	Entire County	Percent of County
Impaired (miles)	Abandoned Mine Drainage	50.0	--	7.9	--	40.6	--	127.3	1.9	227.6	12.5%
	Agriculture	3.8	4.2	13.6	--	20.8	--	18.0	--	60.4	3.3%
	Atmospheric Deposition	--	--	--	--	--	--	--	--	0.0	0.0%
	Forestry	--	--	--	--	--	--	--	--	0.0	0.0%
	Hydromodification	--	--	--	--	--	--	--	--	0.0	0.0%
	Industrial or Municipal Point Source	7.4	--	9.3	--	0.2	--	--	--	17.0	0.9%
	Urbanization	--	19.2	7.5	--	41.3	--	3.3	--	71.3	3.9%
	Source Unknown	--	--	--	--	49.3	--	16.9	--	66.2	3.6%
	Other	--	6.5	4.4	--	2.8	--	--	--	13.7	0.8%
	Total Impaired	61.3	29.9	42.7	0.0	154.9	0.0	165.5	1.9	456.0	25.0%
	Percent of Total	13.4%	6.6%	9.4%	0.0%	34.0%	0.0%	36.3%	0.4%	100.0%	

Table 9.1. Summary of Impaired Segments by Watershed

Stream Name	Source - Cause	Act 167 Watershed	Length (miles)
UNT Allegheny River	Abandoned Mine Drainage	Allegheny River	4.99
Bear Creek	Abandoned Mine Drainage	Allegheny River	0.68
Bear Creek	Industrial or Mun. Point Source	Allegheny River	3.11
UNT Bear Creek	Abandoned Mine Drainage	Allegheny River	1.12
Fowler Run	Abandoned Mine Drainage	Allegheny River	3.36
UNT Fowler Run	Abandoned Mine Drainage	Allegheny River	2.97
Little Bull Creek	Agriculture	Allegheny River	2.85
UNT Little Bull Creek	Agriculture	Allegheny River	0.99
Little Scrubgrass Creek	Abandoned Mine Drainage	Allegheny River	2.44
UNT Little Scrubgrass Creek	Abandoned Mine Drainage	Allegheny River	3.71
Lowrey Run	Abandoned Mine Drainage	Allegheny River	2.57
UNT Lowrey Run	Abandoned Mine Drainage	Allegheny River	1.55
North Branch Bear Creek	Abandoned Mine Drainage	Allegheny River	8.45
UNT North Branch Bear Creek	Abandoned Mine Drainage	Allegheny River	14.5
UNT Scrubgrass Creek	Abandoned Mine Drainage	Allegheny River	2.68
South Branch Bear Creek	Abandoned Mine Drainage	Allegheny River	0.29
South Branch Bear Creek	Industrial or Mun. Point Source	Allegheny River	4.33
Thoms Run	Abandoned Mine Drainage	Allegheny River	0.69
Breakneck Creek	Other	Breakneck Creek	6.53
Breakneck Creek	Urbanization	Breakneck Creek	9.8
UNT Breakneck Creek	Urbanization	Breakneck Creek	3.54
Kaufman Run	Agriculture	Breakneck Creek	2.78
Kaufman Run	Urbanization	Breakneck Creek	2.35

Stream Name	Source - Cause	Act 167 Watershed	Length (miles)
UNT Kaufman Run	Agriculture	Breakneck Creek	1.4
UNT Kaufman Run	Urbanization	Breakneck Creek	3.48
Buffalo Creek	Abandoned Mine Drainage	Buffalo Creek	1.88
Buffalo Creek	Industrial or Mun. Point Source	Buffalo Creek	0.26
Buffalo Creek	Urbanization	Buffalo Creek	2.36
UNT Buffalo Creek	Abandoned Mine Drainage	Buffalo Creek	5.42
UNT Buffalo Creek	Agriculture	Buffalo Creek	1.92
UNT Buffalo Creek	Industrial or Mun. Point Source	Buffalo Creek	2.77
UNT Buffalo Creek	Urbanization	Buffalo Creek	2.07
Buffalo Run	Industrial or Mun. Point Source	Buffalo Creek	1.5
Little Buffalo Creek	Agriculture	Buffalo Creek	2.2
Little Buffalo Creek	Industrial or Mun. Point Source	Buffalo Creek	3.29
UNT Little Buffalo Creek	Agriculture	Buffalo Creek	9.48
UNT Little Buffalo Creek	Industrial or Mun. Point Source	Buffalo Creek	1.46
UNT Little Buffalo Creek	Urbanization	Buffalo Creek	3.11
Little Buffalo Run	Other	Buffalo Creek	0.77
UNT Little Buffalo Run	Abandoned Mine Drainage	Buffalo Creek	0.56
UNT Little Buffalo Run	Other	Buffalo Creek	0.86
Rough Run	Other	Buffalo Creek	1.48
UNT Rough Run	Other	Buffalo Creek	1.27
Bonnie Brook	Source Unknown	Connoquenessing Cr	2.37
UNT Bonnie Brook	Abandoned Mine Drainage	Connoquenessing Cr	1.62
Brush Creek	Industrial or Mun. Point Source	Connoquenessing Cr	0.23
Brush Creek	Source Unknown	Connoquenessing Cr	1.14
Brush Creek	Urbanization	Connoquenessing Cr	6.11
UNT Brush Creek	Agriculture	Connoquenessing Cr	2.73
UNT Brush Creek	Urbanization	Connoquenessing Cr	17.28
Camp Run	Abandoned Mine Drainage	Connoquenessing Cr	1.44
UNT Camp Run	Abandoned Mine Drainage	Connoquenessing Cr	0.59
Connoquenessing Creek	Abandoned Mine Drainage	Connoquenessing Cr	0.05
Connoquenessing Creek	Source Unknown	Connoquenessing Cr	27.2
Connoquenessing Creek	Urbanization	Connoquenessing Cr	5.3
UNT Connoquenessing Creek	Abandoned Mine Drainage	Connoquenessing Cr	1.53
UNT Connoquenessing Creek	Urbanization	Connoquenessing Cr	4.49
Glade Run	Agriculture	Connoquenessing Cr	3.59
Glade Run	Source Unknown	Connoquenessing Cr	0.06
Glade Run	Urbanization	Connoquenessing Cr	3.06
UNT Glade Run	Agriculture	Connoquenessing Cr	9.9
UNT Glade Run	Urbanization	Connoquenessing Cr	5.05
Little Connoquenessing Creek	Abandoned Mine Drainage	Connoquenessing Cr	5.33
UNT Little Connoquenessing Cr.	Abandoned Mine Drainage	Connoquenessing Cr	1.39
Little Yellow Creek	Abandoned Mine Drainage	Connoquenessing Cr	2.46
UNT Stony Run	Abandoned Mine Drainage	Connoquenessing Cr	1.55
UNT Stony Run	Source Unknown	Connoquenessing Cr	7.43
Sullivan Run	Source Unknown	Connoquenessing Cr	2.07
Thorn Creek	Source Unknown	Connoquenessing Cr	9.01
UNT Thorn Creek	Agriculture	Connoquenessing Cr	4.54
UNT Thorn Creek	Other	Connoquenessing Cr	2.77
Yellow Creek	Abandoned Mine Drainage	Connoquenessing Cr	9.46

Stream Name	Source - Cause	Act 167 Watershed	Length (miles)
UNT Yellow Creek	Abandoned Mine Drainage	Connoquenessing Cr	15.14
Big Run	Abandoned Mine Drainage	Slippery Rock Creek	5.21
UNT Big Run	Abandoned Mine Drainage	Slippery Rock Creek	6.92
Blacks Creek	Abandoned Mine Drainage	Slippery Rock Creek	5.27
UNT Blacks Creek	Abandoned Mine Drainage	Slippery Rock Creek	12.26
Christy Run	Agriculture	Slippery Rock Creek	3.57
UNT Christy Run	Agriculture	Slippery Rock Creek	5.53
Findlay Run	Agriculture	Slippery Rock Creek	2.21
UNT Findlay Run	Agriculture	Slippery Rock Creek	2.19
UNT Glade Run	Abandoned Mine Drainage	Slippery Rock Creek	13.4
Muddy Creek	Abandoned Mine Drainage	Slippery Rock Creek	3.46
Muddy Creek	Source Unknown	Slippery Rock Creek	2.73
UNT Muddy Creek	Source Unknown	Slippery Rock Creek	3.23
UNT N. Branch Slippery Rock Cr.	Abandoned Mine Drainage	Slippery Rock Creek	6.33
UNT N. Branch Slippery Rock Cr.	Abandoned Mine Drainage	Slippery Rock Creek	14.48
Seaton Creek	Abandoned Mine Drainage	Slippery Rock Creek	4.15
UNT Seaton Creek	Abandoned Mine Drainage	Slippery Rock Creek	7.19
Slippery Rock Creek	Abandoned Mine Drainage	Slippery Rock Creek	13.46
UNT Slippery Rock Creek	Abandoned Mine Drainage	Slippery Rock Creek	15.09
UNT Slippery Rock Creek	Urbanization	Slippery Rock Creek	3.25
S. Branch Slippery Rock Creek	Abandoned Mine Drainage	Slippery Rock Creek	10.06
S. Branch Slippery Rock Creek	Source Unknown	Slippery Rock Creek	5.02
UNT S. Branch Slippery Rock Cr.	Abandoned Mine Drainage	Slippery Rock Creek	10.01
UNT S. Branch Slippery Rock Cr.	Agriculture	Slippery Rock Creek	2.49
UNT S. Branch Slippery Rock Cr.	Source Unknown	Slippery Rock Creek	5.91
Swamp Run	Agriculture	Slippery Rock Creek	2.05
UNT Wolf Creek	Abandoned Mine Drainage	Wolf Creek	1.86

Table 9.2. Non-Attaining Streams in Butler County

DRAFT

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. However, 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. National Pollution Discharge Elimination System, 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 Butler County.

Waterbody	TMDL Category	Cause	Status
Blacks Creek	AMD	Metals, pH	EPA Approved 1-19-2005
Brush Creek	Point Source	DO/BOD, Organic Enrichment/Low DO, Pathogens	EPA Approved 4-9-1999
Fowler Run	AMD	Other Inorganics, Metals, pH	EPA Approved 4-9-2003
Little Connoquenessing Creek Watershed	AMD	Cause Unknown, Metals	EPA Approved 4-9-2003
Little Scrubgrass Creek	AMD	Metals, pH	EPA Approved 5-15-2007
North Branch Bear Creek	AMD	Metals	EPA Approved 5-19-2008
Scrubgrass Creek Watershed	AMD	Other Inorganics, Metals, pH	EPA Approved 5-19-2008
Seaton Creek	AMD	Other Inorganics, Metals, pH	EPA Approved 1-19-2005
UNT Connoquenessing Creek	AMD	Suspended Solids	EPA Approved 4-9-2009

Table 9.2. TMDLs in Butler 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 Pennsylvania the leading nonpoint sources of impairment are:

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

Some of these sources are regulated by stormwater ordinances and have been covered in previous section. However, several of these categories are more appropriately addressed by other regulations. Although these activities cannot be regulated by the provisions within the stormwater management ordinance of this Plan, they play a major role in the water quality of

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surface waters. The following is a summary of the nonpoint sources and causes for impairment that affect Butler County waters:

AGRICULTURAL ACTIVITIES

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

SEDIMENT/SILTATION

The most common agricultural cause for surface water impairment is sediment and siltation. Of the 110 miles of impaired streams in Butler County, agriculture related siltation is attributed for 94.1 miles of impairment. This pollutant results from typical agricultural practices such as plowing and tilling, livestock grazing, and livestock access to waterbodies. When appropriate conservation practices are implemented, these activities can be continued while reducing erosion and enhancing and protecting water quality.

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

NUTRIENTS

The second most common agricultural cause for surface water impairment is nutrients. Agricultural activity related nutrients account for 64.9 miles of the 110 miles of impaired streams in Butler County. Nutrients such as nitrogen, phosphorus, potassium and other micronutrients are essential to proper plant growth and development. However, when the available nutrients exceed those required for plant development, or when nutrients are improperly applied, they pose potential environmental hazards. Nutrient pollution results from agricultural activities such as fertilizer and manure application, livestock access to waterbodies, and animal concentration areas.

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

ATMOSPHERIC DEPOSITION

As water moves through the hydrologic cycle, it falls as precipitation, travels varied paths through the system and then evaporates back to the atmosphere as it continues through the cycle. Other substances, including toxic pollutants such as mercury, can follow this same pathway. They evaporate to the atmosphere, where wind currents can carry them very long distances before depositing them elsewhere. Atmospheric deposition is believed to be the dominant avenue by which mercury loads are delivered to most watersheds.

Mercury, impairing 76.8 miles of surface waters within the county, is the primary cause of impairment in Butler County. Impacting 89.9% of the impaired waters within the county, mercury is, by far, the principal impairment concern. Mercury enters the cycle through natural sources such as volcanoes and geologic deposits and also through anthropogenic sources. Anthropogenic emissions largely result from combustion sources such as coal fired power plants, medical waste incinerators and hazardous waste combustion. Other sources of anthropogenic mercury include manufacturing processes related to chlor-alkali production, portland cement production, and pulp and paper manufacturing (Lynch et al., 2007). Although mercury exists in various forms, and people are exposed to each form in different ways, the most common way humans are exposed to mercury is by consuming fish containing methylmercury.

Once emitted to the atmosphere, mercury may be deposited through wet or dry deposition onto land and water surfaces. After reaching an aquatic environment, biological processes work to transform the various forms of elemental mercury into methylmercury, a neurotoxin, which accumulates in top predator fish and the people and wildlife who eat them. As a result of the complex and far-reaching emission, transport and deposition characteristics of mercury in the environment, it is extremely difficult to pinpoint the sources of mercury in a given location.

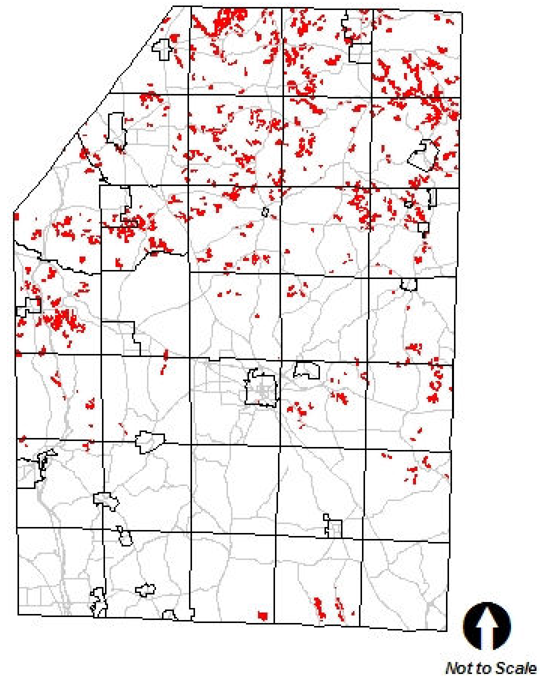
The complexities of atmospheric deposition of mercury and the interrelationship with air pollution and air quality standards make this impairment very difficult to address through stormwater regulations.

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 Pennsylvania. AMD, impairing nearly 198 miles of surface waters within the county, is the leading cause of impairment in Butler County. Impacting 74.6% of the impaired waters within the county, AMD is, by far, the principal impairment concern. Abandoned mine sites have left dangerous highwalls, open pits, coal refuse spoil piles, old mine openings, and miles of streams polluted by abandoned mine drainage. 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.

Vast bituminous coal deposits underlie western and north-central Pennsylvania, including Butler County. Indeed, bituminous coal mining and coke making dominated much of western Pennsylvania's economy during the late nineteenth and early twentieth century. The Pennsylvania 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 Pennsylvania'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. Years of coal mining that was 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.

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 Abandoned Mine Sites can be classified in several categories:



Butler County Abandoned Mine Lands

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 characterization of AML sites 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. Acid mine drainage also leads to increased road maintenance costs, due to the corrosive effects of this drainage on culverts. Streams and drainage systems are often clogged by sedimentation from abandoned mine sites, which, in turn, may cause flooding as a secondary result.

Pennsylvania has an estimated 2,500 miles of streams polluted by acid mine drainage; 250,000 acres of unreclaimed surface mine land; 100 million cubic feet of burning coal refuse; and potential subsidence problems for hundreds of thousands of acres (DEP, 1996). The majority of AMD water related problems are a product of the reaction between a metal sulfide (often pyrite), water, and oxygen. A series of chemical reactions occur when these three elements are present, resulting in contaminants such as ferrous iron, ferric iron, and hydrogen (H^+) ions which increase the acidity of water.

ACIDITY (pH)

Healthy streams, as measured by biodiversity indicators, generally have a pH close (i.e. within one point) to neutral (pH = 7). As the pH drops below 6, the aquatic life diversity within the waterbody decreases as acid intolerant species either die off and other species begin to loose their food supply. **Because pH is measured on a logarithmic scale, each declining unit represents 10 times more acidity.** In AMD impaired waters, oxidation of metal sulfides results in an increase in H^+ ions. As the presence of H^+ ions increase the water becomes more acidic (i.e. the pH becomes lower). Extremely acidic mine waters have been documented with pH values as low as -3.6 (Nordstrom et al., 2000). While this level of extreme acidity is rare, most streams impacted by AMD have some degree of impairment cause by low pH.

METALS

Abandoned mine drainage often contains high concentrations of metals. As the acidity of water increases, more metals (iron, copper, zinc, etc.) can be dissolved from the rocks and go into solution in the water. AMD from coal mines typically contains elevated levels of iron and aluminum, although other metals including manganese and zinc may also be present. Waters with excessive amounts of dissolved metals can be toxic to aquatic organisms.

In addition to dissolved metals, metal precipitates become problematic downstream as AMD mixes with other water sources and in-stream acidity levels decrease. Iron and other metals precipitates out of solution as the pH of the water increase. This metal precipitate, sometimes referred to as "yellowboy", forms the characteristic red, orange, or yellow sediments often seen in the bottom of streams containing mine drainage. Metals degrade water quality and limit the beneficial uses of the surface waters. Beneficial uses that may be affected extend beyond aquatic life support to impact human activities that include drinking water supply, swimming, fishing, and other recreation.

SILTATION AND SUSPENDED SOLIDS

Abandoned mine drainage can result in different forms of suspended solids in receiving waters. Accelerated overland erosion often occurs in mine areas due to vast areas that are unstabilized by vegetation. These areas often remain for many years after active mining operations cease due to the unfavorable conditions for vegetative growth. Erosion of these areas discharges sediment and fine silt particles into receiving streams. Other suspended solids include metal precipitates formed through the chemical processes of oxidation as previously described.

Elevated levels of suspended solids can have a direct negative impact on aquatic species, as well as leading to increased stream temperatures as darker particles absorb heat (EPA, 1997). As water temperatures rise, dissolved oxygen levels (which are critical for many aquatic species) decrease. These changes caused by sediment and siltation are all substantial contributors to aquatic life impairments.

URBANIZATION

This is a broad category that includes the following three 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 initial abstraction is greatly reduced and surface runoff increases. This topic has been the focus of this Plan. The quantity of runoff from urbanized areas, and the water quality characteristics of the runoff, are the two base causes of surface water impairments. These two 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 in turn changes the physical structure of the receiving streams by causing increased bank 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 and turbidity, which can in turn lead to increased stream temperatures as darker particles absorb heat (EPA, 1997). As water temperatures rise, dissolved oxygen levels (which are critical for many aquatic species) 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 new sediment in the channel as flows subside. 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. This includes 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 group such as a local watershed group or the County Conservation District would 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 as necessary to ensure that the water quality goals are eventually obtained.

RECOMMENDED AGRICULTURAL CONSERVATION PRACTICES

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

Riparian Buffers

Riparian areas, land situated along the bank of a water source, typically occur as natural buffers between uplands and adjacent water bodies. They act as natural filters of 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 water bodies provides significant water quality benefits. In addition to the filtering benefits that grass buffers provide, forested buffers provide shade to the stream helping to reduce negative thermal impacts.

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 principals are the same for all of the methods. These principals are keeping "clean" water away from the barnyard and collecting runoff from the barnyard and filtering it with an appropriate BMP or storing it in a manure storage facility for field application. Clean water is diverted away from ACAs with roof runoff structures, diversions, and drainage structures. 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 to maintain crop yields while also limiting excess nutrients that would otherwise be susceptible to transport eventually contributing to NPS pollution. Pollutant delivery reductions achieved by implemented nutrient management plans are greatly varied by individual agricultural operations and there is no efficiency directly associated with this practice. Several cost-share programs are available to assist costs associated with plan development and implementation.

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 County Conservation District has several cost incentive programs to encourage use of cover crops. The efficiency of cover crops varies based on when the crop is planted and whether or not the crop is harvested. 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 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 for each field.

RECOMMENDATIONS FOR ABANDONED MINE DRAINAGE

As discussed previously in this section, the challenges associated with improving AMD impairments are significant. It is generally extremely difficult and cost prohibitive to remediate an AMD source. Because of this, treating the cause of impairment is oftentimes the only option for remediation. Two methods can be used to treat AMD impairments, active treatment and passive treatment. Active treatment methods use alkaline chemicals such as limestone, hydrated lime, soda ash, caustic soda, and ammonia to neutralize acidic AMD impaired water and decrease the solubility of dissolved metals (EPA, 2008b). Active treatment systems are designed and operated to treat specific contaminants at a given site. These treatment systems are very effective at improving water quality, but they are a long-term undertaking. They require ongoing doses of expensive chemicals and are expensive to construct and operate. Passive treatment systems employ chemical and biological reactions (most often employing limestone) in systems that require minimal maintenance to minimize AMD. While passive systems are generally less effective at total treatment than active systems, they are much less expensive to construct and operate. However, they will all accumulate metal precipitates and eventually require maintenance or need to be replaced. Several simple, time-proven passive systems that may be useful in remediating AMD impaired waters are as follows:

Open Limestone Channels/Anoxic Limestone Drains

Open limestone channels can be constructed off-line with mine drainage diverted through the constructed channel, or limestone can simply be placed in the existing stream. This simple passive treatment method uses placed limestone to add alkalinity to the water. The dissolution of the limestone raises the pH of the water. This type of system requires large quantities of limestone for long-term operation (DEP, 2010). One drawback of this system is that iron and aluminum precipitates can coat the limestone and reduce the dissolution of the limestone. This is sometimes referred to as armoring. High flow velocities and turbulent flow can improve the performance of limestone channels by keeping precipitates in suspension and reducing the amount of armoring that can occur. Anoxic drains operate on the same principal as open channels, except they are constructed underground to reduce contact with atmospheric oxygen. Keeping oxygen out of the water prevents oxidation of metals and reduces armoring of the limestone (DEP, 2010). Anoxic drains are also useful for treating subsurface mine water flows.

Diversion Wells

Diversion wells also utilize the technique of using limestone to add alkalinity to contaminated waters. Acidic water is diverted from the stream into a cylindrical well containing limestone aggregate. The water enters the well near the bottom and the hydraulic force of in incoming water agitates and abrades the aggregate. The turbulence in the water increases dissolution and reduces armoring on the limestone. "Treated" water is drawn off the top of the well and directed back into the stream where it mixes with contaminated water. This simple system works well, but requires periodic replenishment of limestone.

Constructed Wetlands

Constructed wetlands are a passive systems that utilize precipitation of metals and natural processes associated with wetland plants to remove dissolved metals from mine drainage within the controlled environment of the treatment system. Constructed wetlands can be aerobic (with oxygen) or anaerobic (without oxygen) which refers to the conditions in which the chemical reactions are occurring. Aerobic wetlands are used primarily for removing metals from contaminated water. They are shallow (1- to 3-foot deep) ponds, that may be lined or unlined, used to facilitate natural oxidation of the metals and precipitate iron, manganese, and other metals (Ford, 2003). Anaerobic wetlands are used to neutralize acidity and reduce metals to the sulfide form. Anaerobic wetlands are shallow ponds filled with organic matter, such as compost, and underlain by limestone gravel. Water percolates through the compost and becomes anaerobic and metals precipitate from the water as sulfides. Microorganisms facilitate this reaction by first consuming oxygen (Ford, 2003).

Initial design and construction of wetland treatment systems can be expensive. However, this step is important as proper initial sizing of wetlands is critical to their success. Constructed wetlands are also sensitive to system stressors such as lack of flow, drastic flow variations, and extreme cold temperatures. These systems are also more maintenance intensive than the previously mentioned treatment systems.

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. Still today, the county lives with the legacy of coal mining. According to DEP, there are 393 documented Abandoned Mine Land sites and 2,135 un-reclaimed AML Features which cover 15,227 acres in Butler County. There have been many reclamation projects completed In Butler County and more are in progress. According to DEP (Webb, 2009), a total of 60 reclamation projects involving 1,620 acres have been undertaken within the county, at a cost of $9,611,036.

POTENTIAL FUNDING SOURCES

Butler County has a variety of potential sources for funding projects and individual practices that will help improve water quality. Some of these programs are county-wide 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. However, there are many activities that fall outside the scope of stormwater management regulations that have a significant impact on stormwater runoff and the goals of sound stormwater management planning. Generally, standards for many of these activities are contained within Zoning Regulations and Subdivision and Land Development Ordinances. Some of these activities and their impact on stormwater management are discussed below.

These measures are included here because they are beyond the regulatory scope of this Plan but may provide valuable tools in obtaining the goals discussed in *Section II*. 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 some, or all, of these activities. A holistic approach that considers all land use policies, and how they impact stormwater runoff, is necessary to maximize the effectiveness of a stormwater management program.

MUNICIPAL ZONING

Municipal zoning is perhaps the single most influential factor on 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 hinderance to successful implentation of the program. Only 34% of rural municpalites have enacted zoning ordinances and the majority of these are located in the southeast portion of the Commonwealth (Center for Rural Pennsylvania, 2001). Instituting new zoning regulations, or even changes to existing regulations, 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. This being said, the impacts of zoning regulation reach far beyond stormwater management. Zoning changes should be developed with careful consideration of all of the potential effects of the ordinance changes.

Recommendations for Improved Municipal Zoning

The following zoning tools are recommended by the Center for Watershed Protection that, if possible to implement, may 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-releated overlay zoning may be "Impervious Overlay Zoning" in areas with documented stormwater problems, which 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 architectual styles. Watershed-related performance zoning might provide precise limits on storwater quality and quantity. This may be one 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 and areas appropriate for traditionally rural land uses, such as 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 miximizing 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, etc.) management approaches. River corridors provide an important spatial context for maintaining and restoring the river processes and dynamic equilibrium associated with high quality aquatic habitats (Kline, 2008). The river corridor includes the existing channel, the floodplain, and the 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 through dynamic fluvial processes in response to the varying inputs of water, sediment, and debris. Natural adjustments to these inputs are occuring 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, meadering stream channels, and the inevitable conflict between the stream and nearby human infrastructure. The more significant changes, such as channel relocation, usually occur during large flood events. 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 policy focuses on future development and reducing the likelihood of increased flooding while floodplain management focuses on preventive and corrective measures to reduce flood damage. Implementation of the Model Stormwater Management Ordinance will reduce the probability of new flooding problems, but will have only minor impacts on existing problems. Examples of these problems are documented in *Section V – Significant Problem Areas and Obstructions*. Many of these problems are due to historic development that has occurred in the floodplain 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*, Butler 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 the impact of such events by reducing the conflicts between human infrastructure and floodplains. 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 restrict future development within floodplains and corrective measures that reduce flood damage in existing problem areas.

<u>**Recommendations for Floodplain Management**</u>

- **Adopt and enforce the Pennsylvania Department of Community and Economic Development (DCED) Model Floodplain Ordinance.** When the FIRMs in Butler 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.** 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 of floodplains 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 and thereby reducing stormwater requirements.
- **Acquire and relocate flood-prone buildings so they are no longer within the floodplain.** Repetitive loss properties (properties for which two 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 2% of all properties have accounted for 33% of flood insurance claims since 1978 (FEMA, 2002). 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 more rural areas of Butler County, than to install structural alternatives such as 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. Implement a systematic inspection and maintenance program where periodic

inspections are conducted on all channels, conveyance and storage facilities and remove debris and perform maintenance as necessary.

RIVER CORRIDOR PLANNING

River corridor planning is a process for selecting and implementing river corridor management alternatives in which all aspects of the river are considered. The process is accomplished through river specific assessments and planning that is able to characterize the river and identify important features as well as the areas that are susceptible to potential threats to those features. This is a form of land use planning that focuses on the impacts of land use on the river system.

One particularly useful aspect of river corridor planning is to use the assessment information to designate corridors along the rivers where natural river changes are most likely to occur resulting in accelerated erosion or bank failures. These areas are sometimes referred to as "fluvial erosion hazard zones" and are responsible for a large portion of the damage to human infrastructure during flood events (Dolan, 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, such as roads and utilities, out of the high risk areas greatly reduces the cost of protecting and maintaining this infrastructure.

Recommendations for River Corridor Planning

- **Identify areas that could benefit river corridor planning and initiate the planning process.** 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, 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 geologic processes or human-induced changes to watershed hydrology or hydraulics. A geomorphic assessment can identify the areas that are most likely to experience channel changes through erosion. These areas can then form the basis for an overlay zoning district or area with specified stream buffers for additional protection. Another option that has been implemented in the state of Vermont, is to integrate Fluvial Erosion Zones into the floodplain mapping process, so that all of the tools of floodplain management are available for the specified areas (Vermont Agency of Natural Resources, 2009).

RIPARIAN ZONE PROTECTION

The riparian zone is the transitional zone between the aquatic zone and adjacent uplands. It generally includes the streambanks, flood plain, 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, all of which provide a natural buffer between waterways and human land use as well as providing vital and unique natural habitat.

Riparian zones provide two principal benefits in regards to stormwater management. They offer flood protection by providing temporary storage area, slowing the velocity of flood waters, and provide a small amount of volume reduction through infiltration and permanent retention of water by disconnected low lying areas. The second primary benefit of riparian zones is the water quality functions they offer. The vegetation in the riparian zone provides shade that reduces water temperature, traps and removes pollutants from stormwater, and provides 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 are in accord with the recently proposed changes to the statewide erosion and sediment pollution control regulations (Pennsylvania 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 approch will limit future development within the riparian zone, but will have little affect 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, cost-share programs such as USDA’s Environmental Quality Incentives Program (EQIP), as well as grant and loan programs.

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. Novitzki (1979, 1989) 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.

Wetlands can also maintain good 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. Wetlands also trap, precipitate, transform, recycle, and export sediment, as well as nutrients, trace metals, and organic material. Water leaving a wetland can differ noticeably from that entering (Mitsch and Gosselink, 1993; Elder, 1987).

Recommendations for Wetland Protection

- **Identify and protect special value wetlands.** Due to the diversity of the benefits provided by wetlands, they are protected through various levels of federal and state regulations. 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.

LOW-IMPACT DEVELOPMENT 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 alters 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 (USEPA, 2009). 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 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, collector). Most ordinances assume a standard 12-foot wide travel lane and then add width for shoulders, parking lanes, bicycle lanes, and other considerations. Reducing the travel lane width to 11 feet for minor roads (e.g., roads within a subdivision development) could reduce the impervious cover of those roadways by up to 8 percent.

- **On-Street Parking** – Parking lanes are often specified to be 8 or 10 feet wide. Standardizing the maximum width of these lanes to 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 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 and to use inlets and storm sewers to remove and transport the runoff from the roads. Ordinances should be modified to allow roadside swales that would provide 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. However, the ordinances do not always 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 and 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 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 absorbant top layer that provides significant stormwater management functions through initial abstraction. 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 soil type to another or because of varied site conditions. However, 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, 2006) have shown that compacted pervious area effectively approaches the infiltration behavior of an impervious surface.

Recommendations for Topsoil Management

- **Adopt ordinance language that discourages the common practice of removing all topsoil from development sites during construction.** The area of disturbance during 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 post construction stormwater management.
- **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 and 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 Chesapeake Bay portion of Virginia, Lassiter (2007) identified and ranked several impediments to LID implementation. The two most important impediment 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 (*Chesapeake Bay Program, 2002*). Many existing municipal regulations were developed to provide adequate infrastructure to meet the needs of growing communities. Often times these standards 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 encourage to review their ordinances for regulations that conflict with low-impact development 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.** As decision makers, and the group responsible for setting policy, 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 such as this Plan and included references.** 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 (2000). These resources 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. However, 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 Conservation District would be invaluable to developers and design professional in determining what may or may not work in Butler 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, and 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 Plan Advisory Committee review (with focused assistance from others including Legal Advisors and Municipal Engineer's review, Municipal 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. Plan Advisory Committee Review - This body has been formed to assist in the development of the Butler County Act 167 Stormwater Management Plan. Municipal members of the Committee have provided input data to the process in the form of storm drainage problem area documentation, storm sewer documentation, proposed solutions to drainage problems, etc. The Committee met on three occasions to review the progress of the Plan. Municipal representatives on the Committee have the responsibility to report on the progress of the Plan to their respective municipalities. Review of the draft Plan by the Plan Advisory Committee will be expedited by the fact that the members are already familiar with the objectives of the Plan, the runoff control strategy employed, and the basic contents of the Plan. The output of the Plan Advisory Committee review will be a revised draft Plan for Municipal and County consideration.

    a. Municipal Engineers Review - This body has been formed 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 - This body has been formed 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. Of primary concern during the municipal review would be the Butler County Stormwater Management Model Ordinance that would implement the Plan through municipal adoption. 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 Plan Advisory Committee, with assistance from the Municipal Engineer and Legal Advisory focus groups, and each municipality, the draft Plan will be submitted to the County Board of Commissioners for their consideration.

The Butler 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 a public hearing. 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 Butler County would be by resolution and require an affirmative vote of the majority of the members of the County Board of Commissioners.

The County will then submit the adopted Plan to DEP for their consideration for approval. The review comments of the municipalities will accompany the submission of the 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, as used here, is a general term that 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.
- Enforcement of the municipal regulations.

Each municipality will need to determine how to best implement the provisions of this Plan within their jurisdiction. Three 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 County Conservation District) 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 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, the Butler County Planning Commission and/or the Butler County Conservation District for compliance with the provisions of the Plan and consistency among the various related regulations.

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 Butler County Act 167 Stormwater Management Plan will be as outlined below.

1. Monitoring of the Plan Implementation - The Butler 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 BCPC 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 Plan Advisory Committee will be convened periodically to review the Stormwater Management Plan and determine if the Plan is adequate for minimizing the runoff impacts of new development. At a minimum, the information to be reviewed by the Committee will be as follows:

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

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

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