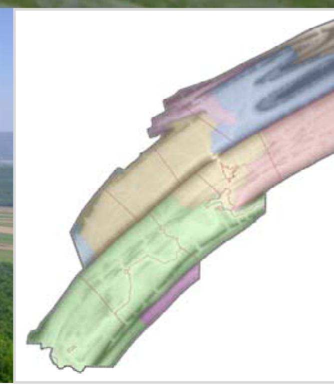
Mifflin County
Act 167 Countywide
Stormwater Management Plan
Phase II

Prepared for:

Mifflin County Planning Commission

June 2010



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[BUILDING RELATIONSHIPS.
DESIGNING SOLUTIONS.]

Mifflin County Planning
And Development Department

With Financial and Technical Assistance From:

Mifflin County Conservation District

pennsylvania
Department of Environmental Protection

ACKNOWLEDGEMENTS

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Douglas Kepner	Juniata Terrace Borough	Dwight Aurand	Wayne Township

Mifflin County obtained a grant from DEP to complete Phase I which the County matched the grant with 25% in in-kind services. For Phase II, DEP developed an agreement with the County which they will reimburse 75% of the costs with the County matching 25% mostly with in-kind services.

RESOLUTION NO. 2010-25
OF THE MIFFLIN COUNTY BOARD OF COMMISSIONERS
ADOPTING THE MIFFLIN COUNTY STORMWATER MANAGEMENT PLAN

WHEREAS, the Stormwater Management Act 167 of 1978 provides for the regulation of land and water use for flood control and stormwater management, requires the Pennsylvania Department of Environmental Protection to designate watersheds, provides for grants to be appropriated and administered by the Department for plan preparation and implementation costs, and provides that each county will prepare and adopt a stormwater management plan for each designated watershed;

WHEREAS, the Mifflin County Board of Commissioners entered into a grant contract with the Pennsylvania Department of Environmental Protection to develop the Countywide stormwater management plan for all the designated watersheds within the County;

WHEREAS, the purpose of the Mifflin County Stormwater Management Plan is to protect public health and safety and to prevent or mitigate the adverse impacts related to the conveyance of excessive rates and volumes of stormwater runoff by providing for the management of stormwater runoff and control of erosion and sedimentation; and

WHEREAS, design criteria and standards of stormwater management systems and facilities within the County's watersheds shall utilize the criteria and standards as found in the stormwater management plan.

NOW, THEREFORE, BE IT RESOLVED that the Mifflin County Commissioners hereby adopt the Mifflin County Stormwater Management Plan, including all volumes, sections, parts, figures, maps, plates and appendices, and forward the Plan to the Stormwater Planning and Management Section of the Pennsylvania Department of Environmental Protection for approval this seventeenth day of June 2010.

MIFFLIN COUNTY COMMISSIONERS

Mark A. Sunderland, Chairman

Otis E. Riden, Jr., Vice Chairman

Robert A. Reck, Secretary

ATTEST:

Cathy L. Romig, Chief Clerk

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Section I – Introduction

This Stormwater Management Plan (Plan) is the product of a collaborative effort between the varied stakeholders within the Act 167 Designated Watersheds in Mifflin County, Pennsylvania. The Plan has been developed based upon the requirements contained within 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 within 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 within impaired waters. The specific goals of this plan are discussed in detail in the following section. This section introduces some basic concepts relating the physical elements of stormwater management, the hydrologic concepts, and the planning approach used throughout this study.

RAINFALL AND STORMWATER RUNOFF

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

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

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

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of thought is exacerbated when the individual land development projects are scattered throughout a watershed (and in many different municipalities). It 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 within 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 within a watershed are unique to each watershed. An effective stormwater management plan must be responsive to the existing characteristics of the watershed and recognize the changing conditions resulting from planned development. In Pennsylvania, stormwater management is generally regulated on the municipal level with varying degrees of coordination on types and levels of stormwater management required between adjoining municipalities. A watershed-based stormwater management plan can minimize inconsistencies to more effectively address the issues that contribute to a watershed's degradation. While land use regulation remains at the municipal level, the framework established within a watershed plan enables municipalities to see the impact of their regulations on the overall system and coordinate their efforts with other stakeholders within the watershed.

WATERSHED HYDROLOGY

Under natural conditions, watershed hydrology is in dynamic equilibrium. That is, the watershed, its ground and surface water supplies, and resulting stream morphology and water quality evolve and change with the existing rainfall and runoff patterns. This natural state is displayed by stable channels with minimal erosion, relatively infrequent flooding, adequate groundwater recharge, adequate baseflow, and relatively high water quality. When all of these conditions are present, streams support comparatively 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 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, the magnitude of which 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

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diminished, or removed, causing more rainfall to become runoff that flows to receiving streams instead of infiltrating. Less water is retained in the watershed to replenish groundwater supplies.

4. Baseflow – Loss of groundwater recharge, as described above, leads to insufficient groundwater available to replenish stream flow during dry weather. As a result, streams that may have an adequate baseflow during dry weather under natural conditions may experience reduced flow, or become completely dry, during periods of low precipitation in developed watersheds. Thermal degradation of the waterbody often accompanies the reduction of baseflow originating from groundwater. This source of baseflow is generally much cooler than surface water sources. The increase in water temperature can be detrimental to many ecological communities.

5. Water Quality – Stormwater from developed surfaces carries a wide variety of contaminants. Pesticides, herbicides, fertilizers, automotive fluids, hydrocarbons, sediment, detergents, bacteria, increased water temperatures, and other contaminants that are found on land surfaces are carried into streams by runoff. These contaminants affect the receiving streams in different ways, but they all have an adverse impact on the quality of the water in the stream.

6. Stream Biology – Biological communities reflect the overall ecological integrity of a stream. The composition and density of organisms in aquatic communities responds proportionately to stressors placed on their habitat. Communities integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions. The adverse impacts of improperly managed runoff and increased pollution are evident in the biological changes in impacted streams. When biological communities within a waterbody degrade, the overall ecological integrity of the stream is also diminishing.

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

The stormwater management philosophy of this Plan is reflected in the technical standards: peak flow management, volume control, channel protection, and water quality management. The philosophy and standards reflect an attempt to manage stormwater in such a way as to maintain the watershed hydrology as near to existing, or historical, conditions as possible.

STORMWATER MANAGEMENT PLANNING

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

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

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

1. Stormwater regulatory responsibility, 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 within 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 can, and do, cause stormwater problems for downstream neighbors. In these situations, downstream municipalities are forced to deal with problems associated with increased water volume, increased sediment loads, and increased pollutants that originate in areas they have no control over.
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 that mimics the natural hydrologic regime by managing rainfall at the source using uniformly distributed, decentralized, micro-scale controls (Low Impact Development Center, 2007). These concepts are the origin of many of the strategies identified to achieve the goals presented in this Plan.

As a comprehensive technology-based approach to managing stormwater, LID has developed significantly in terms of policy implementation and technical knowledge. The goals and principles of LID, as described in *Low-Impact Development Design Strategies* (Prince George's County, 1999) are defined as follows:

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- 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 best management practices (BMPs) are derived from the following conceptual framework (Prince George's County, 1999):

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

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

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

Table 1.1. Comparison of LID Versus Traditional Stormwater Management Approach

When implemented at the site level, LID has been found to have a beneficial impact on water quality and in reducing peak flows for more frequent storm events (Bedan and Clausen, 2009; Hood et. al., 2007). There are numerous case studies and pilot projects that emphasize similar finding 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.

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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.

GOALS OF THIS PLAN

The overall objective of this Plan is to provide a plan for comprehensive watershed stormwater management throughout Mifflin 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 Mifflin County.

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

5. Preserve the existing natural drainageways and watercourses.

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 stategies to address the goals and where these strategies are addressed in the Plan:

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1. Manage stormwater runoff created by new development activities by taking into account the cumulative basin-wide stormwater impacts from peak runoff rates and runoff volume	
Develop models of selected watersheds to determine their response to rainfall	*Section VI, Appendix A*
Determine appropriate stormwater management controls for these basins	*Section VI, Appendix A*
2. Meet the legal water quality requirements under Federal and State laws	
Provide recommendations for improving impaired waters within the county	*Section IX*
Encourage the use of particularly effective stormwater management best management practices (BMPs).	*Section VII*
3. Provide uniform standards throughout Mifflin 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 Mifflin 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 I, Section X*
Require use of the Design Storm Method or the Simplified Method	*Model Ordinance*
4. Preserve the existing natural drainageways and watercourses	
Provide education on the function and importance of natural drainageways	*Section I, Section X*
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 V, Appendix C*
Analyze problem areas and provide conceptual solutions to the problems	*Section V, Appendix C*

Table 2.1. Preferred Strategies to Address Plan Goals

STORMWATER PLANNING AND THE ACT 167 PROCESS

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

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

As described in Act 167, each county must prepare and adopt a watershed stormwater management plan for each watershed located in the county, as designated by DEP, in consultation with the municipalities located within each watershed, and shall periodically review and revise such plan at least every five (5) years. Within six (6) months following adoption and approval of the watershed stormwater plan, each municipality must adopt or amend, and must

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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 5(b) OF ACT 167
(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.

Table 2.2. Elements of Act 167

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SECTION 5(c) OF ACT 167
(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 5c
(1) Contain such provisions as are reasonably necessary to manage stormwater such that development or activities in each municipality within the watershed do not adversely affect health, safety and property in other municipalities within the watershed and in basins to which the watershed is tributary; and
With the adoption of the Model Stormwater Management Ordinance provided with this Plan, each municipality must enforce development, redevelopment, and other regulated activities consistent with the standards and criteria contained in the Model Ordinance. These standards and criteria have been developed to ensure regulated activities will not adversely affect health, safety, and property in the County.
(2) Consider and be consistent with other existing municipal, county, regional and State environmental and land-use plans.
Section 3 identifies several planning efforts which the County conducted in the past. These include watershed Act 167 Plans, comprehensive planning including open space planning and land use plans, and hazard mitigation planning.

Table 2.2 (continued). Elements of Act 167

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PLAN ADVISORY COMMITTEES (PACS)

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

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

As 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.

In addition to the PAC, several meetings were held with other groups to discuss the Plan, providing an educational aspect, soliciting input, and discussing implementation alternatives. The groups include the Mifflin County Planning Commission and the Council of Governments.

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PAC Meeting	Purpose of Meeting	Meeting Dates
3	Phase 2 Start-up Meeting - Introduce the Phase 2 planning process. Emphasize the importance of municipal involvement. Present summary of the data collection questionnaire from Phase 1.	6.17.2008
4	Reviewed the project status, reviewed identified problem areas, maps & land use, solicit input from municipalities. Reviewed stormwater management standards as well as model ordinance provisions. Began stream impairment discussions.	9.16.2008
4	Technical issues for detailed models: Review model selection and setup, initial modeling runs, calibration procedures, solicit input on technical standards & model ordinance provisions and implementation strategies; stream impairment strategies to address water quality issues.	12.16.2008
5	With municipal engineers, discusses technical issues for detailed models including input parameters, results and calibration; Review standards and criteria; discuss water quality issues and preliminary technical content for ordinances.	4.14.2009
6	Meeting with PAC, municipal engineers and solicitors discussing state budget impacts on scope, schedule and budget on the project; Reviewed Model Ordinance and Ordinance Implementation soliciting input. (Draft Model Ordinance sent to municipalities prior to meeting).	3.10.2010
7	Meetings with PAC, municipal engineers and solicitors reviewing draft Plan, review technical comments, and revised Model Ordinance. Gather general comments and feedback prior to finalization of the Plan. (Draft Plan sent to municipalities prior to meeting).	4.29.2010
Public Hearing	Conduct the hearing as required by Act 167 to present the PLAN to the public.	6.10.2010

Table 2.3. Summary of PAC Meetings

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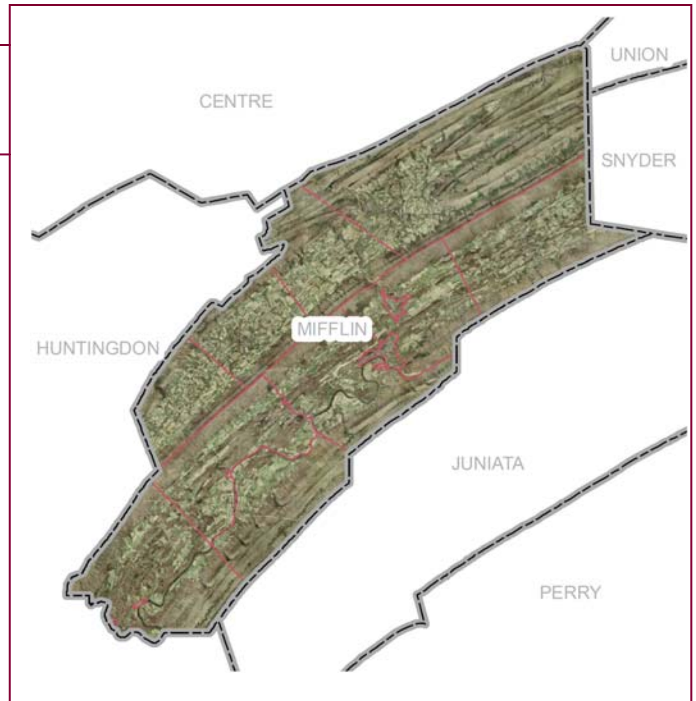
Section III – Mifflin County Description



Mifflin County is located in central Pennsylvania and was established in 1789 by legislative act. It was named in honor of the first Governor of Pennsylvania, Thomas Mifflin. Mifflin County is approximately 14 miles wide by 35 miles long and encompasses 264,299 acres (413 square miles). The topography of the county is ridge-and-valley terrain with approximately 66% of the county being forested terrain and significant amount of agricultural lands. The elevation range of the county is from a low of 430 feet along the Juniata River to a high of 2,340 feet on Jacks Mountain. Parts of the county have been urbanized through industrial growth and its accompanying population growth. However, the bulk of the county has retained its rural character. The County seat is Lewistown, which also has the largest population in the county.

POLITICAL JURISDICTIONS

The County is comprised of sixteen (16) municipalities. The political jurisdictions include six (6) boroughs and ten (10) second class townships. Mifflin County is classified as a sixth class county and is ranked 46th of 67 counties with a population of 46,486, according to the 2000 census. The sixteen (16) municipalities in Mifflin County and their associated land area are as follows:

TOWNSHIPS	AREA (mi^2)	BOROUGHS	AREA (mi^2)
Armagh Township	92.8	Burnham Borough	1.1
Bratton Township	32.8	Juniata Terrace Borough	0.1
Brown Township	33.2	Kistler Borough	0.3
Decatur Township	45.2	Lewistown Borough	2.0
Derry Township	31.1	McVeytown Borough	0.1
Granville Township	40.1	Newton Hamilton Borough	0.2
Menno Township	23.8		
Oliver Township	34.6		
Union Township	25.5		
Wayne Township	47.9		

Table 3.1. Mifflin County Municipalities

LAND USE

GENERAL DEVELOPMENT PATTERNS

The core area of the County is the "Greater Lewistown Area", which includes Lewistown, Juniata Terrace, and Burnham Boroughs, with portions of Derry and Granville Townships. The *Mifflin County Comprehensive Plan*, completed by the Mifflin County Planning and Development Department in 2000, has identified "Zoned High Growth Areas" surrounding the Greater Lewistown Area, generally following Routes 322, 522, and 22. In addition, the Belleville area (Belleville Borough and Union Township) and the Milroy/Reedsville area (Armagh and Brown

Townships) were identified as "High Growth Areas". These areas have the greatest potential for attracting new development, both commercial/industrial as well as residential.

Peripheral growth areas were identified as "Limited Growth Areas" scattered throughout the County around existing villages. The Limited Growth Areas typically have resulted in residential subdivisions of three (3) lots or less.

With major employment centers in Centre County within commuting distance, coupled with the relatively inexpensive land costs in Mifflin County, development pressures in Mifflin County have increased in recent years. Larger residential subdivisions are currently planned in Derry and Brown Townships, Areas outside the Greater Lewistown Area continue to see small residential subdivisions. New commercial/Industrial developments are also planned in areas identified as High Growth Areas.

TRANSPORTATION

Transportation development in Mifflin County played a prominent role in the growth of the region. In fact, historically and geographically, Lewistown was considered the central point between Philadelphia and Pittsburgh, between the anthracite and bituminous coal regions, and central in terms of rail facilities and leading markets.

Major roads of the area include east-west access on US Routes 22 and 322. North-south access includes US Route 522, and PA Route 655. The routes are generally two-lane roads, except for US 22/322, which is a four-lane limited access highway. Railroads transporting both passenger and freight serve the County as does one (1) business class airport.

FARMLANDS

Prime farmland, as defined by the U.S. Department of Agriculture (USDA) in the National Soil Survey Handbook, is the land that is best suited to producing food, feed, forage, and fiber and oilseed crops. It has the soil quality, growing season, and water supply needed to economically produce a sustained high yield of crops when it is treated and managed using acceptable farming methods (NRCS, 2007). In 1972, the USDA assigned the Soil Conservation Service the task of inventorying the prime and unique farmlands and farmlands of state and local importance. This inventory was designed to assist planners and other officials in their decision making to avoid unnecessary, irrevocable conversion of good farmland to other uses. On the USDA's important farmland inventory map, the farmlands are categorized into four (4) classifications: prime farmland, unique farmland, additional farmland of statewide importance, and additional farmland of local importance. According to the USDA, prime farmland soils are usually classified as capability Class I or II. Of Mifflin County's total land area, 3,078 acres (1.2 percent) are classified as Class I soils and 42,502 acres (16.1 percent) are classified as Class II soils as identified in the *Soil Survey of Juniata and Mifflin Counties, Pennsylvania* (SCS, 1981).

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.

Mifflin County's prime agricultural soils are concentrated in the Kishacoquillas Valley, Ferguson Valley, Juniata River Valley, and those valleys located throughout Derry and Decatur Townships. According to USDA's National Agriculture Statistic Service, there are 755 active farms in Mifflin County covering over 90,000 acres.

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The importance of identifying these areas, 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.

Between 1975 and 1995, the County lost over 3,000 acres of the most productive farmland to residential uses. To address this problem, Mifflin County has active Ag Security and Ag Land Preservation programs. It is noted, however, that Ag Land Preservation programs are dependent upon state funding.

CLIMATE

Mifflin County is situated in the Middle Susquehanna Climatic Divisions and the climate is classified as humid continental. The area is mostly affected by weather systems that develop in the Midwest and are steered by prevailing westerly winds. The primary source of moisture is the Gulf of Mexico with a secondary contribution by the Atlantic Ocean. Due to the long overland trajectory, the cold Canadian air masses are somewhat modified by the time they reach central Pennsylvania. The annual precipitation of 38.71 inches reflects the drying effect of the Appalachian chain to the west. The average annual temperature is 50.6° Fahrenheit (F). The winters are generally cold with average monthly temperatures below freezing in December, January, and February. The coldest month is January with an average temperature of 28.9° F. The warmest month is July with an average temperature of 72.6° F (USACOE, 1995). An inch or more of snow is observed on an average 33 days and six (6) inches or more eight (8) days annually. Very little snow is observed after mid-March. The average growing season is 175 days, although it has varied from 122 to 219 days.

According to the draft *Mifflin County Water Plan* (Gannett Fleming, 2000), the water budget analyses of watersheds within the Juniata River basin reveal stream discharge to represent about 40 to 48% of precipitation, or about 15.5 to 18.5 inches. In a normal year, about 0.763 million gallons of water per day per square mile is recharged to the surface water and groundwater systems in the County.

RAINFALL

Figures 3.1 and 3.2 show the rainfall statistics for Mifflin County. The average rainfall, shown in Figure 3.1, portrays the amount of precipitation throughout each year since 1939. Although there can be significant variation in the annual rainfall total (between 25 and 55 inches). While this variation can have a significant impact on water supply and vegetative growth, it is the quantity of rain in a relatively short time period (1-hour, 6-hour, 24-hour, or 48-hour) that receives the focus of most stormwater regulations.

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

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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 lead 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 Mifflin County comes from storms low magnitudes, as shown in Figure 3.3. Between 1939 and 2009, only 0.27% of the daily storm totals exceeded the NOAA Atlas 14 24-hour, 2-Year storm total of 2.76 inches. Only 10% of the daily storm totals exceeded 0.81 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 best management practices (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 14, 2-year, 24-hour storm event total of 2.76 inches was exceeded 23 times in more than 60 years of data. When analyzing only the annual maximum series, the NOAA Atlas 24-hour, 2-year storm was exceeded only 18 times. Thus, viewing only the annual maximum series neglects a substantial number of significant historical rainfall events. The implication for stormwater policy in Mifflin County is that BMPs should incorporate the NOAA Atlas 14, partial duration data series to ensure the best available data is being used for design purposes.

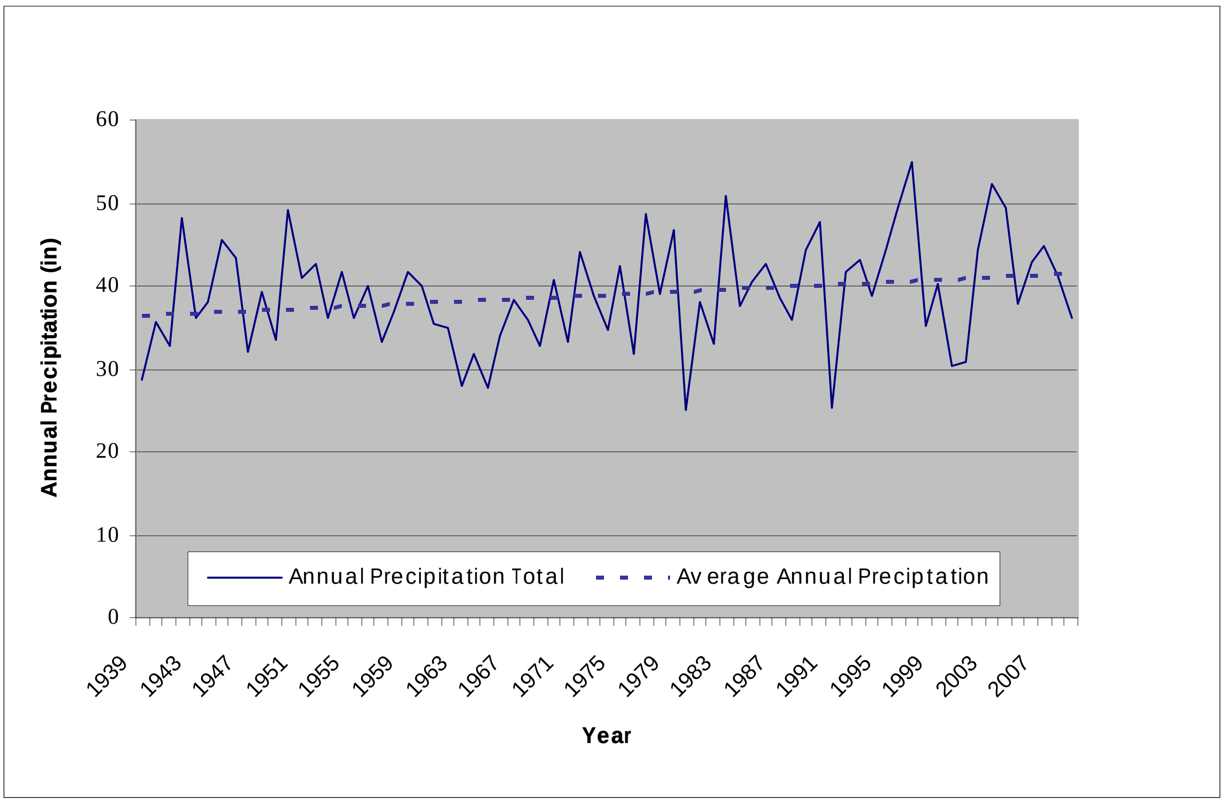

Figure 3.1. Annual Precipitation at Lewistown, Pennsylvania (Coop ID #364992)

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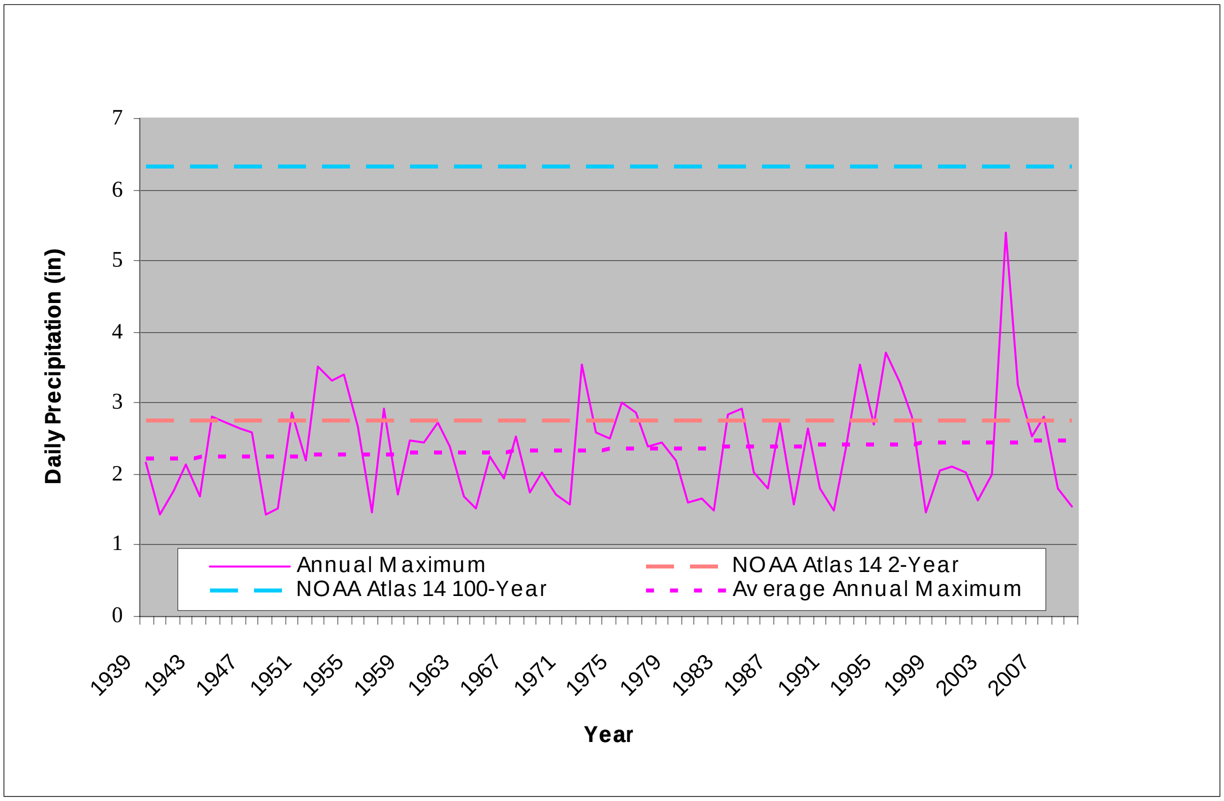

Figure 3.2. Daily Precipitation at Lewistown, Pennsylvania (Coop ID #364992)

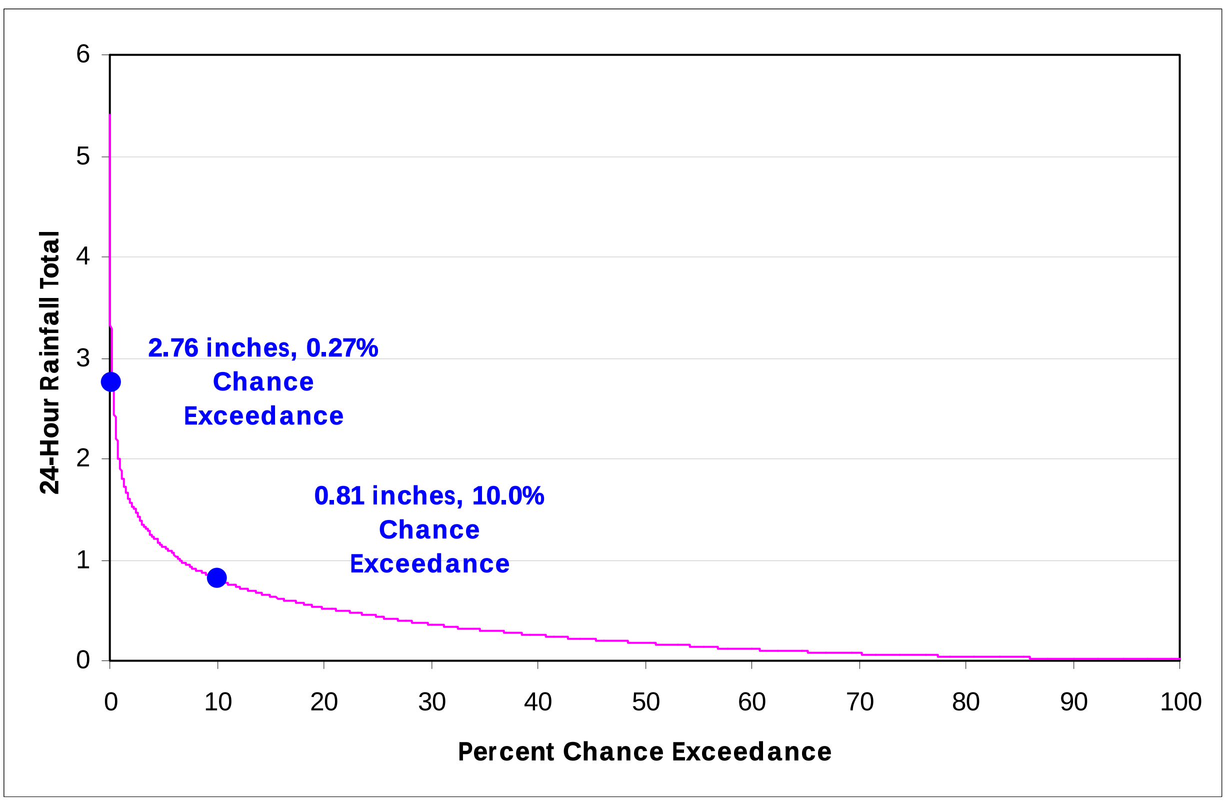

Figure 3.3. Exceedance Curve of Daily Precipitation at Lewistown, Pennsylvania (Coop ID #364992)

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GEOLOGY

Mifflin County is located in the Appalachian Mountains Section of the Ridge and Valley Physiographic Province. The Ridge and Valley Province is characterized by alternating series of long, narrow, and even-crested ridges and valleys. The ridge and valleys are oriented in a northeast to easterly direction. Some karst terrain exists in the valleys. Stone Mountain, Shade Mountain, and Blue Mountain are other ridges above 2,100 feet (Sevon, 2000). Big Valley, Ferguson Valley, and the Juniata River Valley are the major valleys between the main ridge lines. The High Plateau Section is characterized by broad, rounded to flat uplands having deep, angular valleys. The local relief is moderate (301 to 600 feet) to very high (> 1000 feet) with trellis, angulate, and some karst drainage patterns (Sevon, 2000). Refer to *Plate 6 – Geology* for more information.

BEDROCK FORMATIONS

Exposed bedrock in Mifflin County is sedimentary in origin and includes 23 different geologic formations that range from Middle Devonian-Age to Ordovician-Age. The formations consist of conglomerate, sandstone, siltstone, shale, limestone, and dolomite. In general, the limestone and dolomite formations underlie the valleys, the shale and siltstone formations underlie the foothills, and the formations containing conglomerate, sandstone, siltstone, and shale underlie the ridges. The formation names are as follows:

Formation	Dominant Lithology	% of County
Axemann Formation	Limestone	1.8
Bald Eagle Formation	Sandstone	5.4
Bellefonte Formation	Dolomite	4.8
Benner Formation through Loysburg Formation, undivided	Limestone	3.3
Bloomsburg and Mifflintown Formations, undivided	Shale	6.8
Clinton Group	Shale	10.0
Coburn Formation through Nealmont Formation, undivided	Limestone	4.1
Hamilton Group	Shale	7.9
Juniata Formation	Sandstone	11.0
Keyser and Tonoloway Formations, undivided	Limestone	7.8
Onondaga and Old Port Formations, undivided	Calcareous shale	8.0
Reedsville Formation	Shale	10.1
Trimmers Rock Formation	Siltstone	0.0
Tuscarora Formation	Quartzite	11.4
Wills Creek Formation	Calcareous shale	7.6

Table 3.2. Geologic Formations (PA Geological Survey, 2010)

In general, the older Ordovician rocks occur in the northern part of the county and the younger Silurian and Devonian rocks in the southern part. There is considerable repetition of the geologic formations due to the strata folding during mountain-building events. Ridges are often several miles apart and underlain by the same formation. The resistant sandstone formations, such as the Tuscarora, Juniata, and Bald Eagle Formations, form the steep topography and provide limitations to development in the county. The less resistant limestone and shale formations, such as the Keyser and Tonoloway Formations and Clinton Group, form the valleys where present and future development can occur in the county.

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KARST TOPOGRAPHY

Portions of Mifflin County's landscape are underlain by limestone based geologic formations. Limestone, which is a carbonate-rich material, is highly soluble and susceptible to the formation of solution caverns and sinkholes (i.e. karst topography). Karst refers to any terrain where the topography has been formed chiefly by the dissolving of rock. Landforms associated with karst include sinkholes, caves, sinking streams, springs, and solution valleys.

Because of the unique geologic and hydrologic features associated with highly developed subterranean networks, the scope of problems related to the karst environment is large. A karst landscape is particularly sensitive to environmental degradation, with the depletion and contamination of groundwater supplies being among the most severe.

Stormwater runoff also contributes to sinkhole activity. According to Kochanov in his work *Sinkholes in Pennsylvania,* "The stormwater drainage problem is compounded in karst areas by the fact that development reduces the surface area available for rainwater to infiltrate naturally into the ground. A typical residential development having quarter-acre lots may reduce the natural ground surface by 25 percent, whereas a shopping center and parking lot may reduce it by 100 percent. If stormwater, gathered over a specific area, is collected and directed into a karst area, the concentration of water may unplug one of the karst drains". Although karst landforms pose hazardous conditions, they are, in fact, valuable for various reasons. They serve as areas for endangered species of flora and fauna, may contain cultural resources (i.e., historic and prehistoric), contain rare minerals or unique landforms, and provide scenic and challenging recreational opportunities.

OUTSANDING 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). Mifflin County contains two (2) of these resources as identified below.

Mammoth Spring – Located in Armagh Township, this spring is the 3rd largest in Pennsylvania and is the headwaters of Honey Creek. From the head of the cave, the spring rushes through a short gorge for the first several hundred yards of Honey Creek. In the early 1920's, these two (2) caverns were open to the public and called Alexander Caverns, but the entrances were sealed due to significant vandalism.

Prayer Rock – Located at the crest of Jacks Mountain in Menno and Oliver Township, this overlook provides a magnificent view of Kishacoquillas Valley. Massive outcrops of steeply-dipping Tuscarora Quartzite form the ridge. The Mifflin County Federation of Men's Bible Classes erected a monument on this site.

SLOPES

Mifflin County is located entirely within the tightly folded and faulted geologic region. As a result, much of the county contains sizeable areas of steep slopes in municipalities located along Jacks Mountain, Blue Mountain, Stone Mountain, Broad Mountain, and Long Mountain. Slopes with grades of 15% or greater are considered steep. If disturbed, these areas can yield heavy sediment loads on streams. Very steep slopes, with over 25% grade, produce heavy soil erosion and sediment loading. Of the County's total land area, approximately 42% is classified as having slopes of 15% or greater. Slope values are broken into four (4) categories and shown in *Table 3.3* and *Figure 3.4*. Also shown is the total area in Mifflin 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.

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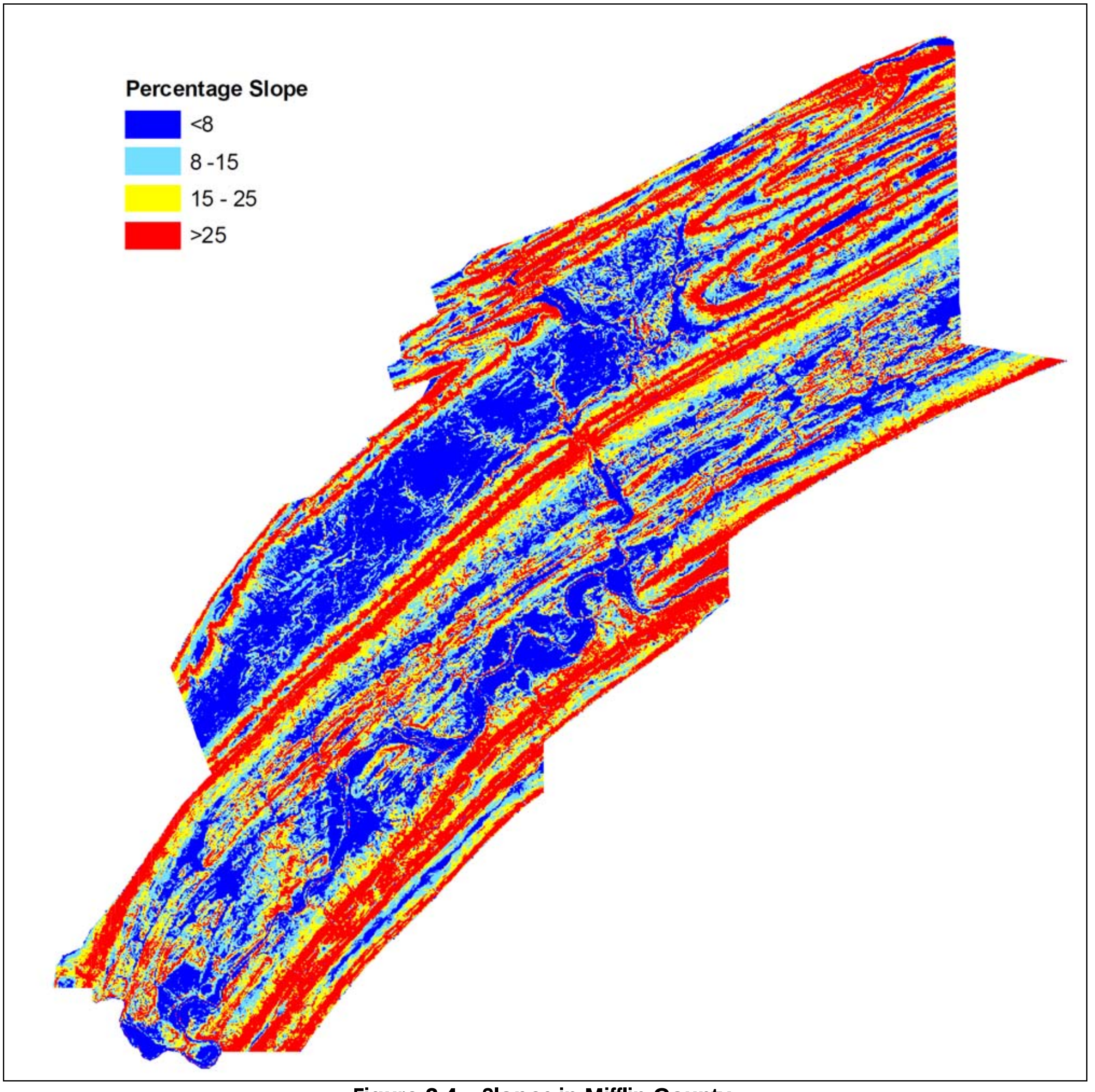

Figure 3.4. Slopes in Mifflin County

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Slope Classification	Slope Range	Land Area (mi²)	Portion of Total Area	Slope Restrictions
Flat to Moderate	0-8%	122.4	29.5%	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%	92.5	22.3%	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%	86.5	20.8%	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%	113.4	27.3%	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 Mifflin County

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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 within Mifflin County have variable drainage characteristics and have various restrictions on their ability to drain, promote vegetative growth, and allow infiltration. They are generally moderately to poor drained and have a high runoff potential. The following describes the predominant soil series that occupy greater that 1% of land cover in Mifflin County (SCS, 1981).

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Allegheny	AbB	B	1.3	
Alvira	AlB	C/D	<0.1	Fragipan (16-28in.)
Andover	AnB, AoB, AoC	D	4	Fragipan (18-28in.)
Ashton	As	B	0.3	
Atkins	At	D	0.9	Lithic bedrock (60-99in.)
Berks	BkB, BkC, BlD, BMF	C	7.8	Lithic bedrock (20-40in.)
Brinkerton	BrA, BrB	D	1.8	Fragipan (15-34in.)
Buchanan	BuB, BuC, BxB, BxD	C	5.7	Lithic bedrock (60-99in.)
Chavies	CaB	B	0.4	
Edom	EdB, EdC, EdD, EeB, EeC, EeD, EfB, EfC, EfD	C	4.6	Paralithic bedrock (40-72in.)
Elliber	ElB, ElC, ElD, ElF	A	1.5	
Ernest	ErB, ErC	C/D	1.2	Fragipan (20-36in.)
Evendale	Ev	C	0.1	Paralithic bedrock (60-84in.)
Hagerstown	HaB, HcB, HcC, HcD, HeB, HeD	B	8.1	Lithic bedrock (40-84in.)
Hazleton	HhB, HhC, HhD, HSB, HSD, HTF	B	27.4	Lithic bedrock (40-84in.)
Klinesville	KlB, KlC, KlD, KlF	C	1.2	Paralithic bedrock (10-20in.)
Kreamer	KrB, KrC	C	0.4	
Laidig	LaB, LaC, LaD, LcB, LcD, LDF	C	12.1	Fragipan (28-35in.)
Leetonia	LtB	C	1	Lithic bedrock (40-60in.)
Melvin	Ma	D	0.5	Lithic bedrock (72-99in.)
Mertz	MeB, MeC, MeD	C	2.7	Lithic bedrock (72-99in.)
Millheim	MnB, MnC	C	0.2	Paralithic bedrock (40-72in.)
Monongahela	MoA, MoB	C	1.1	Fragipan (18-30in.)
Morrison	MrB, MrC, MrD	B	1.3	
Murrill	MuB, MuC	B	1.8	Lithic bedrock (72-99in.)
Newark	Ne	C	0.1	
Nolin	No	B	0.6	Lithic bedrock (60-99in.)
Opequon	OpB, OpC, OpD, ORF	C	4.7	Lithic bedrock (12-20in.)
Penlaw	Pe	C	0.4	Fragipan (15-30in.)
Philo	Ph	B	0.6	Lithic bedrock (61-120in.)
Pope	Po	B	0.2	
Purdy	Pu	D	0.5	
Rubble land	Ru	B	3.2	Lithic bedrock (40-99in.)
Tyler	Ty	D	0.5	Fragipan (15-24in.)
Vanderlip	VaC	A	0.2	
Watson	WaB, WaC	C	<0.1	Fragipan (18-32in.)
Weikert	WeB, WeC, WeD	C	0.7	Paralithic bedrock (10-20in.)
Other	W, QU, IW, CG	--	1	Water, Quarries, Industrial Waste, Udorthents

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

One (1) of the impediments to drainage throughout Mifflin County is the presence of fragipan soils, typically a loamy, brittle soil layer that has minimal porosity and organic content and low or moderate in clay, but high in 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 Mifflin County (Ciolkosz and Waltman, 2000; NRCS, 2008). Thus, higher runoff rates and reduced infiltration capacity typically exist in these soils. Additional impediment to subsurface drainage include lithic and paralithic bedrock (i.e., solid and weather or broken layers of bedrock),

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although the depths (varying between 2'-10') and type of bedrock (i.e., carbonate bedrock) may offer excellent drainage. *Table 3.5* displays the proportion of fragipan and bedrock in Mifflin County.

Restrictions	% of County
Fragipan	25.8
Paralithic bedrock	11.3
Lithic bedrock	55.8
None identified	7.2

Table 3.5. Soil Restrictions in Mifflin County

An additional indicator of the response to rainfall of the soils in Mifflin County is the hydrologic soil group assigned to each soil. This classification varies between "A" which has very low runoff potential and high permeability and "D", which typically has very high runoff potential and low impermeability. *Table 3.6* show a summary of the hydrologic soil groups for Mifflin County. Some soils have variable runoff potential depending on whether or not they are drained or undrained. For example, agricultural field with tile drainage may decrease the runoff potential from hydrologic soil group D to hydrologic soil group A. Over 90% of the soils in Mifflin County are hydrologic soil group A, B, or C, indicating a moderate runoff potential, particularly in soils underlain by karst features (Refer to *Plate 4 – Hydrologic Soils*).

Hydrologic Soil Group	Runoff Potential	% of County
A	Low	1.7
B	Moderate to Low	45.1
C	Moderate to High	43.3
C/D		0.7
D	High	8.2
Not identified		1.0

Table 3.6. Hydrologic Soil Groups in Mifflin 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 Mifflin County:

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Alvira silt loam	Ernest silt loam	Monongahela silt loam	Pope soils
Andover gravelly loam	Evendale cherty silt loam	Murrill gravelly loam	Purdy silt loam
Atkins silt loam	Klinesville shaly silt loam	Newark silt loam	Tyler silt loam
Berks shaly silt loam	Kreamer cherty silt loam	Nolin silt loam	Watson gravelly silt loam
Brinkerton silt loam	Laidig extremely stony loam	Penlaw silt loam	Weikert shaly silt loam
Buchanan gravelly loam	Melvin silt loam	Philo silt 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. Often, a watershed is called a "basin", but is also a "subbasin" to an even larger watershed. This indistinct nature often leads to confusion when trying to categorize watersheds. As shown in *Figure 3.5*, DEP has divided Pennsylvania into seven (7) different major river basins based upon the major waterbody to which they are tributary. These include: Lake Erie Basin, Ohio River Basin, Genesee River Basin, Susquehanna River Basin, Potomac River Basin, Elk & Northeast / Gunpowder Rivers Basin, and Delaware River Basin.

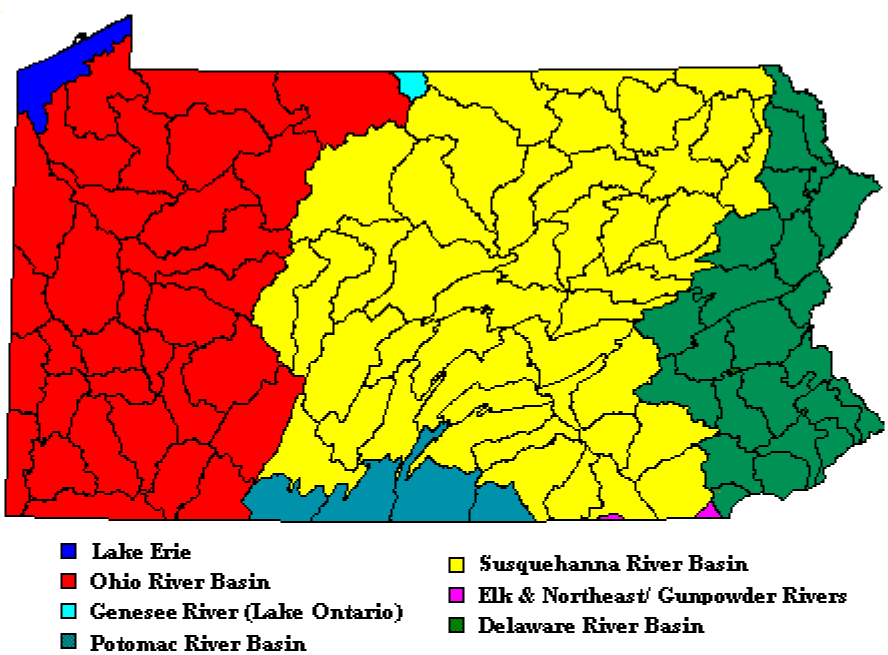

Figure 3.5. Pennsylvania's Major River Basins as Delineated by DEP (DEP, 2009)

For the purpose of this Plan, these are the largest basins within the Commonwealth. The major river basins are further divided into "subbasins" and "Act 167 Designated Watersheds" for

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stormwater management purposes. Act 167 divided the Commonwealth into 29 subbasins and 357 designated watersheds. Mifflin County lies completely within the Susquehanna River Basin, but is tributary to two (2) different subbasins: Juniata River (From Centre County to Confluence with Susquehanna River) and Susquehanna River (From Confluence with West Branch Susquehanna River to the Confluence with Juniata River). Mifflin 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
Susquehanna	Juniata River	Juniata River
		Jacks Creek
		Kishacoquillas Creek
		Laurel Creek
		Honey Creek
		East Licking Creek
		Mill Creek
	Susquehanna River	Middle Creek
		Penns Creek

Table 3.8. Classification of Mifflin County Watersheds

ACT 167 DESIGNATED WATERSHEDS

A very large portion of Mifflin County (36.6%) is within the Juniata River Subbasin. Furthermore, nearly all of this area is within three primary Act 167 Designated Watersheds: Juniata River, Jacks Creek, and Kishacoquillas Creek. The Laurel Creek and Honey Creek watersheds are both subwatersheds that are tributary to Kishacoquillas Creek. These three (3) designated watersheds have a combined drainage area of 186.4 square miles within the county. An Act 167 Stormwater Management Plan was prepared and approved in 2003 for the Kishacoquillas Creek Watershed. These drainage areas were not part of the detailed analysis completed for this Plan.

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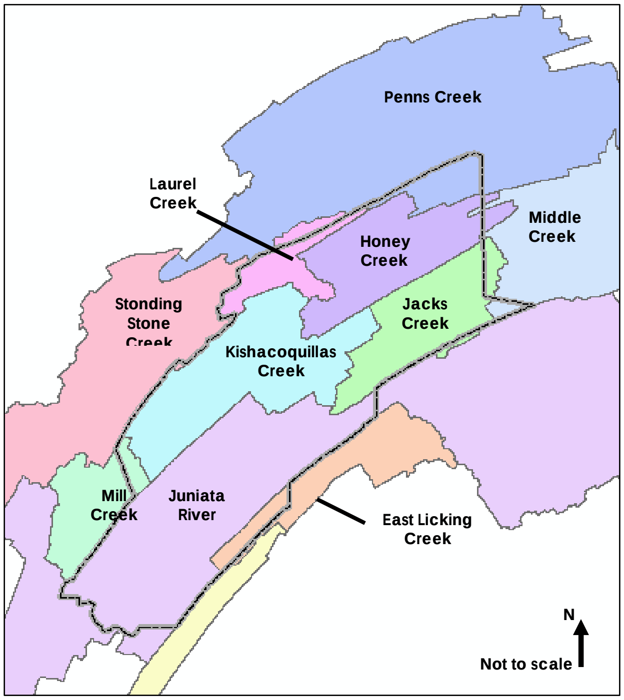

Figure 3.6. Act 167 Watersheds in Mifflin County

The remaining four (4) Act 167 Designated Watersheds have relatively small drainage areas within Mifflin County. Part of the Mill Creek watershed is in the northwest part of the county, with a total drainage area of 10,314 acres within the county. It is tributary to the Juniata River in Huntingdon County. East Licking Creek has a small drainage area in the extreme southcentral part of the county. Draining a land area of 5,281 acres, this watershed is the second smallest watershed area in Mifflin County. It flows northeast into Juniata County. Penns Creek and Middle Creek have small drainage areas in the northeast and southeast part of the county, respectively. Both flow east into Snyder County and are part of the Susquehanna River subbasin. These watersheds were also not part of the detailed study area for this Plan.

Juniata River Watershed

The Juniata River Watershed includes direct discharges to the Juniata River that are not included in other designated watershed. This watershed is located in the southwest corner of Mifflin County. It drains an area of approximately 505.2 square miles, of which 151.0 square miles are located within Mifflin County. *Table 3.9* details the municipalities within the watershed, and their contributing area:

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Watershed	Municipality	Area (mi²)
Juniata River	Bratton Township	33.2
	Granville Township	32.4
	Juniata Terrace Borough	0.2
	Kistler Borough	0.2
	McVeytown Borough	0.1
	Newton Hamilton Borough	0.2
	Oliver Township	35.4
	Wayne Township	49.3

Table 3.9. Juniata River Watershed

The Juniata River forms a portion of the border between Mifflin County and Huntingdon County. The river first enters the County along the border of these two counties approximately 19.5 miles southwest of Lewistown. The river flows 6.8 miles along the Huntingdon County border before traversing 29.6 miles in a northeasterly direction through the county at an average bed slope of 0.11%. The river eventually flows into Juniata County, approximately 3.6 miles east-southeast of the intersection of S.R. 322 and S.R. 522 in Lewistown Borough, at elevation 435.2.

Jacks Creek Watershed

The Jacks Creek Watershed is located in the southeast corner of Mifflin County. Most of Decatur Township and a portion of Derry Township lie within the watershed. It drains an area of approximately 38,524 acres (60.2 square miles), of which 54.0 square miles are located within Mifflin County. The following table details the municipalities within the watershed and their land area:

Watershed	Municipality	Area (mi²)
Jacks Creek	Decatur Township	42.1
	Derry Township	11.9

Table 3.10. Jacks Creek Watershed

The Jacks Creek watershed begins in its most distant headwaters in Snyder County. This watershed's drainage flows southwest from the headwaters in Snyder County towards the southeast edge of Lewistown Borough where in joins the Juniata River. The creek enters Mifflin County briefly before flowing back into Snyder County for a short distance before re-entering Mifflin County approximately 4.0 miles northwest of the tri-county intersection of Mifflin, Snyder, and Juniata Counties. Jacks Creek flows 10.2 miles from this location, at an average bed slope of 0.11%, to where it joins the Juniata River.

Kishacoquillas Creek Watershed

Kishacoquillas Creek and its subwatershed areas are located in the northwestern portion of Mifflin County. *Table 3.11* provides the portions of each municipality located in this watershed. It drains 196 square miles, most of which is underlain by limestone geological formations (Gannet Fleming, 2003). Many of these formations have a significant effect on the overall watershed hydrology.

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Watershed	Municipality	Area (mi²)
Kishacoquillas Creek	Armagh Township	1.2
	Brown Township	23.1
	Burnham Borough	1.1
	Decatur Township	0.6
	Derry Township	17.2
	Granville Township	8.1
	Lewistown Borough	1.0
	Menno Township	19.3
	Oliver Township	0.0
	Union Township	25.5
Honey Creek	Armagh Township	62.3
	Brown Township	3.1
	Decatur Township	0.01
	Derry Township	0.002
Laurel Creek	Armagh Township	14.3
	Brown Township	6.4

Table 3.11. Kishacoquillas Creek Watershed

A more detailed analysis of the physical characteristics and overall watershed hydrology of the Kishacoquillas watershed is provided in the Act 167 Stormwater Management Plan for Kishacoquillas Creek (Gannett Fleming, 2003).

IMPOUNDMENTS

There is only one (1) major water impoundment located in Mifflin County. It is the Lewistown Municipal Water Authority's Laurel Run Dam and Reservoir. Located on Laurel Run Creek, it covers approximately 67 acres and stores a maximum of 4,080 acre-feet. This area is not part of the detailed analysis study area.

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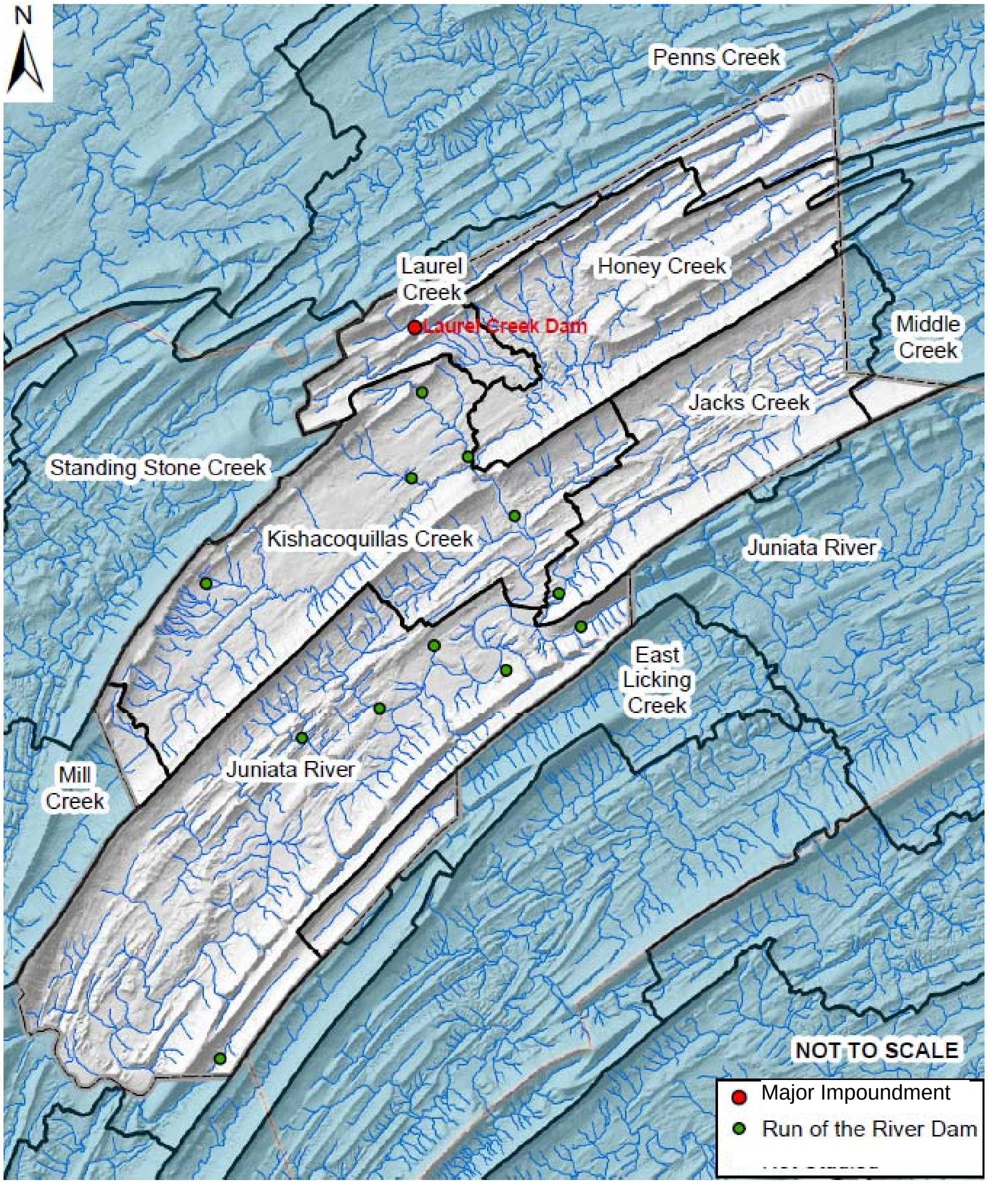

Figure 3.7. Mifflin County Impoundments

SURFACE WATER QUALITY

Water Quality Standards for the Commonwealth are addressed in *The Pennsylvania Code, Title 25, Chapter 93*. Within Chapter 93, all surface waters are classified according to their water quality criteria and protected water uses. According to the antidegradation requirements of §93.4a, "Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected." Certain waterbodies which exhibit exceptional water quality and other environmental features, as established in §93.4b, are referred to as "Special Protection Waters." These waters are classified as High Quality (HQ) or Exceptional Value (EV) waters and are among the most valuable surface waters within the Commonwealth. Activities that could adversely affect surface water are more stringently regulated in those watersheds than waters of lower protected use classifications. The existing water quality regulations are discussed in more detail in *Section IV – Existing Stormwater Regulations and Related Plans*.

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Mifflin County streams are shown with their Chapter 93 protected use classification in *Figure 3.8* 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*.

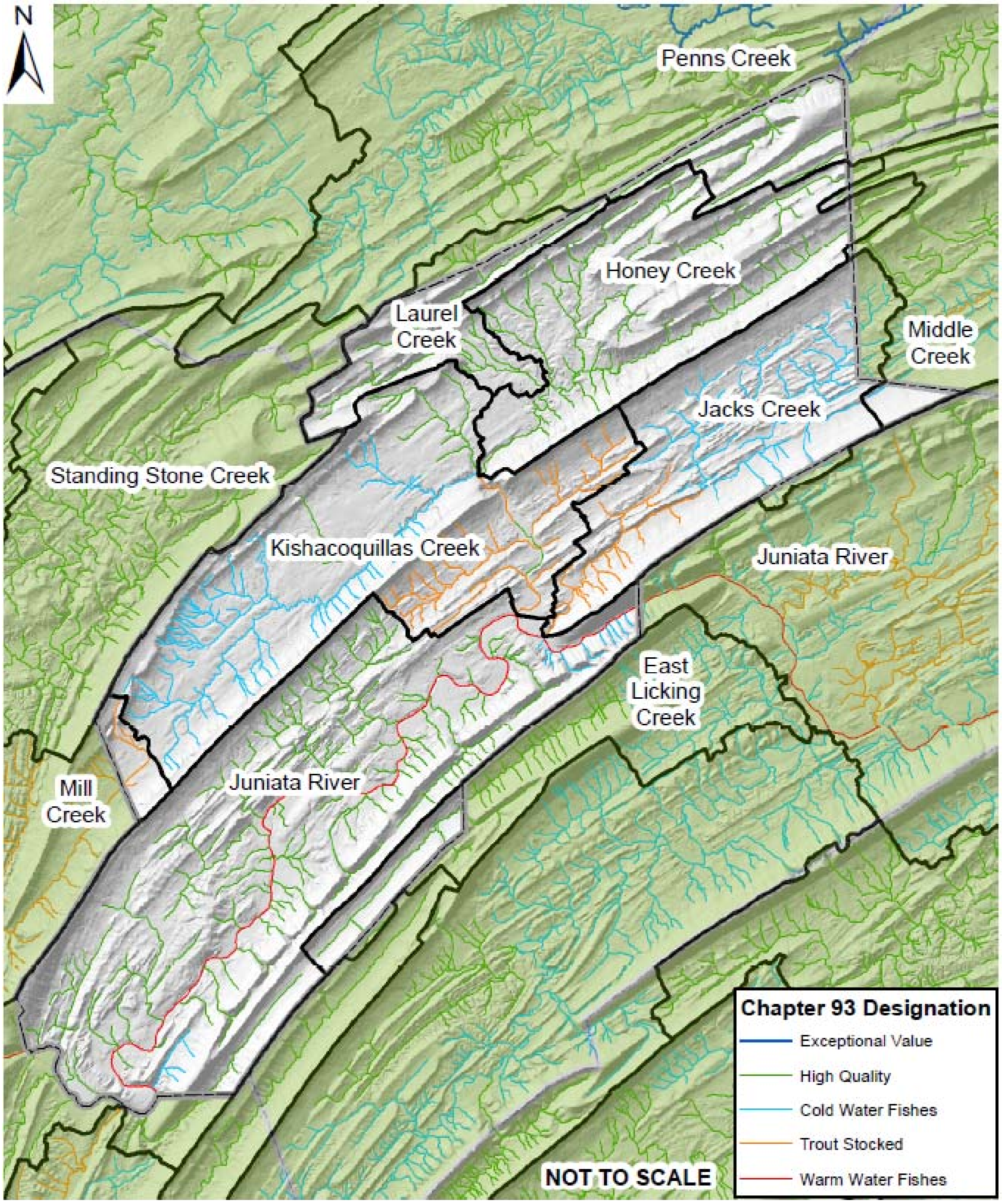

Figure 3.8. Chapter 93 Classification of Mifflin County Streams

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. A figure showing the impaired waters within Mifflin County is also included in that section.

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

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characterized in terms of return periods, e.g., the 50-year flood event. In regulating floodplains, the standard is the 100-year floodplain, the flood that is defined as having a one (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 3.12* summarizes the findings from this study.

Storm Event	Number of Buildings at Least Moderately Damage	Total Economic Loss
10	92	$58 million
100	149	$76 million
500	200	$93 million

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

<u>Detailed Studies</u>

There are various levels of detail in floodplain mapping. Detailed studies (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 3.9* 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).

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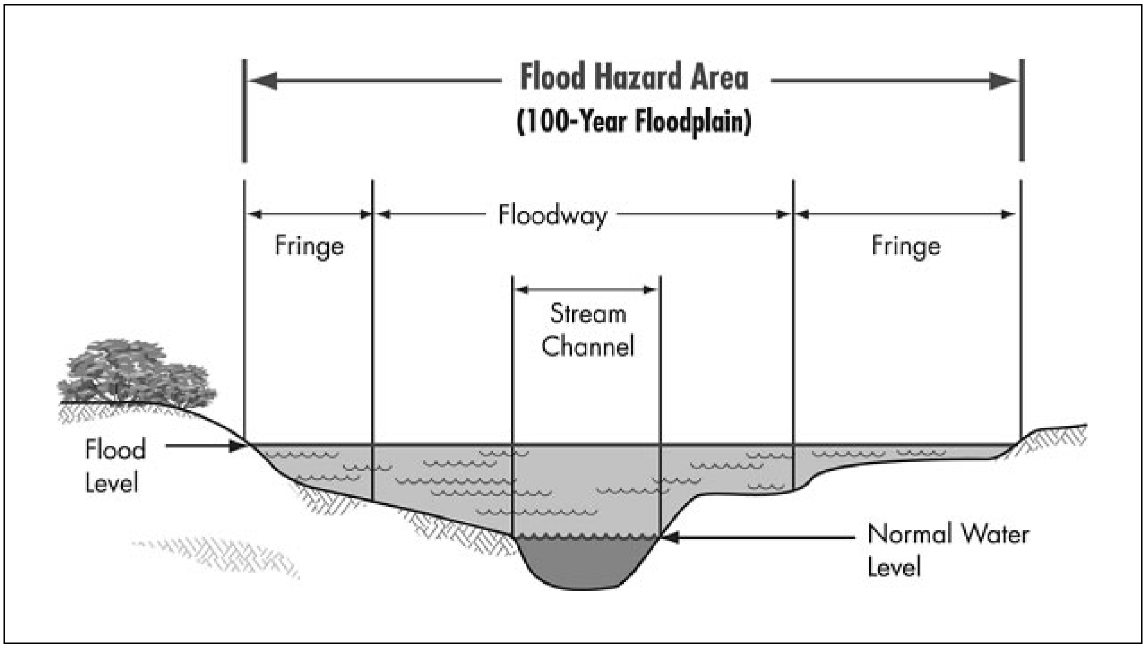

Figure 3.9. Floodplain Cross Section and Flood Fringe (NH Floodplain, 2007)

A review of the FIRMs revealed that several 100-year floodplains exist within Mifflin County 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*.

Approximate Studies and Non-delineated Floodplains

Approximate studies (Zone A on the DFIRM) delineate the flood hazard area, but are prepared using approximate methods that result in the delineation of a floodplain without providing base flood elevations or a distinction between floodway and flood fringe. If no detailed study information is available, some ordinances allow the base flood elevation to be determined based on the location of the proposed development relative to the approximated floodplain; at times, a municipality may find it necessary to have the developer pay for a detailed study at the location in question. *Table 3.13* shows the approximate studies within Mifflin County.

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

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

Community Rating System (CRS)

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

Flood insurance premiums can be reduced by as much as 45% for communities that obtain the highest rating. Only 28 of the Commonwealth's 2500+ municipalities participate in the CRS. Currently, there are no municipalities within Mifflin County participating in the CRS.

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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

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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, found in *The Pennsylvania Code, Title 25*, 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 Maximum 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 five (5) acres or more or for areas of one (1) acre or more with a point source discharge.
Chapter 105	Dam Safety and Waterway Management	Regulates the construction, operation, and maintenance of dams on streams in the Commonwealth. Also regulates water obstructions and encroachments (e.g., road crossings, walls, etc.) that are located in, along, across or projecting into a watercourse, floodway, wetland, or body of water.
Chapter 106	Floodplain Management	Manages the construction, operation, and maintenance of structures located within the floodplain of a stream if owned by the State, a political subdivision, or a public utility.

Table 4.2. Existing State Regulations

STATE WATER QUALITY STANDARDS

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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 Mifflin County.

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

Table 4.3. Chapter 93 Designations in Mifflin 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.

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For WWF, TSF, or CWF waterbodies, many of the antidegradation requirements can be addressed using guidance provided in this plan and the DEP BMP Manual; for HQ or EV watersheds, the current regulations follow DEP's antidegradation policy.

For new or additional point source discharges with a peak flow increase to an HQ or EV water, the developer is required to use a non-discharge alternative that is cost-effective and environmentally sound compared with the costs of the proposed discharge. If a non-discharge alternative is not cost-effective and environmentally sound, the developer must use the best available combination of treatment, pollution prevention, and wastewater reuse technologies and assure that any discharge is non-degrading. In the case where allowing lower water quality discharge is necessary to accommodate important economic or social development in an area, DEP may approve a degrading discharge after satisfying a multitude of intergovernmental coordination and public participation requirements (DEP, 2003).

Water Quality Criteria (§93.6 - §93.8c)

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

Designated Water Uses and Water Quality Criteria (§93.9)

The designated use and water quality criteria for each stream reach or watershed is specified in §93.9. The majority of streams within Mifflin County have a High Quality - Cold Water Fisheries designated use. This is also the leading designated use within the county, in terms of total miles, with almost 340 miles of stream designated as High Quality - Cold Water Fisheries. *Table 4.4* below summarizes the designate uses of all stream uses in Mifflin County.

Designated Use	Total Length (mi)	Percentage
Warm Water Fishes (WWF)	40.3	6.9%
Cold Water Fishes (CWF)	143.9	24.6%
High Quality Waters (HQ-CWF)	339.4	58.1%
Trout Stocking (TSF)	60.9	10.4%

Table 4.4. Summary of Designated Uses for Mifflin County Waters

On the following page, *Table 4.5* shows the Chapter 93 designated uses for Mifflin County as defined by §93.9. This table was developed from the information contained in the Pennsylvania General Code. This information can be difficult to navigate in list form. A good resource for viewing stream designations graphically is DEP's internet based analytical mapping tool, *eMapPA* which can be accessed at the following website: <http://www.emappa.dep.state.pa.us/emappa/viewer.htm>

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Stream (Zone)[1]	Designated Use[2]
Beaverdam Run	HQ-CWF
Buck Run	TSF
Carlisle Run	HQ-CWF
Frog Hollow	HQ-CWF
Furnace Run	HQ-CWF
Granville Run	HQ-CWF
Honey Creek	HQ-CWF
Hungry Run	TSF
Jacks Creek (Meadow Creek to mouth)	TSF
Jacks Creek (source to Meadow Creek)	CWF
Juniata River	WWF
Kishacoquillas Creek (Frog Hollow to Tea Creek)	CWF
Kishacoquillas Creek (main stem, Mill Road Bridge to mouth)	TSF
Kishacoquillas Creek (main stem, Tea Creek to RR bridge between Yeagertown and Burnham)	TSF
Kishacoquillas Creek (main stem, Yeagertown/Burnham RR bridge to SR 2005 (Mill Road) Bridge at Mount Rock)	HQ-CWF
Kishacoquillas Creek (source to Frog Hollow)	CWF
Meadow Creek	CWF
Minehart Run	HQ-CWF
Musser Run	HQ-CWF
Penns Creek (Pine Creek to Cherry Run)	HQ-CWF
Shanks Run	HQ-CWF
Strodes Run	HQ-CWF
Sugar Valley Run	CWF
Tea Creek	HQ-CWF
Town Run	HQ-CWF
UNT to Juniata River (Kishacoquillas Creek to Little Buffalo Creek)	CWF
UNT to Juniata River (Raystown Branch to Kishacoquillas Creek)	HQ-CWF
UNT to Kishacoquillas Creek (Mill Road Bridge to mouth)	TSF
UNT to Kishacoquillas Creek (Tea Creek to Yeagertown/Burnham RR bridge)	TSF
UNT to Kishacoquillas Creek (Yeagertown/Burnham RR Bridge to Mill Road Bridge)	TSF
Wakefield Run	HQ-CWF
Wharton Run	HQ-CWF

Notes: [1] For specific site determinations, it should be noted that that the most current version of the Chapter 93 Regulations, Title 25 PA Code Chapter 93 since this list is frequently updated.
[2] The above acronyms are:
WWF: Warm Water Fishes
CWF: Cold Water Fishes
HQ-CWF: High Quality Waters
TSF: Trout Stocking

Table 4.5. Mifflin County Designated Water Uses

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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*.

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 4.6* provides a summary of existing regulations for the sixteen (16) municipalities within Mifflin County.

MIFFLIN COUNTY MUNICIPAL ORDINANCES

MUNICIPALITY	STORMWATER MANAGEMENT		SUBDIVISION & LAND DEVELOPMENT (SALDO)		ZONING		FLOODPLAIN MANAGEMENT	
Armagh Township	Yes (Kish Act 167)	2004	Yes	1990	No		Yes	1984
Bratton Township	No		No (County)		No		Yes	1988
Brown Township	Yes (Kish Act 167)	2004	Yes	2007	Yes	1973	Yes	1992
Burnham Borough	Yes (Kish Act 167)	2004	Yes	1975	Yes	1973	Yes	1973
Decatur Township	Yes (Kish Act 167)	2007	Yes	1994	No		Yes	1987
Derry Township	Yes (Kish Act 167)	2004	Yes	2000	Yes	1997	Yes	1997
Granville Township	Yes (Kish Act 167)	2004	Yes	1989	Yes	1998	Yes	1980
Juniata Terrace Borough	No		No (County)		No		No	
Kistler Borough	No		No (County)		Yes	1997	Yes	1997
Lewistown Borough	Yes (Kish Act 167)	2004	Yes	1954	Yes	1954	Yes	1973
McVeytown Borough	No		No (County)		Yes	2004	Yes	
Menno Township	No		Yes	1991	No		No	
Newton Hamilton Borough	No		No (County)		No		Yes	1973
Oliver Township	Yes		Yes	1993	No		Yes	1984
Union Township	Yes (Kish Act 167)	2004	Yes	1978	Yes	1969	Yes	1987
Wayne Township	No		No (County)		No		Yes	1980

Table 4.6. Mifflin County Municipal Ordinance Matrix

The *Kishacoquillas Creek Watershed Act 167 Stormwater Management Plan* December 4, 2003 (Kish Act 167 Plan) contains the following control provisions:

1. Peak rate control - The Kish Act 167 Plan identifies two (2) release rate districts. A 100% release rate district covers the majority of watershed including all of the less developed areas. The 75% release rate district immediately surrounds the existing developed areas. The

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release rate in this district may be increase to 100% if groundwater recharge requirement is met.

2. Water Quality Requirement - The Plan requires all new development to capture and treat the first 1½" of runoff.
3. Groundwater Recharge - The requirements state that new development must recharge the increased volume from a 2-year, 24-hour storm event.

EXISTING RELATED PLANS

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

Plan Title	Date	Author
Mifflin County Public Sewer Plan	August 2008	County Planning & Development/Rettew/ Material Matters, Inc.
Natural Heritage Inventory of Mifflin County, Pennsylvania	June 2007	Pennsylvania Natural Heritage Program Western Pennsylvania Conservancy
Kishacoquillas Creek Watershed Stormwater Management Plan	December 2003	County Planning & Development/Gannet Fleming
Jacks Creek Watershed Stormwater Management Plan	June 1995	County Planning & Development/Gannet Fleming
Mifflin County Water Supply Plan	December 2000	County Planning & Development/Gannet Fleming
Paths and Bridges to the 21st Century, Mifflin County Comprehensive Plan	December 2000	County Planning & Development/Gannet Fleming
Western Mifflin County Comprehensive Plan	September 2001	County Planning & Development
Pennsylvania Rivers Conservation Program - Juniata Watershed Management Plan	September, 2000	Juniata Clean Water Partnership
Juniata River Basin Reconnaissance Study	September 1995	US Army Corps of Engineers

Table 4.8. Related Plans Review

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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 then 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 (Refer to *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 Mifflin County Stormwater Management Plan. All of the problem areas and obstructions were evaluated and potential solutions were developed. Where possible, the individual problem areas and obstructions were modeled to determine approximate capacities to be used for planning purposes. A preliminary prioritization assessment was conducted to give a countywide overview of the severity of the existing problems. The priority assessment also provides general guidance on the relative order in which the problems should be addressed when considered at a countywide level.

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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 Mifflin County. The questionaire enabled the municipalities to report all of the known problem areas and obstructions within their municipality. Of the sixteen (16) municipalities in Mifflin county, thirteen (13) participated in the assessment process by returning completed questionaires. The responses were summarzied and reported in the Phase I Scope of Study. The responses were reviewed during Phase II of the Act 167 planning process. Field reconnaissance was subsequently conducted to confirm problem area locations, assess existing conditions, identify the general drainage patterns and gather data to complete a planning level analysis.

All of the reported problem areas, obstructions, and structures are listed in *Table 5.* 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.

ID[1]	Municipality	Location	Description
O01	Lewistown Borough	East Walnut Street	SS Aerial collects debris.
O02	Menno Township	School House Road	The existing culvert does not appear to provide sufficient conveyance capacity.
O03	Granville Township	Granville Road	The existing bridge does not appear to provide sufficient conveyance capacity.
O04	Granville Township	Granville Run Road	
O05	Oliver Township	South River Road	The existing culvert does not appear to provide sufficient conveyance capacity.
O06	Burnham Borough	Uni-Mart on Freedom Street	Kish. Creek flooding.
O07	Armagh Township	Naiginey	Sinkhole development located in a farm field on private property.
O08	Armagh Township	Hostetler Quarry Road	The "Shrader Sinkhole".
O09	Armagh Township	Unidentified	Unidentified
O10	Armagh Township	Honey Creek Road	The existing bridge does not appear to provide sufficient conveyance capacity.
O11	Armagh Township	Honey Creek Road	The existing bridge does not appear to provide sufficient conveyance capacity.
O13	Armagh Township	Honey Creek Road	The existing bridge does not appear to provide sufficient conveyance capacity.
P01	Lewistown Borough	Victory Park Railroad Bridge	Debris build up at the Victory Park Railroad Bridge during flood events.
P02	Lewistown Borough	Fairview Avenue	Flooding and erosion at a private lane along Fairview Avenue.
P03	Decatur Township	Hoffman Road	The existing bridge does not appear to provide sufficient conveyance capacity.
P04	Decatur Township	Back Maitland Road	The existing channel does not appear to provide sufficient capacity and erosion protection.
P05	Menno Township	Alison Gap	The existing channel does not appear to provide sufficient erosion protection.
P06	Granville Township	Caldwell Road	The existing channel does not appear to provide sufficient erosion protection.
P07	Granville Township	Middle Road	The channel banks are being to erode therefore impacting the bridge abutments and an embankment of a private pond.
P08	Oliver Township	Old State Road	The existing bridge does not appear to provide sufficient conveyance capacity.
P09	Oliver Township	Kansas Road	Stormwater ponds along Kansas Road.
P10	Burnham Borough	Burnham Park Pool	The swimming pool at Burnham Park is located in the floodway of Hungry Run
P11	Burnham Borough	E. Walnut St. & Freedom Ave.	Flooding of Hungry Run at East Walnut Street and Freedom Avenue.
P12	Burnham Borough	Uni-mart along Freedom Street	The existing bridge does not appear to provide sufficient conveyance capacity.

Notes: [1] O = Obstruction; P= Problem Area.

Table 5.1. Reported Problem Areas and Obstructions

FINAL

ID[1]	Municipality	Location	Description
P13	Burnham Borough	Kishacoquillas Creek	Debris is deposited at the bridge pier during flooding event.
P14	Burnham Borough	South Logan Blvd.	Flooding along Buck Run.
P15	Burnham Borough	South Logan Blvd.	Flooding along Buck Run.
P16	Burnham Borough	2nd Street	Streambank erosion along Kishacoquillas Creek at 2nd Street.
P17	Brown Township	Duchess Street	The existing culvert does not appear to provide sufficient conveyance capacity.
P18	Brown Township	Reedsville Playground Baseball Field	Baseball field is located in the floodway and always becomes saturated.
P19	Wayne Township	Wharton Road	Wharton Road is located in the floodway.
P20	Wayne Township	SR 0103	SR 0103 is located in the floodway.
P21	McVeytown Borough	North Water Street	Sewage pump station at North Water Street experiences flooding which leads to inflow and infiltration.
P22	McVeytown Borough	River Road Pump Station	Sewage pump station at River Road experiences flooding which leads to inflow and infiltration.
P23	Juniata Terrace	Delaware Avenue	The existing conveyance system does not appear to provide sufficient conveyance capacity.
P24	Juniata Terrace	Delaware Avenue	The existing conveyance system does not appear to provide sufficient conveyance capacity.
P25	Armagh Township	Brooknar Development	Homes and garages flood in the Brooknar Development.
P26	Armagh Township	1408 Honey Road Bridge	The existing bridge does not appear to provide sufficient conveyance capacity.
P27	Armagh Township	SR 1002	The existing bridge does not appear to provide sufficient conveyance capacity.
P28	Armagh Township	T-448	The existing culvert does not appear to provide sufficient conveyance capacity.
P29	Armagh Township	Broad Street & Anita Street	The existing culvert does not appear to provide sufficient conveyance capacity.
P30	Derry Township	Armory Building	The existing culvert does not appear to provide sufficient conveyance capacity.
P31	Derry Township	Glenwood Avenue	The existing culvert does not appear to provide sufficient conveyance capacity.
P32	Union Township	Sale Barn Lane & Kist Street	The existing culvert does not appear to provide sufficient conveyance capacity.
P33	Union Township	Cayuga Road	Flooding along Cayuga Road due to the lack of a conveyance system.

Notes: [1] O = Obstruction; P= Problem Area.

Table 5.1 (continued). Reported Problem Areas and Obstructions

FINAL

ID[1]	Municipality	Location	Description
P34	Brown Township	Unipar Property	Stormwater runoff from the Unipar Property is overtopping inadequately sized drainage channels and flooding the Hillandale Farm Property.
P35	Brown Township	Emergency Access Road to Lumber City	The driving surface on the emergency access road to Lumber City becomes unsafe during rain events.
P36	Brown Township	Willow Lane	Flooding of residential houses along Honey Run.
P37	Granville Township	Middle Road	The existing channel does not appear to provide sufficient erosion protection.
P38	Kistler Borough	Riverside Drive	The pump station floods and causes the electrical panels to be submerged.
P39	Bratton Township	River Road	River Road floods during large rainfall events.
P40	Bratton Township	Carlisle Gap Road	Flooding of Carlisle Gap Road due to stormwater overtopping the roadway channel.
P41	Menno Township	Water Street in Allensville	Streambank erosion and flooding along Water Street in Allensville.

Notes: [1] O = Obstruction; P= Problem Area.

Table 5.1 (continued). Reported Problem Areas and Obstructions

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HYDRAULIC MODELING

Potentiall solutions were initally offered by the municipality, or the project engineer, for every identified problem based on a field view of the area. Some problems and obstructions are not related to conveyance capacity or were not conducive to basic hydraulic modeling. Public feedback and county staff reviews also have to be considered in whether or not to evaluate capacity of a particular problem. For these reasons, the full list of problem areas and obstructions contains some sites that were not modeled. *Table 5.2* lists the reported problem areas, obstructions, and structures that were modeled to determine the existing conveyance capacities.

ID	Municipality	Location	Description	Storm Event of Overtopping[1]
O03	Granville Township	Granville Road	The existing bridge does not appear to provide sufficient conveyance capacity.	Between 10YR and 25YR
P07	Granville Township	Middle Road	The channel banks are beginning to erode, impacting the bridge abutments and the embankment of a private pond.	Between 2YR and 10YR
P08	Oliver Township	Old State Road	The existing bridge does not appear to provide sufficient conveyance capacity.	Between 10YR and 50YR
P12	Burnham Borough	Uni-mart along Freedom Street	The existing bridge does not appear to provide sufficient conveyance capacity.	Greater than 100YR
P17	Brown Township	Duchess Street	The existing culvert does not appear to provide sufficient conveyance capacity.	Less than 2YR
P26	Armagh Township	1408 Honey Road Bridge	The existing bridge does not appear to provide sufficient conveyance capacity.	Between 10YR and 50YR
P27	Armagh Township	SR 1002	The existing bridge does not appear to provide sufficient conveyance capacity.	Between 10YR and 50YR
P28	Armagh Township	T-448	The existing culvert does not appear to provide sufficient conveyance capacity.	Less than 2YR
P29	Armagh Township	Broad Street & Anita Street	The existing culvert does not appear to provide sufficient conveyance capacity.	Between 2YR and 10YR
P30	Derry Township	Armory Building	The existing culvert does not appear to provide sufficient conveyance capacity.	Less than 2YR
P31	Derry Township	Glenwood Avenue	The existing culvert does not appear to provide sufficient conveyance capacity.	Between 10YR and 50YR

Notes: 1 Estimated flow capacities are for planning uses only and should not be used for design.

Table 5.2. Problem Areas and Obstructions with Hydraulic Modeling Completed

The stated flow capacities are an estimate of the flow capacity meant to give an indication of whether or not flow capacity is actually causing the stated problem. If this analysis indicates inadequate flow capacity, a detailed analysis should be conducted prior to making any plans to replace the system. These flow values also give insight to the general types of problem areas

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found throughout the county. The following figure depicts a graphical summary of the calculated conveyance capacities for the problem areas that were modeled in Mifflin County.

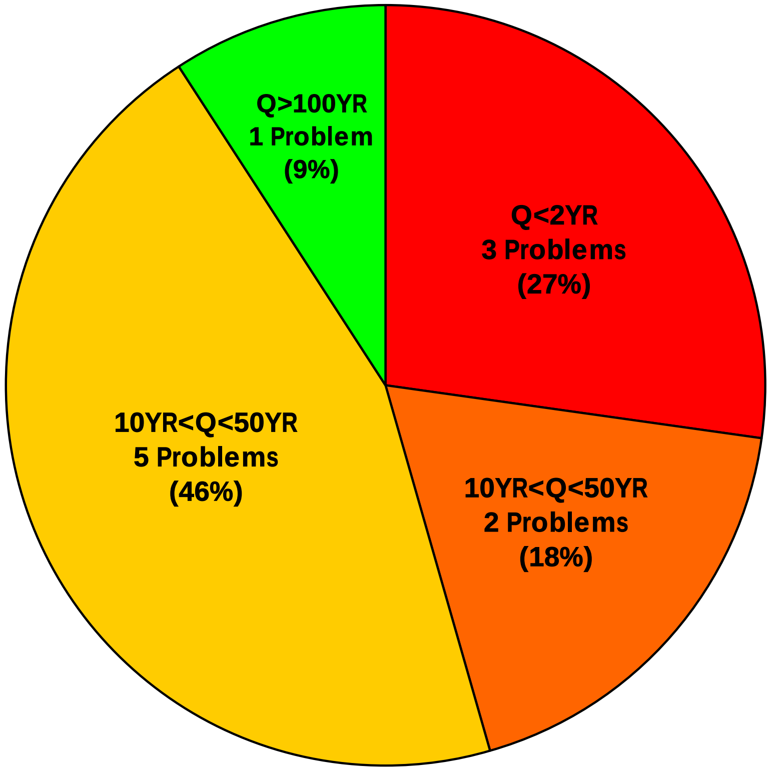

Figure 5.1. Overview of Problem Area Conveyance Capacity

If the modeling results show that the existing drainage system needs to be replaced because it provides inadequate conveyance resulting in frequent and chronic flooding, then solutions capable of preventing flooding could be developed. If a system is shown to have adequate capacity, the system needs to be further evaluated to determine other possible causes of flooding. The detailed data sheets in *Appendix C* list the proposed solutions for each problem area and obstruction.

PROBLEM AREA ASSESSMENT

Upon completion of the hydraulic modeling and analysis of all of the problem areas and obstructions, an objective method was needed to assess the order in which the proposed solutions should be implemented. An analysis like this is necessary in order to prioritize where available funding is most needed. The chosen assessment system evaluates each problem area or obstuction independetly of the others. This is more valuable than a ranking system which lists the problems in an order because it helps gauge the amount of resources that should be dedicated to addressing the existing problem areas and obstructions. As with any prioritization scheme, this assessment could not encompass all factors in the decision making process and should be considered as a guide for future planning efforts.

A set of criteria had to be developed to determine the priority of each problem area. Criteria from a stormwater prioritization assessment completed in Columbus, Ohio were used to establish a system for prioritization (Tickle, 2008). *Table 5.3* provides a list of criteria that were used to assess each problem area or obstruction. Each problem was assigned a rating between one (1)

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and ten (10) for each of the six (6) criteria. The criteria were equally weighted in order to calculate a single relative rating between one (1) and ten (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 5.3. Problem Area/Obstruction Rating Criteria (Adapted from Tickle, 2008)

Each of the obstructions and problem areas have been categorized in one (1) of three (3) categories based on their composite score: 1) Highest Priority Problem, 2) Significant Problem, or 3) General Problem. A composite rating between seven (7) and ten (10) would classify a problem area or obstruction as a Highest Priority Problem. A composite rating between four (4) and 6.9 would classify a problem area or obstruction as a Significant Problem and a rating between one (1) and 3.9 would be classified as a General Problem. Because each problem was evaluated independetly, 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 5.3, have been analyzed in more detail. Table 5.4, shown below, is a list of the Highest Priority Problems. The data sheets in *Appendix C* for these problem areas include a more descriptive overview and a more detailed recommended solution. *Tables 5.5* and *5.6* provide a list of Significant Problems and General Problems respectively. All of the problem areas and obstructions are listed in the order of their relative ranking.

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ID	Problem	Municipality
P33	Insufficient Conveyance Capacity	Union Township
P04	Insufficient Conveyance Capacity	Decatur Township
P17	Insufficient Conveyance Capacity	Brown Township
P24	Insufficient Conveyance Capacity	Juniata Terrace
P02	Flooding and Erosion	Lewistown Borough
P37	Erosion	Granville Township
P06	Erosion	Granville Township
P34	Flooding	Brown Township
P23	Insufficient Conveyance Capacity	Juniata Terrace
P16	Erosion	Burnham Borough

Table 5.4. Highest Priority Problems

ID	Problem	Municipality
P41	Flooding and Erosion	Menno Township
P09	Ponding	Oliver Township
P28	Insufficient Conveyance Capacity	Armaugh Township
P29	Insufficient Conveyance Capacity	Armaugh Township
P07	Erosion	Granville Township
P30	Insufficient Conveyance Capacity	Derry Township
P13	Maintenance Issue	Burnham Borough
P35	Erosion	Brown Township
P03	Insufficient Conveyance Capacity	Decatur Township
P05	Erosion	Menno Township
P25	Flooding	Armaugh Township
P08	Insufficient Conveyance Capacity	Oliver Township
P14	Flooding	Burnham Borough
P15	Flooding	Burnham Borough
P27	Insufficient Conveyance Capacity	Armaugh Township
P31	Insufficient Conveyance Capacity	Derry Township
P32	Insufficient Conveyance Capacity	Union Township
P36	Flooding	Brown Township
P39	Flooding	Bratton Township
P40	Flooding	Bratton Township
O02	Insufficient Conveyance Capacity	Menno Township
O03	Insufficient Conveyance Capacity	Granville Township
O05	Insufficient Conveyance Capacity	Oliver Township
O10	Insufficient Conveyance Capacity	Armaugh Township
O11	Insufficient Conveyance Capacity	Armaugh Township
O13	Insufficient Conveyance Capacity	Armaugh Township

Table 5.5. Significant Problems

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ID	Problem	Municipality
P12	Insufficient Conveyance Capacity	Burnham Borough
P21	Flooding	McVeytown Borough
P22	Flooding	McVeytown Borough
P38	Flooding	Kistler Borough
P11	Flooding	Burnham Borough
P19	Flooding	Wayne Township
P20	Flooding	Wayne Township
P26	Insufficient Conveyance Capacity	Armaugh Township
P10	Flooding	Burnham Borough
P18	Flooding	Brown Township
P01	Maintenance Issue	Lewistown Borough
O01	Maintenance Issue	Lewistown Borough
O04	Unidentified	Granville Township
O06	Flooding	Burnham Borough
O07	Sinkhole	Armaugh Township
O08	Sinkhole	Armaugh Township
O09	Unidentified	Armaugh Township

Table 5.6. General Problems

Figure 5.2 on the following page shows the composite rating for all of the reported problem areas and obstructions throughout the entire county.

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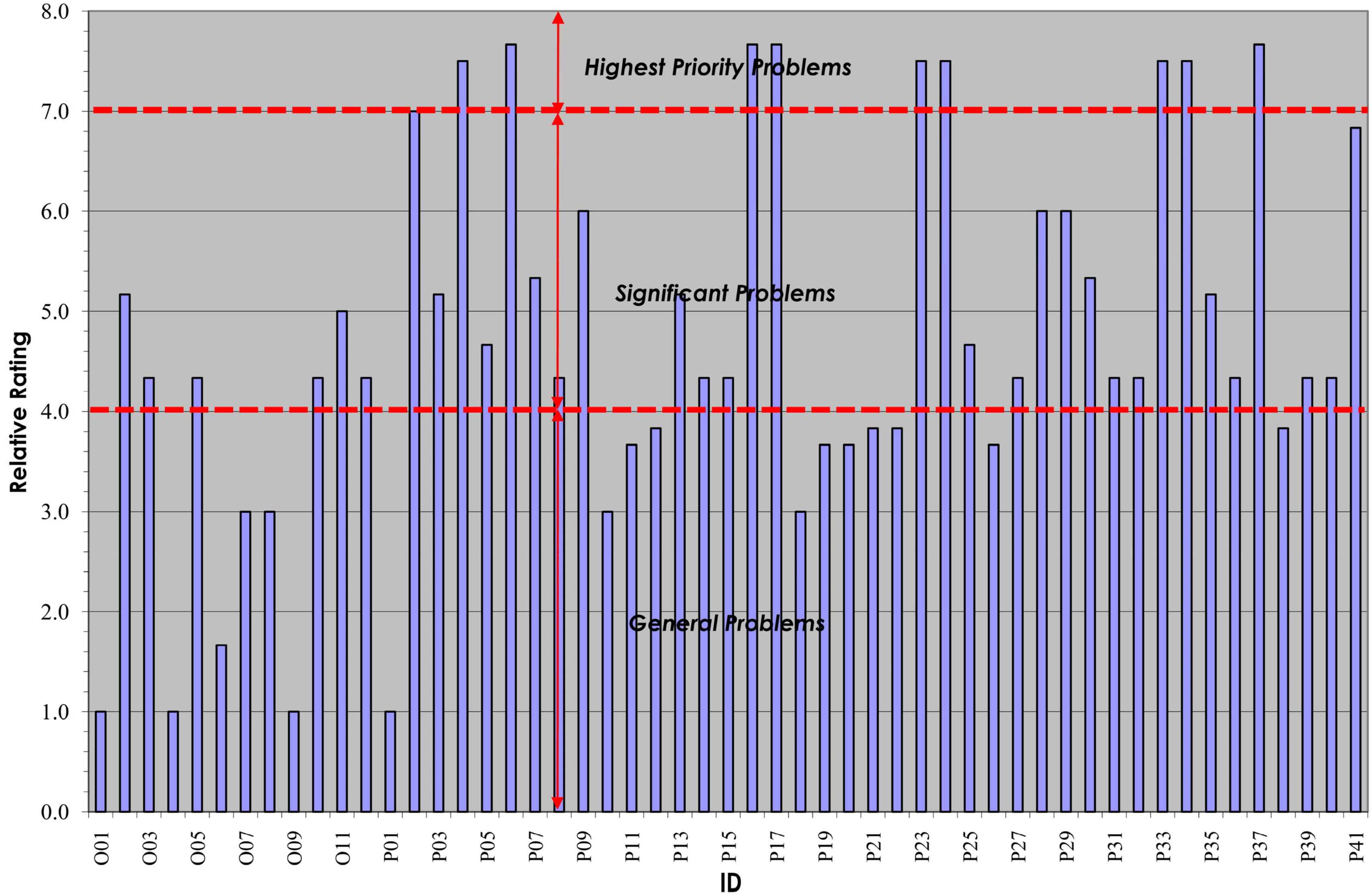

Figure 5.2. Problem Area/Obstruction Rating System Results

RECOMMENDATIONS

The reported stormwater problems within the study area can be attributed to one (1) or more of several principle causes:

1. The existing storm drain system has insufficient capacity.
2. There is an incomplete collection and conveyance system or a lack of a formal/comprehensive system.
3. Maintenance is required on an existing system (e.g. catch basin inlets become plugged and local flooding occurs).
4. Problem areas are located in the floodplain area.

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.

Future development without the appropriate stormwater controls will likely 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. HRG, in cooperation with Mifflin County Planning, is taking the lead to develop economical solutions that address stormwater runoff issues that lead the industry and provide the regulatory community with solutions that meet EPA and DEP standards. Looking ahead, it is expected that the status of the current stormwater infrastructure will keep deteriorating with time. In addition to imposing stronger regulations to control new development, increased expenditures for maintenance and other improvements is necessary, or the systems will continue to deteriorate faster than the ability to fix and maintain them.

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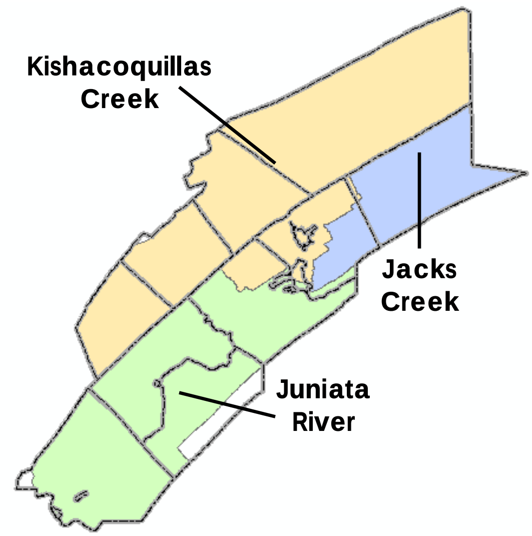
Section VI – Technical Analysis - Modeling



TECHNICAL APPROACH

To provide technical guidance in the Act 167 planning process, hydrologic models were prepared for specific watersheds identified by the municipalities, the county and DEP. The results from these models increase the overall understanding of watershed response to rainfall and help guide policy. Through the development and analysis of a hydrologic model, effective and fair regulations can be applied on a county-wide basis, while addressing specific issues identified by the individual communities in Mifflin 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 (2) watersheds within the county were selected for hydrologic modeling: Juniata River and Jacks 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.

JUNIATA RIVER MODEL

This watershed has a total drainage area of 2,607 square miles and was divided into 30 subwatersheds for the HEC-HMS model. The HEC-HMS model developed for this study focused on the tributaries to the Juniata River, not the main stem that is greatly affected by upstream dam

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operations at Raystown Lake. *Figure 6.2* shows the Juniata River subwatersheds and cumulative discharge points. The flows for all cumulative discharge points are provided in *Appendix A*.

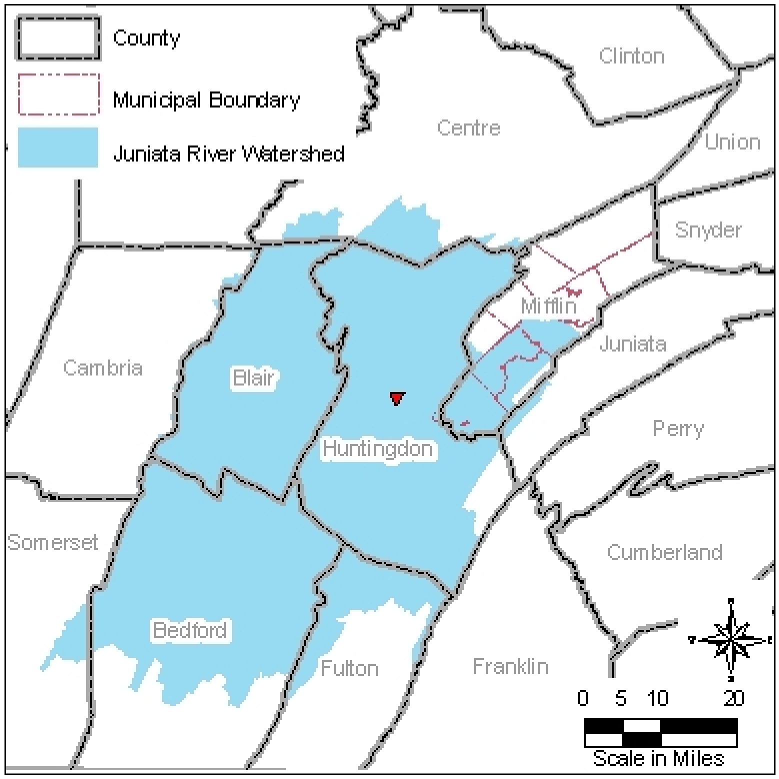

Figure 6.1. Juniata River above confluence with Kishacoquillas Creek

JACKS CREEK MODEL

The Jacks Creek watershed has a drainage area of 59.9 square miles. It was divided into 24 subwatersheds that were included in the HEC-HMS model. *Figure 6.3* shows the Jacks Creek subwatersheds and cumulative discharge points.

In addition to provided general spatial orientation for the Juniate River and Jacks Creek watersheds, Figures 6.2 and 6.3 describe the hydrologic components in the HEC-HMS model. Each subbasin in the HEC-HMS is preceded by a "W" and a corresponding identification number. For example, W113 and W114 in Figure 6.2 represent subbasins in the Juniata River HEC-HMS Model. The data for these subbasins is provided in tables in *Appendix A*.

The small green circles in Figures 6.2 and 6.3 refer to cumulative discharge points at various locations in the watershed. The data associated with the discharge points in provided in table at the end of *Appendix A*.

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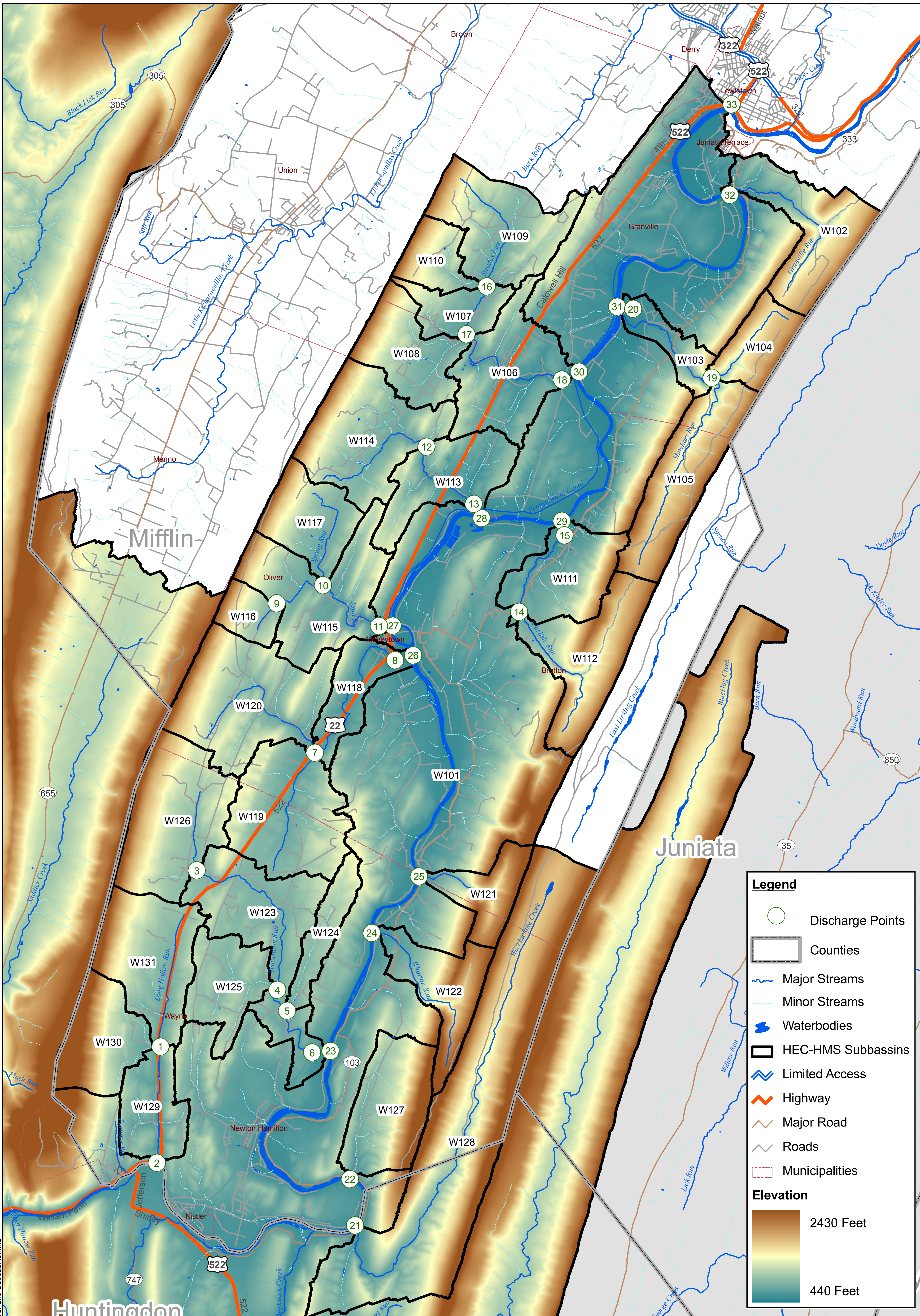

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Scale in Miles

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

DATA SOURCES:
HEC-HMS Basins - HRG
Streams and Waterbodies - USGS NHD (2009)
Municipalities - Mifflin County (2008)
Major Highways - ESRI (2008)
Roads - Mifflin County (2008)
Counties - PASDA (2004)

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure 6.2
Juniata River HEC-HMS Model
Mifflin County, Pennsylvania

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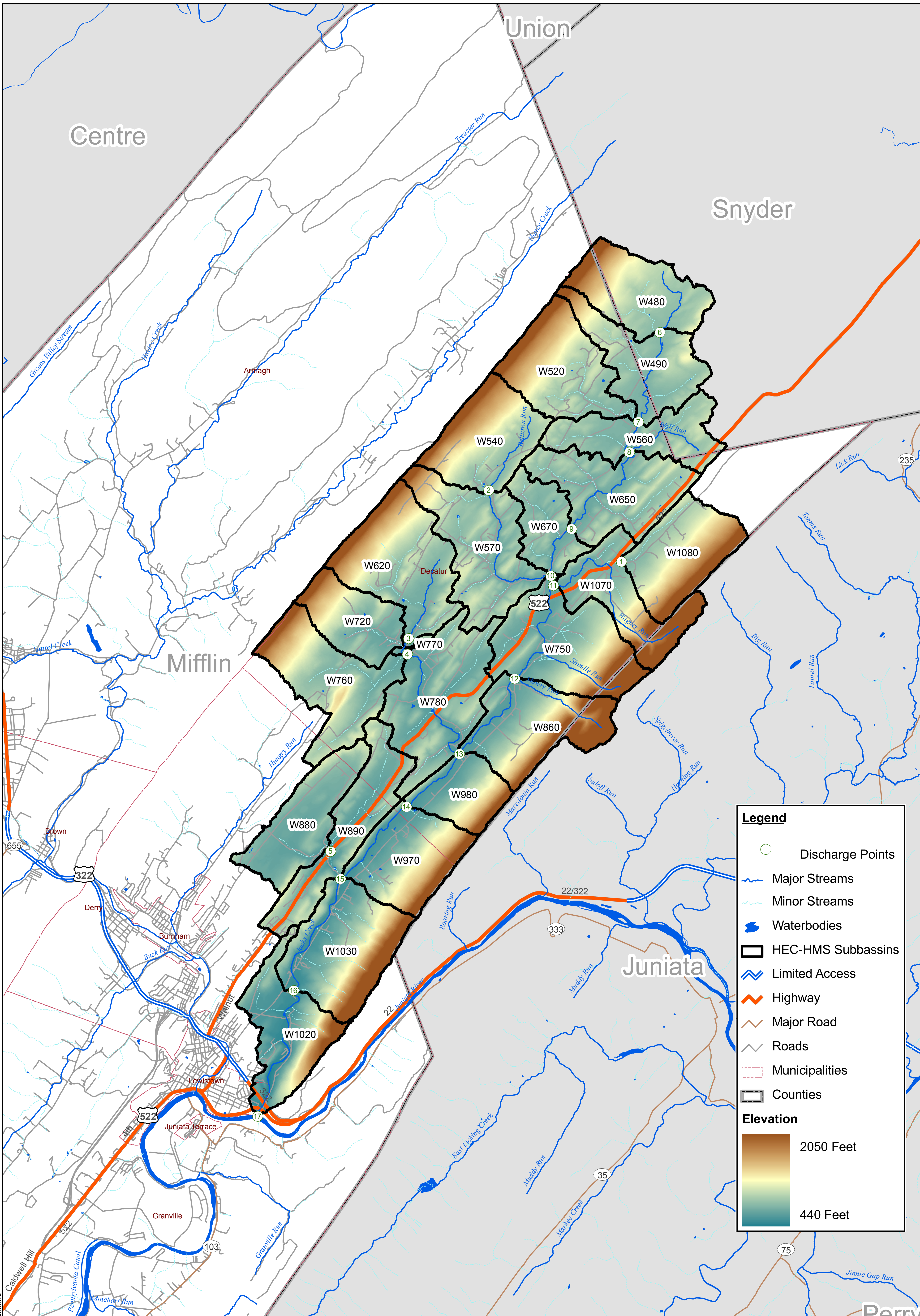

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Scale in Miles

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W:\4004049\0003\Projects\Figure 5_3 Jacks Creek.mxd

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Counties - PASDA (2004)

[BUILDING RELATIONSHIPS. DESIGNING SOLUTIONS.]

Figure 6.3
Jacks Creek HEC-HMS Model
Mifflin County, Pennslyvania

HYDROLOGIC MODEL PARAMETERS

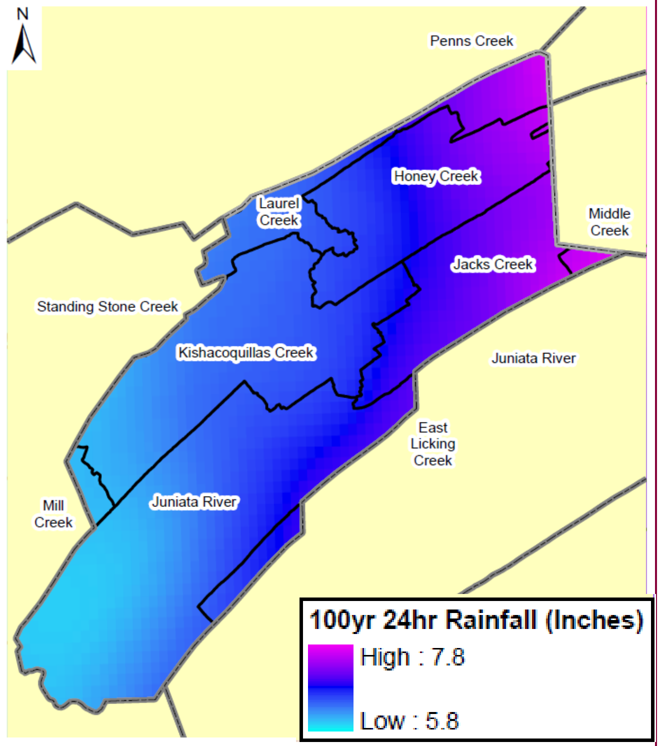
The various parameters entered into the hydrologic models include subwatershed area, soil-type, land cover, lag time, reach lengths and slopes, reach cross-sectional dimensions, and design rainfall depths. These parameters are discussed in further detail in the technical appendix. A brief description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

Design Storm (years)	24-hr Rainfall Depth (in)
2	2.76
10	4.00
25	4.83
50	5.54
100	6.32

Table 6.2. Rainfall Values for Mifflin 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 the PA Stormwater BMP Manual.

SUBWATERSHED AREA

Generally, the subwatershed area for the modeled watersheds was 3-5 square miles. The drainage areas may be slightly larger or smaller depending on hydrologic characteristics and location of problem areas. Subwatersheds with an area less than one (1) square mile were included in the model if they formed a junction between two (2) larger basins or were tributary to a defined problem area.

Basins with drainage area outside of Mifflin 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. The Juniata River was modeled using constant inflows using the assumptions outlined in *Table 6.1*.

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Storm Event	Inflow (cfs)	Source
2-year	2,740	Average annual flow from 1973-2006
10-year	52,500	FEMA (2006)
25-year	62,200	Log between the 10-year and 50-year flow
50-year	82,500	FEMA (2006)
100-year	104,000	FEMA (2006)

Table 6.1. Juniata River Inflows to HEC-HMS Model

SOILS

Soil properties, specifically infiltration rate and subsurface permeability, are an important factor in runoff estimates. Runoff potential of different soils can vary considerably. Soils are classified into four (4) Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate (SCS 1986). Hydrologic Soil Group A refers to soils with relatively high permeability and favorable drainage characteristics; Hydrologic Soil Group 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 3.4 show the relative percentage of hydrologic soil groups in Mifflin County. The location of these soil types corresponds to the location of many of the counties' identified problem areas.

LAND USE

Natural 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*.

Natural Land Use Categories and Criteria	Curve Numbers for Each Hydrologic Soil Group			
	A	B	C	D
Agriculture in Good Condition	39	61	74	80
Forest Good Condition	30	55	70	77
Meadow Good Condition	30	58	71	78
Natural Impervious Rock Outcropping	98	98	98	98
Wetland	30	55	70	77

Notes: [1] In Good Condition

Table 6.3. Natural Curve Numbers Used in the Juniata and Jacks Creek Watersheds

The imperviousness of existing and future land uses for the year 2010 and 2020 were projected by the Mifflin County Planning and Development Department using the Community VIZ GIS-based software. *Table 6.4* provides estimates of the total imperviousness in each watershed. The impervious percentage for each individual subbasin is provided in *Appendix A*. It should be

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noted that the future impervious estimates assumed only a small amount of future growth. These estimates compare favorably with other growth projections for similar studies. The 1995 Act 167 for Jacks Creek projected 44 acres of new imperviousness (0.1 % increase) in a 10-year period and the Kish Act 167 Plan projected approximately 2,137 acres of new imperviousness (1.7% increase) in a 10-year period (data extracted from Gannett Fleming, 1995 and Gannett Fleming, 2003).

Watershed	2010 Imperviousness (%)	2010 Imperviousness (acres)	2020 Imperviousness (%)	2010 Imperviousness (acres)
Juniata River (tributaries only)	1.04	582.6	1.13	633.9
Jacks Creek	1.98	759.8	2.11	810.4

Table 6.4. Impervious Estimates in the Juniata River and Jacks Creek Watersheds

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 Mifflin 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*.

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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.

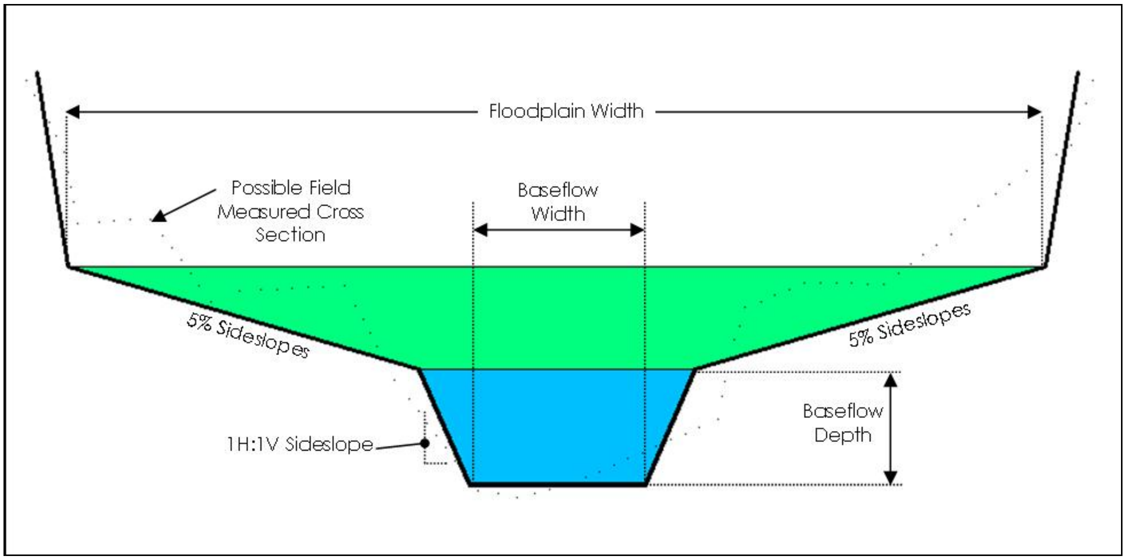

Figure 6.3. Cross Sections Used for Reaches in HEC-HMS Model

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.

USGS Gage 01565000 Kishacoquillas Creek at Reedsville, PA Source: USGS (2010)

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.

There are two (2) USGS stream gages located in Mifflin County. The following table lists these gages and their respective statistics.

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There were no gages within the watersheds being analyzed for this study. Of the two (2) gages that do exist within the county, neither is appropriate for use for either the tributaries of the Juniata River of Jacks Creek. The gage along the Juniata River has a much larger watershed than the watersheds in this study and is heavily impacted by upstream dam operations. The gage along the Kishacoquillas Creek reflects the hydrology of a watershed that is also impacted by upstream dam operations.

USGS Stream Gage No.	Site Name	Drainage Area square miles	Number of Gage Years at Gage	Used in HEC-HMS Model
01564895	Juniata River at Lewistown, PA	2,519	21	Not used
01565000	Kishacoquillas Creek at Reedsville, PA	164	55	Not used

Table 6.5. USGS Stream Gages in Mifflin County

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). Mean Elevation, Percent Carbonate Rock, and Percent Storage, the applicable parameters within Mifflin 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 6.4-6.7*) show the overall watershed calibration results for the Juniata River and Jacks Creek. As can be shown, the calibration results are in general agreement with the range of values for other hydrologic studies.

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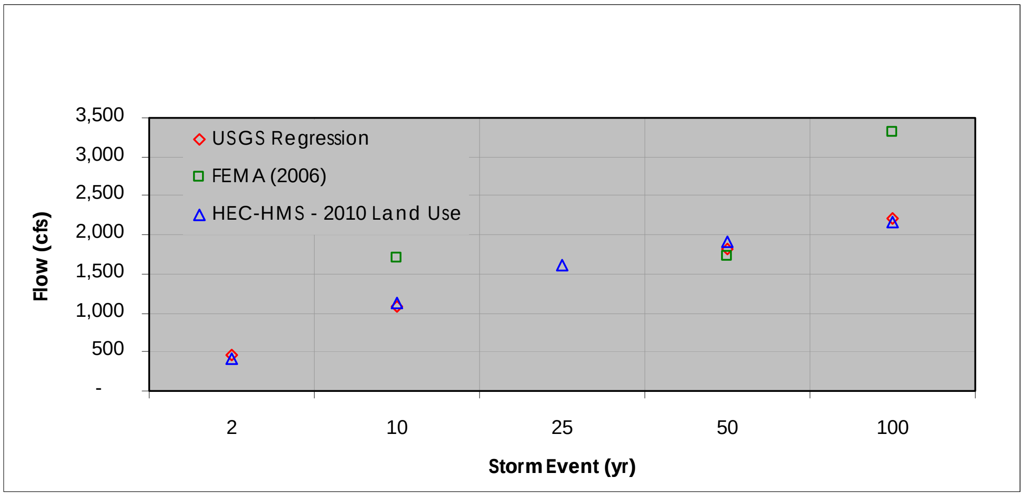

Figure 6.4. Existing Condition Flows for Musser Run confluence with Juniata River

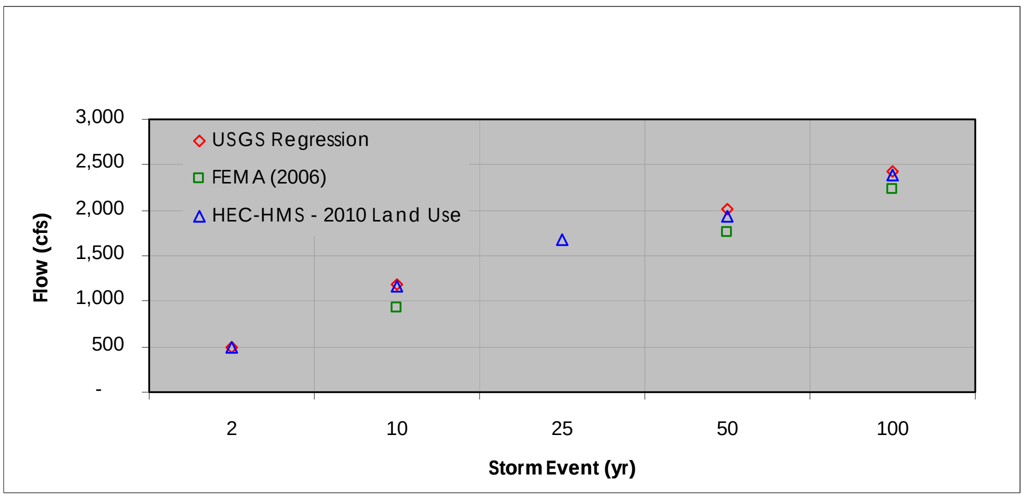

Figure 6.5. Existing Condition Flows for Strodes Run confluence with Juniata River

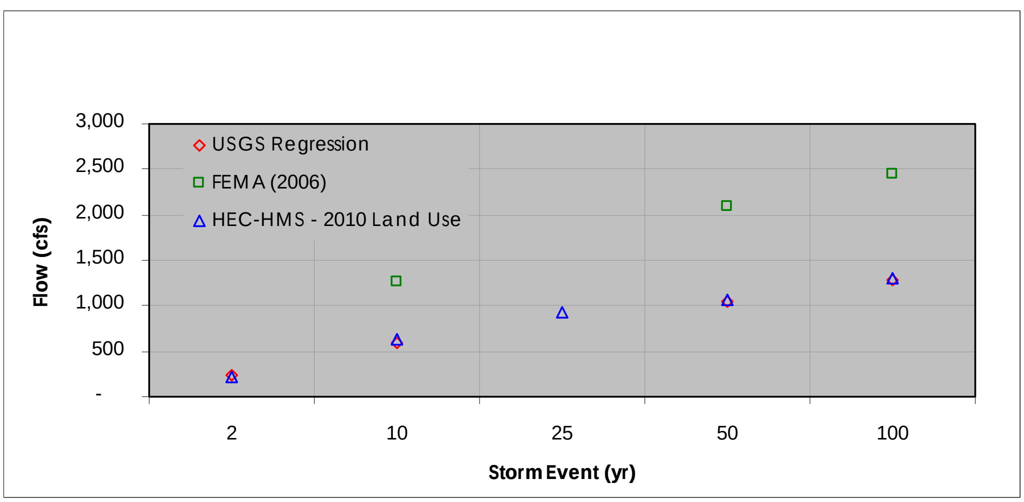

Figure 6.6. Existing Condition Flows for Town Run confluence with Juniata River

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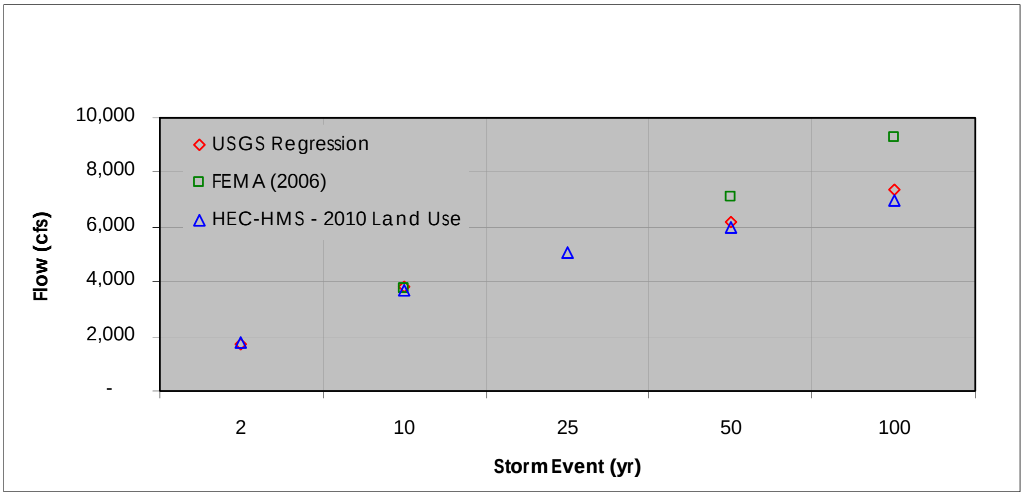

Figure 6.7. Existing Condition Flows for Jacks Creek Confluence with Juniata River

Table 6.6 shows numerical comparison of these values with FEMA studies on Musser Run, Strodes Run, and Town Run. Values for Musser Run and Strodes Run are within the standard error for the USGS Regression equations, but the Effective FEMA FIS has much higher values for Town Run (FEMA, 2006). The target flow at these locations used the results from the most current USGS regression methodology (USGS, 2008). The reasons for using the current USGS regression methodology instead of the Effective FEMA FIS values for target flows were as follows: 1) For all three (3) locations, the Effective FIS uses regression methodology that considers a shorter period of record for the current methodology; 2) the methodology in the Effective FIS does not explicitly consider carbonate geology or storage; and 3) FEMA re-studies generally use the newer methodology wherever a HEC-HMS model is not required.

Point of Interest	FEMA (2006)			HEC-HMS Existing Flows			% Difference from FEMA (2006)		
	10-yr	50-yr	100-yr	10-yr	50-yr	100-yr			
	cfs	cfs	cfs	cfs	cfs	cfs	10-yr	50-yr	100-yr
Musser Run confluence w/ Juniata River	1,700	1,724	3,308	1,131	1,921	2,169	(33)	11	(34)
Strodes Run confluence w/ Juniata River	925	1,759	2,239	1,170	1,934	2,386	26	10	7
Town Run confluence w/ Juniata River	1,260	2,100	2,450	640	1,062	1,295	(49)	(49)	(47)

Table 6.6 Comparison with hydrology from FEMA Flood Insurance Study

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.

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

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

Future Conditions with No Stormwater Controls (F-1)
A future conditions model was developed and analyzed using the projected future land use coverage for the year 2020. 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 increase 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*. *Table 6.7* provides a summary of projected flow increases between years 2010 and 2020 throughout the detailed model areas of the Juniata River and Jacks Creek. Although a substantial portion of the subbassins will some increase in peak flows, the magnitude of this increase is typically small (<3%).

Storm Event (year)	Effects of Future Condition on Discharges		
	Maximum % Increase in Future Conditions	Average % Increase in Future Conditions[1]	Portion of subbasins with Increase (%)
2	3.2	0.03	32.7
10	2.2	0.03	27.3
25	2.0	0.03	27.3
50	2.0	0.03	29.1
100	2.0	0.03	27.3

Notes: [1] Area weighted averages

Table 6.7. Future Condition Increases with No Stormwater Management Controls for Jack Creek and Juniata River HEC-HMS Models

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The increases in the Juniata River and Jacks Creek watersheds are minor and are spread equally throughout various parts of the watershed, as shown in *Figures 6.8* and *6.9*.

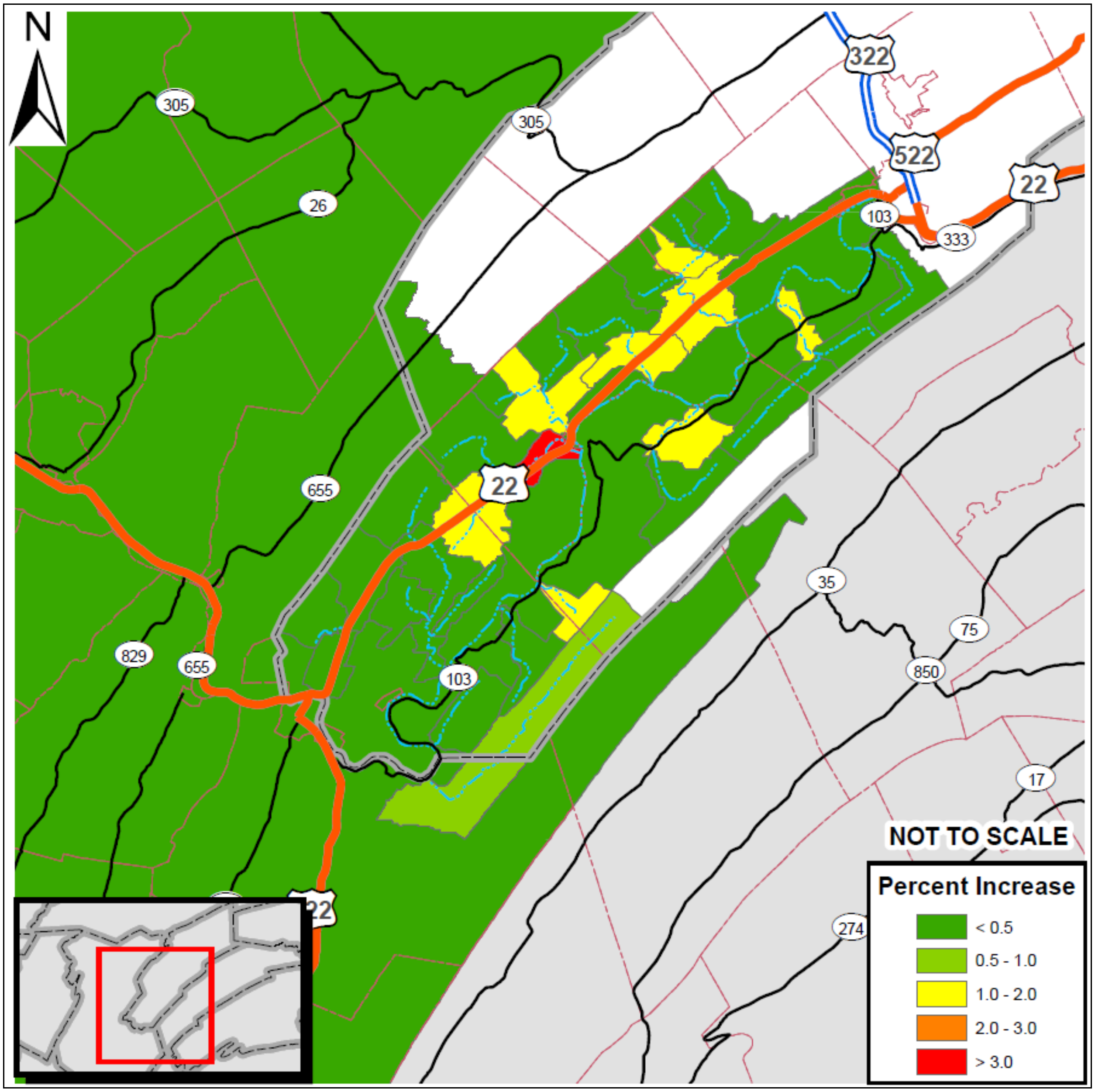

Figure 6.8. Increase in Flow for 2-year Storm Event with No SWM Controls for Juniata River

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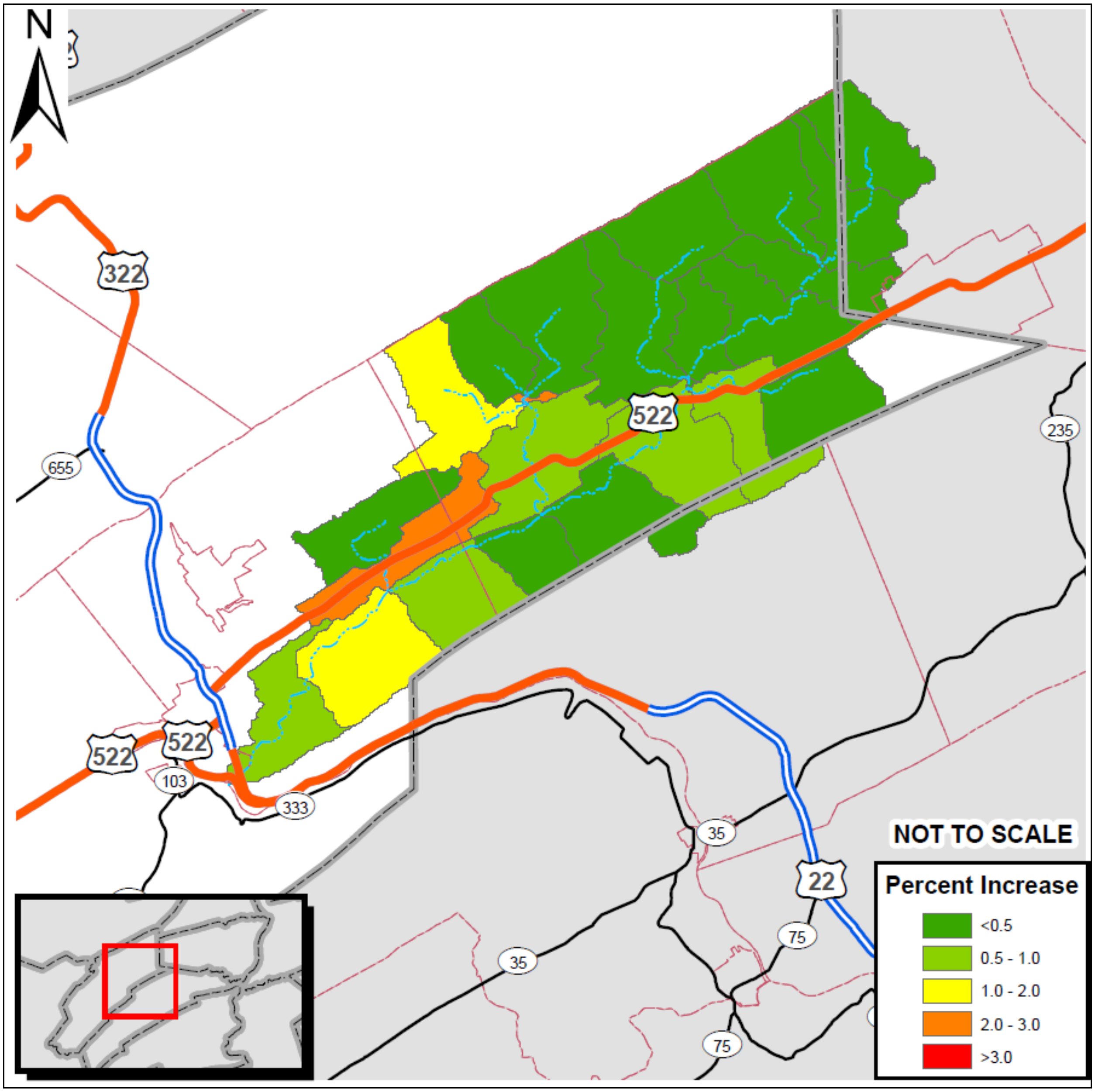

Figure 6.9. Increase in Flow for 2-year Storm Event with No SWM Controls for Jack Creek

Table 6.8 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.

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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	0.02	21.8
10	2.1	0.02	20.0
25	2.1	0.02	25.5
50	1.8	0.02	27.3
100	2.0	0.02	23.6

Notes: [1]Area weighted averages

Table 6.8 Future Subbasin Flows with Design Storm Method Only – No peak control Jack Creek and Juniata River HEC-HMS Models

Since there was no a significant increase at any point of interest in either the Juniata River or Jacks Creek watersheds, the allowable release rate for both watershed will be 100%.

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 Plan 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.

Since there is little future project growth, there is no location of the stormwater management districts in Mifflin County.

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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. The runoff response to NOAA Atlas 14 rainfall in Mifflin County was lower than standard NRCS methods predict for the 10-year, 24-hour storm event and above. This has the potential to allow designers to undersize their stormwater facilities and to increase peak discharges for the higher magnitude events. It is recommended, for curve number calculations, to assume 'good condition' 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 guideline criteria. The control guideline criteria will provide a direct benefit with volume reduction and also an indirect benefit of channel protection.

Provide a clear alternative volume control and peak rate control strategy for areas with poorly-drained soils or areas with geologic restrictions. Mifflin County has a substantial number of potential limitations to infiltration facilities: karst topography, fragipans, shallow bedrock, Hydrologic Soil Group D soils, floodplains, and documented problem areas. *Section VII* provides a recommended procedure for sites with these limitations.

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

TECHNICAL STANDARDS FOR STORMWATER MANAGEMENT

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

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

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

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

4. Water Quality Standards – The water quality standards contained in this Plan are meant to provide a level of pollutant removal from runoff prior to discharge to receiving streams.

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Stormwater runoff can deliver a wide range of contaminants to the receiving stream, which leads to a variety of negetive 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 Mifflin County. Mathematical modeling techniques, as discussed in the previous chapter, were used to simulate the existing conditions throughout the county and to determine the effects anticipated future development will have on stormwater runoff within these watersheds. The models were used to determine the outcome of a variety of different stormwater control scenarios. These results were then used to determine a group of control criteria that provides the best results on a watershed-wide basis. The outcome of each analysis is stormwater control criteria that are appropriate and applicable to that watershed.

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

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

PEAK DISCHARGE RATE CONTROLS

Peak discharge rate controls have been the primary method of implementing stormwater management controls for many years. 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.

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

1. Areas not covered by a Release Rate Map:

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

2. Areas covered by a Release Rate Map:

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

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VOLUME CONTROLS

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

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

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

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

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

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

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

   B. For modeling purposes:

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

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

2. *The Simplified Method* (CG-2 in the PA Stormwater BMP Manual) 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") 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. Actual field infiltration tests at the location of the proposed elevation of the stormwater BMPs are required. Infiltration test shall be conducted in accordance with the *PA Stormwater BMP Manual*. Notification of the Municipality shall be provided to allow witnessing of the testing.

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

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

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

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

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WATER QUALITY CONTROLS

Urban runoff is one of the primary contributors to water pollution in developed areas. The most effective method for controlling nonpoint source pollution is through reduction, or elimination, of the sources. 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 BMPs to reduce the sources of water pollution and treat those that cannot be eliminated.

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

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

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

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

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Non-Structural BMP	Stormwater Functions[1]			
	Peak Rate Control	Volume Reduction	Recharge	Water Quality
Protect Sensitive / Special Value Features	Very High	Very High	Very High	Very High
Protect / Conserve / Enhance Riparian Areas	Low/Med.	Medium	Medium	Very High
Protect / Utilize Natural Flow Pathways in Overall Stormwater Planning and Design	Med./High	Low/Med.	Low	Medium
Cluster Uses at Each Site; Build on the Smallest Area Possible	Very High	Very High	Very High	Very High
Concentrate Uses 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 BMPs

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

Structural BMP	Stormwater Functions[1]			
	Peak Rate Control	Volume Reduction	Recharge	Water Quality
Porous Pavement with Infiltration Bed	Medium	Medium	Medium	Medium
Infiltration Basin	Med./High	High	High	High
Subsurface Infiltration Bed	Med./High	High	High	High
Infiltration Trench	Medium	Medium	High	High
Rain Garden / Bioretention	Low/Med.	Medium	Med./High	Med./High
Dry Well / Seepage Pit	Medium	Medium	High	Medium
Constructed Filter	Low-High*	Low-High*	Low-High*	High
Vegetated Swale	Med./High	Low/Med.	Low/Med.	Med./High
Vegetated Filter Strip	Low	Low/Med.	Low/Med.	High

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Structural BMP	Stormwater Functions[1]			
	Peak Rate Control	Volume Reduction	Recharge	Water Quality
Infiltration Berm and Retentive Grading	Medium	Low/Med.	Low	Med./High
Vegetated Roof	Low	Med./High	None	Medium
Rooftop Runoff - Capture and Reuse	Low	Med./High	Low	Medium
Constructed Wetland	High	Low	Low	High
Wet Pond / Retention Basin	High	Low	Low	Medium
Dry Extended Detention Basin	High	Low	None	Low
Water Quality Filter	None	None	None	Medium
Riparian Buffer Restoration	Low/Med.	Medium	Medium	Med./High
Landscape Restoration	Low/Med.	Low/Med.	Low/Med.	Very High
Soils Amendment and Restoration	Medium	Low/Med.	Low/Med.	Medium

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

Table 7.2. Stormwater Functions of Structural BMPs

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

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

RAIN GARDENS

A rain garden, also referred to as bioretention, is an excavated shallow surface depression planted with native, water-resistant, drought and salt tolerant plants with high pollutant removal potential that is used to capture and treat stormwater runoff. Rain gardens treat stormwater by collecting and pooling water on the surface and allowing filtering and settling of suspended solids and sediment prior to infiltrating the water. Rain gardens are generally constructed to provide twelve (12) inches or less of 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 thermal impacts, and enhance evapotranspiration. Their versatility has proved extremely successful in most applications, including urban and suburban areas (DEP, 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

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site with a high degree of flexibility and can be used in coordination with a variety of other structural BMPs. They can also enhance the aesthetic value of a site through the selection of appropriate native vegetation.

DRY WELL / ROOF SUMP

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

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

VEGETATED SWALES

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

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

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

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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 (DEP, 2006). These systems are also well suited for cold climates as they can function year-round if constructed below the frostline.

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 (Model Ordinance) developed as part of the Plan. The Model Ordinance contains provisions to realize the standards and criteria outlined in this section. Providing uniform stormwater management standards throughout the county is one (1) of the stated goals of this Plan. This goal will be achieved through adoption of the Model Ordinance by all of the municipalities in Mifflin 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.

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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 best management practice (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*.

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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.

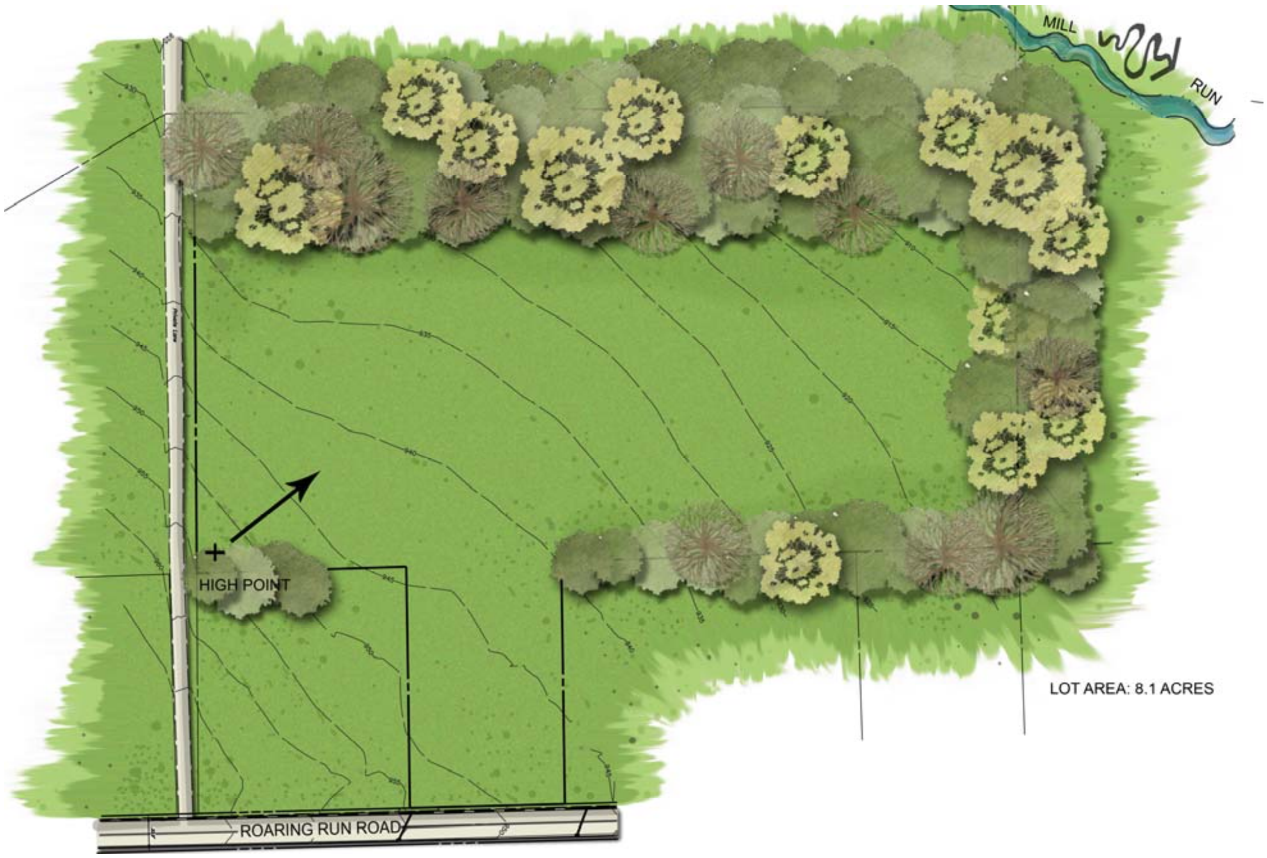

Figure 8.1. Design Example 1 – Pre-Development Conditions

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

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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

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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 ft³. 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., $Q = C \times I \times A$) 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

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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.

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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

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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. <u>Cost Comparison</u> – 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. <u>Life-Cycle Cost Analysis</u> – 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. <u>Cost-Benefit Analysis</u> – 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*.

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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.

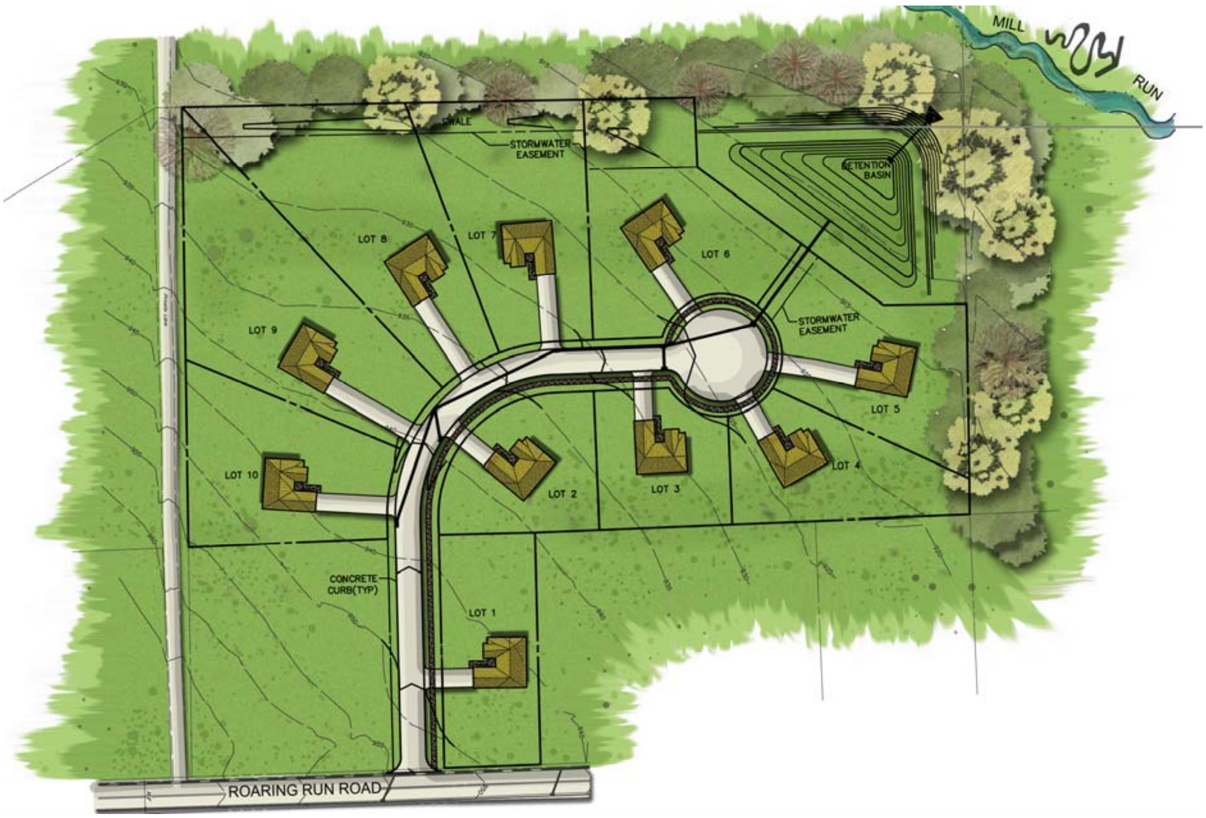

Figure 8.3. Traditional Subdivision Layout (Designed for Peak Rate Control)

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 8.6. 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 8.7. Project Profit

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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.

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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 waterbody can receive and still safely meet the state's water quality standards for that pollutant. TMDLs are a regulatory tool used by states to meet water quality standards in impaired waterbodies where other water quality restoration strategies have not achieved the necessary corrective results.

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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 (4) different uses, as defined in DEP's rules and regulations:

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

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

Category 1: Waters attaining all designated uses.

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

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

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

Category 4A: TMDL has been completed.

Category 4B: Expected to meet all designated uses within a reasonable timeframe.

Category 4C: Not impaired by a pollutant and not requiring a TMDL.

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

MIFFLIN COUNTY IMPAIRMENTS

If a stream segment is not attaining any one (1) of its designated uses, it is considered to be "impaired". *Figure 9.1* shows the non-attaining stream segments in Mifflin County and identifies the primary source of the impairment listing. As shown, over 100 miles of the 123.7 impaired stream miles in Mifflin County are related agricultural land use practices.

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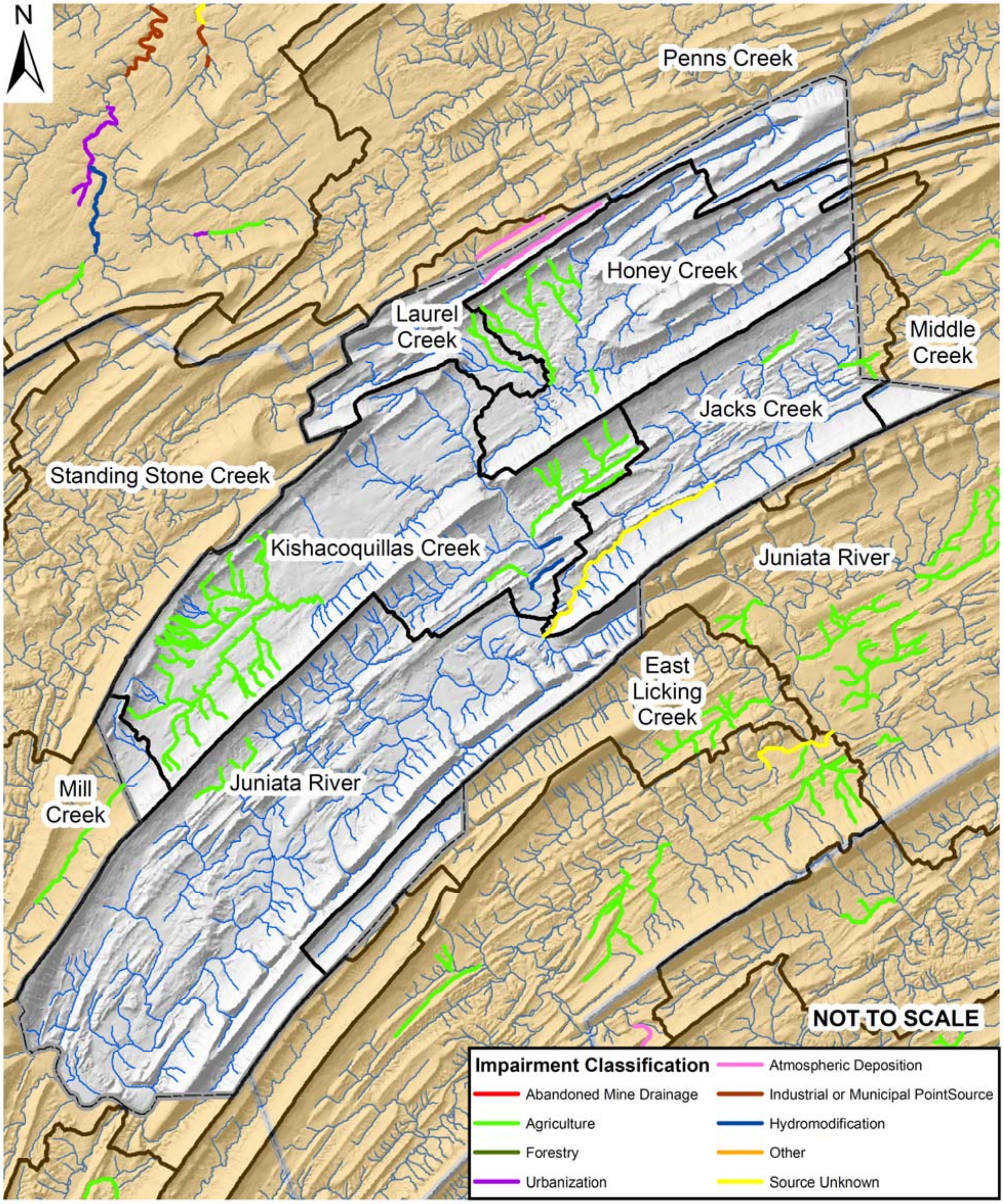

Figure 9.1. Impaired Stream Segments in Mifflin County

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In Mifflin 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.

	Act 167 Watersheds (miles of impaired stream)										
Category	**East Licking Creek**	**Honey Creek**	**Jacks Creek**	**Juniata River**	**Kishacoquillas Creek**	**Laurel Creek**	**Middle Creek**	**Mill Creek**	**Penns Creek**	**Entire County**	**Percent of County**
Abandoned Mine Drainage	--	--	--	--	--	--	--	--	--	0.0	0.0
Agriculture	--	16.6	4.5	5.4	72.0	3.2	--	1.7	--	103.3	13.2
Atmospheric Deposition	--	--	--	--	--	7.8	--	--	--	7.8	1.0
Forestry	--	--	--	--	--	--	--	--	--	0.0	0.0
Urbanization	--	--	--	--	--	--	--	--	--	0.0	0.0
Source Unknown	--	--	10.3	--	--	--	--	--	--	10.3	1.3
Other	--	--	--	--	2.2	--	--	--	--	2.2	0.3
Total Impaired	0.0	16.6	14.8	5.4	74.2	11.0	0.0	1.7	0.0	123.7	15.8
Percent of Total	0.0	16.1	14.3	1.9	44.2	24.4	0.0	12.6	0.0	15.8	15.8

Table 9.1. Summary of Impaired Segments by Watershed

TMDL DISCUSSION

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

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

$$TMDL = WLA + LA + MOS$$

Where: TMDL = Total Maximum Daily Load

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

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

MOS = Margin of Safety

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

There are currently no waterbodies with approved TMDLs in Mifflin 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 a previous section. However, several of these categories are more appropriately addressed by the Model Ordinance of this Plan. They play a major role in the water quality of surface waters. The following is a summary of the nonpoint sources and causes for impairment that affect Mifflin County waters:

AGRICULTURAL ACTIVITIES

Agricultural land use has many beneficial effects on a landscape's response to rainfall and properly managed agricultural activities provide many positive environmental benefits. 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.

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SEDIMENT/SILTATION

The most common agricultural cause for surface water impairment is sediment and siltation. Of the 123.7 miles of impaired streams in Mifflin 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 best management practices (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. Agriculture related nutrients account for 64.9 miles of the 123.7 miles of impaired streams in Mifflin County. Nutrients such as nitrogen, phosphorus, potassium, and other micronutrients are essential to proper plant growth and development. There could be a potential environmental hazard when the available nutrients exceed those required for plant development or when nutrients are improperly applied. Nutrient pollution results from agricultural activities like fertilizer and manure application, livestock access to waterbodies, and animal concentration areas.

Nutrient management regulations have been developed in PA 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 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 is listed as the source of impairment for 7.8 miles of surface waters within the county, making it the second leading indentified source of impairment in Mifflin County. Mercury enters the cycle through natural sources like geologic deposits, but anthropogenic sources are the main source of mercury non-attainment. 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

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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.

RECOMMENDATIONS

Addressing water quality impairments is achieved most effectively through watershed-wide planning and implementation. The first step in the process is perhaps the development of this Plan (and the other plans discussed in Section IV) and the subsequent and adoption of the Model Ordinance by municipalities within the county. An additional step is using DEP's "Integrated Waters List" as it 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 strategies that effectively address the sources of water quality impairment on a site-by-site basis.

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

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

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

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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 Mifflin 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 and has been implemented in various locations along Kishacoquillas Creek.

Riparian Buffers

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

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

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

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Barnyard Runoff Control

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

Nutrient Management

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

Animal Waste Management Systems

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

Cover Crops

Cover crops are planted in the fall after the primary crop has been harvested. The cover crop grows through the fall and provides ground cover for the field throughout the winter months and early spring when the soil is extremely susceptible to erosion. The cover crop also provides nitrogen removal benefits as it utilizes excess nitrogen in the soil. The cover crop can either be harvested as a commodity crop in the spring or it can be killed and left as ground cover prior to spring planting. Cover crops provide excellent soil erosion protection when the fields need it most. The County Conservation District has several cost

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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 annual soil loss estimate for each field.

POTENTIAL FUNDING SOURCES

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

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

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

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

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

Tributary Strategy for Mifflin County – This program is through the Chesapeake Bay Program. It provides financial incentive payments to implement nutrient management plans and other conservation BMPs. Nutrient management plans, cover crops, waste storage facilities, conservation buffers and conservation tillage are all practices included in this program.

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NONPOINT SOURCE POLLUTION REDUCTION PROGRAMS

Addressing environmental resource concerns and implementing conservation practices is one of the primary focuses of the Mifflin County Conservation District and the USDA NRCS. The process of improving the county's water quality impairments has already been initiated by these two groups.

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Section X – Additional Recommendations and Considerations

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

The measures contained in Section X provide a supplement to the regulatory scope of the municipal stormwater management ordinance. It is suggested that all municipalities consider these additional recommendations and determine whether adoption of some of these policies could be beneficial to their respective communities. Municipalities with substantial stormwater problem areas could especially benefit from regulation of 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 in a stormwater management program. This is because the rainfall-runoff response of a given geographical area is directly linked to land use. In this manner, zoning regulations can help achieve the goals of a stormwater program or they can be a hinderance to successful implentation of the program. Only 34% of rural municpalites have enacted zoning ordinances and the majority of these municipalities are located in the southeast portion of the Commonwealth (Lembeck et al., 2001). Instituting new or updating existing zoning 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. That 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 and perceived effects of the ordinance changes.

Recommendations for Improved Municipal Zoning

The following zoning tools are recommended by the Center for Watershed Protection that 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.

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- **Overlay Zoning** – With this option, specific criteria can be applied to isolated areas without the limitations of underlying base zoning. Overlay zoning superimposes additional regulatory standards, specifies permitted uses, or applies specific development criteria onto existing zoning provisions. Overlay zones may take up only part of an underlying zone or may encompass several underlying zones. An example of watershed-related overlay zoning may be "Impervious Overlay Zoning" in areas with documented stormwater problems that set 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 as well as areas appropriate for traditionally rural land uses (e.g., agriculture and forest preservation). Growth boundaries are typically set for up a specific time period (e.g. 10 to 20 years) and re-evaluated at appropriate intervals.
- **Infill Community Redevelopment** – This strategy encourages use of vacant or under-used land within existing growth centers for urban redevelopment. This practice is one method used to reduce the negative impacts of urban sprawl and minimize additional impervious area by maximizing utilization of existing infrastructure.
- **Transfer of Development Rights** – This allows transfer of development rights from sensitive subwatersheds (where the potential for adverse impacts is relatively high) to other watersheds designated for growth (where the potential for adverse impacts are relatively low).

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RIVER CORRIDOR PROTECTION

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

Rivers and streams adjust over time in response to the varying inputs of water, sediment, and debris due to dynamic fluvial processes. Natural adjustments to these inputs are continually occuring 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 reduces the likelihood of increased flooding. Floodplain management focuses on preventive and corrective measures to reduce flood damage. Implementation of the *Model Ordinance* will reduce the probability of new flooding problems, but will have only minor impacts on existing problems. 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*, Mifflin County incurs a substantial economic loss in major hydrologic events (as much as $58 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.

Recommendations for Floodplain Management

- **Adopt and enforce the Pennsylvania Department of Community and Economic Development (DCED) Model Floodplain Ordinance.** When the FIRMs in Mifflin County were updated, it was strongly recommended by DCED that each municipality adopt the DCED model ordinance. This will ensure that the local ordinance addresses the minimum state and federal requirements of the NFIP and provide a consistent basis of floodplain management between all of municipalities in the county.
- **Participate in the Community Rating System (CRS).** The CRS gives communities credit for reducing the risk of flood hazards. By implementing many of the same principles that are discussed in this Plan, municipalities can reduce flood insurance rates for residents inside 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 (2) or more claims of at least $1000 have been paid by the NFIP within any 10-year period since 1978) constitute a large portion of the NFIP flood insurance claims. Nationally, less than 1% of all properties with flood insurance have accounted for 30% of flood insurance claims between 1978 and 2004 (U.S. General Accounting Office, 2004). Removing these and any other structure that incurs flood risk on an annual basis reduces the overall risk of the NFIP and reduces the community's exposure to flood damage. It is usually more economical to remove properties (particularly in rural areas like Mifflin County) than it is to install structural alternatives like levies, diversion projects, or dams.
- **Implement a drainage system maintenance program.** As noted in *Section V*, there are numerous locations where clogged or poorly-maintained facilities result in flooding of areas not normally prone to flooding. Most engineering design calculations for stormwater detention and conveyance facilities assume full function of a bridge or culvert. A systematic inspection and maintenance program should be implemented that includes periodic inspections on all channels, conveyance facilities, and storage

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facilities. Routine maintenance should be performed as necessary to fix problems and to remove debris.

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 and subsequent 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 and Kline, 2008). Once these areas are identified and mapped, land use planning mechanisms are used to protect identified sensitive areas and limit future development within this zone. Keeping infrastructure, such as roads and utilities, out of the high risk areas greatly reduces the cost of protecting and maintaining this infrastructure.

<u>Recommendations for River Corridor Planning</u>

- **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, floodplain areas that would provide greater benefit by being conserved, or areas that currently experience persistent flood damage.
- **Identify and protect fluvial erosion hazard zones.** Flood damage may also occur as a stream channel changes course and meanders. The channel changes may result from either naturally occurring fluvial processes or human-induced changes to watershed hydrology or hydraulics. A 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 define areas with specified stream buffers for additional protection. The state of Vermont has integrated Fluvial Erosion Zones into the floodplain mapping process, so that all of the tools of floodplain management are available for the specified areas (Dolan and Kline, 2008).

RIPARIAN ZONE PROTECTION

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

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providing a small amount of volume reduction through infiltration and permanent retention of water in disconnected low lying areas. The second primary benefit of riparian zones is the water quality functions they provide. Vegetation in the riparian zone reduces water temperature by providing shade, 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 complement the recently proposed changes to the statewide erosion and sediment pollution control regulations (The Pennsylvania Code, Title 25, 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 effect on existing land uses in critical riparian areas. There are numerous existing incentive programs that offer technical and/or financial assistance to encourage land owners to alter existing land uses and establish riparian buffers. These include agricultural land retirement programs such as USDA's Conservation Reserve Enhancement Program (CREP) program and cost-share programs, such as USDA's Environmental Quality Incentives Program (EQIP). Grant and loan programs could also help to meet this objective.

WETLAND PROTECTION

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

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

Recommendations for Wetland Protection

- **Identify and protect special value wetlands.** Wetlands are protected through various levels of federal and state regulations due to the diversity of benefits they provide. 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.

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LIMIT IMPERVIOUS COVER

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

Recommendations to Limit Impervious Cover

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

- **Road Widths** – These are usually specified based on the anticipated road use category (e.g., major, minor, or collector). Most ordinances assume a standard 12-foot wide travel lane and add width for shoulders, parking lanes, bicycle lanes, and other considerations. Reducing the travel lane width to eleven (11) feet for minor roads (e.g., roads within a subdivision development) could reduce the impervious cover of those roadways by up to eight (8) percent.

- **On-Street Parking** – Parking lanes are often specified to be eight (8) or ten (10) feet wide. Standardizing the maximum width of these lanes to eight (8) feet would reduce runoff. Also, limiting parking to one side of a street, particularly in subdivisions, could result in a significant reduction in total runoff. Another option would be to require that the parking lanes be constructed of pervious pavement, grid blocks, or another pervious surface.
- **Sidewalks** – In instances where ordinances require sidewalks, consideration should be given to only requiring them on one 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 some instances, the sidewalk could be laid out so that it does not parallel the roadway, providing even greater opportunity for infiltration.
- **Curb and Gutter Systems With Storm Sewers** – In heavy residential areas, many ordinances require the developer to install curb and gutters along roadways as well as to use inlets and storm sewers to remove and transport the runoff from the roads. Ordinances should be modified to allow roadside swales, providing additional infiltration opportunity and some water quality benefit through filtration. This option would have the added benefits of significantly reducing development costs and minimizing future maintenance requirements.
- **Parking Requirements and Parking Stall Dimensions** – Consideration should be given to reducing the number of parking spaces that must be provided on-street or in parking lots for residential, commercial, educational, and industrial developments. Furthermore, stall sizes in parking lots should be set to 8-feet wide by 18-feet long. In addition, consideration could be given to requiring that larger parking lots establish special areas for compact cars with stall sizes reduced to 7-feet wide by 15-feet long. Finally, the ordinances should include requirements for a minimum amount of "green space" in parking lots, which should allow runoff from the impervious surfaces to flow over them so that infiltration and water quality filtration would be enhanced.
- **Lot Sizes and Total Impervious Cover** – Most ordinances establish minimum lot sizes for various types of development and the number of "units" permitted on each lot. 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. 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.

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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. Soil compaction plays a significant role in the ability of a given soil type to hold water. As topsoil is disturbed or compacted, the holding capacity of the soil is drastically reduced, thus limiting its effectiveness in reducing runoff. Previous studies (Gregory et al., 2006) have shown that compacted pervious area effectively approaches the infiltration behavior of an impervious surface.

Recommendations for Topsoil Management

- **Adopt ordinance language that discourages the common practice of removing all topsoil from development sites during construction.** The area of disturbance during the construction phase of a project should be limited to the minimum area necessary. 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, demarcated, and protected by in-field measures. This is especially important for areas intended for infiltration-based stormwater management facilities.

IMPEDIMENTS TO LID IMPLEMENTATION

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

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

Recommendations to Remove LID Impediments

- **Provide education activities and training workshops to various stakeholder groups.** Municipal and county officials should be encouraged to obtain additional education on LID practices. Other stakeholders, such as developers, builders, and homeowners, should also have educational resources available to increase awareness and encourage implementation of LID practices. Education is the key to successful implementation of LID practices.

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- **Promote guidance documents.** There are a variety of publications and internet sites that discuss LID and offer design solutions: Low Impact Development Center (2009), DEP (2006), and Prince George's County (1999). These resources, along with this Plan, should be made available through municipal offices, websites, or trainings.
- **Alter existing Subdivision and Land Development Ordinances and Zoning Ordinances to allow for successful LID implementation.** Adoption of the Model Stormwater Management Ordinance in this Plan is an important tool in accomplishing the goals of LID. 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. 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 best management practice (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 works in Mifflin County.

SUMMARY

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

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Section XI – Plan Adoption, Implementation and Update Procedures

PLAN REVIEW AND ADOPTION

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

1. Plan Advisory Committee Review - This body has been formed to assist in the development of the Mifflin County Act 167 Stormwater Management Plan. Municipal members of the PAC have provided input to the process in the form of storm drainage problem area documentation, storm sewer documentation, proposed solutions to drainage problems, etc. The PAC met on many occasions to review the progress of the Plan. Municipal representatives on the PAC have the responsibility to report on the progress of the Plan to their respective municipalities. Review of the draft Plan by the PAC will be expedited by the fact that the members are already familiar with the objectives of the Plan, the runoff control strategy employed, and the basic contents of the Plan. The output of the PAC review will be a revised draft Plan for Municipal and County consideration.

   a. Municipal Engineers Review - 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.

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

3. County Review and Adoption - Upon completion of the review by the PAC, with assistance from the Municipal Engineers, Legal Advisory Committee, and each municipality, the draft Plan will be submitted to the County Board of Commissioners for their consideration.

The Mifflin County review of the draft Plan will include a detailed review by the County Board of Commissioners and an opportunity for public input through the holding of public hearings. Public

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

IMPLEMENTATION OF THE PLAN

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

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

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

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

1. Monitoring of the Plan Implementation - The Mifflin County Planning Commission (MCPC) 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 MCPC will monitor the following data records:

    a. All subdivision and land developments subject to review per the Plan that have been approved within the study area.

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

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

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

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Model Stormwater Management Ordinance

Mifflin County
Act 167 Countywide
Stormwater Management Plan

June 2010

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474 Windmere Drive • State College, PA 16801 • 814.238.7117 [phone]

Using The Model Stormwater Management Ordinance

Municipal Requirements: This Model Stormwater Management Ordinance was developed during the *Mifflin County Act 167 Stormwater Management Plan*. The Pennsylvania Stormwater Management Act (Act 167) requires that each municipality adopt a stormwater management ordinance to implement the stormwater management plan. Section 11(b) of Act 167 states:

> "Within six months following the DEP's approval of the this plan, each municipality is required to adopt new and/or amend existing stormwater ordinances or other ordinances, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development in a manner consistent with plan."

Any ordinance(s) adopted or amended by the municipality to comply with the stormwater management standards and criteria of the *Mifflin County Act 167 Stormwater Management Plan* must be sent by a municipal official to the DEP with the municipal ordinance number and including the date the ordinance was enacted.

Enacting and Amending Municipal Ordinances: It is recommended that municipalities enact the Model Ordinance as a stand-alone ordinance. In addition, it is recommended that municipalities review existing ordinances (subdivision and land development, zoning, etc.) and consider amending them to refer to and coordinate with the new municipal stormwater management ordinance.

Ordinance Provisions: Ordinances adopted by municipalities are the legal instrument that implements the standards and criteria of this stormwater management plan.

- The text ***[Municipality]*** in the Model Ordinance should be replaced by the name of the individual municipality.
- Provisions with **[OPTIONAL]** is recommended but may be modified or deleted by the municipality. When deleting an **[OPTIONAL]** Article, the municipality should consider leaving the Article as "Reserved for future use".
- *The text before some **[OPTIONAL]** provisions is provided as guidance to consider when deciding upon inclusion of the **[OPTIONAL]** provision. The box and text should be deleted in the final adopted ordinance.*

The final ordinance adopted by the municipality should be developed in conjunction with, reviewed by, and agreed upon by the municipal solicitor, engineer, and governing body.

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STORMWATER MANAGEMENT MODEL ORDINANCE

Implementing the Requirements of the

Mifflin County Stormwater Management Plan

ORDINANCE NO. _________ OF_________

FINAL

____________________, MIFFLIN COUNTY, PENNSYLVANIA

Adopted at a Public Meeting Held on
_________________, 2010

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ARTICLE I - GENERAL PROVISIONS

Section 101. Short Title

This Ordinance shall be known and may be cited as the "***Municipality*** Stormwater Management Ordinance."

Section 102. Statement of Findings

The governing body of ***Municipality*** finds that:

A. Inadequate management of accelerated stormwater runoff resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of existing streams and storm sewers, greatly increases the cost of public facilities to convey and manage stormwater, undermines floodplain management and flood reduction efforts in upstream and downstream communities, reduces groundwater recharge, threatens public health and safety, and increases non-point source pollution of water resources.

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

C. Inadequate planning and management of stormwater runoff resulting from land development and redevelopment throughout a watershed can also harm surface water resources by changing the natural hydrologic patterns; accelerating stream flows (which increase scour and erosion of streambeds and stream banks thereby elevating sedimentation); destroying aquatic habitat; and elevating aquatic pollutant concentrations and loadings such as sediments, nutrients, heavy metals, and pathogens. Groundwater resources are also impacted through loss of recharge.

D. Stormwater is an important water resource which provides groundwater recharge for water supplies and base flow of streams, which also protects and maintains surface water quality.

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

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

G. Non-stormwater discharges to municipal separate storm sewer systems can contribute to pollution of Waters of the Commonwealth.

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Section 103. Purpose

The purpose of this Ordinance is to promote health, safety, and welfare within ***[Municipality]***, Mifflin County, by minimizing the harms and maximizing the benefits described in Section 102 of this Ordinance through provisions intended to:

A. Meet legal water quality requirements under state law, including regulations at 25 PA Code Chapter 93 to protect, maintain, reclaim, and restore the existing and designated uses of the Waters of the Commonwealth.

B. Manage accelerated runoff and erosion and sedimentation problems close to their source, by regulating activities that cause these problems.

C. Preserve the natural drainage systems as much as possible.

D. Maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to otherwise protect water resources.

E. Maintain existing flows and quality of streams and watercourses.

F. Preserve and restore the flood-carrying capacity of streams and prevent scour and erosion of stream banks and streambeds.

G. Manage stormwater impacts close to the runoff source, with a minimum of structures and a maximum use of natural processes.

H. Provide procedures, performance standards, and design criteria for stormwater planning and management.

I. Provide proper operations and maintenance of all temporary and permanent stormwater management facilities and Best Management Practices (BMPs) that are constructed and implemented.

J. Provide standards to meet the NPDES permit requirements.

Section 104. Statutory Authority

A. Primary Authority:

[Municipality] is empowered to regulate these activities by the authority of the Act of October 4, 1978, 32 P.S., P.L. 864 (Act 167), 32 P.S. Section 680.1 et seq., as amended, the "Storm Water Management Act", and the ***[applicable Municipal Code]***.

B. Secondary Authority:

[Municipality] also is empowered to regulate land use activities that affect runoff by the authority of the Act of July 31, 1968, P.L. 805, No. 247, The Pennsylvania Municipalities Planning Code, as amended.

Section 105. Applicability

This Ordinance shall apply to all areas of ***[Municipality]***, any Regulated Activity within ***[Municipality]***, and all stormwater runoff entering into ***[Municipality's]*** separate storm sewer system from lands within the boundaries of ***[Municipality]***.

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Earth disturbance activities and associated stormwater management controls are also regulated under existing state law and implementing regulations. This Ordinance shall operate in coordination with those parallel requirements; the requirements of this Ordinance shall be no less restrictive in meeting the purposes of this Ordinance than state law.

"Regulated Activities" are any earth disturbance activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff. "Regulated Activities" include, but are not limited to, the following listed items:

A. Earth Disturbance Activities
B. Land Development
C. Subdivision
D. Construction of new or additional impervious or semi-pervious surfaces
E. Construction of new buildings or additions to existing buildings
F. Diversion or piping of any natural or man-made stream channel
G. Installation of stormwater management facilities or appurtenances thereto
H. Installation of stormwater BMPs

See Section 302 of this Ordinance for Exemption/Modification Criteria.

Section 106. Repealer

Any ordinance, ordinance provision(s), or regulation of ***[Municipality]*** inconsistent with any of the provision(s) of this Ordinance is hereby repealed to the extent of the inconsistency only.

Section 107. Severability

In the event that a court of competent jurisdiction declares any section(s) or provision(s) of this Ordinance invalid, such decision shall not affect the validity of any of the remaining section(s) or provision(s) of this Ordinance.

Section 108. Compatibility with Other Ordinance Requirements

Approvals issued and actions taken pursuant to this Ordinance do not relieve the Applicant of the responsibility to comply with or to secure required permits or approvals for activities regulated by any other applicable codes, laws, rules, statutes, or ordinances. To the extent that this Ordinance imposes more rigorous or stringent requirements for stormwater management, the specific requirements contained in this Ordinance shall be followed.

Section 109. Duty of Persons Engaged in the Development of Land

Notwithstanding any provision(s) of this Ordinance, including exemptions, any landowner or any person engaged in the alteration or development of land which may affect stormwater runoff characteristics shall implement such measures as are reasonably necessary to prevent injury to health, safety, or other property. Such measures also shall include actions as are required to manage the rate, volume, direction, and quality of resulting stormwater runoff in a manner which otherwise adequately protects health, property, and water quality.

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ARTICLE II - DEFINITIONS

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

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

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

C. The word "person" includes an individual, firm, association, organization, partnership, trust, company, corporation, or any other similar entity.

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

E. The words "used or occupied" include the words "intended, designed, maintained, or arranged to be used, occupied or maintained".

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

Agricultural Activities - Activities associated with agriculture such as agricultural cultivation, agricultural operation, and animal heavy use areas. This includes the work of producing crops, tillage, land clearing, plowing, disking, harrowing, planting, harvesting crops, or pasturing and raising of livestock and installation of conservation measures. Construction of new buildings or impervious area is not considered an Agricultural Activity.

Alteration - As applied to land, a change in topography as a result of the moving of soil and rock from one location or position to another; changing of surface conditions by causing the surface to be more or less impervious; land disturbance.

Applicant - A landowner, developer, or other person who has filed an application for approval to engage in any Regulated Activities at a project site within the municipality.

Best Management Practices (BMPs) - Activities, facilities, designs, measures or procedures used to manage stormwater impacts from Regulated Activities, to meet State Water Quality Requirements, to promote groundwater recharge and to otherwise meet the purposes of this Ordinance. Stormwater BMPs are commonly grouped into one of two broad categories or measures: “non-structural” or “structural”. “Non-structural” BMPs are measures referred to as operational and/or behavior-related practices that attempt to minimize the contact of pollutants with stormwater runoff whereas “structural” BMPs are measures that consist of a physical device or practice that is installed to capture and treat stormwater runoff. “Structural” BMPs include, but are not limited to, a wide variety of practices and devices, from large-scale retention ponds and constructed wetlands, to small-scale underground treatment systems, infiltration facilities, filter strips, low impact design, bioretention, wet ponds, permeable paving, grassed swales, riparian or forested buffers, sand filters, detention basins, and manufactured devices. “Structural” stormwater BMPs are permanent appurtenances to the project site.

Channel Erosion - The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to large floods.

Cistern - An underground reservoir or tank used for storing rainwater.

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Conservation District - The Mifflin County Conservation District. The Mifflin County Conservation District has the authority under a delegation agreement executed with the Department of Environmental Protection to administer and enforce all or a portion of the regulations promulgated under 25 PA Code Chapter 102.

Culvert - A structure with appurtenant works that carries a stream and/or stormwater runoff under or through an embankment or fill.

Dam - An artificial barrier, together with its appurtenant works, constructed for the purpose of impounding or storing water or another fluid or semifluid, or a refuse bank, fill or structure for highway, railroad or other purposes which does or may impound water or another fluid or semifluid.

Design Storm - The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., a 25-year storm) and duration (e.g., 24-hours), used in the design and evaluation of stormwater management systems. Also see Return Period.

Designee - The agent of this municipality and/or agent of the governing body involved with the administration, review or enforcement of any provisions of this Ordinance by contract or memorandum of understanding.

Detention Basin - An impoundment structure designed to manage stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate.

Detention Volume - The volume of runoff that is captured and released into Waters of the Commonwealth at a controlled rate.

Developer - A person, partnership, association, corporation, or other entity, or any responsible person therein or agent thereof, that undertakes any Regulated Activity of this Ordinance.

Development Site - (Site) - The specific tract of land for which a Regulated Activity is proposed. Also see Project Site.

Disturbed Area - An unstabilized land area where an Earth Disturbance Activity is occurring or has occurred.

Downslope Property Line - That portion of the property line of the lot, tract, or parcels of land being developed located such that all overland or pipe flow from the site would be directed toward it.

Drainage Conveyance Facility - A stormwater management facility designed to convey stormwater runoff and shall include streams, channels, swales, pipes, conduits, culverts, storm sewers, etc.

Drainage Easement - A right granted by a landowner to a grantee, allowing the use of private land for stormwater management, drainage, or conveyance purposes.

Drainageway - Any natural or artificial watercourse, trench, ditch, pipe, swale, channel, or similar depression into which surface water flows.

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

Erosion - The movement of soil particles by the action of water, wind, ice, or other natural forces.

Erosion and Sediment Pollution Control Plan - A plan which is designed to minimize accelerated erosion and sedimentation.

Exceptional Value Waters - Surface waters of high quality, which satisfies PA Code Title 25 Environmental Protection, Chapter 93 Water Quality Standards 93.4b(b) (relating to anti-degradation).

Existing Conditions - The initial condition of a project site prior to the proposed construction. If the initial condition of the site is undeveloped land and not forested, the land use shall be considered as "meadow" unless the natural land cover is documented to generate lower Curve Numbers or Rational "C" Coefficient.

FEMA - The Federal Emergency Management Agency.

Flood - A general but temporary condition of partial or complete inundation of normally dry land areas from the overflow of streams, rivers, and other Waters of the Commonwealth.

Flood Fringe - The remaining portions of the 100-year floodplain outside of the floodway boundary.

Floodplain - Any land area susceptible to inundation by water from any natural source or delineated by applicable Department of Housing and Urban Development, Federal Insurance Administration Flood Hazard Boundary - mapped as being a special flood hazard area. Included are lands adjoining a river or stream that have been or may be inundated by a 100-year flood. Also included are areas that comprise Group 13 Soils, as listed in Appendix A of the Pennsylvania Department of Environmental Protection (PADEP) Technical Manual for Sewage Enforcement Officers (as amended or replaced from time to time by PADEP).

Floodway - The channel of the watercourse and those portions of the adjoining floodplains that are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed - absent evidence to the contrary - that the floodway extends from the stream to 50 feet from the top of the bank of the stream.

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Forest Management/Timber Operations - Planning and activities necessary for the management of forestland. These include timber inventory and preparation of forest management plans, silvicultural treatment, cutting budgets, logging road design and construction, timber harvesting, site preparation and reforestation.

Freeboard - A vertical distance between the elevation of the design high water and the top of a dam, levee, tank, basin, or diversion ridge. The space is required as a safety margin in a pond or basin.

Grade - A slope, usually of a road, channel or natural ground specified in percent and shown on plans as specified herein.

(To) Grade - To finish the surface of a roadbed, top of embankment or bottom of excavation.

Groundwater Recharge - Replenishment of existing natural underground water supplies.

HEC-HMS Model Calibrated - (Hydrologic Engineering Center Hydrologic Modeling System) A computer-based hydrologic modeling technique adapted to the watershed(s) in _________ County for the Act 167 Plan. The model has been calibrated by adjusting key model input parameters.

High Quality Waters - Surface water having quality, which exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water by satisfying PA Code Title 25 Environmental Protection, Chapter 93 Water Quality Standards 93.4b(a).

Hydrologic Soil Group (HSG) - Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into one of four HSG (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. The Natural Resource Conservation Service (NRCS) of the US Department of Agriculture defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report from the local NRCS office or the County Conservation District.

Impervious Surface (Impervious Area) - A surface that prevents the infiltration of water into the ground. Impervious surface (or areas) include, but is not limited to: roofs, additional indoor living spaces, patios, garages, storage sheds and similar structures, parking or driveway areas, and any new streets and sidewalks. Any surface areas proposed to initially be gravel or crushed stone shall be assumed to be impervious surfaces.

Impoundment - A retention or detention basin designed to retain stormwater runoff and release it at a controlled rate.

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

Inlet - A surface connection to a closed drain. A structure at the diversion end of a conduit. The upstream end of any structure through which water may flow.

Karst - A type of topography or landscape characterized by surface depressions, sinkholes, rock pinnacles/uneven bedrock surface, steep-sided hills, underground drainage and caves. Karst is formed on carbonate rocks, such as limestone or dolomites and sometimes gypsum.

Land Development (Development) - (i) The improvement of one lot or two or more contiguous lots, tracts or parcels of land, whether proposed initially or cumulatively, for any purpose involving (a) a group of two or more more residential or nonresidential buildings, or a single nonresidential building on a lot or lots regardless of the number of occupants or tenure, or (b) the division or allocation of land or space between or among two or more existing or prospective occupants by means of, or for the purpose of streets, common areas, leaseholds, condominiums, building groups, or other features; (ii) Any subdivision of land; (iii) Development in accordance with Section 503(1.1) of the PA Municipalities Planning Code.

Main Stem (Main Channel) - Any stream segment or other runoff conveyance facility used as a reach in the Mifflin County Act 167 watershed hydrologic model(s).

Manning Equation (Manning Formula) - A method for calculation of velocity of flow (e.g., feet per second) and flow rate (e.g., cubic feet per second) in open channels based upon channel shape, roughness, depth of flow and slope. "Open channels" may include closed conduits so long as the flow is not under pressure.

Municipality - ***[Municipality]***, Mifflin County, Pennsylvania.

National Pollutant Discharge Elimination System (NPDES) - The federal government’s system for issuance of permits under the Clean Water Act, which is delegated to PADEP in Pennsylvania.

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NOAA Atlas 14: - Precipitation-Frequency Atlas of the United States, Atlas 14, Volume 2, US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Hydrometeorological Design Studies Center, Silver Spring, Maryland (2004). NOAA's Atlas 14 can be accessed at Internet address: http://hdsc.nws.noaa.gov/hdsc/pfds/.

Non-point Source Pollution - Pollution that enters a water body from diffuse origins in the watershed and does not result from discernible, confined, or discrete conveyances.

NRCS - Natural Resource Conservation Service (previously Soil Conservation Service (SCS)).

Open Channel - A drainage element in which stormwater flows with an open surface. Open channels include, but shall not be limited to, natural and man-made drainageways, swales, streams, ditches, canals, and pipes not under pressure.

Outfall - (i) Point where water flows from a conduit, stream, or drain; (ii) "Point Source" as described in 40 CFR § 122.2 at the point where the Municipality's storm sewer system discharges to surface Waters of the Commonwealth.

Outlet - Points of water disposal from a stream, river, lake, tidewater, or artificial drain.

PADEP - The Pennsylvania Department of Environmental Protection.

Parking Lot Storage - Involves the use of impervious parking areas as temporary impoundments with controlled release rates during rainstorms.

Peak Discharge - The maximum rate of stormwater runoff from a specific storm event.

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

Pervious Area - Any area not defined as impervious. A surface that presents an opportunity for precipitation to infiltrate into the ground.

Pipe - A culvert, closed conduit, or similar structure (including appurtenances) that conveys stormwater.

Planning Commission - The Planning Commission of ***[Municipality]***.

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

Probable Maximum Flood (PMF) - The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in any area. The PMF is derived from the probable maximum precipitation (PMP) as determined on the basis of data obtained from the National Oceanographic and Atmospheric Administration (NOAA).

Project Site - The specific area of land where any Regulated Activities in the Municipality are planned, conducted, or maintained.

Qualified Professional - Any person licensed by the Pennsylvania Department of State or otherwise qualified by law to perform the work required by the Ordinance.

Rational Formula - A rainfall-runoff relation used to estimate peak flow.

Redevelopment - Earth disturbance activities on land, which has previously been developed.

Regulated Activities - Any earth disturbance activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff.

Regulated Earth Disturbance Activity - Activity involving Earth Disturbance subject to regulation under 25 PA Code Chapter 92, Chapter 102, or the Clean Streams Law.

Release Rate - The percentage of pre-development peak rate of runoff from a site or subwatershed area to which the post-development peak rate of runoff must be reduced to protect downstream areas.

Release Rate District - Those subwatershed areas in which post-development flows must be reduced to a certain percentage of pre-development flows as required to meet the plan requirements and the goals of Act 167.

Retention Basin - An impoundment in which stormwater is stored and not released during the storm event. Stored water may be released from the basin at some time after the end of the storm.

Retention Volume/Removed Runoff - The volume of runoff that is captured and not released directly into the surface Waters of this Commonwealth during or after a storm event.

Return Period - The average interval, in years, within which a storm event of a given magnitude can be expected to recur. For example, the 25-year return period rainfall would be expected to recur on the average once every twenty-five years; or stated in another way, the probability of a 25-year storm occurring in any one given year is 0.04 (i.e. a 4% chance).

Riparian Buffer - A vegetated area bordering perennial and intermittent streams and wetlands, that serves as a protective filter to help protect streams and wetlands from the impacts of adjacent land uses.

Riser - A vertical pipe extending from the bottom of a pond that is used to control the discharge rate from the pond for a specified design storm.

Road Maintenance - Earth disturbance activities within the existing road right-of-way, such as grading and repairing existing unpaved road surfaces, cutting road banks, cleaning or clearing drainage ditches, and other similar activities. Road maintenance activities that do not disturb the subbase of a paved road (such as milling and overlays) are not considered earth disturbance activities.

Rooftop Detention - Temporary ponding and gradual release of stormwater falling directly onto flat roof surfaces by incorporating controlled-flow roof drains into building designs.

Runoff - Any part of precipitation that flows over the land surface.

Runoff Capture Volume - The volume of runoff that is captured (retained) and not released into surface Waters of the Commonwealth during or after a storm event.

Sediment - Soils or other materials transported by surface water as a product of erosion.

Sediment Basin - A barrier, dam, retention or detention basin located and designed to retain rock, sand, gravel, silt, or other material transported by stormwater runoff.

Sediment Pollution - The placement, discharge, or any other introduction of sediment into Waters of the Commonwealth occurring from the failure to properly design, construct, implement or maintain control measures and control facilities in accordance with the requirements of this Ordinance.

Sedimentation - The process by which mineral or organic matter is accumulated or deposited by the movement of water.

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

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

Sheet Flow - Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.

Soil Cover Complex Method - A method of runoff computation developed by the NRCS that is based on relating soil type and land use/cover to a runoff parameter called Curve Number (CN).

Spillway (Emergency) - A depression in the embankment of a pond or basin, or other overflow structure, that is used to pass peak discharges greater than the maximum design storm controlled by the pond or basin.

State Water Quality Requirements - The regulatory requirements to protect, maintain, reclaim, and restore water quality under Title 25 of that Pennsylvania Code and the Clean Streams Law.

Storage Indication Method - A reservoir routing procedure based on solution of the continuity equation (inflow minus outflow equals the change in storage) with outflow defined as a function of storage volume and depth.

Storm Frequency - The number of times that a given storm "event" occurs or is exceeded on the average in a stated period of years. See also Return Period.

Storm Sewer - A system of pipes and/or open channels that convey intercepted runoff and stormwater from other sources, but excludes domestic sewage and industrial wastes.

Stormwater - Drainage runoff from the surface of the land resulting from precipitation, snow, or ice melt.

Stormwater Hotspot - A land use or activity that generates higher concentrations of hydrocarbons, trace metals, or toxicants than are found in typical stormwater runoff.

Stormwater Management Facilities - Any structure, natural or man-made, that, due to its condition, design, or construction, conveys, stores, or otherwise affects stormwater runoff. Typical stormwater management facilities include, but are not limited to: detention and retention basins, open channels, storm sewers, pipes and infiltration facilities.

Stormwater Management Plan - The Mifflin County Stormwater Management Plan for managing stormwater runoff in Mifflin County as required by the Act of October 4, 1978, P.L. 864, (Act 167) and known as the “Storm Water Management Act”.

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Stormwater Management Site Plan (SWM Site Plan) - The plan prepared by the Applicant or his representative indicating how stormwater runoff will be managed at the project site in accordance with this Ordinance.

Stream Enclosure - A bridge, culvert, or other structure in excess of 100 feet in length upstream to downstream which encloses a regulated Waters of the Commonwealth.

Subwatershed Area - The smallest drainage unit of a watershed for which stormwater management criteria has been established in the Stormwater Management Plan.

Subdivision - The division or re-division of a lot, tract, or parcel of land by any means, into two or more lots, tracts, parcels or other divisions of land including changes in existing lot lines for the purpose, whether immediate or future, of lease, transfer of ownership, or building or lot development, provided; however, that the subdivision by lease of land for agricultural purposes into parcels of more than ten acres, not involving any new street or easement of access or any residential dwellings, shall be exempt {Pennsylvania Municipalities Planning Code, Act of July 31, 1968, P.L. 805, No. 247}.

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

Timber Operations - See "Forest Management".

Time of Concentration (T_c) - The time for surface runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. This time is the combined total of overland flow time and flow time in pipes or channels, if any.

USDA - The United States Department of Agriculture.

Watercourse - A channel or conveyance of surface water, such as a stream or creek, having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Waters of the Commonwealth - Rivers, streams, creeks, rivulets, impoundments, ditches, watercourses, storm sewers, lakes, dammed water, wetlands, ponds, springs and other bodies or channels of conveyance of surface and underground water, or parts thereof, whether natural or artificial, within or on the boundaries of the Commonwealth of Pennsylvania.

Watershed - Region or area drained by a river, watercourse, or other surface water, whether natural or artificial.

Wetland - Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas. (The term includes but is not limited to wetland areas listed in the State Water Plan, the United States Forest Service Wetlands Inventory of Pennsylvania, the Pennsylvania Coastal Zone Management Plan and a wetland area designated by a river basin commission. This definition is used by the United States Environmental Protection Agency and the United States Army Corps of Engineers.)

ARTICLE III - STORMWATER MANAGEMENT STANDARDS

Section 301. General Requirements

A. For all Regulated Activities, unless specifically exempted in Section 302:

1. Preparation and implementation of an approved SWM Site Plan is required.
2. No Regulated Activities shall commence until the municipality issues written approval of a SWM Site Plan, which demonstrates compliance with the requirements of this Ordinance.
3. The SWM Site Plan shall demonstrate that adequate capacity will be provided to meet the Volume and Rate Control Requirements, as described under Sections 304 and 305 of this Ordinance.
4. The SWM Site Plan approved by the municipality, shall be on-site throughout the duration of the Regulated Activities.

B. For all Regulated Earth Disturbance Activities, erosion and sediment control BMPs shall be designed, implemented, operated, and maintained during the Regulated Earth Disturbance Activities (e.g., during construction) to meet the purposes and requirements of this Ordinance and to meet all requirements under Title 25 of the Pennsylvania Code (including, but not limited to Chapter 102 Erosion and Sediment Control) and the Clean Streams Law. Various BMPs and their design standards are listed in the *Erosion and Sediment Pollution Control Program Manual* (E&S Manual), No. 363-2134-008 (April 15, 2000), as amended and updated.

C. For all Regulated Activities, stormwater BMPs shall be designed, installed, implemented, operated, and maintained to meet the purposes and requirements of this Ordinance and to meet all requirements under Title 25 of the Pennsylvania Code and the Clean Streams Law, conform to the State Water Quality Requirements, meet all requirements under the Storm Water Management Act and any more stringent requirements as determined by the municipality.

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

E. All Regulated Activities shall include, to the maximum extent practicable, measures to:

1. Protect health, safety, and property.
2. Meet the water quality goals of this Ordinance by implementing measures to:
   a. Minimize disturbance to floodplains, wetlands, natural slopes, existing native vegetation and woodlands.
   b. Create, maintain, or extend riparian buffers and protect existing forested buffers.
   c. Provide trees and woodlands adjacent to impervious areas whenever feasible.
   d. Minimize the creation of impervious surfaces and the degradation of Waters of the Commonwealth and promote groundwater recharge.
   e. Protect natural systems and processes (drainageways, vegetation, soils, and sensitive areas) and maintain, as much as possible, the natural hydrologic regime.
   f. Incorporate natural site elements (wetlands, stream corridors, mature forests) as design elements.
   g. Avoid erosive flow conditions in natural flow pathways.
   h. Minimize soil disturbance and soil compaction.

i. Minimize thermal impacts to Waters of the Commonwealth.
j. Disconnect impervious surfaces by directing runoff to pervious areas, wherever possible and decentralize and manage stormwater at its source.

F. Impervious Areas:
1. The measurement of impervious areas shall include all of the impervious areas in the total proposed development, even if development is to take place in stages.
2. For developments taking place in stages, the entire development plan must be used in determining conformance with this Ordinance.
3. **[OPTIONAL]** For projects that add impervious area to a developed parcel, to the maximum extent practicable and at the discretion of the Municipal Engineer, the total impervious area on the parcel may be subject to the requirements of this Ordinance.

G. If diffused flow is proposed to be concentrated and discharged onto adjacent property, the Applicant must document that adequate downstream conveyance facilities exist to safely transport the concentrated discharge, or otherwise prove that no erosion, sedimentation, flooding, or other harm will result from the concentrated discharge.
1. Applicant must provide an easement for proposed concentrated flow across adjacent properties.
2. Such stormwater flows shall be subject to the requirements of this ordinance.

H. Stormwater drainage systems shall be provided in order to permit unimpeded flow along natural watercourses, except as modified by stormwater management facilities or open channels consistent with this Ordinance.

I. Where watercourses traverse a development site, drainage easements (with a minimum width of 20 feet) shall be provided conforming to the line of such watercourses. The terms of the easement shall prohibit excavation, the placing of fill or structures, and any alterations that may adversely affect the flow of stormwater within any portion of the easement. Also, maintenance, including mowing of vegetation within the easement may be required, as approved by the appropriate governing authority.

J. When it can be shown that, due to topographic conditions, natural drainageways on the site cannot adequately provide for drainage, open channels may be constructed conforming substantially to the line and grade of such natural drainageways. Work within natural drainage ways shall be subject to approval by PADEP under regulations at 25 PA Code Chapter 105 through the Joint Permit Application process, or, where deemed appropriate by PADEP, through the General Permit process.

K. Any stormwater management facilities or any facilities that constitute water obstructions (e.g., culverts, bridges, outfalls, or stream enclosures, etc.) that are regulated by this Ordinance, that will be located in or adjacent to Waters of the Commonwealth (including wetlands), shall be subject to approval by PADEP under regulations at 25 PA Code Chapter 105 through the Joint Permit Application process, or, where deemed appropriate by PADEP, the General Permit process. When there is a question whether wetlands may be involved, it is the responsibility of the Applicant or his agent to show that the land in question cannot be classified as wetlands; otherwise, approval to work in the area must be obtained from PADEP.

L. Should any stormwater management facility require a dam safety permit under PADEP Chapter 105, the facility shall be designed in accordance with Chapter 105 and meet the regulations of Chapter 105 concerning dam safety.

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M. Any stormwater management facilities regulated by this Ordinance that will be located on, or discharged onto State highway rights-of-ways shall be subject to approval by the Pennsylvania Department of Transportation (PENNDOT).

N. Minimization of impervious surfaces and infiltration of runoff through seepage beds, infiltration trenches, etc., are encouraged, where soil conditions and geology permit, to reduce the size or eliminate the need for detention facilities.

O. Infiltration BMPs should be dispersed throughout the site, made as shallow as practicable, and located to maximize use of natural on-site infiltration features while still meeting the other requirements of this Ordinance.

P. The design of facilities over karst shall include an evaluation and implementation of measures to minimize adverse effects.

Q. Roof drains shall not be connected to streets, sanitary or storm sewers, or roadside ditches in order to promote overland flow and infiltration/percolation of stormwater where it is advantageous to do so. When it is more advantageous to connect directly to streets or storm sewers, then the Municipality shall permit it on a case-by-case basis.

R. Applicants are encouraged to use Low Impact Development Practices to comply with the requirements of this Ordinance and the State Water Quality Requirements.

S. When stormwater management facilities are proposed within 1,000 feet of a downstream Municipality, the SWM Plan shall be submitted to the downstream Municipal's Engineer for review and comment.

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Section 302. Exemptions/Modifications

A. Under no circumstance shall the Applicant be exempt from implementing such measures as necessary to:

1. Meet State Water Quality Standards and Requirements.
2. Protect health, safety, and property.
3. Meet special requirements for High Quality (HQ) and Exceptional Value (EV) watersheds.

B. The Applicant must demonstrate that the following BMPs are being utilized to the maximum extent practicable to receive consideration for the exemptions:

1. Design around and limit disturbance of Floodplains, Wetlands, Natural Slopes over 15%, existing native vegetation, and other sensitive and special value features.
2. Maintain riparian and forested buffers.
3. Limit grading and maintain non-erosive flow conditions in natural flow paths.
4. Maintain existing tree canopies near impervious areas.
5. Minimize soil disturbance and reclaim disturbed areas with topsoil and vegetation.
6. Direct runoff to pervious areas.

C. The Applicant must demonstrate that the proposed development/additional impervious area will not adversely impact the following:

1. Capacities of existing drainageways and storm sewer systems.
2. Velocities and erosion.
3. Quality of runoff if direct discharge is proposed.

4. Existing known problem areas.
5. Safe conveyance of the additional runoff.
6. Downstream property owners.

D. An Applicant proposing Regulated Activities, after demonstrating compliance with Sections 302.A, 302.B, and 302.C, may be exempted from various requirements of this Ordinance according to the following table:

New Impervious Area[1, 2] (square feet)	**Applicant Must Provide**
Less than 5,000	---
Greater than or Equal to 5,000	Rate Controls, Volume Controls & SWM Site Plan[3]

NOTES:
[1] New Impervious Area since the date of Adoption of this Ordinance.
[2] Gravel in existing condition shall be considered pervious and gravel in proposed condition shall be considered impervious.
[3] The Small Project Stormwater Management Application included in Appendix E may be used for single family residential projects over 5,000 sf of new impervious surface. The Small Project SWM Application allows documentation of new impervious surface, credits through disconnection of impervious surfaces and tree planting, and sizing of Volume Control BMP's that may be required.

E. Single Family Residential activities with more than 5,000 square feet of impervious surface are exempt from these requirements provided the construction:
1. Comply with Sections 302.A, 302.B, and 302.C, and
2. Have completed, submitted, and received municipal approval for the Small Projects SWM Application. **[Please refer to Appendix E of this Ordinance]**
3. Have buildings setback 75 feet from downstream property lines, and
4. Driveways:
   a. Runoff must discharge onto pervious surface with a gravel strip or other spreading device.
   b. No more than 1,000 square feet of paved surface may discharge to any one point.
   c. The length of flow on the pervious must exceed the length of the paved surface flow.

F. An Applicant proposing Regulated Activities, after demonstrating compliance with Sections 302.A, 302.B, and 302.C, may be exempted from various requirements of this Ordinance if documentation can be provided that a downstream man-made water body (i.e., reservoir, lake, or man-made wetlands) has been designed or modified to address the potential stormwater flooding impacts of the proposed development.

G. The purpose this section is to ensure consistency of stormwater management planning between local ordinances and NPDES permitting (when required) and to ensure that the Applicant has a single and clear set of stormwater management standards to which the Applicant is subject. The Municipality may accept alternative stormwater management controls under this section provided that:

1. The Municipality, in consultation with the PADEP (or Delegated Authority), determines that meeting the Volume Control requirements (See Section 304) is not possible or places an undue hardship on the Applicant.
2. The alternative controls are documented to be acceptable to PADEP (or Delegated Authority), for NPDES requirements pertaining to post construction stormwater management requirements.

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3. The alternative controls are in compliance with all other sections of this ordinance, including but not limited to Sections 301.D and 302.A-C.

H. Agricultural activities are exempt from requirements of this Ordinance provided the activities are performed according to the requirements of 25 PA Code Chapter 102.

I. Forest management and timber operations are exempt from the Rate and Volume Control requirement and SWM Site Plan preparation requirement of this Ordinance provided the activities are performed according to the requirements of 25 PA Code Chapter 102. It should be noted that temporary roadways are not exempt.

Section 303. Waivers

A. The provisions of this Ordinance are the minimum standards for the protection of the public welfare.

B. All waiver requests must meet the provisions of Section 303.G. and H. Waivers shall not be issued from any of the following:

1. Meeting State Water Quality Standards and Requirements;
2. Protecting health, safety, and property; or,
3. Meeting special requirements for High Quality (HQ) and Exceptional Value (EV) watersheds.

The Municipality will consider waiver requests in accordance with Section 301.D. Waiver requests from provisions Sections 701.B and 701.C will be processed by the Municipality at its sole discretion.

[**OPTIONAL:** The review and evaluation of the waiver request shall be made by the Municipal Engineer]

C. If an Applicant demonstrates to the satisfaction of the governing body of the Municipality that any mandatory provision of this Ordinance is unreasonable or causes unique or undue unreasonableness or hardship as it applies to the proposed Project, or that an alternate design may result in a superior result within the context of Section 102 and 103 of this Ordinance, the governing body of the Municipality upon obtaining the comments and recommendations of the Municipal Engineer and Conservation District may grant a waiver or relief so that substantial justice may be done and the public interest is secured; provided that such waiver will not have the effect of nullifying the intent and purpose of this Ordinance.

D. The Applicant shall submit all requests for waivers in writing and shall include such requests as a part of the plan review and approval process. The Applicant shall state in full the facts of unreasonableness or hardship on which the request is based, the provision or provisions of the Ordinance that are involved, and the minimum waiver or relief that is necessary. The Applicant shall state how the requested waiver and how the Applicant's proposal shall result in an equal or better means of complying with the intent or Purpose and general principles of this Ordinance.

E. The Municipality shall keep a written record of all actions on waiver requests.

F. The Municipality may charge a fee for each waiver request, which shall be used to offset the administrative costs of reviewing the waiver request. The Applicant shall also agree to reimburse the Municipality for reasonable and necessary fees that may be incurred by the Municipal Engineer in any review of a waiver request.

G. In granting waivers, the Municipality may impose reasonable conditions at will, in its judgment, secure substantially the objectives of the standards or requirements that are to be modified.

H. The Municipality may grant applications for waivers when the following findings are made, as relevant:

1. That the waiver shall result in an equal or better means of complying with the intent of this Ordinance.
2. That the waiver is the minimum necessary to provide relief.
3. That the applicant is not requesting a waiver based on cost considerations.
4. That existing down gradient stormwater problems will not be exacerbated.
5. That runoff is not being diverted to a different drainage area.
6. That increased flooding or ponding on off-site properties or roadways will not occur.
7. That potential icing conditions will not occur.
8. That increase of peak flow or volume from the site will not occur.
9. That erosive conditions due to increased peak flows or volume will not occur.
10. That adverse impact to water quality will not result.
11. That increased 100-Year Floodplain levels will not result.
12. That increased or unusual municipal maintenance expenses will not result from the waiver.
13. That the amount of stormwater generated has been minimized to the greatest extent allowed.
14. That infiltration of runoff throughout the proposed site has been provided where practicable and pre-development ground water recharge protected.
15. That peak flow attenuation of runoff has been provided.
16. That long term operation and maintenance activities are established.
17. That the receiving streams and/or water bodies will not be adversely impacted in flood carrying capacity, aquatic habitat, channel stability and erosion and sedimentation.

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Section 304. Volume Controls

A. The Low Impact Development Practices provided in the BMP Manual and in Appendix B of this Ordinance shall be utilized for all Regulated Activities to the maximum extent practicable.

B. Stormwater runoff Volume Controls shall be implemented using the *Design Storm Method* or the *Simplified Method* as defined below. For Regulated Activity areas equal or less than one (1) acre that do not require hydrologic routing to design the stormwater facilities, this Ordinance establishes no preference for either method; therefore, the Applicant may select either method on the basis of economic considerations, the intrinsic limitations on applicability of the analytical procedures associated with each methodology, and other factors.

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

   a. Do not increase the post-development total runoff volume when compared to the pre-development total runoff volume for the 2-year/24-hour storm event.

   b. For hydrologic modeling purposes:

      i. Existing non-forested pervious areas must be considered meadow (good condition) for pre-development hydrologic calculations.

ii. Twenty (20) percent of existing impervious area, when present within the proposed project site, shall be considered meadow (good condition) for pre-development hydrologic calculations for re-development.

2. The *Simplified Method* (CG-2 in the BMP Manual) 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 1 acre or for projects that require detailed design of stormwater storage facilities. For new impervious surfaces:

   a. Stormwater facilities shall capture at least the first 2 inches of runoff from all new impervious surfaces.

   b. At least the first 1 inch of runoff from new impervious surfaces shall be permanently removed from the runoff flow, i.e. it shall not be released into surface Waters of the 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 0.5 inch of the permanently removed runoff should be infiltrated.

   d. Actual field infiltration tests at the location of the proposed elevation of the stormwater BMPs are required. Infiltration test shall be conducted in accordance with the BMP Manual. Notification of the Municipality shall be provided to allow witnessing of the testing.

3. In cases where it is not possible or desirable to use infiltration-based best management practices to partially fulfill the requirements in either Section 304.B.1 or 304.B.2, the following procedure shall be used:

   a. At a minimum, the following documentation shall be provided to justify the decision to not use infiltration BMPs:
      i. Description of and justification for field infiltration/permeability testing with respect to the type of test and test locations).
      ii. An interpretive narrative describing existing site soils and their structure as these relate to the interaction between soils and water occurring on the site. In addition to providing soil and soil profile descriptions, this narrative shall identify depth to seasonal high water tables and depth to bedrock, and provide a description of all subsurface elements (fragipans and other restrictive layers, geology, etc.) that influence the direction and rate of subsurface water movement.
      iii. A qualitative assessment of the site's contribution to annual aquifer recharge shall be made, along with identification of any restrictions or limitations associated with the use of engineered infiltration facilities.
      iv. The provided documentation must be signed and sealed by a professional engineer or geologist.

   b. 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

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c. The performance criteria for water quality best management practices shall be determined from the Pennsylvania Stormwater Best Management Practices Manual, most current version.

C. The applicable Worksheets from the BMP Manual must be used in calculations to establish Volume Control.

Section 305. Rate Controls

A. For all lands within Mifflin County, the Post-development discharge rates shall not exceed the pre-development discharge rates for the 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year storms.

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Section 306. Sensitive Areas and Stormwater Hotspots

A. Sensitive areas and stormwater hotspots as defined below which require special consideration with regard to stormwater management.

1. Sensitive areas are defined as those areas that, if developed, have the potential to endanger a water supply. These areas consist of the delineated 1-year zone of contribution and direct upslope areas tributary to the water supply wells. Municipalities may update the sensitive area boundaries based on new research or studies as required.
2. Stormwater hotspots are defined as a land development project that has a high potential to endanger local water quality, and could potentially threaten ground water reservoirs. The Municipal Engineer will determine what constitutes these classifications on a case-by-case basis. The PADEP wellhead protection contaminant source list shall be used as a guide in these determinations. Industrial manufacturing site and hazardous material storage areas must provide NPDES SIC codes. Industrial sites referenced in 40 CFR 125 are also examples of hotspots.

B. Performance Standards

1. The location of the boundaries of sensitive areas is set by drainage areas tributary to any public water supply. The exact location of these boundaries as they apply to a given development site, shall be determined using mapping at a scale which accurately defines the limits of the sensitive area. If the project site is within the sensitive area (in whole or in part), 2-foot contour interval mapping shall be provided to define the limits of the sensitive area. If the project site is adjacent to but within 500 linear feet of a defined Sensitive Area, a 5-foot contour interval map defining the limits of the Sensitive Area shall be included in the Stormwater Management Plan to document the site's location relative to the sensitive area.
2. Stormwater hotspots may be required to prepare and implement a stormwater pollution prevention plan and file notice of intent as required under the provision of the EPA Industrial Stormwater NPDES Permit Requirements.
3. Stormwater hotspots must use an acceptable pre-treatment BMP prior to volume control and/or rate control BMPs. Acceptable pre-treatment BMPs for these developments include those based on filtering, settling, or chemical reaction processes such as coagulation which remove the expected pollutant.
4. Stormwater hotspots and development in sensitive areas must include Riparian Buffers as defined in Article VI.

ARTICLE IV - E&S STANDARDS [OPTIONAL]

The following E&S Standards are recommended to reinforce the importance of BMP's during the construction process. As E&S Standards regulated through PA DEP and Conservation Districts as well as required through other municipal ordinances, this Article may be redundant.

Section 401. Erosion and Sedimentation Requirements During Earth Disturbance Activities

A. The applicant shall meet requirements as contained in 25 PA Code, Chapters 92 and 102 as required and applicable as follows:

   1. The implementation and maintenance of erosion and sediment control BMPs.
   2. Development of written plans.
   3. Submission of plans for approval.
   4. Obtaining Erosion and Sediment Control and NPDES permits.
   5. Maintaining plans and permits on site.

B. Evidence of any necessary plan or permit approval for Earth Disturbance activities from PADEP or the Mifflin County Conservation District must be provided to the Municipality.

C. A copy of the approved Erosion and Sediment Control Plan and any other permit, as required by PADEP or the Mifflin County Conservation District, shall be available at the project site at all times if required under Chapter 102.

D. Construction of temporary roadways (e.g., for utility construction, timber harvesting, etc.) shall comply with all applicable standards for erosion and sedimentation control and stream crossing regulations under 25 PA Code, Chapters 102 and 105. The Erosion and Sedimentation Control Plan shall be submitted to the Mifflin County Conservation District for approval and shall address the following, as applicable:

   1. Design of the roadway system, including haul roads, skid roads, landing areas, trails, and storage and staging areas.
   2. Runoff control structures (e.g., diversions, culverts, detention ponds, etc.).
   3. Stream crossings for both perennial and intermittent streams.
   4. Access to public roadways, including design of rock construction entrance for mud and debris control.
   5. A remediation plan for restoring the disturbed area through re-grading, topsoil placement, reseeding, and other stabilization techniques, as required.

E. Additional erosion and sedimentation control design standards and criteria that must be applied where infiltration BMPs are proposed include the following:

   1. Areas proposed for infiltration BMPs shall be protected from sedimentation and compaction during the construction phase, as to maintain their maximum infiltration capacity.
   2. Infiltration BMPs shall be protected from receiving sediment-laden runoff.
   3. The source of protection for infiltration BMPs shall be identified (i.e. orange construction fence surrounding the perimeter of the BMP).

ARTICLE V – PROTECTED WATERSHED STANDARDS

Section 501. Protected Watershed Requirements

A. For any Regulated Activity within a protected watershed (High Quality or Exceptional Value), the applicant shall meet requirements as contained in 25 PA Code, Chapters 93 as required and applicable.

B. Existing Resources and Site Analysis Plan. Shall be prepared to provide the developer and the Municipality with a comprehensive analysis of existing conditions, both on the proposed development site and within 500 feet of the site. Conditions beyond the parcel boundaries may be described on the basis of existing published data available from governmental agencies and from aerial photographs. The Municipality shall review the plan to assess its accuracy, conformance with Municipal ordinances, and likely impact upon the natural and cultural resources on the property. The following information shall be required:

1. Complete current perimeter boundary survey of the property to be subdivided or developed prepared by a registered surveyor, showing all courses, distances, and area and tie-ins to all adjacent intersections.

2. A vertical aerial photograph enlarged to a scale not less detailed than one inch equals 400 feet, with the site boundaries clearly marked.

3. Natural features, including:
   a. Contour lines at intervals of not more than two feet. (Ten-foot intervals are permissible beyond the parcel boundaries, interpolated from USGS published maps.) Contour lines shall be based on information derived from a topographic survey for the property, evidence of which shall be submitted, including the date and source of the contours. Datum to which contour elevations refer and references to known, established benchmarks and elevations shall be included on the plan.
   b. Steep slopes in the following ranges: 15% to 25%, 25% and greater. The location of these slopes shall be graphically depicted by category on the plan. Slope shall be measured over three or more two-foot contour intervals.
   c. Areas within the floodway, flood fringe, and approximated floodplain.
   d. Watercourses, either continuous or intermittent and named or unnamed, and lakes, ponds or other water features as depicted on the USGS Quadrangle Map, most current edition.
   e. Wetlands and wetland margins.
   f. Riparian buffers.
   g. Soil types and their boundaries, as mapped by the USDA Natural Resource Conservation Service, including a table listing the soil characteristics pertaining to suitability for construction and, in unsewered areas, for septic suitability. Alluvial and hydric soils shall specifically be depicted on the plan.
   h. Existing vegetation, denoted by type, including woodlands, hedgerows, tree masses, tree lines, individual freestanding trees over six inches DBH, wetland vegetation, pasture or croplands, orchards, permanent grass land, old fields, and any other notable vegetative features on the site. Vegetative types shall be described by plant community, relative age, and condition.
   i. Any identified Pennsylvania Natural Diversity Inventory (PNDI) site conflicts.
   j. Geologic formations on the tract, including rock outcroppings, cliffs, sinkholes, and fault lines, based on available published information or more detailed data obtained by the applicant.

4. Existing man-made features, including:

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a. Location, dimensions, and use of existing buildings and driveways.
b. Location, names, widths, center line courses, paving widths, identification numbers, and rights-of-way, of existing streets and alleys.
c. Location of trails that have been in public use (pedestrian, equestrian, bicycle, etc.).
d. Location and size of existing sanitary sewage facilities.
e. Location and size of drainage facilities.
f. Location of water supply facilities, including wellhead protection areas.
g. Any easements, deed restrictions, rights-of-way, or any other encumbrances upon the land, including location, size, and ownership.
h. Site features or conditions such as hazardous waste, dumps, underground tanks, active and abandoned wells, quarries, landfills, sandmounds, and artificial land conditions.

5. Total acreage of the tract, the adjusted tract area, where applicable, and the constrained land area with detailed supporting calculations.

C. Stormwater Management System Concept Plan. A written and graphic concept plan of the proposed post-development stormwater management system shall be prepared and include:
1. Preliminary selection and location of proposed structural stormwater controls;
2. Location of existing and proposed conveyance systems such as grass channels, swales, and storm drains;
3. Location of floodplain/floodway limits;
4. Relationship of site to upstream and downstream properties and drainages.
5. Preliminary location of proposed stream channel modifications, such as bridge or culvert crossings.

D. Consultation Meeting Prior to any stormwater management permit application submission, the land owner or developer shall meet with the Municipality for a consultation meeting on a concept plan for the post-development stormwater management system to be utilized in the proposed project. This consultation meeting shall take place at the time of the preliminary plan or other early step in the development process. The purpose of this meeting is to discuss the post-development stormwater management measures necessary for the proposed project, as well as to discuss and assess constraints, opportunities and potential ideas for stormwater management designs before the formal site design engineering is commenced.

E. All proposed Regulated Activities within a protected watershed shall utilize, to the maximum extent possible, Low Impact Development Practices as contained in Appendix B.

1. SWM Plan and Report shall address the following:
   a. Design using nonstructural BMPs
      i. Lot configuration and clustering.
         (a) Reduced individual lot impacts by concentrated/clustered uses and lots
         (b) Lots/development configured to avoid critical natural areas
         (c) Lots/development configured to take advantage of effective mitigative stormwater practices
         (d) Lots/development configured to fit natural topography

      ii. Minimum disturbance
         (a) Define disturbance zones (excavation/grading) for the site and individual lots to protect maximum total site area from disturbance

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(b) Barriers/flagging proposed to protect designated non-disturbance areas
(c) Considered mitigative practices for minimal disturbance areas (e.g., Soil Restoration)
(d) Considered re-forestation and re-vegetation opportunities

iii. Reduce Impervious coverage
(a) Reduced road width
(b) Reduced driveway lengths and widths
(c) Reduced parking ratios and sizes
(d) Utilized porous surfaces for applicable features

iv. Stormwater disconnected from impervious area
(a) Disconnected drives/walkways/small impervious areas to natural areas
(b) Use rain barrels and/or cisterns for lot irrigation

b. Apply structural BMP selection process that meets runoff quantity and quality needs.
(a) Manage close to source with collection with conveyance minimized
(b) Consistent with site factors (e.g., soils, slope, available space, amount of sensitive areas, pollutant removal needs)
(c) Minimize footprint and integrate into already disturbed areas/other building program components (e.g., recharge beneath parking areas, vegetated roofs)
(d) Consider other benefits such as aesthetic, habitat, recreational and educational benefits
(e) BMP's select based on maintenance needs that fit owner/users
(f) BMP's sustainable using a long-term maintenance plan

ARTICLE VI – RIPARIAN BUFFER STANDARDS

Riparian Buffer Standards are recommended to reduce land use impact on water resource with effective control of non-point source pollutants such as sediment and nutrients. Riparian buffers also enhance the environment by mitigating temperature and light; increasing habitat diversity; stabilizing channel morphology; and protecting floodplains and its flow capacity.

Specifically, riparian buffer standards will help address identified Stream Impairments within Mifflin County.

It should be noted that the requirements as modified below are less stringent than those included in the recently proposed statewide statewide erosion and sediment pollution control regulations (The Pennsylvania Code, Title 25, Chapter 102). The proposed standards in the Chapter 102 changes contain different zones and are 150' for HQ & EV watersheds. The changes are expected to occur in late summer 2010.

Section 601. Riparian Buffer Requirements

Riparian Buffers are required for Regulated Activity other than one single family residence and shall be established as follows:

A. The buffer shall be measured perpendicularly from the top of the stream bank landward.
   1. A minimum of 50 feet; or,
   2. As determined by a stream corridor study approved by PADEP and the Municipality.

B. The riparian buffer shall be located on both sides of all perennial and intermittent streams. The perennial and intermittent streams and the riparian buffer boundaries shall be shown on all applications for Building Permits, subdivision, or land development. Existing uses within the buffer are permitted to continue but not be expanded. Placement of new structures or roadways within the riparian buffer shall be prohibited. Where a wetland exists within the buffer area, the buffer shall be extended landward to provide a minimum buffer of 25 feet, as measured perpendicularly from the wetland boundary.

C. The buffer shall be undisturbed forest consisting of appropriate native species.

D. Where wetlands are located partially or entirely within a buffer, the buffer shall be extended to encompass the wetland and shall be widened by a distance sufficient to provide a 25 foot forested buffer measured perpendicularly from the wetland boundary.

E. The following uses shall be permitted in the buffer:

   1. Footpaths, trails and bike paths provided that:
      a. Width is limited to 5 feet;
      b. Width may be increased provided a corresponding increase in the buffer is provided;
      c. Construction shall have minimal impact to the buffer.
   2. Stream crossings, provided the crossing is designed and constructed in such a manner as to minimize the impact to the buffer. The Riparian Buffer shall be restored to its original condition, to the maximum extent practical, upon completion of construction.
   3. Utility lines, provided that the crossing is designed and constructed in such a manner as to minimize the impact to the inner buffer and provided that there is no practical alternative to locating the utility line within the buffer. The Riparian Buffer shall be restored to its original condition, to the maximum extent practical, upon completion of construction.
   4. Maintenance and restoration of the Riparian Buffer.

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5. Projects conducted with the objective of improvement, stabilization, restoration, or enhancement of the stream bank, stream channel, floodplain, watershed hydrology, riparian buffers, or aquatic habitat and maintenance activities associated with such projects. These projects include, but are not limited to agricultural and stormwater management best management practices. Such projects must receive appropriate permits and approvals from PADEP prior to starting the project.
6. Minor private recreational uses for the property owner. Such uses include benches, fire rings, and similar uses. Such uses do not include structures such as cabins, sheds, pavilions, garages, dwellings or similar structures.

F. Disturbance of the Riparian Buffer shall be limited to the area necessary to perform an allowable use.

G. Where possible and practical, disturbances shall be phased with each phase restored prior to beginning the next phase.

H. Allowable activities shall not cause stormwater flow to concentrate.

I. Any vegetation removed for an allowable activity shall be replaced immediately upon completion of the activity. Where mature trees are removed, such trees shall be replaced with the largest practical tree of acceptable native species.

J. Erosion and sediment pollution control shall be installed and maintained during construction. Evidence of an approved Erosion and Sediment Control Plan and/or NPDES Permit, if required, shall be submitted prior to issuance of local permits.

K. If a permit from PADEP is required for the activity, evidence of an approved permit shall be submitted prior to issuance of local permits.

L. Riparian buffers shall be maintained in a manner consistent with sound forest management practices. In the absence of a site specific management plan, the following maintenance guidelines apply:

1. Buffers shall be inspected periodically for evidence of excessive sediment deposition, erosion or concentrated flow channels. Prompt action shall be taken to correct these problems and prevent future occurrence.
2. Trees presenting an unusual hazard of creating downstream obstructions shall be removed. Such material shall be removed from the floodplain or the riparian buffer (whichever is widest); or cut into sections small enough so as to prevent the possibility of creating obstructions downstream. Wherever possible, large stable debris should be conserved.
3. Vegetation should be inspected periodically to ensure diverse vegetative cover and vigorous plant growth consistent with buffering objectives.
    a. Invasive plant species that may threaten the integrity of the buffer shall be removed.
    b. Periodic cutting of trees may be necessary to promote vigorous growth and encourage regeneration.
4. Excessive use of fertilizers, pesticides, herbicides, and other chemicals shall be avoided. These products should be used only when absolutely necessary to maintain buffer vegetation.

Section 602. Riparian Buffer Easement

For all Riparian Buffers, an easement shall be provided:

A. Easements shall be in accordance with Section 901 and recorded in accordance with Section 1403 of this Ordinance.

Section 701. Design Criteria for Stormwater Management & Drainage Facilities

A. General Design Guidelines:

1. Stormwater shall not be transferred from one watershed to another, unless (1) the watersheds are sub-watersheds of a common watershed which join together within the perimeter of the property; (2) the effect of the transfer does not alter the peak rate discharge onto adjacent lands; or (3) easements from the affected landowner(s) are provided.

2. Consideration shall be given to the relationship of the subject property to the drainage pattern of the watershed. A concentrated discharge of stormwater to an adjacent property shall be within an existing watercourse or confined in an easement or returned to a pre-development flow type condition.

3. Low Impact Design Stormwater BMPs and recharge facilities are encouraged (e.g., rooftop storage, drywells, cisterns, recreation area ponding, diversion structures, porous pavements, holding tanks, infiltration systems, in-line storage in storm sewers, and grading patterns). They shall be located, designed, and constructed in accordance with the latest technical guidance published by PADEP, provided they are accompanied by detailed engineering plans and performance capabilities and supporting site specific soils, geology, runoff and groundwater and infiltration rate data to verify proposed designs. Additional guidance from other sources may be accepted at the discretion of the Municipal Engineer (a pre-application meeting is suggested).

4. All existing and natural watercourses, channels, drainage systems and areas of surface water concentration shall be maintained in their existing condition unless an alteration is approved by the appropriate regulatory agency.

5. The design of all stormwater management facilities shall incorporate sound engineering principles and practices. The Municipality shall reserve the right to disapprove any design that would result in the continuation or exacerbation of a documented adverse hydrologic or hydraulic condition within the watershed, as identified in the Plan.

6. The design and construction of multiple use stormwater detention facilities are strongly encouraged. In addition to stormwater management, facilities should, where appropriate, allow for recreational uses including ball fields, play areas, picnic grounds, etc. Consultation with the Municipality, and prior approval are required before design. Provision for permanent wet ponds with stormwater management capabilities may also be appropriate.

    a. Multiple use basins should be constructed so that potentially dangerous conditions are not created.
    b. Water quality basins or recharge basins that are designed for a slow release of water or other extended detention ponds are not permitted for recreational uses, unless the ponded areas are clearly separated and secure.

7. Should any stormwater management facility require a dam safety permit under PADEP Chapter 105, the facility shall be designed in accordance with Chapter 105 and meet the regulations of Chapter 105 concerning dam safety.

B. Stormwater Management Facility Design Considerations: All stormwater management facilities shall meet the following design requirements:

1. No outlet structure from a stormwater management facility, or swale, shall discharge directly onto a Municipal or State roadway.

2. The top, or toe, of any slope shall be located a minimum of 10 feet from any property line.

3. The minimum horizontal distance between any structure and any stormwater facility shall be 25 feet. The lowest floor elevation of any structure constructed immediately adjacent to a detention basin or other stormwater facility shall be a minimum of 2 feet above the 100-year water surface elevation.

4. Stormwater management facility bottom (or surface of permanent pool) elevations must be greater than adjacent floodplain elevations (FEMA or HEC-RAS analysis). If no floodplain is defined, bottom elevations must be greater than existing ground elevations 50 feet from top of stream bank in the facilities' vicinity.

5. Basin outflow culverts discharging into floodplains must account for tailwater. Tailwater corresponding to the 100-year floodplain elevation must be used for all design storms, or the Applicant may elect to determine flood elevations of the adjacent watercourse for each design storm. The floodplain is assumed to be 50 feet from top of stream bank in areas where a floodplain is not designated, or no other evidence is provided.

6. The invert of all stormwater management facilities and underground infiltration/storage facilities shall be located a minimum of 2 feet above the seasonal high groundwater table. The invert of stormwater facilities may be lowered if adequate sub-surface drainage is provided.

7. Whenever possible the side slopes and basin shape shall be amenable to the natural topography. Vertical side slopes and rectangular basins shall be avoided whenever possible.

8. Exterior slopes of compacted soil shall not exceed 3:1, and may be further reduced if the soil has unstable characteristics.

9. Interior slopes of the basin shall not exceed 3:1.

10. Unless specifically designed as a volume control facility, all stormwater management facilities shall have a minimum slope of 1% extending radially out from the principal outlet structure. Facilities designed as water quality / infiltration BMPs may have a bottom slope of zero.

11. Impervious low-flow channels are not permitted within stormwater management facilities.

12. Unless specifically designed as a Volume Control or water quality facility, all stormwater management facilities must empty over a period of time not less than 24 hours and not more than 72 hours from the end of the facility's inflow hydrograph. Infiltration tests performed at the facility locations and proposed basin bottom depths, in accordance with the BMP Manual, must support time-to-empty calculations if infiltration is a factor.

13. Energy dissipators and/or level spreaders shall be installed at points where pipes or drainageways discharge to or from basins. Discharges to drainage swales shall be dissipated, or piped, to an acceptable point.

14. Landscaping and planting specifications must be provided for all stormwater management basins and be specific for each type of basin.

    a. Minimal maintenance, saturation tolerant vegetation must be provided in basins designed as water quality / infiltration BMPs.

15. A safety fence may be required, at the discretion of the Municipality, for any stormwater management facility. The fence shall be a minimum of 4 feet high, and of a material acceptable to the Municipality. A gate with a minimum opening of 10 feet shall be provided for maintenance access.

16. <u>Karst:</u> The following apply to all stormwater management facilities located within karst topography:
    a. No stormwater facilities shall be placed in, over or immediately adjacent to the following features:
        i. Sinkholes
        ii. Closed depressions
        iii. Lineaments in carbonate areas
        iv. Fracture traces
        v. Caverns
        vi. Intermittent Streams
        vii. Ephemeral streams
    b. The minimum isolation distance from stormwater management basins to the listed geologic features shall be as follows:
        i. 100 feet from the rim of sinkholes or closed depressions;
        ii. 100 feet from disappearing streams;
        iii. 50 feet from lineaments or fracture traces; or
        iv. Recommendations by a professional geologist.
    c. Stormwater runoff from any regulated activities shall not be discharged into sinkholes unless approved by the Municipal Engineer.

17. <u>Principal Outlet Structures</u>: The primary outlet structure shall be designed to pass all 24-hour design storms (up to and including the 100-year event) without discharging through the emergency spillway. All principal outlet structures shall:
    a. Be constructed of reinforced concrete or an alternative material approved by the Municipal Engineer. When approved for use, all metal risers shall:
        i. Be suitably coated to prevent corrosion.
        ii. Have a concrete base attached with a watertight connection. The base shall be sufficient weight to prevent flotation of the riser.
        iii. Provide a trash rack or similar appurtenance to prevent debris from entering the riser.
        iv. Provide an anti-vortex device, consisting of a thin vertical plate normal to the basin berm.
    b. Provide trash racks to prevent clogging of primary outflow structure stages for all orifices equivalent to 12 inches or smaller in diameter.
    c. Provide outlet aprons and shall extend to the toe of the basin slope at a minimum.

18. <u>Emergency Spillways</u>: Any stormwater management facility designed to store runoff shall provide an emergency spillway designed to convey the 100-year post-

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development peak rate flow with a blocked primary outlet structure. The emergency spillway shall be designed per the following requirements:

a. The top of embankment elevation shall provide a minimum 1 foot of freeboard above the maximum water surface elevation. This is to be calculated when the spillway functions for the 100-year post-development inflow, with a blocked outlet structure.
b. Avoid locating on fill areas, whenever possible.
c. The spillway shall be armored to prevent erosion during the 100-year post-development flow, with a blocked primary outlet structure.
    i. Synthetic liners or riprap may be used, and calculations sufficient to support proposed armor must be provided. An earthen plug must be used to accurately control the spillway invert if riprap is the proposed armoring material. Emergency spillway armor must extend up the sides of the spillway, and continue at full width to a minimum of 10 feet past the toe of slope.
d. Municipal Engineer may require the use of additional protection when slopes exceed 4:1 and spillway velocities might exceed NRCS standards for the particular soils involved.
e. Any underground stormwater management facility (pipe storage systems) must have a method to bypass flows higher than the required design (up to a 100-year post-development inflow) without structural failure, or causing downstream harm or safety risks.

19. Stormwater Management Basins: Design of stormwater management facilities having 3 feet or more of water depth (measured vertically from the lowest elevation in the facility to the crest of the emergency spillway) shall meet the following additional requirements:

    a. The maximum water depth within any stormwater management facility shall be no greater than 8 feet when functioning through the primary outlet structure.
    b. The top of embankment width shall be at least 10 feet.
    c. A 10 foot wide access to the basin bottom must be provided with a maximum longitudinal slope of 10%.
    d. Berms shall be constructed using soils that conform to the unified soil classification of CH, MH, CL or ML. The embankments will be constructed in a maximum of 6 inch lifts. The lifts will each be compacted to a density of 98% of a standard proctor analysis as per each layer of compacted fill shall be tested to determine its density analysis per ASTM 698. Each layer of compacted fill shall be tested to determine its density per ASTM 2922 or ASTM 3017.
    e. A cutoff and key trench of impervious material shall be provided under all embankments 4 feet or greater in height. The cutoff trench shall run the entire length of the embankment and tie into undisturbed natural ground.
    f. Anti-seep collars, or a PADEP approved alternative, must be provided on all outflow culverts in accordance with the methodology contained in the latest edition of the PADEP E&S Manual. An increase in seepage length of 15 percent must be used in accordance with the requirements for permanent anti-seep collars.

20. Construction of Stormwater Management Facilities:

    a. Basins used for rate control only shall be installed prior to or concurrent with any earthmoving or land disturbances, which they will serve. The phasing of their construction shall be noted in the narrative and on the plan.

b. Basins that include water quality or recharge components shall have those components installed in such a manner as to not disturb or diminish their effectiveness.
c. Compaction test reports shall be kept on file at the site and be subject to review at all times with copies being forwarded to the Municipal Engineer upon request.
d. Temporary and permanent grasses or stabilization measures shall be established on the sides and base of all earthen basins within 15 days of construction.

21. Exceptions to these requirements may be made at the discretion of the Municipality for BMPs that retain or detain water, but are of a much smaller scale than traditional stormwater management facilities.

C. Stormwater Carrying Facilities:

1. All storm sewer pipes, grass waterways, open channels, swales and other stormwater carrying facilities that service drainage areas within the site must be able to convey post-development runoff from the 10-year design storm.

2. Stormwater management facilities that convey off-site water through the site shall be designed to convey the 25-year storm event (or larger events, as determined by the Municipal Engineer).

3. All developments shall include provisions that allow for the overland conveyance and flow of the post-development 100-year storm event without damage to public or private property.

4. Storm Sewers:

a. Storm sewers must be able to convey post-development runoff without surcharging inlets for the 10-year storm event.

b. When connecting to an existing storm sewer system, the Applicant must demonstrate that the proposed system will not exacerbate any existing stormwater problems and that adequate downstream capacity exists.

c. Inlets, manholes, pipes, and culverts shall be constructed in accordance with the specifications set forth in PENNDOT's Publication 408, and as detailed in the PENNDOT's Publication 72M - Standards for Roadway Construction (RC) or other detail approved by the Municipal Engineer. All material and construction details (inlets, manholes, pipe trenches, etc.), must be shown on the SWM Site Plan, and a note added that all construction must be in accordance with PENNDOT's Publication 408 and PENNDOT's Publication 72M, latest edition. A note shall be added to the plan stating that all frames, concrete top units, and grade adjustment rings shall be set in a bed of full mortar according to Publication 408.
d. A minimum pipe size of fifteen (15) inches in diameter shall be used in all roadway systems (public or private) proposed for construction in the Municipality. Pipes shall be designed to provide a minimum velocity of 2½ feet per second when flowing full, but in all cases, the slope shall be no less then 0.5%. Arch pipe of equivalent cross-sectional area may be substituted in lieu of circular pipe where cover or utility conflict conditions exist.

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e. All storm sewer pipes shall be laid to a minimum depth of 1 foot from subgrade to the crown of pipe.

f. In curbed roadway sections, the maximum encroachment of water on the roadway pavement shall not exceed half of a through travel lane or one (1) inch less than the depth of curb during the ten (10) year design storm of five (5) minute duration. Gutter depth shall be verified by inlet capture/capacity calculations that account for road slope and opening area.

   i. Inlets shall be placed at a maximum of 600 feet apart.
   ii. Inlets shall be placed so drainage cannot cross intersections or street centerlines.

g. Standard Type "C" inlets with 8 inch hoods shall be used along curbed roadway networks. Type "C" inlets with 10 inch hoods that provide a 2 inch sump condition may be used with approval of the Municipal Engineer when roadway longitudinal slopes are 1.0% or less.

h. For inlets containing a change in pipe size, the elevation for the crown of the pipes shall be the same or the smaller pipe's crown shall be at a higher elevation.

i. All inlets shall provide a minimum 2 inch drop between the lowest inlet pipe invert elevation and the outlet pipe invert elevation.

j. On curbed sections, a double inlet shall be placed at the low point of sag vertical curves, or an inlet shall be placed on each side of the low point at a distance not to exceed 100 feet, or at an elevation not to exceed 0.2 feet above the low point.

k. At all roadway low points, swales and easements shall be provided behind the curb or swale and through adjacent properties to channelize and direct any overflow of stormwater runoff away from dwellings and structures.

l. All inlets in paved areas shall have heavy duty bicycle safe grating. A note to this effect shall be added to the SWM Site Plan or inlet details therein.

m. Inlets must be sized to accept the specified pipe sizes without knocking out any of the inlet corners. All pipes entering or exiting inlets shall be cut flush with the inside wall of the inlet. A note to this effect shall be added to the SWM Site Plan or inlet details therein.

n. Inlets shall have weep holes covered with geotextile fabric placed at appropriate elevations to completely drain the sub grade prior to placing the base and surface course on roadways.

o. Inlets, junction boxes, or manholes greater then five (5) feet in depth shall be equipped with ladder rungs and shall be detailed on the SWM Site Plan.

p. Inlets shall not have a sump condition in the bottom (unless designed as a water quality BMP). Pipe shall be flush with the bottom of the box or concrete channels shall be poured.

q. Accessible drainage structures shall be located on continuous storm sewer system at all vertical dislocations, at all locations where a transition in storm sewer pipe sizing is required, at all vertical and horizontal angle points exceeding 5 degrees, and at all points of convergence of 2 or more storm sewer pipes.

r. All storm drainage piping shall be provided with either reinforced concrete headwalls or end sections compatible with the pipe size involved at its entrance and discharge.

s. Outlet protection and energy dissipaters shall be provided at all surface discharge points in order to minimize erosion consistent with the E&S Manual.

    i. Flow velocities and volumes from any storm sewer shall not result in a degradation of the receiving channel.

t. Stormwater roof drains and pipes shall not be connected to storm sewers or discharge onto impervious areas without approval by the Municipal Engineer.

5. Swale Conveyance Facilities:
    a. Swales must be able to convey post-development runoff from a 10-year design storm with 6 inches of freeboard to top of the swale.

    b. Swales shall have side slopes no steeper than 3:1.

    c. All swales shall be designed, labeled on the SWM Site Plan, and details provided to adequately construct and maintain the design dimension of the swales.

    d. Swales shall be designed for stability using velocity or shear criteria. Velocity criteria may be used for channels with less than 10% slope. Shear criteria may be used for all swales. Documentation must be provided to support velocity and/or shear limitations used in calculations.

    e. Where swale bends occur, the computed velocities or shear stresses shall be multiplied by the following factor for the purpose of designing swale erosion protection:

        i. 1.75 – When swale bend is 30 to 60 degrees
        ii. 2.00 – When swale bend is 60 to 90 degrees
        iii. 2.50 – When swale bend is 90 degrees or greater

    f. Manning's "n" values used for swale capacity design must reflect the permanent condition.

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Section 702. Calculation Methodology

A. All calculations shall be consistent with the guidelines set forth in the BMP Manual, as amended herein.

B. Stormwater runoff from all development sites shall be calculated using either the Rational Method or the NRCS Rainfall-Runoff Methodology. Methods shall be selected by the design professional based on the individual limitations and suitability of each method for a particular site.

C. Rainfall Values:

1. Rational Method – The Pennsylvania Department of Transportation Drainage Manual, Intensity-Duration-Frequency Curves, Publication 584, Chapter 7A, latest edition, shall be used in conjunction with the appropriate time of concentration and return period.

2. NRCS Rainfall-Runoff Method – The Soil Conservation Service Type II, 24-hour rainfall distribution shall be used in conjunction with rainfall depths from NOAA Atlas 14 or be consistent with the following table:

Return Interval (Year)	24-hour Rainfall Total (inches)
1	2.36
2	2.83
10	4.10
25	4.95
50	5.68
100	6.49

D. Runoff Volume:

1. Rational Method – Not to be used to calculate runoff volume.

2. NRCS Rainfall-Runoff Method – This method shall be used to estimate the change in volume due to Regulated Activities. Combining Curve Numbers for land areas proposed for development with Curve Numbers for areas unaffected by the proposed development into a single weighted curve number is NOT acceptable.

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E. Peak Flow Rates:

1. Rational Method – This method may be used for design of conveyance facilities only. Extreme caution should be used by the design professional if the watershed has more then one main drainage channel, if the watershed is divided so that hydrologic properties are significantly different in one versus the other, if the time of concentration exceeds 60 minutes, or if stormwater runoff volume is an important factor. The combination of Rational Method hydrographs based on timing shall be prohibited.

2. NRCS Rainfall-Runoff Method – This method is recommended for design of stormwater management facilities and where stormwater runoff volume must be taken into consideration. The following provides guidance on the model applicability:

   a. NRCS's TR-55 – limited to 100 acres in size
   b. NRCS's TR-20 or HEC-HMS – no size limitations
   c. Other models as pre-approved by the Municipal Engineer

   The NRCS antecedent runoff condition II (ARC II, previously AMC II) must be used for all simulations. The use of continuous simulation models that vary the ARC are not permitted for stormwater management purposes.

3. For comparison of peak flow rates, flows shall be rounded to a tenth of a cubic foot per second (cfs).

F. Runoff Coefficients:

1. Rational Method – Use Table C-1 (Appendix C).
2. NRCS Rainfall-Runoff Method – Use Table C-2 (Appendix C). Curve Numbers (CN) should be rounded to tenths for use in hydrologic models as they are a design tool with statistical variability. For large sites, CN's should realistically be rounded to the nearest whole number.
3. For the purposes of pre-development peak flow rate and volume determination, existing non-forested pervious areas conditions shall be considered as meadow (good condition).
4. For the purposes of pre-development peak flow rate and volume determination, 20 percent of existing impervious area, when present, shall be considered meadow (good condition).

G. Design Storm:

1. All stormwater management facilities shall be verified by routing the proposed 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year hydrographs through the facility using the storage indication method or modified puls method. The 24-hour design storm hydrograph shall be computed using a calculation method that produces a full hydrograph.
2. The stormwater management and drainage system shall be designed to safely convey the post development 100-year storm event to stormwater detention facilities, for the purpose of meeting peak rate control.
3. All structures (culvert or bridges) proposed to convey runoff under a Municipal road shall be designed to pass the 50-year design storm with a minimum 1 foot of freeboard measured below the lowest point along the top of the roadway.

H. Time of Concentration:

1. The Time of Concentration is to represent the average condition that best reflects the hydrologic response of the area. The following Time of Concentration (T_c) computational methodologies shall be used unless another method is pre-approved by the Municipal Engineer:

   a. Pre-development – NRCS's Lag Equation:

   Time of Concentration = T_c = [(T_{lag}/.6) * 60] (minutes)

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

   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 = NRCS Curve Number for watershed

   b. Post-development; commercial, industrial, or other areas with large impervious areas (>20% impervious area) – NRCS Segmental Method. The length of sheet flow shall be limited to 100 feet. T_c for channel and pipe flow shall be computed using Manning's equation.
   c. Post-development; residential, cluster, or other low impact designs less than or equal to 20% impervious area – NRCS Lag Equation or NRCS Segmental Method.

2. Additionally, the following provisions shall apply to calculations for Time of Concentration:

   a. The post-development T_c shall never be greater that the pre-development T_c for any watershed or sub-watershed. This includes when the designer has specifically used swales to reduce flow velocities. In the event that the designer believes that the post-development T_c is greater, it will still be set by default equal to the pre-development T_c for modeling purposes.

   b. The minimum T_c for any watershed shall be 5 minutes.

   c. The designer may choose to assume a 5 minute T_c for any post development watershed or subwatershed without providing any computations.

   d. The designer must provide computations for all pre-development T_c paths. A 5 minute T_c can not be assumed for pre-development.

   e. Undetained fringe areas (areas that are not tributary to a stormwater facility but where a reasonable effort has been made to convey runoff from all new impervious coverage to best management practices) may be assumed to represent the pre-development conditions for purpose of T_c calculation.

I. Drainage areas tributary to sinkholes or closed depressions in areas underlain by limestone or carbonate geologic features shall be excluded from the modeled point of analysis defining pre-development flows. If left undisturbed during construction activities, areas draining to closed depressions may also be used to reduce peak runoff rates in the post-development analysis. New, additional contributing runoff should not be directed to existing sinkholes or closed depressions.

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J. Where uniform flow is anticipated, the Manning's equation shall be used for hydraulic computations and to determine the capacity of open channels, pipes, and storm sewers. The Manning's equation should not be used for analysis of pipes under pressure flow or for analysis of culverts. Manning's "n" values shall be obtained from PENNDOT's Drainage Manual, Publication 584. Inlet control shall be checked at all inlet boxes to ensure the headwater depth during the 10-year design event is contained below the top of grate for each inlet box.

K. The Municipality may approve the use of any generally accepted full hydrograph approximation technique that shall use a total runoff volume that is consistent with the volume from a method that produces a full hydrograph.

L. The Municipality has the authority to require that computed existing runoff rates be reconciled with field observations, conditions and site history. If the designer can substantiate, through actual physical calibration, that more appropriate runoff and time of concentration values should be utilized at a particular site, then appropriate variations may be made upon review and recommendation of the Municipality.

Section 703. Downstream Hydraulic Capacity Analysis

A. Any downstream or off-site hydraulic capacity analysis conducted in accordance with this Ordinance shall use the following criteria for determining adequacy:

   1. Natural or man-made channels or swales must be able to convey the post-development runoff associated with a 10-year return period event within their banks at velocities consistent with protection of the channels from erosion. Acceptable velocities

shall be based upon criteria included in the PA*DEP Erosion and Sediment Pollution Control Program Manual*.

2. Natural or man-made channels or swales must be able to convey the post-development 25-year return period runoff without creating any hazard to persons or property.
3. Culverts, bridges, storm sewers or any other facilities which must pass or convey flows from the tributary area must be designed in accordance with *PADEP, Chapter 105* regulations (if applicable) and, at a minimum, pass the post-development 25-year return period runoff.
4. It must be demonstrated that the downstream conveyance channel, other stormwater facilities, roadways, or overland areas must be capable of safely conveying the 100-year design storm without causing additional damage to buildings or other infrastructure.
5. Where the downstream conveyance channel or other facility is located within a special flood hazard area (as documented on the Flood Insurance Rate Map), it must be demonstrated that the limits of said flood hazard area are not increased by the proposed activity.

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ARTICLE VIII - SWM SITE PLAN & REPORT REQUIREMENTS

Section 801. General Requirements

For any of the activities regulated by this Ordinance and not eligible for the exemptions provided in Section 302, the final approval of subdivision and/or land development plans, the issuance of any building or occupancy permit, or the commencement of any land disturbance activity, may not proceed until the Applicant has received written approval of a SWM Site Plan from the Municipality.

Section 802. SWM Site Plan & Report Contents

The SWM Site Plan & SWM Site Report shall consist of all applicable calculations, maps, and plans. All SWM Site Plan materials shall be submitted to the Municipality in a format that is clear, concise, legible, neat and well organized; otherwise, the SWM Site Plan shall be rejected.

Appropriate sections from the Municipal Subdivision and Land Development Ordinance, and other applicable local ordinances, shall be followed in preparing the SWM Site Plan.

A. SWM Site Plan shall include, but not be limited to:

1. Plans shall be of one size and in a form that meets the requirements for recording in the Office of the Recorder of Deeds of Mifflin County.
    a. Plans for tracts of less than 20 acres shall be drawn at a scale of one inch equals no more than 50 ft.;
    b. Plans for tracts of 20 acres or more, plans shall be drawn at a scale of one inch equals no more than 100 ft;
    c. All lettering shall be drawn to a size to be legible if the plans are reduced to half size.

2. The name of the development; name and location address of the property site; name, address, and telephone number of the Applicant/Owner of the property; and name, address, telephone number, email address, and engineering seal of the individual preparing the SWM Site Plan.

3. The date of submission and dates of all revisions.

4. A graphical and written scale on all drawings and maps.

5. A north arrow on all drawings and maps.

6. A location map at a minimum scale of one (1) inch equals one-thousand (1,000) feet and illustrates the project relative to highways, municipalities or other identifiable landmarks.

7. Metes and bounds description of the entire tract perimeter.

8. Existing and final contours at intervals:

    a. Slopes less than 5%: no greater than one (1) foot;
    b. Slopes between 5 and 15%: no greater than two (2) feet;
    c. Steep slopes (greater than 15%), 5-foot contour intervals may be used.

9. Perimeters of existing waterbodies within the project area including stream banks, lakes, ponds, springs, field delineated wetlands or other bodies of water, sinkholes, flood

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hazard boundaries (FEMA delineated floodplains and floodways), areas of natural vegetation to be preserved, the total extent of the upstream area draining through the site, and overland drainage paths. In Addition, any areas necessary to determine downstream impacts, where required for proposed stormwater management facilities must be shown.

10. The location of all existing and proposed man-made features including utilities, on-lot wastewater facilities, water supply wells, sanitary sewers, and water lines on and within fifty (50) feet of property lines including inlets, manholes, valves, meters, poles, chambers, junction boxes, and other utility system components.

11. A key map showing all existing man-made features beyond the property boundary that may be affected by the project.

12. Soil names and boundaries with identification of the Hydraulic Soil Group classification including rock outcroppings.

13. Proposed impervious surfaces (structures, roads, paved areas, and buildings), including plans and profiles of roads and paved areas and floor elevations of buildings.

14. Existing and proposed land use(s).

15. Horizontal alignment, vertical profiles, and cross sections of all open channels, pipes, swales and other BMPs.

16. The location and clear identification of the nature of permanent stormwater BMPs.

17. The location of all erosion and sedimentation control facilities, shown on a separate from the SWM Site Plan (typically an E&S Plan).

18. A minimum twenty (20) foot wide access easement around all stormwater management facilities that would provide ingress to and egress from a public right-of-way. In lieu of providing an easement to the public right-of-way, a note may be added to the plan granting the Municipality or their designees access to all easements via the nearest public right-of-way.

19. Construction details for all drainage and stormwater BMPs.

20. Identification of short-term and long-term ownership, operations, and maintenance responsibilities.

21. Notes and Statements:

    a. A statement, signed by the landowner, acknowledging that the stormwater BMPs are fixtures that cannot be altered or removed without prior approval by the Municipality.
    b. A statement referencing the Operation and Maintenance (O&M) Agreement and stating that the O&M Agreement is part of the SWM Site Plan.
    c. A note indicating that Record Drawings will be provided for all stormwater facilities prior to occupancy, or the release of the surety bond.
    d. The following signature block for the registered professional preparing the Stormwater Management Plan:

"I, ___________________________, hereby certify that the Stormwater Management Plan meets all design standards and criteria of the ***[Municipality's]*** Stormwater Management Ordinance."

e. The following signature block for the Municipal Engineer reviewing the Stormwater Management Plan:

"I, _____________________________, have reviewed this Stormwater Management Plan in accordance with the Design Standards and Criteria of the ***[Municipality's]*** Stormwater Management Ordinance."

B. SWM Site Report shall include (but not limited to):

1. General data including:
   a. Project Name
   b. Project location - address of the property site
   c. Name, address, and telephone number of the Applicant/Owner of the property;
   d. Name, address, telephone number, email address, and engineering seal of the individual preparing the SWM Site Report;
   e. Date of submission and revisions.

2. Project description narrative that clearly discusses the project and provides the following information:
   a. Narrative
      - Statement of the regulated activity describing what is being proposed. Overall stormwater management concept with description of permanent stormwater management techniques, including construction specifications and materials to be used for stormwater management facilities.
      - Expected project schedule
      - Location map showing the project site and its location relative to release rate districts.
      - Detailed description of the existing site conditions including a site evaluation completed for projects proposed in areas of carbonate geology or karst topography, and other environmentally sensitive areas such as brownfields.
      - Total site area – pre and post, which must be equal or have an explanation as to why it is not
      - Total site impervious area
      - Total off-site areas
      - Number and description of stormwater management facilities
      - Type of development
      - Pre-development land use
      - Whether site is a water quality sensitive (WQS) development
      - Whether site is in a defined sensitive area
      - Types of water quality and recharge systems used, if applicable
      - Complete hydrologic, hydraulic, and structural computations for all stormwater management facilities.
      - A written maintenance plan for all stormwater features including detention facilities and other stormwater management elements.
      - Identification of ownership and maintenance responsibility for all permanent stormwater management facilities.
      - Other pertinent information, as required

   b. Summary Tables

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- Pre-development Hydrologic soil group (HSG) assumptions, curve numbers (CN), Computation of average slope, hydraulic length, computed time of concentration
- Existing conditions runoff volume & peak rate of runoff
- Post-development runoff volume & peak rate of runoff
- Undetained areas, areas to ponds
- Land use for each subarea
- Hydrologic soil group (HSG) assumptions, curve numbers (CN)
- Time of concentration computed for each subarea
- Post-development peak rate of runoff routed to ponds and out
- Pond maximum return period design data including: maximum water surface elevation, berm elevation, and emergency spillway elevation
- Water quality depth and volume requirements

c. Calculations
- Complete hydrologic, hydraulic and structural computations, calculations, assumptions, and criteria for the design of all stormwater BMPs.
- Details of the berm embankment and outlet structure indicating the embankment top elevation, embankment side slopes, top width of embankment, emergency spillway elevation, perforated riser dimensions, pipe barrel dimensions and dimensions and spacing of antiseep collars.
- Design computations for the control structures (pipe barrel and riser, etc).
- A plot or table of the stage-storage (volume vs. elevation) and all supporting computations.
- Routing computations.

d. Drawings
- Drainage area maps for all watersheds and inlets depicting the time of concentration path for both existing conditions and post developed condition.
- All stormwater management facilities must be located on a plan and described in detail including easements and buffers boundaries.

3. Reports that do not clearly indicate the above information may be rejected for review by the Municipal and will be returned to the applicant.

4. Description of, justification, and actual field results for infiltration testing with respect to the type of test and test location for the design of infiltration BMPs.

5. The effect of the project (in terms of runoff volumes, water quality, and peak flows) on surrounding properties and aquatic features and on any existing municipal stormwater collection system that may receive runoff from the project site.

6. Description of the proposed changes to the land surface and vegetative cover including the type and amount of impervious area to be added.

7. Identification of short-term and long-term ownership, operation, and maintenance responsibilities as well as schedules and costs for inspection and maintenance activities for each permanent stormwater or drainage BMP, including provisions for permanent access or maintenance easements.

C. Supplemental information to be provided prior to recording of the SWM Site Plan, as applicable:

1. Signed and executed Operations and Maintenance Agreement (Appendix A).
2. Signed and executed easements, as required for all on-site and off-site work.
3. An Erosion and Sedimentation Control Plan & approval letter from the Mifflin County Conservation District.
4. A NPDES Permit.
5. Permits from PADEP and ACOE.
6. Geologic Assessment.
7. Soils investigation report, including boring logs, compaction requirements, and recommendations for construction of detention basins.
8. A Highway Occupancy Permit from PENNDOT when utilization of a PENNDOT storm drainage system is proposed or when proposed facilities would encroach onto a PENNDOT right-of-way.

Section 803. SWM Site Plan & Report Submission

A. The Applicant shall submit the SWM Site Plan & Report for the Regulated Activity.

B. Five (5) copies of the SWM Site Plan & Report shall be submitted and be distributed as follows:

1. Two (2) copies to the Municipality accompanied by the requisite executed Review Fee Reimbursement Agreement, as specified in this Ordinance
2. One (1) copy to the Municipal Engineer
3. One (1) copy to the Mifflin County Planning Commission
4. One (1) copy to the Mifflin County Conservation District **[OPTIONAL; DEPENDENT ON COUNTY CONSERVATION DISTRICT]**

C. Additional copies shall be submitted as requested by the Municipality or PADEP.

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Section 804. SWM Site Plan & Report Review

A. The Municipality shall require receipt of a complete SWM Site Plan & Report as specified in this Ordinance. The Municipality shall review the SWM Site Plan & Report for consistency with the purposes, requirements, and intent of this Ordinance.

B. The Municipality shall not approve any SWM Site Plan & Report that is deficient in meeting the requirements of this Ordinance. At its sole discretion and in accordance with this Article, when a SWM Site Plan & Report is found to be deficient, the Municipality may disapprove the submission and require a resubmission, or in the case of minor deficiencies, the Municipality may accept submission of modifications.

C. The Municipality shall notify the Applicant in writing within forty-five (45) calendar days whether the SWM Site Plan & Report is approved or disapproved if the SWM Site Plan & Report is not part of a Subdivision or Land Development Plan. If the SWM Site Plan & Report involves a Subdivision or Land Development Plan, the timing shall following the Subdivision and Land Development process according to the Municipalities Planning Code.

D. The Municipal Building Permit Office shall not issue a building permit for any Regulated Activity if the SWM Site Plan & Report has been found to be inconsistent with this Ordinance, as determined by the Municipality. All required permits from PADEP must be obtained prior to issuance of a building permit.

Section 805. Modification of Plans

A. A modification to a submitted SWM Site Plan & Report for a development site that involves a change in stormwater management facilities or techniques, or that involves the relocation or re-design of stormwater management facilities, or that is necessary because soil or other conditions are not as stated on the SWM Site Plan as determined by the Municipality, shall require a resubmission of the modified SWM Site Plan in accordance with this Ordinance.

Section 806. Resubmission of Disapproved SWM Site Plan & Report

A. A disapproved SWM Site Plan & Report may be resubmitted with the revisions addressing the Municipality's concerns documented in writing, to the Municipality in accordance with this Ordinance. The applicable Municipal Review Fee must accompany a resubmission of a disapproved SWM Site Plan & Report.

Section 807. Authorization to Construct and Term of Validity

A. The Municipality's approval of a SWM Site Plan & Report authorizes the Regulated Activities contained in the SWM Site Plan for a maximum term of validity of five (5) years following the date of approval. The Municipality may specify a term of validity shorter than five (5) years in the approval for any specific SWM Site Plan. Terms of validity shall commence on the date the Municipality signs the approval for a SWM Site Plan. If stormwater management facilities included in the approved SWM Site Plan have not been constructed, or if an Record Drawing of these facilities has not been approved within this time, then the Municipality may consider the SWM Site Plan disapproved and may revoke any and all permits or approvals.

Section 808. Record Drawings, Completion Certificate and Final Inspection

A. The Applicant shall be responsible for providing Record Drawings of all stormwater BMPs included in the approved SWM Site Plan. The Record Drawing and an explanation of any discrepancies with the approved SWM Site Plan shall be submitted to the Municipality as a prerequisite for the release of the guarantee or issuance of an occupancy permit.

B. The Record Drawing shall include a certification of completion signed by a Qualified Professional verifying that all permanent stormwater BMPs have been constructed according to the approved SWM Site Plan & Report.
   1. Drawings shall show all approved revisions and elevations and inverts to all manholes, inlets, pipes, and stormwater control facilities.

C. After receipt of the Record Drawing and certification of completion by the Municipality, the Municipality may conduct a final inspection.

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ARTICLE IX - EASEMENTS

Section 901. Easements

A. Easements shall be established to accommodate the existence of drainageways.

B. Where a tract is traversed by a watercourse, drainage-way, channel or stream, there shall be provided an easement paralleling the line of such watercourse, drainage-way, channel or stream with a width adequate to preserve the unimpeded flow of natural drainage in the 100-year floodplain.

C. Easements shall be established for all on-site stormwater management or drainage facilities, including but not limited to: detention facilitates (above or below ground), infiltration facilities, all stormwater BMPs, drainage swales, and drainage facilities (inlets, manholes, pipes, etc.).

D. Easements are required for all areas used for off-site stormwater control.

E. All easements shall be a minimum of 20 feet wide and shall encompass the 100-year surface elevation of the proposed stormwater facility.

F. Easements shall provide ingress to, and egress from, a public right-of-way. In lieu of providing an easement to the public right-of-way, a note may be added to the plan granting the Municipality or their designees access to all easements via the nearest public right-of-way able for vehicle ingress and egress on grades of less than 10% for carrying out inspection or maintenance activities.

G. Where possible, easements shall be centered on side and/or rear lot lines.

H. Nothing shall be planted or placed within the easement which would adversely affect the function of the easement, or conflict with any conditions associated with such easement.

I. All easement agreements shall be recorded with a reference to the recorded easement indicated on the site plan. The format and content of the easement agreement shall be reviewed and approved by the Municipal Engineer and Solicitor.

ARTICLE X - MAINTENANCE RESPONSIBILITIES

Section 1001. Financial Guarantee

A. The Applicant shall provide a Financial Guarantee to the Municipality for the timely installation and proper construction of all stormwater management controls as required by the approved SWM Site Plan and this Ordinance, equal to 110% of the full construction cost of the required controls in accordance with the Municipalities Planning Code.

B. At the completion of the project and as a prerequisite for the release of the Financial Guarantee, the Applicant shall:

1. Provide a certification of completion from an engineer, architect, surveyor or other qualified person, verifying that all permanent facilities have been constructed according to the SWM Site Plan & Report and approved revisions thereto.
2. Provide a set of Record Drawings.
3. Request a final inspection from the Municipality to certify compliance with this Ordinance, after receipt of the certification of completion and Record Drawings by the Municipality.

Section 1002. Maintenance Responsibilities

A. The SWM Site Plan & Report for the project site shall describe the future operation and maintenance responsibilities. The operation and maintenance description shall outline required routine maintenance actions and schedules necessary to ensure proper operation of the stormwater control facilities.

B. The SWM Site Plan & Report for the project site shall establish responsibilities for the continuing operating and maintenance of all proposed stormwater control facilities, consistent with the following principals:

1. If a development consists of structures or lots that are to be separately owned and in which streets, sewers, and other public improvements are to be dedicated to the Municipality, stormwater control facilities/BMPs may also be dedicated to and maintained by the Municipality.
2. If a development site is to be maintained in a single ownership or if sewers and other public improvements are to be privately owned and maintained, then the ownership and maintenance of stormwater control facilities/BMPs shall be the responsibility of the owner or private management entity.
3. Facilities, areas, or structures used as stormwater BMPs shall be enumerated as permanent real estate appurtenances and recorded as deed restrictions or easements that run with the land.
4. The SWM Site Plan & Report shall be recorded as a restrictive deed covenant that runs with the land.
5. The Municipality may take enforcement actions against an Applicant for failure to satisfy any provision of this Ordinance.

C. The Municipality, upon recommendation of the Municipal Engineer, shall make the final determination on the continuing maintenance responsibilities prior to final approval of the SWM Site Plan & Report. The Municipality may require a dedication of such facilities as part of the requirements for approval of the SWM Site Plan. Such a requirement is not an indication that the Municipality will accept the facilities. The Municipality reserves the right to accept or reject the ownership and operating responsibility for any portion of the stormwater management controls.

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D. If the Municipality accepts ownership of stormwater BMPs, the Municipality may, at its discretion, require a fee from the Applicant to the Municipality to offset the future cost of inspections, operations, and maintenance.

E. It shall be unlawful to alter or remove any permanent stormwater BMP required by an approved SWM Site Plan, or to allow the property to remain in a condition, which does not conform to an approved SWM Site Plan, unless the Municipality grants an exception in writing.

Section 1003. Maintenance Agreement for Privately Owned Stormwater Facilities

A. Prior to final approval of the SWM Site Plan & Report, the Applicant shall sign the Operation and Maintenance (O&M) Agreement (Appendix A) covering all stormwater control facilities that are to be privately owned. The Operation and Maintenance (O&M) Agreement shall be recorded with the SWM Site Plan and made a part hereto.

B. Other items may be included in the Operation and Maintenance (O&M) Agreement where determined necessary to guarantee the satisfactory operation and maintenance of all BMP facilities. The Operation and Maintenance (O&M) Agreement shall be subject to the review and approval of the Municipality and the Municipal Solicitor.

C. The owner is responsible for operation and maintenance of the stormwater BMPs. If the owner fails to adhere to the Operation and Maintenance (O&M) Agreement, the Municipality may perform the services required and charge the owner appropriate fees. Non-payment of fees may result in a lien against the property.

ARTICLE XI - INSPECTIONS

Section 1101. Schedule of Inspections

A. PADEP or its designees normally ensure compliance with any permits issued, including those for stormwater management. In addition to PADEP compliance programs, the Municipality or their municipal assignee may inspect all phases of the installation of temporary or permanent stormwater management facilities.

B. During any stage of Earth Disturbance Activities, if the Municipality determines that the stormwater management facilities are not being installed in accordance with the approved SWM Site Plan, the Municipality shall revoke any existing permits or approvals until a revised SWM Site Plan is submitted and approved as specified in this Ordinance.

C. Stormwater BMPs shall be inspected by the landowner, or the landowner's designee according to the inspection schedule described on the SWM Site Plan for each BMP.

1. The Municipality may require copies of the inspection reports, in a form as stipulated by the Municipality.

2. If such inspections are not conducted or inspection reports not submitted as scheduled, the Municipality, or their designee, may conduct such inspections and charge the owner appropriate fees. Non-payment of fees may result in a lien against the property.
   a. Prior to conducting such inspections, the Municipality shall inform the owner of its intent to conduct such inspections. The owner shall be given thirty (30) days to conduct required inspections and submit the required inspection reports to the Municipality.

Section 1102. Right-of-Entry

A. Upon presentation of proper credentials, duly authorized representatives of the Municipality may enter at reasonable times, upon any property within the Municipality, to inspect the implementation, condition, or operations and maintenance of the stormwater BMPs in regard to any aspect governed by this Ordinance.

B. Stormwater BMP owners and operators shall allow persons working on behalf of the Municipality ready access to all parts of the premises for the purposes of determining compliance with this Ordinance.

C. Persons working on behalf of the Municipality shall have the right to temporarily locate on any stormwater BMP in the Municipality such devices, as are necessary, to conduct monitoring and/or sampling of the discharges from such stormwater BMP.

D. Unreasonable delay in allowing the Municipality access to a stormwater BMP is a violation of this Ordinance.

ARTICLE XII - ENFORCEMENT AND PENALTIES

Section 1201. Notification

A. In the event that a person fails to comply with the requirements of this Ordinance, an approved SWM Site Plan, or fails to conform to the requirements of any permit or approval issued hereunder, the Municipality shall provide written notification of the violation. Such notification shall set forth the nature of the violation(s) and establish a time limit for correction of these violation(s).

B. Failure to comply within the time specified shall subject such person to the Penalties Provisions of this Ordinance. All such penalties shall be deemed cumulative and shall not prevent the Municipality from pursuing any and all other remedies. It shall be the responsibility of the owner of the real property on which any Regulated Activity is proposed to occur, is occurring, or has occurred, to comply with the terms and conditions of this Ordinance.

Section 1202. Enforcement

A. The municipal governing body is hereby authorized and directed to enforce all of the provisions of this Ordinance. The approved SWM Site Plan shall be on file at the project site throughout the duration of the construction activity. The Municipality or their designee may make periodic inspections during construction.

B. Adherence to Approved SWM Site Plan

   1. It shall be unlawful for any person, firm, or corporation to undertake any Regulated Activity on any property except as provided for by an approved SWM Site Plan and pursuant to the requirements of this Ordinance.

   2. It shall be unlawful to alter or remove any control structure required by the SWM Site Plan pursuant to this Ordinance.

   3. It shall be unlawful to allow a property to remain in a condition that does not conform to an approved SWM Site Plan.

Section 1203. Public Nuisance

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

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

Section 1204. Suspension and Revocation

A. Any approval or permit issued by the Municipality may be suspended or revoked for:

   1. Non-compliance with or failure to implement any provision of the approved SWM Site Plan or Operation & Maintenance (O&M) Agreement.
   2. A violation of any provision of this Ordinance or any other applicable law, Ordinance, rule or regulation relating to the Regulated Activity.
   3. The creation of any condition or the commission of any act, during the Regulated Activity which constitutes or creates a hazard or nuisance, pollution, or which endangers the life or property of others.

B. A suspended approval or permit may be reinstated by the Municipality when:

1. The Municipality or their designee has inspected and approved the corrections to the violation(s) that caused the suspension.
2. The Municipality is satisfied that the violation(s) has been corrected.

C. An approval that has been revoked by the Municipality cannot be reinstated. The Applicant may apply for a new approval under the provisions of this Ordinance.

Section 1205. Penalties

[Municipalities should ask their solicitors to provide appropriate wording for this section.]

A. Anyone violating the provisions of this Ordinance shall be guilty of a summary offense and upon conviction, shall be subject to a fine of not more than $ ____ for each violation, recoverable with costs. Each day that the violation continues shall be a separate offense and penalties shall be cumulative.

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

Section 1206. Appeals

A. Any person aggrieved by any action of the Municipality or its designee, relevant to the provisions of this Ordinance, may appeal to the Municipality within thirty (30) days of that action.

B. Any person aggrieved by any decision of the Municipality, relevant to the provisions of this Ordinance, may appeal to the Mifflin County Court of Common Pleas within thirty (30) days of the Municipality's decision.

ARTICLE XIII - PROHIBITIONS

Section 1301. Prohibited Discharges and Connections

A. Any drain (including indoor drains and sinks), or conveyance whether on the surface or underground, that allows any non-stormwater discharge including sewage, process wastewater, and wash water to enter the Municipality's separate storm sewer system or Waters of the Commonwealth is prohibited.

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

C. No person shall allow, or cause to allow, discharges into the Municipality's separate storm sewer system or into surface Waters of the Commonwealth, which are not composed entirely of stormwater, except: (1) as provided in subsection 1301.D below, and (2) discharges allowed under a state or federal permit.

D. The following discharges are authorized unless they are determined to be significant contributors to pollution to the Waters of the Commonwealth:

-Discharges from fire fighting activities
-Potable water sources including dechlorinated water and fire hydrant flushings
-Air conditioning condensate
-Springs
-Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spill material has been removed) and where detergents are not used
-Water from crawl space pumps
-Flows from riparian habitats and wetlands
-Uncontaminated water from foundations or from footing drains
-Irrigation or Lawn watering
-Dechlorinated swimming pool discharges
-Water from individual residential car washing
-Routine external building washdown (which does not use detergents or other compounds)

E. In the event that the Municipality or PADEP determines that any of the discharges identified in subsection 1301.D is a significant contributor to pollution to the Waters of the Commonwealth, the responsible person(s) shall be notified to cease the discharge. Upon notice provided by the Municipality or PADEP, the discharger will have a reasonable time, as determined by the Municipality or PADEP, to cease the discharge, consistent with the degree of pollution caused by the discharge.

F. Nothing in this Section shall affect a discharger's responsibilities under Commonwealth Law.

Section 1302. Roof Drains

A. Roof drains and sump pumps shall discharge to infiltration areas, vegetative BMPs, or pervious areas to the maximum extent practicable.

Section 1303. Alteration of BMPs

A. No person shall modify, remove, fill, landscape, or alter any existing stormwater BMP, facilities, areas, or structures unless it is part of an approved maintenance program, without the written approval of the Municipality.

B. No person shall place any structure, fill, landscaping, or vegetation into a stormwater BMP, facilities, areas, structures, or within a drainage easement which would limit or alter the functioning of the BMP without the written approval of the Municipality.

FINAL

ARTICLE XIV - FEES AND EXPENSES

Section 1401. General

A. The fee required by this Ordinance is the Municipal Review Fee. The Municipal Review Fee shall be established by the Municipality to defray review costs incurred by the Municipality and the Municipal Engineer. The Applicant shall pay all fees.

Section 1402. Expenses Covered by Fees

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

1. Administrative and Clerical Costs.
2. Review of the SWM Site Plan & Report by the Municipality.
3. Pre-construction meetings.
4. Inspection of stormwater management facilities/BMPs and drainage improvements during construction.
5. Final inspection upon completion of the stormwater management facilities/BMPs and drainage improvements presented in the SWM Site Plan.
6. Any additional work required to enforce any permit provisions regulated by this Ordinance, correct violations, and assure proper completion of stipulated remedial actions.

Section 1403. Recording of Approved SWM Site Plan and Related Agreements

A. The owner of any land upon which permanent BMPs will be placed, constructed, or implemented, as described in the SWM Site Plan, shall record the following documents in the Office of the Recorder of Deeds of Mifflin County, within (__) days of approval of the SWM Site Plan by the Municipality:

1. The SWM Site Plan.
2. Operations and Maintenance (O&M) Agreement (Appendix A).
3. Easements under Section 901.
4. Riparian buffers under Section 602.

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

FINAL

(ORDINANCE NAME)

(ORDINANCE NUMBER)

ENACTED and ORDAINED at a regular meeting of the

____

on this ________ day of ___________________, 20_______.

This Ordinance shall take effect immediately.

(Name)	(Title)

(Name)	(Title)

(Name)	(Title)

ATTEST:

____
Secretary

I hereby certify that the foregoing Ordinance was advertised in the [name of newspaper] on [date], a newspaper of general circulation in the Municipality and was duly enacted and approved as set forth at a regular meeting of the [name of municipal governing body] held on [date].

____
Secretary

FINAL

APPENDIX A - OPERATION AND MAINTENANCE AGREEMENT

FINAL

OPERATION AND MAINTENANCE (O&M) AGREEMENT
STORMWATER MANAGEMENT BEST MANAGEMENT PRACTICES (SWM BMPs)

THIS AGREEMENT, made and entered into this ___________ day of ________, 20___, by and between __________________________________, (hereinafter the "Landowner"), and ____________________________, Mifflin County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

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

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

WHEREAS, the SWM Site Plan approved by the Municipality (hereinafter referred to as the "Plan") for the property identified herein, which is attached hereto as Appendix A and made part hereof, as approved by the Municipality, provides for management of stormwater within the confines of the Property through the use of BMPs; and

WHEREAS, the Municipality, and the Landowner, his successors and assigns, agree that the health, safety, and welfare of the residents of the Municipality and the protection and maintenance of water quality require that on-site SWM BMPs be constructed and maintained on the Property; and

WHEREAS, the Municipality requires, through the implementation of the SWM Site Plan, that stormwater BMPs as required by said Plan and the Municipal Stormwater Management Ordinance be constructed and adequately operated and maintained by the Landowner, successors and assigns.

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

1. The Landowner shall construct the BMPs in accordance with the plans and specifications identified in the SWM Site Plan.
2. The Landowner shall operate and maintain the BMPs as shown on the Plan in good working order in accordance with the specific maintenance requirements noted on the approved SWM Site Plan.
3. The Landowner hereby grants permission to the Municipality, its authorized agents, and employees, to enter upon the property, at reasonable times and upon presentation of proper credentials, to inspect the BMPs whenever necessary. Whenever possible, the Municipality shall notify the Landowner prior to entering the property.
4. In the event the Landowner fails to operate and maintain the BMPs per paragraph 2, the Municipality or its representatives may enter upon the Property and take whatever action is deemed necessary to maintain said BMPs. It is expressly understood and agreed that the Municipality is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the Municipality.
5. In the event the Municipality, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the Municipality for all expenses (direct and indirect) incurred within ten (10) days of receipt of invoice from the Municipality.
6. The intent and purpose of this Agreement is to ensure the proper maintenance of the onsite BMPs by the Landowner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability of any party for damage alleged to result from or be caused by stormwater runoff.

FINAL

7. The Landowner, its executors, administrators, assigns, and other successors in interests, shall release the Municipality from all damages, accidents, casualties, occurrences or claims which might arise or be asserted against said employees and representatives from the construction, presence, existence, or maintenance of the BMPs by the Landowner or Municipality.
8. The Municipality may inspect the BMPs at a minimum of once every three years to ensure their continued functioning.

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

ATTEST:

WITNESS the following signatures and seals:

(SEAL)

For the Municipality:

____

For the Landowner:

____

ATTEST:

___________________________ (City, Borough, Township)

County of Mifflin, Pennsylvania

I, ____________________________________, a Notary Public in and for the County and State aforesaid, whose commission expires on the _________ day of ________________, 20_____, do hereby certify that _____________________________________ whose name(s) is/are signed to the foregoing Agreement bearing date of the __________ day of _________________, 20_____, has acknowledged the same before me in my said County and State.

GIVEN UNDER MY HAND THIS ____________ day of ______________, 20_______.

______________________________ __________________________________

NOTARY PUBLIC **(SEAL)**

FINAL

APPENDIX B – LOW IMPACT DEVELOPMENT PRACTICES

FINAL

LOW IMPACT DEVELOPMENT PRACTICES
ALTERNATIVE APPROACHES FOR MANAGING STORMWATER RUNOFF

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

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

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

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

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

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

- **Reducing the Hydraulic Connectivity of Impervious Surfaces**. Impervious surfaces are significantly less of a problem if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are: routing of roof runoff over lawns; and reducing the use of storm sewers.

Site grading should promote increasing travel time of stormwater runoff and should help reduce concentration of runoff to a single point in the development.

- **Routing Roof Runoff Over Lawns.** Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. The routing of roof drains and crowning the driveway to allow runoff to discharge to pervious areas is desirable as the pervious area essentially acts as a filter strip.

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

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

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

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

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

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

In summary, careful consideration of the existing topography and implementation of a combination of the above mentioned techniques may avoid construction of costly stormwater control measures. Other benefits include: reduced potential of downstream flooding, reduced water quality degradation of receiving streams and water bodies, enhancement of aesthetics, and reduction of development costs. Beneficial results include: more stable baseflows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

APPENDIX C - STORMWATER MANAGEMENT DESIGN CRITERIA

FINAL

TABLE C-1 - RATIONAL METHOD RUNOFF COEFFICIENTS

Hydraulic Soil Group		A			B			C			D		
Slope Range	Storm	0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%
Cultivated Land	<25yr	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
	≥25yr	0.14	0.08	0.22	0.16	0.21	0.28	0.2	0.25	0.34	0.24	0.29	0.41
Pasture	<25yr	0.12	0.2	0.3	0.18	0.28	0.37	0.24	0.34	0.44	0.3	0.4	0.5
	≥25yr	0.15	0.25	0.37	0.23	0.34	0.45	0.3	0.42	0.52	0.37	0.5	0.62
Meadow	<25yr	0.10	0.16	0.25	0.14	0.22	0.3	0.2	0.28	0.36	0.24	0.3	0.4
	≥25yr	0.14	0.22	0.3	0.2	0.28	0.37	0.26	0.35	0.44	0.3	0.4	0.5
Forest	<25yr	0.05	0.08	0.11	0.08	0.11	0.14	0.1	0.13	0.16	0.12	0.16	0.2
	≥25yr	0.08	0.11	0.14	0.1	0.14	0.18	0.12	0.16	0.2	0.15	0.2	0.25
Residential													
1/8 Acre	<25yr	0.25	0.28	0.31	0.27	0.3	0.35	0.3	0.33	0.38	0.33	0.36	0.42
	≥25yr	0.33	0.37	0.4	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
1/4 Acre	<25yr	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.3	0.34	0.4
	≥25yr	0.3	0.34	0.37	0.33	0.37	0.42	0.36	0.4	0.47	0.38	0.42	0.52
1/3 Acre	<25yr	0.19	0.23	0.26	0.22	0.26	0.3	0.25	0.29	0.34	0.28	0.32	0.39
	≥25yr	0.28	0.32	0.35	0.3	0.35	0.39	0.33	0.38	0.45	0.36	0.4	0.5
1/2 Acre	<25yr	0.16	0.2	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.3	0.37
	≥25yr	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
1 Acre	<25yr	0.14	0.19	0.22	0.17	0.21	0.26	0.2	0.25	0.31	0.24	0.29	0.35
	≥25yr	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.4	0.31	0.35	0.46
Industrial	<25yr	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.7
	≥25yr	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	<25yr	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	≥25yr	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.9	0.89	0.89	0.9
Streets	<25yr	0.7	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	≥25yr	0.76	0.77	0.79	0.8	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open Space	<25yr	0.05	0.1	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
	≥25yr	0.11	0.16	0.2	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking or Impervious	<25yr	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	≥25yr	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

Source: Rawls, W.J., S.L. Long, and R.H. McCuen, 1981. Comparison of Urban Flood Frequency Procedures. Preliminary Draft Report prepared for the Soil Conservation Service, Beltsville, Maryland.

For simplification, a designer may use 0.3 for all pervious areas and 0.95 for all impervious areas.

TABLE C-2 - RUNOFF CURVE NUMBERS (FROM NRCS (SCS) TR-55)

Runoff Curve Numbers for Urban Areas					
Cover Description		**Curve Numbers for Hydrologic Soil Groups**			
Cover Type and Hydrologic Condition	***Average Percent Impervious Area***	***A***	***B***	***C***	***D***
Fully Developed Urban Areas (Vegetation Established)					
Open Space (lawns, parks, golf courses, etc):					
Poor Condition (grass cover < 50%)		68	79	86	89
Fair Condition (grass cover 50% to 75%)		49	69	79	84
Good Condition (grass cover > 75%)		39	61	74	80
Impervious Areas:					
Paved Parking Lots, Roofs, Driveways, etc.		98	98	98	98
Streets and Roads:					
Paved: Curbed and Storm Sewers		98	98	98	98
Paved: Open Ditches		83	89	92	93
Gravel		76	85	89	91
Dirt		72	82	87	89
Urban Districts:					
Commercial and Business	85%	89	92	94	95
Industrial	72%	81	88	91	93
Residential Districts by Average Lot Size:					
1/8 Acres or less	65%	77	85	90	92
1/4 Acre	38%	61	75	83	87
1/3 Acre	30%	57	72	81	86
1/2 Acre	25%	54	70	80	85
1 Acre	20%	51	68	79	84
2 Acres	12%	46	65	77	82

Runoff Curve Numbers for Cultivated Agricultural Lands						
Cover Description			**Curve Numbers**			
Cover Type	***Treatment***	***Hydrologic Condition***	***A***	***B***	***C***	***D***
Fallow	Bare Soil	--	77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & Terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close Seeded or Broadcast Legumes Or Rotation Meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80
Runoff Curve Numbers for Other Agricultural Lands						
Pasture, Grassland, or Range – Continuous Forage for Grazing		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow – Continuous Grass, Protected from Grazing and Generally Mowed for Hay		--	30	58	71	78
Woods – Grass Combination (orchard or tree farm)		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmsteads – Buildings, Lanes, Driveways and Surrounding Lots.		--	59	74	82	86

FINAL

APPENDIX D – REVIEW FEE REIMBERSEMENT AGREEMENT

[OPTIONAL]

THIS AGREEMENT MUST BE COMPLETED AND SIGNED BY THE DEVELOPER/APPLICANT PRIOR TO SUBMISSION OF THE SUBDIVISION/LAND DEVELOPMENT APPLICATION AND PLANS, SKETCH PLANS, CONDITIONAL USE APPLICATIONS OR ANY OTHER SUBMISSION WHICH REQUIRES MUNICPAL CONSULTANT REVIEW.

REVIEW FEE REIMBERSEMENT AGREEMENT

THIS AGREEMENT, made and entered into this ___________ day of ________, 20___, by and between _________________________________, (hereinafter the "Landowner"), and ___________________________, Mifflin County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

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

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

WHEREAS, the Landowner has submitted a SWM Site Plan for review and approval by the Municipality (hereinafter referred to as the "Plan") for the property identified herein; and

WHEREAS, the Developer has requested and/or required the Municipality approval and/or review of its proposed plans, and the Municipality is willing to authorize its professional consultants to review said Plan and/or proposal upon execution of this agreement, and upon deposit of an escrow account according to the current Fee Schedule.

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

1. The Landowner and Municipality hereby authorize and direct the Municipality's professional consultants, as defined at Section 107 of the Pennsylvania Municipalities Planning Code to review Landowner's plans or proposals to use its property, and to make such recommendations and specifications as may be necessary with respect to such plans in accordance with all applicable Municipality ordinances, and State and Federal rules and regulations.
2. The Landowner and Municipality acknowledge that the Municipality will incur costs and fees relating to the review of Landowner's plans by its professional consultants, and Landowner agrees to pay and/or reimburse the Municipality for such costs in accordance with this agreement.
3. The Landowner shall pay the professional consultant's charges and fees for the following: (a) review of any and all Stormwater Management Plans, studies, or other correspondence relating to the Landowners submission; (b) attendance at any and all meetings relating to Landowner's planl; (c) preparation of any reports, legal documents, or other correspondence relating to Landowner's plan or proposal; and (d) administrative cost and incurred expenses relating to the administration of this agreement. It is understood by the execution of this agreement that the Landowner specifically accepts the Fee Schedule currently in effect in the Municipality.
4. The Landowner hereby agrees to deposit with the Municipality the sum of _____________ Dollars ($____________), payable as cash in U.S. Dollars or check drawn on a Pennsylvania bank, as security for the payment of all costs and expenses, charges and fees as set forth in Paragraph 3 above, upon execution of this agreement, which shall be held in a noninterest- bearing account by the Municipality. In the event that the above deposited escrow fund shall fall below fifty percent (50%) of the original deposit, the Landowner shall immediately, upon receipt of written notice from the Municipality or its agent(s), deposit sums with the Municipality necessary to replenish the account to its original balance. In the event that this is insufficient to

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pay current Municipality incurred expenses, Landowner agrees to pay the total amount currently due for Municipality incurred expenses without delay in addition to re-establishing the base escrow account balance. The Municipality will use its best efforts to advise the Landowner of the impending likelihood that its costs have exceeded the required escrow account sums as described above.

5. Landowner and Municipality agree that upon completion of the Municipality's review of Landowner's plan or proposal, all unused portions of the escrow account as described above shall be returned to the applicant upon written request to the Municipality.

6. Landowner and Municipality acknowledge that the Ordinance and appropriate fee schedules require Landowner to pay Municipality's professional consultant fees relating to this plan or project, and in the even that Landowner fails to provide sufficient funds in the above-described revolving escrow account upon fifteen (15) days written notice to the Landowner or make the initial deposit payment described above within five (5) days of the date of this agreement, Landowner shall be in default of this agreement and in violation of the above Sections of Ordinance. In the event of Landowner's default as described above, the Municipality may refuse to issue any permit or grant any approval necessary to further improve or develop the subject site until such time as the terms of this Agreement are strictly met by Landowner. Moreover, final approval or further review may be denied or delayed until such time as the terms of this agreement are strictly met by Landowner.

7. Landowner and the Municipality further agree that all fees or costs arising out of this Agreement shall be paid prior to the issuance of any permit, occupancy or otherwise, for the use, improvement or construction of the buildings as proposed on the Landowner's plan. The Landowner agrees and acknowledges that no permit, occupancy or otherwise, or recordable plans, shall be released by the Municipality until all outstanding professional consultant fees and costs are paid to the Municipality, and provided that the Landowner is not in default under this agreement.

8. The Landowner may at any time terminate all further obligations under this Agreement by giving fifteen (15) days written notice to the Municipality that it does not desire to proceed with the development as set forth on the plan and upon receipt of such written notice by the Landowner to the Municipality, the Landowner shall be liable to the Municipality for its costs and expenses incurred to the date and time of its receipt of the notice, plus the applicable administrative costs and expenses as outlined in Paragraph 3 above.

9. The Landowner and the Municipality further agree that the Municipality shall have the right and privilege to sue the Landowner or then property owner in assumpsit for reimbursement or to lien the property or both, in its sole discretion, for any expense in excess of the then current balance of funds on deposit with the Municipality in accordance with this agreement incurred by the Municipality by reason of any review, supervision and inspection of Landowner's project by its professionals including, but not limited to, the Municipality Engineer and Solicitor. The Municipality's election of its remedies under this paragraph shall not constitute a waiver of any other remedies the Municipality may have.

10. The Landowner and the Municipality acknowledge that this agreement represents their full understanding as to the Municipality's reimbursement for professional or consultant services.

11. This agreement shall be binding on and insure to the benefit of the successors and assigns of Landowner. The Municipality shall receive thirty (30) days advance written notice from Landowner of any proposed assignment of Landowner's rights and responsibilities under this Agreement.

ATTEST:

WITNESS the following signatures and seals:

(SEAL)

For the Municipality:

____

For the Landowner:

____

ATTEST:

_________________________ (City, Borough, Township)

County of Mifflin, Pennsylvania

I, _________________________________, a Notary Public in and for the County and State aforesaid, whose commission expires on the ________ day of _______________, 20____, do hereby certify that __________________________________ whose name(s) is/are signed to the foregoing Agreement bearing date of the _________ day of ________________, 20____, has acknowledged the same before me in my said County and State.

GIVEN UNDER MY HAND THIS ___________ day of _____________, 20______.

___________________________ ______________________________

NOTARY PUBLIC **(SEAL)**

FINAL

APPENDIX E – SMALL PROJECTS SWM APPLICATION

FINAL

Mifflin County
Guidelines for Completing the Small Project Stormwater Management Application

The following application is meant to assist Single Family Residential activities in successfully fulfilling the requirements of this stormwater management ordinance and provide documentation for developments that have less than 5,000 square feet of new impervious area. Potential applicants should consult with municipal officials prior to submission of this application.

As discussed in the *Mifflin County Act 167 Countywide Stormwater Management Plan*, the applicant should also be aware that there are various soil-related, geologic, and topographic hazards to development in Mifflin County including but not limited to fragipan soils (26% of the county), shallow bedrock (over 60% of the county), soil of the hydrologic soil group "D" (8-10% of the county), karst topography, floodplains, and numerous documented problem areas. **If any one of these hazards exists on a project site, a qualified design professional should be consulted prior to the design or construction of any best management practices (BMPs).**

Guidance for the design, construction, and maintenance of BMPs that may be used with the application include:

Best Management Practice	Location in *Pennsylvania Stormwater Best Management Practices Manual (DEP, 2006)*
Rain Garden	Chapter 6, BMP 6.4.5 (pages 49-62)
Infiltration Trench	Chapter 6, BMP 6.4.4 (pages 41-48)
Dry Well	Chapter 6, BMP 6.4.6 (pages 63-70)

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Mifflin County
Small Project Stormwater Management Application

Per [municipality]'s Act 167 Stormwater Management Ordinance, a stormwater management plan is required whenever more than 5,000 square feet of impervious surface or non-exempt single family homes are proposed. Impervious surfaces are areas that prevent the infiltration of water into the ground and shall include, but not be limited to, roofs, patios, garages, storage sheds and similar structures, and any new streets or sidewalks.

To Calculate Impervious Surfaces Please Complete This Table					
Surface Type	**Length (feet)**	**X**	**Width (feet)**	**=**	**New Impervious Area (square feet)**
Building (area per downspout)		x		=	
		x		=	
		x		=	
		x		=	
Driveway		x		=	
		x		=	
		x		=	
Parking Areas		x		=	
		x		=	
		x		=	
Patios/Walks		x		=	
		x		=	
		x		=	
		x		=	
Other		x		=	
		x		=	
		x		=	
New Impervious Surface Area to be managed (sum of all areas)					

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If the Total Impervious Surface Area is GREATER THAN OR EQUAL TO 5,000 Square Feet, complete the remainder of the Application.

Based Upon the information you have provided a ***Stormwater Management Plan IS NOT required*** for this regulated activity. [Municipality] may request additional information and/or SWM for any reason.

Property Owner Acknowledges that submission of inaccurate information may result in a stop work order or permit revocation. Acknowledgement of such is by signature below. I declare that I am the owner or owner's legal representative. I further acknowledge that the information provided is accurate and employees of [municipality] are granted access to the above described property for review and inspection as may be required.

______________________________ **Owner** **Date:** ____________

CREDITS

Credit 1: DISCONNECTION OF IMPERVIOUS AREA

When runoff from impervious areas is directed to a pervious area that allows for infiltration, filtration, and increased time of concentration, all or parts of the impervious areas may qualify as Disconnected Impervious Area (DIA). Using the criteria below, determine the portion of the impervious area that can be excluded from the calculation of total impervious area.

Criteria: An impervious area is considered to be completely or partially disconnected if it meets the requirements listed below

- rooftop area draining to a downspout is ≤500 sf
- paved area draining to a discharge point is ≤1,000 sf
- flow path of paved impervious area is not more than 75'
- soil at discharge point is not designated as hydrologic soil group "D"
- flow path at discharge area has a positive slope of ≤5%
- gravel strip or other spreading device is required at paved discharges.

Length of Pervious Flow Path from discharge point * (ft)	**DIA Credit Factor**
0 – 14	1.0
15 – 29	0.8
30 – 44	0.6
45 – 59	0.4
60 – 74	0.2
75 or more	0

* Flow path cannot include impervious surfaces and must be at least 15 feet from any impervious surfaces.

Calculate DIA Credit & Required Capture Volume

Surface Type	**New Impervious Area (square feet)** (from previous sheet)	**X**	**DIA Credit Factor**	**=**	**Reduced New Impervious Area (square feet)**	**÷**		**=**	**Required Capture Volume (cubic feet)**
Building (area per downspout)		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Driveway		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Parking Areas		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Patios/Walks		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
Other		x		=		÷	6	=	
		x		=		÷	6	=	
		x		=		÷	6	=	
								Required Capture Volume After Credit 1:	

Credit 2: TREE PLANTING

Perhaps the best BMP is a tree as they intercept rainfall, increase evapotranspiration and increase time of concentration. A portion of the required capture volume can be reduced provided the criteria are met.

CREDITS

Deciduous Trees	Evergreen Trees
6 ft^3 per tree planted	10 ft^3 per tree planted

Criteria

To receive credit for planting trees, the following must be met:

- Trees must be native species (see below), minimum 2" caliper and 6 feet tall (min).
- Trees shall be adequately protected during construction.
- Trees shall be maintained until redevelopment occurs.
- No more than 25% of the runoff volume can be mitigated through the use of trees.
- Dead trees shall be replaced within 6 months.
- Non-native species are not applicable.

Native Species Trees (Common Name)

- Blackgum
- Arrow-wood, southern
- Box-elder
- Maple, (red or silver)
- Birch, (river or gray)
- Ironwood
- Hickory, sweet pignut or shag-bark
- Cedar, (Atlantic white or eastern red)
- Beech, American
- Ash, (white, black or green)
- Holly, American
- Tuliptree
- Sycamore, American
- Cotton-wood, eastern
- Aspen, big-tooth or quaking
- Cherry, black
- Oak, (white, swamp white, scarlet, pin, willow, red)
- Willow, black
- Bald Cypress
- Basswood, American
- Serviceberry, (downy or shadbush)
- Redbud, eastern
- Dogwood, flowering
- Magnolia, sweetbay
- Pine, (pitch or eastern white)

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	[ ]	**Required Capture Volume after Credit 1 (ft^3)**
-	[ ]	**Tree Planting Credit (ft^3)**
	[ ]	**Required Capture Volume After Credit 1 and Credit 2 (ft^3)**

Sizing of BMP

	[ ]	How much of the Volume will you manage with a Rain Garden?
+	[ ]	How much of the Volume will you manage with a Dry Well or Infiltration Trench?
	[ ]	**Capture Volume to Managed by Proposed BMPs (ft^3)** **(must be greater than Required Capture Volume After Credit 1 and Credit 2)**

Enter the volumes into the **Small Project SWM Plan Worksheet** on the next sheet.

Small Project SWM Plan Worksheet

Based upon the information you have provided a ***Stormwater Plan IS Required*** for this development activity. The Stormwater Management Ordinance developed through the *Mifflin County Act 167 Stormwater Management Plan* regulates compliance requirements for Stormwater Management in this jurisdiction. A complete copy of the *Plan* can be found on the Mifflin County website.

Regulated activities shall be conducted only after [municipality] approves a stormwater management plan. The *Mifflin County Act 167 Stormwater Management Plan* will assist you in preparing the necessary information and plans for [municipality] to review and approve. **This document will constitute an approved plan if all of the relevant details are to be installed in their entirety AND no part of the stormwater system adversely affects any other property, nor adversely affect any septic systems or drinking water wells on this, or any other, parcel.** If an alternative system is to be used a plan will need to be submitted to [municipality] for approval. A design by a qualified professional may be required for more complex sites.

PLEASE INITIAL EACH APPLICABLE BOX BELOW TO INDICATE THE STORMWATER MANAGEMENT PLAN FOR THIS SITE

☐ Minimum Control #1 Temporary pollution controls during construction (Erosion & Sediment Pollution Control)
Minimum Control #2: Permanent pollution controls after construction (Source Control of Pollution; BMPs)
Minimum Control #3: Preservation of Natural Drainage Systems and Outfalls

☐ The relevant details from the *Pennsylvania Stormwater Best Management Practices Manual* will be installed in their entirety AND the system will be located as not to adversely affect other property, nor any septic systems or drinking water wells on this, or any other, parcel.

To meet this requirement, the following will be installed and maintained:

Capture Volume to be managed (ft^3)			Conversion	Minimum Surface Area of BMPs (ft^2)
	By Rain Garden 6" ponding; 2' soil depth	x	1.20	
	Dry Well or Infiltration Trench 2½' aggregate depth	x	1.25	
	Total		Total	

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☐ In lieu of meeting the above, an alternative and/or professional design is attached for approval AND the system will be located so as not to adversely affect other property, any septic systems or drinking water wells on this, or any other, parcel.

☐ **Site Sketch Plan showing:**

- Property lines with dimensions
- Proposed buildings with dimensions
- Proposed impervious surfaces with dimensions
- Proposed septic system, if applicable
- Proposed well site, if applicable
- Proposed stormwater management system(s)

☐ **Operation and Maintenance Agreement**

Condition on approval - The stormwater management plan must be fully implemented prior to a request for final inspection of the building or zoning permit.

Acknowledgement - By executing below, the Owner acknowledges the following:

- I declare that I am the owner of the property.
- The information provided is accurate.
- I further acknowledge that municipal representatives are granted access to the above described property for review and inspection as may be required.

______________________________ **Owner** **Date:** ______________

Appendix A – Watershed Modeling Technical Data

This appendix supplements the hydrologic modeling general overview presented in Section 6 – Technical Analysis.

DATA COLLECTION

The GIS data for the hydrologic models was compiled from a variety of sources by county, state, and federal agencies. The data was collected and processed using GIS software. A description of GIS data collected, the source, and its use are provided in *Table A.1*.

Data	Source	Use
10-m Digital Elevation Model (DEMs)	USGS (2008a)	Watershed delineation, length, basin slope, stream slope, average elevation
High Resolution Streamlines	USGS (2008b)	Watershed delineation, cartography, spatial orientation
National Land Cover Dataset – Land Use 2001	USGS (2008c)	Curve number generation for watershed subareas; urbanized areas were converted to undeveloped use so impervious areas could be used.
Mifflin County Impervious Coverage 2008	Mifflin County Planning	Calculation of Existing Conditions Impervious Area with County
Mifflin County Impervious Coverage 2020	Mifflin County Planning	Calculation of Future Conditions Impervious Area with County
National Land Cover Dataset – Impervious Coverage 2001	USGS (2008c)	Calculation of impervious areas outside of Mifflin County
SURRGO Soils Data	NRCS (2008)	Curve number generation; analysis of infiltration limitations
Carbonate Bedrock	ERRI (1996)	Calculation of percentage of limestone geology within subwatersheds; analysis of infiltration limitations
Storage (percent of lakes, ponds, and wetlands)	USGS (2008d)	Calculation of parameters for USGS Regression Equations
Roadway Data	PennDOT (2009)	Cartography, spatial orientation

Table A.1. GIS Data Used in Act 167 Technical Analysis

HYDROLOGIC MODEL PARAMETER DATA

SOILS, LAND USE, AND CURVE NUMBERS

The determination of curve numbers is a function of soil type and land use. The hydrologic soil groups were defined by NRCS (2008). The 2001 NLCD was simplified to provide an estimate of natural curve numbers using the scheme shown in *Table A.2*. The assigned curve numbers are shown in *Table A.3*. The existing and future conditions curve number were derived by calculating a composite curve number of each subwatershed. The corresponding percent impervious values for each respective subwatershed area are shown in the tables at the end of this Appendix.

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Land Use Designation	NLCD 2001 Classification Description	Natural Land Use Conversion
11	Open Water	Natural Impervious
21	Developed, Open Space	Meadow
22	Developed, Low Intensity	
23	Developed, Medium Intensity	
24	Developed, High Intensity	
31	Barren Land (Rock/Sand/Clay)	Natural Impervious
41	Deciduous Forest	Forest
42	Evergreen Forest	
43	Mixed Forest	
52	Shrub/Scrub	Meadow
71	Grassland/Herbaceous	
81	Pasture/Hay	Agriculture
82	Cultivated Crops	
90	Woody Wetlands	Forest
95	Emergent Herbaceous Wetlands	Natural Impervious

Table A.2. Development of Natural Land Use for Mifflin County

GIS Value	Description	A	B	C	D
1	Meadow	30	58	71	78
2	Forest	30	55	70	77
3	Natural Impervious	98	98	98	98
4	Agriculture	39	61	74	80
5	Wetland	30	55	70	77

Table A.3. Curve Number Determination for Mifflin County

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The curve numbers presented in the above tables represent "average" antecedent runoff condition (i.e. ARC = 2). In a significant hydrologic event, runoff is often influenced by external factors, such as extremely dry antecedent runoff conditions (ARC=1) or wet antecedent runoff conditions (ARC=3). The antecedent runoff conditions of the above curve numbers were altered during the calibration process so that model results are within a reasonable range of other hydrologic estimates.

INFILTRATION AND HYDROLOGIC LOSS ESTIMATES

Infiltration and all other hydrologic loss estimates (e.g., evapotranspiration, percolation, depression storage, etc.) taken into account within the HEC-HMS model was consistent with the recharge volume criteria contained in Control Guidance 1 and 2 (CG-1 and CG-2). These losses were modeled in existing conditions as the standard initial abstraction in the NRCS Curve Number Runoff method (i.e., $I_a = 0.2S$). CG-1 was simulated by modifying the standard initial abstraction using the following procedure.

The runoff volume is computed by HEC-HMS using the following equation:

$$Q_{volume} = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Where P = Rainfall for a specific storm event (in),
I_a = Initial Abstraction (in), and
S = Maximum Retention (in).

S is defined by the following equation which relates runoff volume to curve number:

$$S = \frac{1000}{CN} - 10$$

The standard initial abstraction I_a used in Pennsylvania is typically ***0.2S***. HEC-HMS calculates this automatically if no value is entered by the user. This was the approach used for the existing and future conditions modeling scenarios.

In future conditions with implementation of CG-1, the following equation is applicable. The goal of CG-1 is to ensure there is no discharge volume increase for the 2-year storm event, so

$$Q_{CG1} = Q_{Existing} = \frac{(P - I_a)^2}{(P - I_a) + S_{Proposed}}$$

Where P = Rainfall for a specific storm event (in),
I_a = Initial Abstraction (in), and
$S_{Proposed}$ = Maximum Retention in proposed conditions as a function of the proposed conditions curve number (in).

Assuming I_a = ***0.2S*** as the Initial abstraction is no longer applicable with CG-1 since BMPs are to be installed to control or remove the increase in runoff volume for the 2-year, 24-hour storm event. Using the HEC-HMS modeling output for $Q_{Existing}$, the initial abstraction for CG-1 may be calculated using the following equation:

$$I_a = P_{2-year} - \frac{1}{2}\left(Q_{Existing} \pm \sqrt{Q_{Existing}^2 + 4Q_{Existing}S_{Proposed}}\right) \text{ for the 2-year event}$$

Thus, the volume control required by CG-1 is implicitly modeled by overriding the HEC-HMS default for initial abstraction with the above value. The qualitative effect of this will be to eliminate the increase in runoff volume for the 2-year, 24-hour storm event and to reduce the increase in runoff volume of the more extreme events. Increases in the peak flow values are reduced for all storms, but not eliminated, since the time of concentrations for proposed condition are decreased. Figure C.1 shows the effects of implementing a CG-1 policy on an example watershed. In the first figure representing a 2-year, 24-hour storm event, the hydrograph volumes are exactly the same and the peaks are similar. In the second figure representing a 100-year, 24-hour storm event, the hydrograph volumes are not the same since only the 2-year, 24-hour storm event volume is abstracted; consequently there is still a substantial

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increase in peak flows, although the CG-1 implementation does reduce the peak flow.

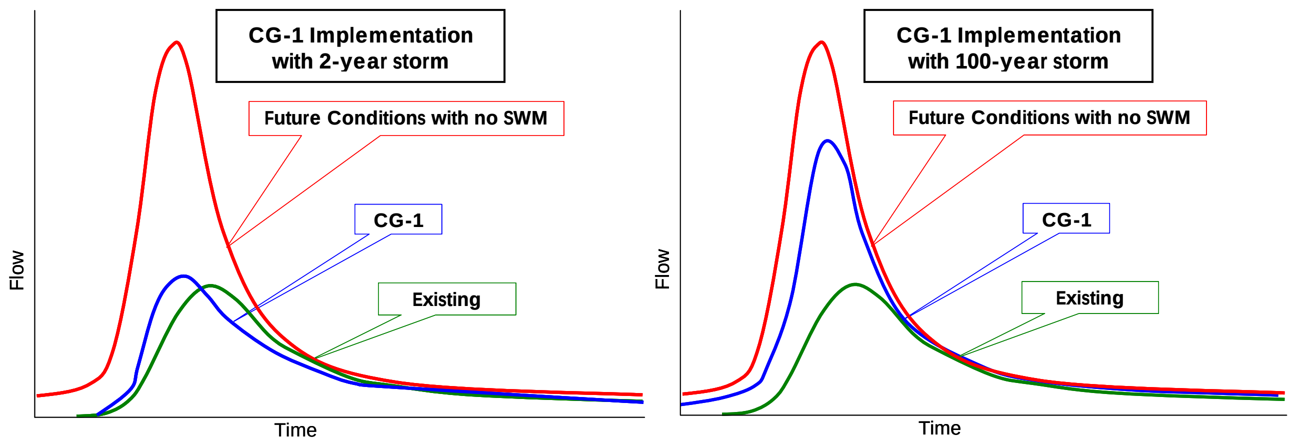

Figure A.1. Typical On-Site Runoff Control Strategy

In the case of this particular sample, release rates might be necessary to prevent increases in peak flow. In situations where there is only a small increase in impervious coverage, however, CG-1 may reduce the proposed conditions peak flow to existing conditions levels without the use of release rates.

For the 2-year, 24-hour storm event, modeling CG-1 with the above equations results in an increased approximation in initial abstraction represented by D:

$$D = I_a^{CG-1} - 0.2S$$

For every event of greater magnitude (e.g., 10, 25, 50, and 100-year, 24-hour storm events), the initial abstraction is calculated using the sum of the traditional method and the increase in initial abstraction for the 2-year event.

$I_a = 0.2S + D$ for all events greater than the 2-year, 24-hour storm event.

MODEL CALIBRATION

Three (3) parameters were modified to develop a calibrated hydrologic model: the curve number, the time of concentration, and the Manning's coefficient used in the Muskingum-Cunge routing method.

The antecedent runoff condition was altered for each storm event so that each subbasin and calibration point was within an acceptable range of a target flow. The equation used to modify antecedent runoff condition (Maryland Hydrology Panel, 2006):

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For ARC≤2:

$$CN_x = \frac{[10 + 5.8(x-2)]CN_2}{10 + 0.058(x-2)CN_2}$$

For ARC>2:

$$CN_x = \frac{[10 + 13(x-2)]CN_2}{10 + 0.013(x-2)CN_2}$$

Thus, a unique ARC and resulting curve number was calculated for each subbasin for each storm event. The same ARC was applied in both existing and proposed conditions. The calibrated and future condition curve numbers for the two (2) watersheds are presented in the Tables at the end of this appendix.

Additionally, lag times were calculated using both TR-55 and the NRCS lag equation. The initial model runs used the results from the NRCS lag equation. A factor between zero (0) and two (2) was applied to the initial value to obtain a calibrated time of concentration value. The same time of concentration was applied to all existing condition storms. The future land use time of concentration was calculated using the NRCS lag equation with future land curve numbers. It was subsequently adjusted by the same factor used in existing conditions.

Finally, the Manning's n value for channels and overbank areas was modified to obtain realistic flow values. The respective ranges for the channel and overbank areas were 0.02-0.07 and 0.03-0.2.

MODELING RESULTS

A summary of the hydrologic modeling results has been provided in *Section V* of this Plan. The full modeling results are as presented in the tables at the end of this appendix.

STORMWATER MANAGEMENT DISTRICTS

The regional philosophy used in Act 167 planning introduces a different stormwater management approach than is found in the traditional on-site approach. The difference between the on-site stormwater control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts throughout an individual watershed. The objective of typical on-site design is to control post-development peak flow rates from the site itself; however, a watershed-level design is focused on maintaining existing peak flow rates in the entire drainage basin. The watershed approach requires knowledge of how the site relates to the entire watershed in terms of the timing of peak flows, contribution to peak flows at various downstream locations, and the impact of the additional runoff volume generated by the development of the site. The proposed watershed-level stormwater runoff control philosophy is based on the assumption that runoff volumes will increase with development and the philosophy seeks to manage the increase in volumes such that peak rates of flow throughout the watershed are not increased. The controls implemented in this Plan are aimed at minimizing the increase in runoff volumes and their impacts, especially for the 2-year, 24-hour storm event.

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

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Presented in *Figure A.2* is a typical on-site runoff control strategy for dealing with the increase in the peak rate of runoff with development. The Existing Condition curve represents the pre-development runoff hydrograph. The Developed Condition curve illustrates three (3) important changes in the site runoff response with development:

1. A higher peak rate,

2. A faster occurring peak (shorter time for the peak rate to occur), and

3. An increase in total runoff volume.

The "Controlled" Developed Condition hydrograph is based on limiting the post-development runoff peak rate to the pre-development level through use of detention facilities; but the volume is still increased. The impact of reducing the post-development peak rate to the pre-development peak rate without reducing the volume causes the peak rate to extend over a much longer period of time. The instantaneous pre-development peak has become an extended peak (approximately two (2) hours long in this example) under the "Controlled" Developed Condition.

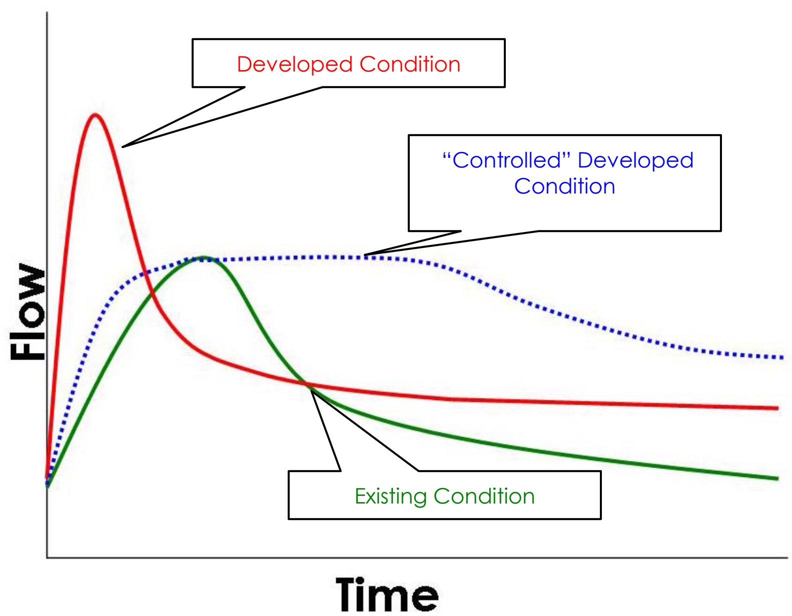

Figure A.2. Typical On-Site Runoff Control Strategy

Considering the outflow from the site only, the maintenance of the pre-development peak rate of runoff is an effective management approach. However, *Figures A.3* and *A.4* illustrate the potential detrimental impact of this approach. *Figure A.3* represents the existing hydrograph at the point of confluence of Watershed A and Watershed B. The timing relationship of the watersheds is such that Watershed A peaks more quickly (at time T_{pA}) than the Total Hydrograph, while Watershed B peaks later (at time T_{pB}), than the Total Hydrograph, resulting in a combined time to peak approximately in the middle (at time T_p). Watershed A is an area of significant development pressure and all new development proposals are met with the on-site runoff control philosophy as depicted in *Figure A.2*. Eventually, the end product of the Watershed A development under the "Controlled" Development Condition is an extended peak rate of runoff as shown in *Figure A.4*. The extended Watershed A peak rate flow occurs long enough that it coincides with the peak of Watershed B. Since the Total Hydrograph at the confluence is the

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summation of Watershed A and Watershed B, the Total Hydrograph peak is increased under these conditions to the "Controlled" Total Hydrograph. The conclusion from the example is that simply controlling peak rates of runoff on-site does not guarantee an effective watershed level of control because of the increase in total runoff volume. The net result is that downstream peaks can increase and extend for longer durations.

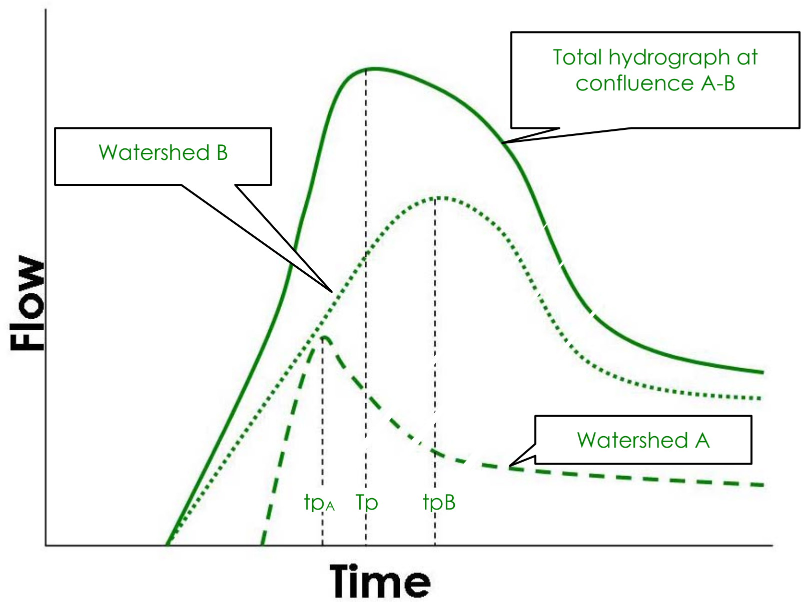

Figure A.3. Existing Hydrograph (Pre-Development)

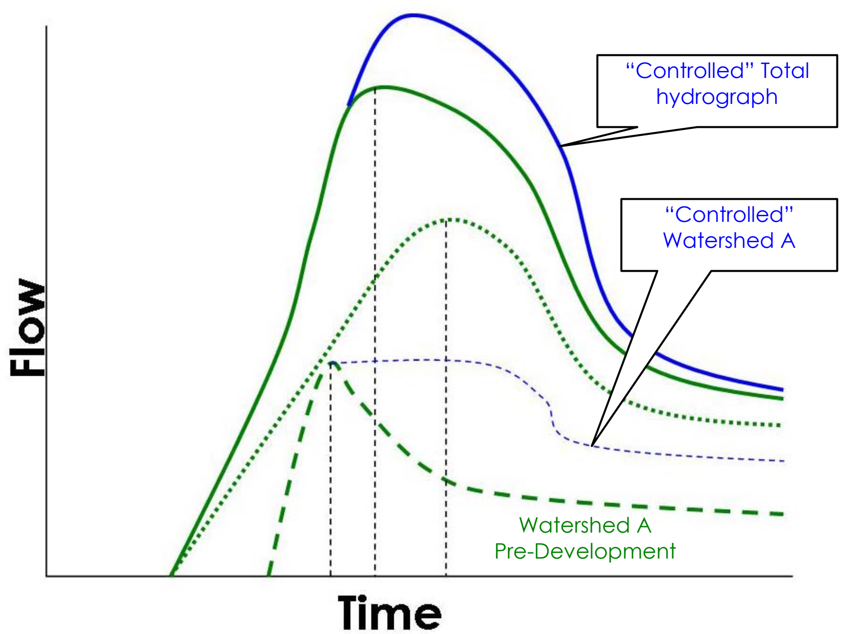

Figure A.4. Controlled Runoff Condition (Post-Development)

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RELEASE RATE CONCEPT

The previous example indicated that, in certain circumstances, it is not enough to control post-development runoff peaks to pre-development levels if the overall goal is no increase in peak runoff at any point in the watershed. The reasons for this potential increase are how the various parts of the watershed interact, in time, with one another, the increased rate and volume of runoff associated with development, and increases in impervious surfaces. The critical runoff criteria for a given site or watershed area is not necessarily its own pre-development peak rate of runoff but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest.

To account for increases of volume and peak flow resulting from the combination of these post-development hydrographs, stormwater management districts have been assigned to various areas within the county boundary that have more restrictive release rates than the conventional 100% release rate. As shown in Plate 10, some areas within specific watersheds have reduced release rates where CG-1 may be difficult to completely implement.

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

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

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

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

Combining volume controls with peak rate controls, as proposed in this Plan, will be more effective than having only peak rate controls. Volume controls have several advantages, such as:

1. Increased runoff volume may infiltrate and provide recharge to existing groundwater supplies. This may not happen with rate controls since all of the runoff excess is discharged in a relatively short time frame.

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

3. Volume controls often have enhanced water quality benefits.

4. The Design Storm Method and The Simplified Method as implemented in this Plan, provide the benefits described above.

SUMMARY MODEL OUTPUT

Hydrologic Parameters for the Juniata River HEC-HMS Model

Hydrologic Results for the Juniata River HEC-HMS Model

Hydrologic Parameters for Jacks Creek HEC-HMS Model

Hydrologic Results for Jacks Creek HEC-HMS Model

Calibration Results for Detailed HEC-HMS Models with 2010 Land Use

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Hydrologic Parameters for Juniata River HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)			Future Conditions (2020)		
			% Imp	CN	Lag (min)	% Imp	CN	Lag (min)
Beaverdam Run	W123	4.28	1.52	65.6	147.1	1.57	65.6	147.0
	W124	1.20	0.90	56.2	109.5	0.90	56.2	109.5
	W125	2.06	0.96	69.9	54.5	0.96	69.9	54.5
	W126	4.06	0.52	65.3	59.3	0.52	65.3	59.3
Carlisle Run	W111	2.56	1.52	68.5	56.4	1.87	68.6	56.2
	W112	3.31	0.17	59.5	82.7	0.18	59.6	82.7
Granville Run	W102	3.15	0.65	64.2	78.2	0.67	64.3	78.2
Juniata River	W101	2398.00	NA	NA	NA	NA	NA	NA
Long Hollow Run	W129	1.88	2.20	69.4	45.6	2.20	69.4	45.6
	W130	2.36	0.17	60.5	56.0	0.17	60.5	56.0
	W131	3.40	0.89	66.0	75.7	0.89	66.0	75.7
Minehart	W105	3.36	0.01	60.3	97.2	0.01	60.3	97.2
Minehart Run	W103	1.11	2.17	66.2	65.9	2.55	66.3	65.7
	W104	1.49	0.00	59.3	55.9	0.00	59.3	55.9
Musser Run	W118	1.63	2.61	65.7	91.8	3.43	66.0	91.2
	W119	3.90	1.06	63.7	96.2	1.39	63.8	95.9
	W120	4.70	0.86	62.1	86.8	0.86	62.1	86.8
Shanks Run	W121	1.54	0.04	58.6	55.4	0.04	58.6	55.4
Spring Run	W117	2.15	1.03	62.7	64.6	1.06	62.7	64.6
Strodes Run	W106	3.42	3.34	67.2	75.8	3.74	67.4	75.6
	W107	1.28	1.12	67.4	51.9	1.16	67.4	51.9
	W108	2.37	1.13	65.0	60.4	1.15	65.0	60.4
	W109	3.40	0.99	66.0	68.3	1.04	66.0	68.3
	W110	1.22	0.28	65.0	45.2	0.30	65.0	45.2
Sugar Valley Run	W127	2.91	0.29	62.6	63.1	0.29	62.6	63.1
Town Run	W115	3.82	1.01	59.5	84.9	1.19	59.6	84.7
	W116	0.88	1.25	61.1	38.1	1.27	61.1	38.1
Wakefield Run	W113	2.58	1.21	65.3	62.4	1.62	65.5	62.1
	W114	3.94	0.92	63.5	70.4	0.97	63.6	70.4
West Licking Ck	W128	11.34	1.41	64.5	145.3	1.41	64.5	145.3
Wharton Run	W122	2.28	0.15	59.7	60.2	0.15	59.7	60.2

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Hydrologic Parameters for Juniata River HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Beaverdam Run	W123	65.6	67.0	64.2	61.2	57.5	55.2
	W124	56.2	69.9	70.6	68.8	66.7	65.2
	W125	69.9	65.6	62.9	59.9	56.5	54.4
	W126	65.3	61.1	56.2	52.3	47.7	45.2
Carlisle Run	W111	68.5	65.0	62.0	59.9	57.7	55.6
	W112	59.5	65.0	61.9	58.7	56.5	54.2
Granville Run	W102	64.2	66.0	62.7	60.4	57.8	55.7
Juniata River	W101	NA	NA	NA	NA	NA	NA
Long Hollow Run	W129	69.4	62.6	58.1	56.0	53.7	50.1
	W130	60.5	63.4	58.6	55.9	52.9	49.3
	W131	66.0	62.6	58.0	55.6	52.9	49.4
Minehart	W105	60.3	65.7	62.7	59.2	56.7	53.3
Minehart Run	W103	66.2	67.0	64.7	62.3	59.7	56.7
	W104	59.3	64.0	60.5	57.3	54.4	51.0
Musser Run	W118	65.7	63.9	62.4	60.4	58.2	55.5
	W119	63.7	65.2	63.3	61.4	59.2	56.1
	W120	62.1	61.1	58.0	55.0	51.4	47.6
Shanks Run	W121	58.6	64.3	60.7	57.6	55.4	53.0
Spring Run	W117	62.7	61.7	57.6	54.6	51.1	48.4
Strodes Run	W106	67.2	63.5	59.7	57.0	53.9	51.6
	W107	67.4	62.4	57.6	54.6	51.2	48.8
	W108	65.0	61.2	56.0	52.9	49.3	46.7
	W109	66.0	62.1	57.4	54.3	50.8	48.2
	W110	65.0	62.6	57.7	54.6	51.0	48.5
Sugar Valley Run	W127	62.6	61.9	57.7	55.2	52.4	50.1
Town Run	W115	59.5	59.1	55.7	52.7	49.4	46.9
	W116	61.1	58.9	55.9	53.1	49.8	47.3
Wakefield Run	W113	65.3	64.7	61.9	59.5	56.8	53.8
	W114	63.5	63.8	60.2	57.3	54.1	50.4
West Licking Ck	W128	64.5	67.0	63.7	61.2	58.3	55.8
Wharton Run	W122	59.7	62.9	58.9	56.3	53.4	51.1

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Hydrologic Parameters for Juniata River HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Beaverdam Run	W123	65.6	67.0	64.3	61.2	57.5	55.2
	W124	56.2	69.9	70.6	68.8	66.7	65.2
	W125	69.9	65.6	62.9	59.9	56.5	54.4
	W126	65.3	61.1	56.2	52.3	47.7	45.2
Carlisle Run	W111	68.6	65.1	62.1	60.1	57.8	55.7
	W112	59.6	65.0	61.9	58.7	56.6	54.2
Granville Run	W102	64.3	66.0	62.7	60.4	57.8	55.7
Juniata River	W101	NA	NA	NA	NA	NA	NA
Long Hollow Run	W129	69.4	62.6	58.1	56.0	53.7	50.1
	W130	60.5	63.4	58.6	55.9	52.9	49.3
	W131	66.0	62.6	58.0	55.6	52.9	49.4
Minehart	W105	60.3	65.7	62.7	59.2	56.7	53.3
Minehart Run	W103	66.3	67.1	64.8	62.5	59.8	56.8
	W104	59.3	64.0	60.5	57.3	54.4	51.0
Musser Run	W118	66.0	64.2	62.7	60.7	58.5	55.8
	W119	63.8	65.3	63.4	61.5	59.3	56.2
	W120	62.1	61.1	58.0	55.0	51.4	47.6
Shanks Run	W121	58.6	64.3	60.7	57.6	55.4	53.0
Spring Run	W117	62.7	61.7	57.6	54.6	51.1	48.4
Strodes Run	W106	67.4	63.7	59.8	57.2	54.1	51.7
	W107	67.4	62.4	57.6	54.6	51.2	48.8
	W108	65.0	61.2	56.0	52.9	49.3	46.7
	W109	66.0	62.1	57.4	54.3	50.8	48.2
	W110	65.0	62.6	57.7	54.6	51.0	48.5
Sugar Valley Run	W127	62.6	61.9	57.7	55.2	52.4	50.1
Town Run	W115	59.6	59.2	55.8	52.8	49.5	46.9
	W116	61.1	59.0	55.9	53.1	49.8	47.3
Wakefield Run	W113	65.5	64.8	62.0	59.6	57.0	53.9
	W114	63.6	63.9	60.2	57.3	54.1	50.4
West Licking Ck	W128	64.5	67.0	63.7	61.2	58.3	55.8
Wharton Run	W122	59.7	62.9	58.9	56.3	53.4	51.1

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Hydrologic Results for Juniata River HEC-HMS Model

Discharge	HEC-HMS	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
Point	Node	x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J1	1938595.4	92456.5	5.80	272	638	935	1,123	1,255	272	638	936	1,124	1,255
2	J13	1967124.9	127161.8	3.00	121	349	502	577	701	121	349	503	578	702
3	J Town Run	1968963.3	122814.2	6.90	211	632	911	1,049	1,280	213	636	916	1,055	1,287
4	J16	1980387.7	135881.9	3.90	209	519	726	840	929	210	522	730	845	934
5	J Wakefield Run	1983685.7	129466.1	6.50	339	844	1,192	1,403	1,584	343	853	1,205	1,419	1,601
6	J18	1983203.0	118725.0	3.30	182	453	605	757	916	182	453	605	757	916
7	J Carlisle Run	1989479.9	124258.2	5.90	294	711	979	1,221	1,488	296	713	981	1,223	1,490
8	J20	1990626.3	147818.0	4.60	206	493	696	787	961	204	489	690	780	953
9	J21	1987369.7	144332.2	8.30	353	842	1,207	1,371	1,685	350	835	1,197	1,359	1,671
10	J Strodes Run	1992723.0	139600.9	11.70	495	1,166	1,674	1,928	2,380	495	1,162	1,668	1,921	2,372
11	J23	2007151.0	132883.6	4.90	246	597	786	951	1,076	246	597	786	951	1,076
12	J Long Hollow Run	1934629.7	82532.1	7.60	334	767	1,125	1,360	1,520	334	767	1,125	1,360	1,519
13	J Minehart Run	2001999.6	141744.3	6.00	308	752	1,001	1,208	1,374	309	753	1,003	1,209	1,375
14	J3	1949770.7	70911.5	2417.00	3,547	54,307	64,730	85,496	107,476	3,555	54,326	64,758	85,529	107,513
15	J4	1950825.6	75149.2	2419.90	3,523	54,323	64,767	85,570	107,600	3,528	54,340	64,792	85,600	107,636
16	J8	1953146.2	86740.6	2431.50	3,718	55,201	65,910	86,784	109,098	3,724	55,213	65,927	86,802	109,119
17	J9	1960409.0	95631.0	2433.80	3,673	54,943	65,574	86,454	108,733	3,677	54,953	65,589	86,471	108,752
18	J10	1966245.3	99029.3	2435.30	3,654	54,857	65,453	86,328	108,589	3,658	54,865	65,465	86,342	108,606
19	J12	1972700.5	118293.8	2445.50	3,742	55,313	66,135	87,234	109,701	3,746	55,322	66,147	87,248	109,717
20	J15	1971850.3	121499.5	2452.40	3,776	55,452	66,320	87,453	109,968	3,780	55,461	66,333	87,467	109,985
21	J17	1982890.6	127979.2	2458.90	3,788	55,452	66,291	87,426	109,934	3,791	55,462	66,304	87,441	109,952
22	J19	1989723.1	125231.0	2464.80	3,819	55,560	66,429	87,632	110,214	3,823	55,570	66,442	87,648	110,233
23	J5	1947263.1	106507.6	4.10	163	408	538	540	671	162	407	536	538	668
24	J22	1995900.7	137576.4	2476.50	3,882	55,833	66,809	88,122	110,876	3,886	55,844	66,823	88,141	110,902
25	J24	2001229.8	141986.4	2482.40	3,892	55,983	67,014	88,381	111,176	3,896	55,995	67,029	88,401	111,202
26	J25	2014384.5	148125.4	2485.60	3,845	55,935	66,917	88,179	110,825	3,848	55,946	66,932	88,196	110,846
27	Juniata Outflow	2017079.8	155364.9	2485.60	3,824	55,845	66,779	87,983	110,557	3,828	55,855	66,792	87,999	110,577
28	J6	1950454.7	93676.1	6.10	213	505	665	690	853	213	503	663	687	850
29	J7	1950646.4	91560.5	7.30	280	674	899	969	1,201	279	671	896	965	1,197
30	J Beaverdam Run	1952899.9	86992.6	11.60	475	1,121	1,492	1,636	2,010	474	1,117	1,487	1,631	2,002
31	J11	1961154.8	112979.2	8.60	350	970	1,378	1,638	1,836	353	978	1,388	1,650	1,850
32	J Musser Run	1971310.9	117929.6	10.20	403	1,110	1,579	1,886	2,130	408	1,121	1,594	1,904	2,150
33	J14	1962538.5	127053.9	0.90	31	114	170	198	245	31	115	170	199	247

Hydrologic Parameters for Jacks Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)			Future Conditions (2020)		
			% Imp	CN	Lag (min)	% Imp	CN	Lag (min)
Belltown Run	W540	2.68	1.2	66.0	56.7	1.25	66.1	56.7
	W570	3.40	2.6	70.7	78.0	2.66	70.7	77.9
Jacks Creek	W1020	2.62	3.4	66.2	82.5	3.62	66.3	82.3
	W1030	3.44	1.9	65.5	69.3	2.13	65.6	69.2
	W480	2.59	0.3	68.8	59.7	0.30	68.8	59.7
	W490	2.50	1.2	72.5	85.5	1.17	72.5	85.5
	W520	2.90	1.1	69.8	65.2	1.19	69.8	65.2
	W560	2.26	2.1	72.4	53.7	2.16	72.4	53.7
	W650	3.09	2.5	72.1	64.4	2.65	72.1	64.3
	W670	1.48	2.7	72.6	51.2	2.71	72.6	51.2
	W730	0.02		73.0	8.0	0.00	73.0	8.0
	W750	3.59	2.0	68.4	70.9	2.06	68.4	70.8
	W860	3.01	1.4	64.6	83.6	1.46	64.6	83.6
	W970	2.63	1.7	67.5	63.1	1.74	67.5	63.0
	W980	1.57	1.0	67.8	47.4	1.01	67.8	47.4
Meadow Creek	W620	3.53	1.6	65.8	76.9	1.71	65.9	76.8
	W720	1.86	1.9	66.4	57.8	2.01	66.4	57.8
	W760	3.09	1.2	63.0	81.4	1.49	63.1	81.1
	W770	0.09	8.0	73.1	15.3	8.72	73.3	15.2
	W780	3.63	3.4	71.4	71.8	3.60	71.5	71.7
	W880	2.41	1.6	69.2	85.2	1.68	69.2	85.2
	W890	2.61	4.8	67.3	78.2	5.57	67.5	77.7
Wagner Run	W1070	2.35	2.2	67.4	91.4	2.36	67.4	91.3
	W1080	2.58	1.1	65.4	60.6	1.11	65.4	60.6

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Hydrologic Parameters for Jacks Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Belltown Run	W540	66.0	65.1	59.9	57.2	54.1	51.0
	W570	70.7	68.2	63.7	61.3	58.4	55.6
Jacks Creek	W1020	66.2	68.6	66.5	63.8	60.9	57.8
	W1030	65.5	64.9	61.6	58.3	54.4	51.5
	W480	68.8	66.1	62.4	59.1	55.3	52.2
	W490	72.5	68.8	65.9	62.8	59.1	56.1
	W520	69.8	66.1	60.9	58.2	55.0	51.8
	W560	72.4	68.3	64.9	62.7	60.2	56.5
	W650	72.1	69.3	65.6	63.6	61.2	57.5
	W670	72.6	68.6	65.6	63.6	61.3	57.8
	W730	73.0	71.1	67.6	65.1	62.2	59.2
	W750	68.4	65.2	60.6	57.9	54.8	51.8
	W860	64.6	66.0	60.9	58.1	54.9	52.0
	W970	67.5	64.3	59.6	56.9	54.0	50.7
	W980	67.8	62.2	57.0	54.0	50.5	48.9
Meadow Creek	W620	65.8	66.1	61.7	59.1	56.1	53.4
	W720	66.4	64.2	59.7	57.2	54.5	51.4
	W760	63.0	65.8	60.9	58.3	55.3	52.4
	W770	73.1	71.3	67.8	65.3	62.4	59.4
	W780	71.4	68.6	64.7	62.2	59.3	55.0
	W880	69.2	61.3	57.9	55.6	53.0	51.2
	W890	67.3	69.1	65.6	63.2	60.5	56.8
Wagner Run	W1070	67.4	67.7	64.5	61.3	57.6	54.6
	W1080	65.4	64.4	60.7	57.3	53.4	50.4

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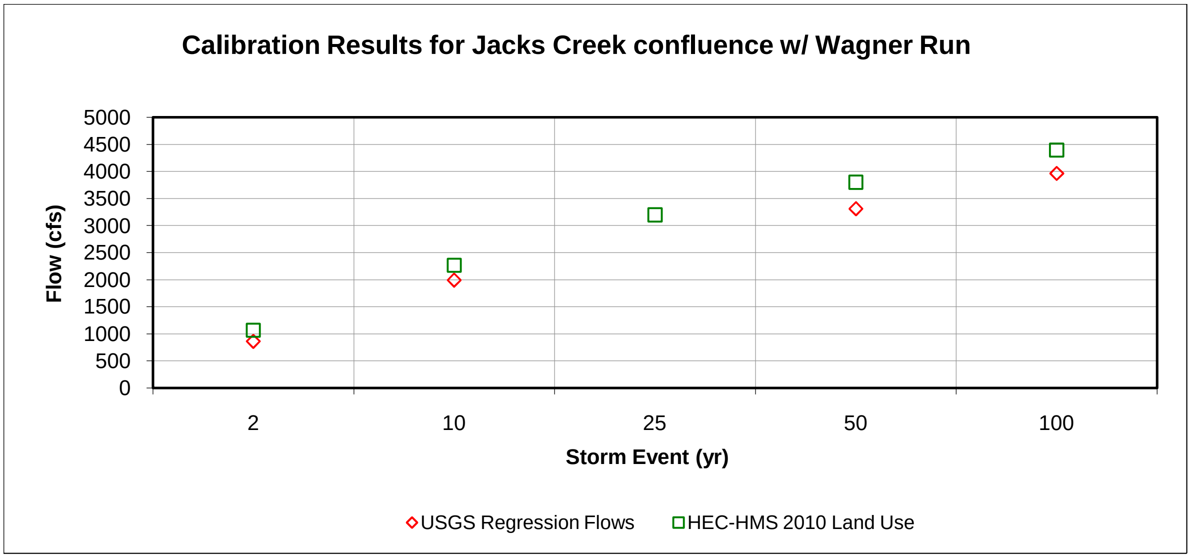
Hydrologic Parameters for Jacks Creek HEC-HMS Model

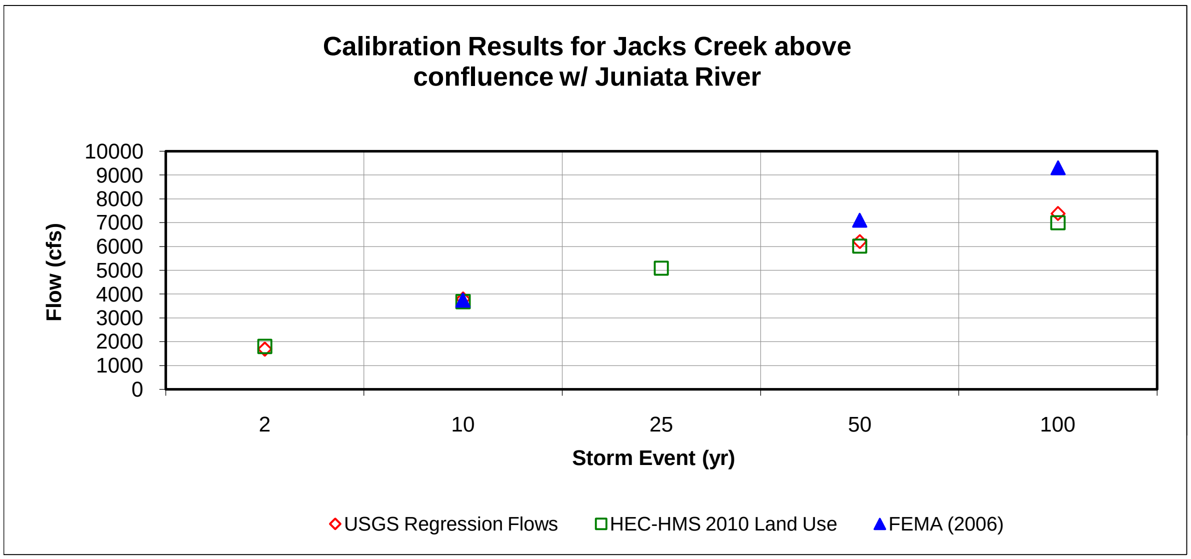
Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Belltown Run	W540	66.1	65.1	59.9	57.2	54.1	51.1
	W570	70.7	68.3	63.7	61.3	58.5	55.6
Jacks Creek	W1020	66.3	68.7	66.5	63.9	61.0	57.8
	W1030	65.6	64.9	61.7	58.4	54.5	51.6
	W480	68.8	66.1	62.4	59.1	55.3	52.2
	W490	72.5	68.8	65.9	62.8	59.1	56.1
	W520	69.8	66.1	60.9	58.2	55.0	51.9
	W560	72.4	68.3	64.9	62.7	60.3	56.6
	W650	72.1	69.3	65.7	63.6	61.3	57.6
	W670	72.6	68.6	65.6	63.6	61.3	57.8
	W730	73.0	71.1	67.6	65.1	62.2	59.2
	W750	68.4	65.3	60.6	57.9	54.8	51.8
	W860	64.6	66.0	60.9	58.2	55.0	52.0
	W970	67.5	64.3	59.6	57.0	54.0	50.7
	W980	67.8	62.2	57.0	54.0	50.5	48.9
Meadow Creek	W620	65.9	66.2	61.8	59.2	56.1	53.4
	W720	66.4	64.2	59.7	57.3	54.5	51.5
	W760	63.1	65.9	61.0	58.4	55.5	52.5
	W770	73.3	71.5	68.1	65.6	62.6	59.7
	W780	71.5	68.6	64.8	62.2	59.3	55.1
	W880	69.2	61.3	57.9	55.6	53.0	51.2
	W890	67.5	69.4	65.9	63.5	60.7	57.1
Wagner Run	W1070	67.4	67.7	64.5	61.4	57.7	54.7
	W1080	65.4	64.4	60.7	57.3	53.4	50.4

Hydrologic Results for Jacks Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi²)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J102	2070423.7	188112.4	2.58	157	386	517	567	660	157	386	517	568	660
2	J286	2063882.8	189123.9	20.89	895	1,868	2,617	3,109	3,635	896	1,869	2,618	3,111	3,637
3	J278	2063792.9	188202.3	25.83	1,068	2,268	3,197	3,800	4,394	1,070	2,270	3,203	3,807	4,400
4	J275	2057521.7	181369.2	29.42	1,133	2,412	3,360	3,991	4,638	1,135	2,415	3,364	3,996	4,644
5	J265	2050396.4	176604.0	44.63	1,639	3,419	4,758	5,624	6,551	1,645	3,427	4,768	5,635	6,564
6	J Near P4	2044170.2	173704.5	46.20	1,633	3,394	4,733	5,600	6,521	1,637	3,402	4,743	5,610	6,533
7	J257	2036213.3	169568.7	53.84	1,754	3,621	5,043	5,974	6,961	1,760	3,630	5,055	5,986	6,975
8	J101	2028660.9	161409.4	57.28	1,765	3,620	5,006	5,922	6,894	1,770	3,628	5,019	5,934	6,909
9	Outlet	2021603.1	151665.5	59.91	1,800	3,683	5,085	6,014	7,001	1,806	3,691	5,097	6,027	7,015
10	J298	2061208.0	198451.9	2.68	187	392	557	654	760	187	393	558	655	761
11	J283	2048980.4	187550.5	5.39	333	734	1,038	1,229	1,445	334	736	1,040	1,233	1,449
12	J270	2049025.3	186853.7	8.56	518	1,113	1,575	1,863	2,185	522	1,120	1,584	1,874	2,198
13	J260	2036213.3	172265.9	2.41	79	220	329	403	516	79	221	329	404	517
14	J308	2080943.0	206701.1	2.59	197	451	601	663	772	197	451	601	663	772
15	J301	2076267.8	199643.2	7.98	489	1,079	1,470	1,693	2,007	489	1,079	1,470	1,694	2,008
16	J295	2074537.0	197328.1	10.24	584	1,264	1,722	1,991	2,359	584	1,264	1,722	1,993	2,360
17	P3	2067142.0	192517.9	13.33	665	1,415	1,936	2,283	2,674	666	1,416	1,937	2,285	2,675

Calibration Results for HEC-HMS Models





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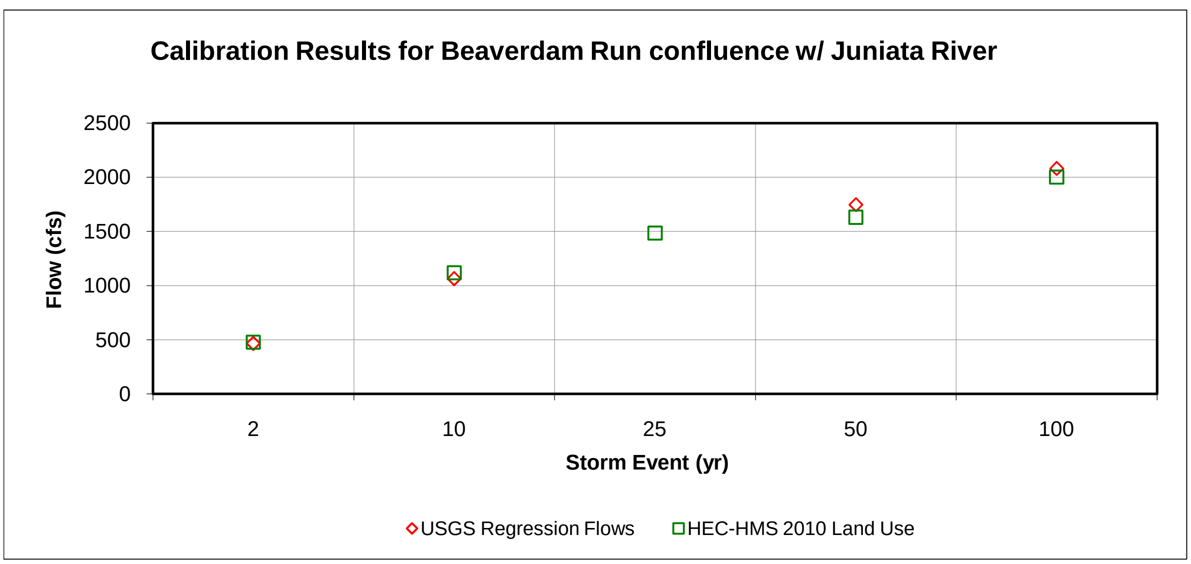
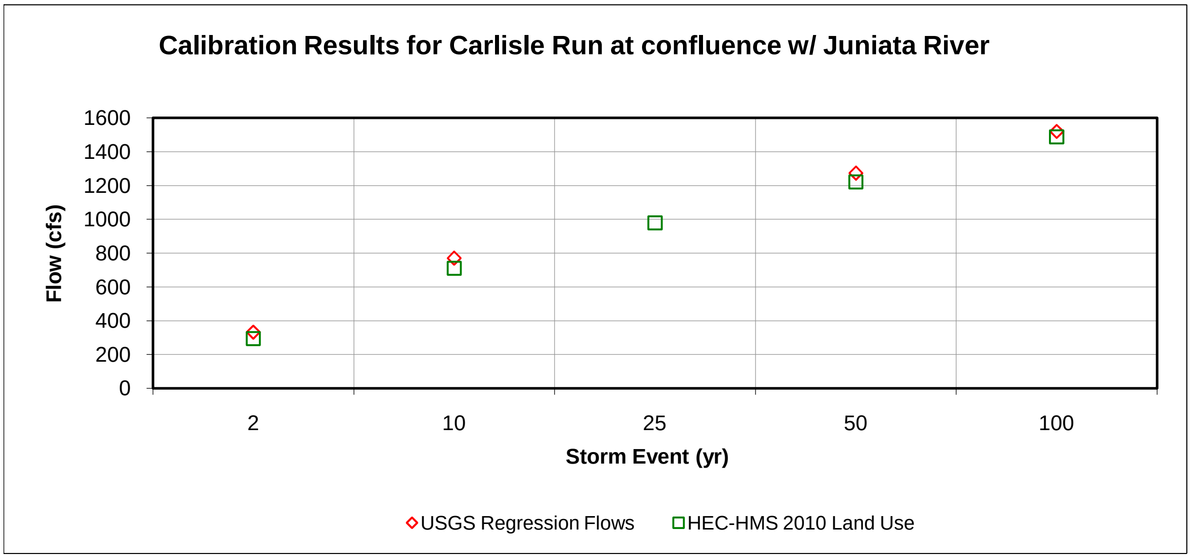
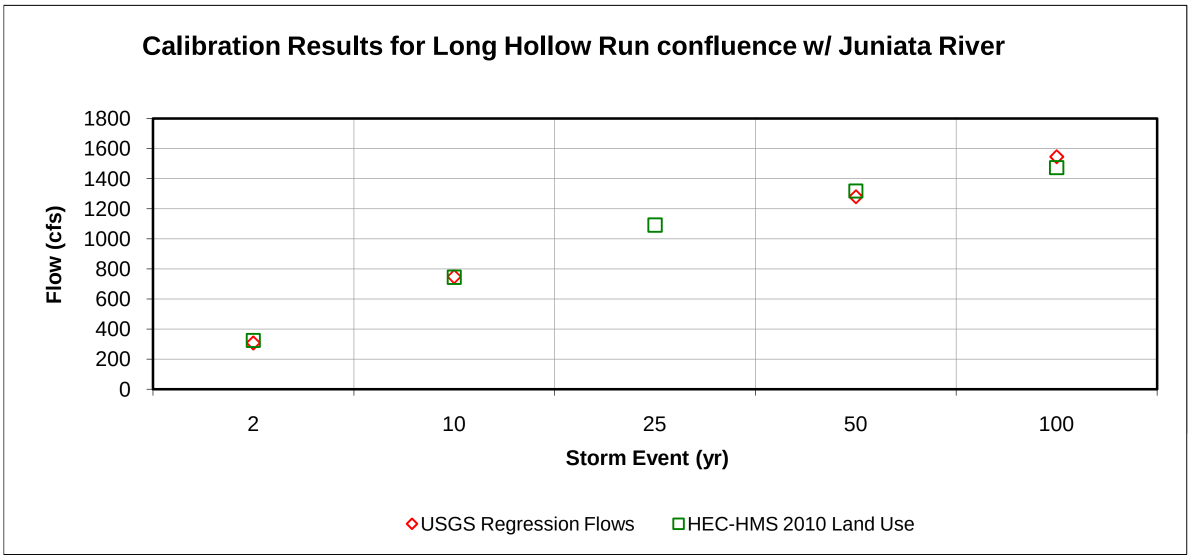
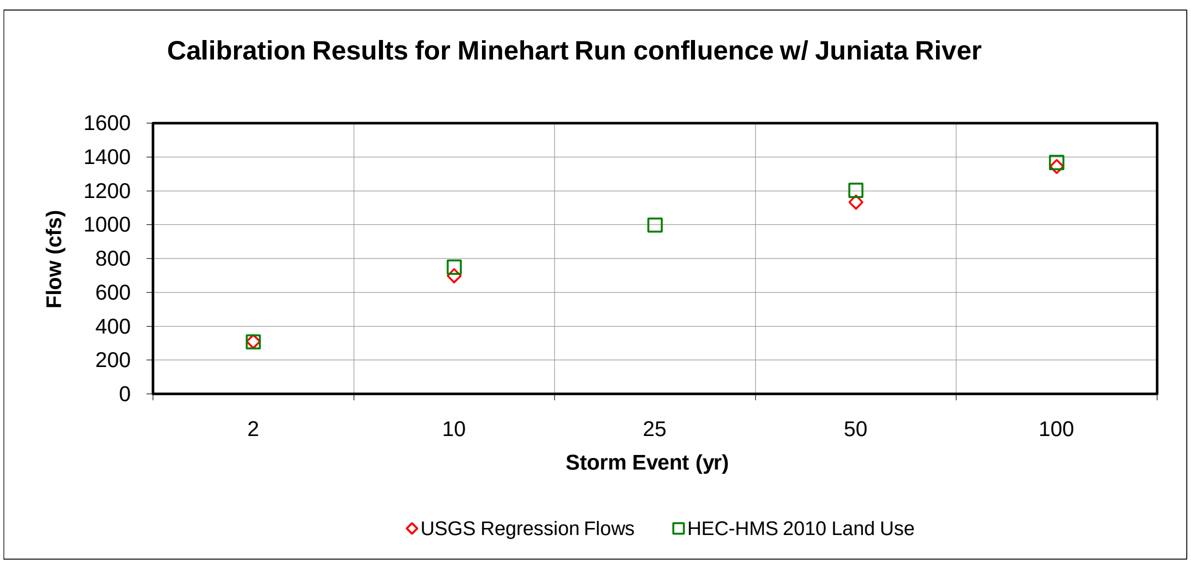


Calibration Results for HEC-HMS Models







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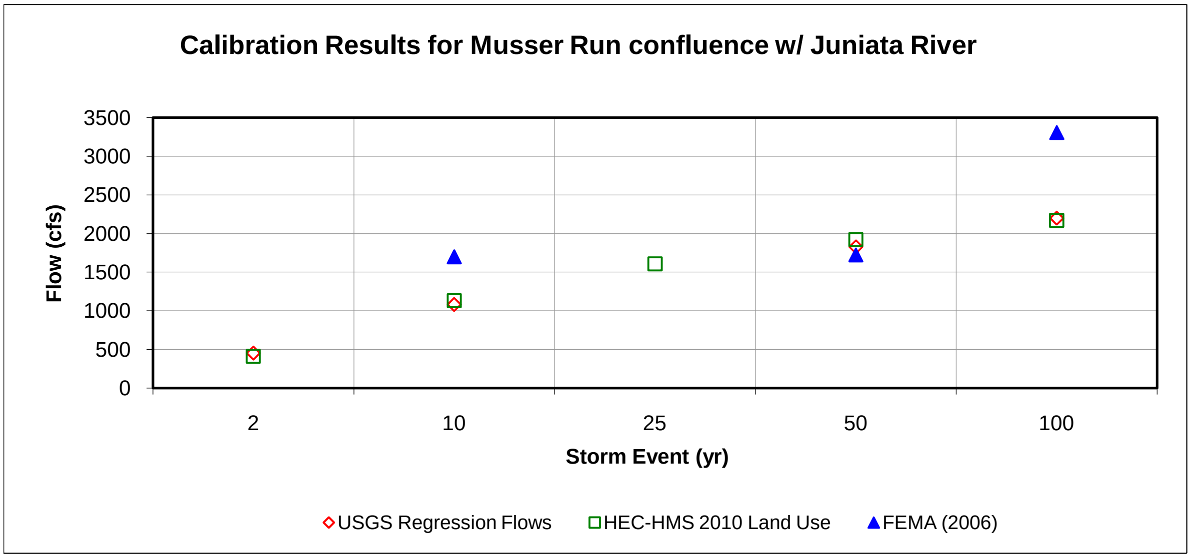
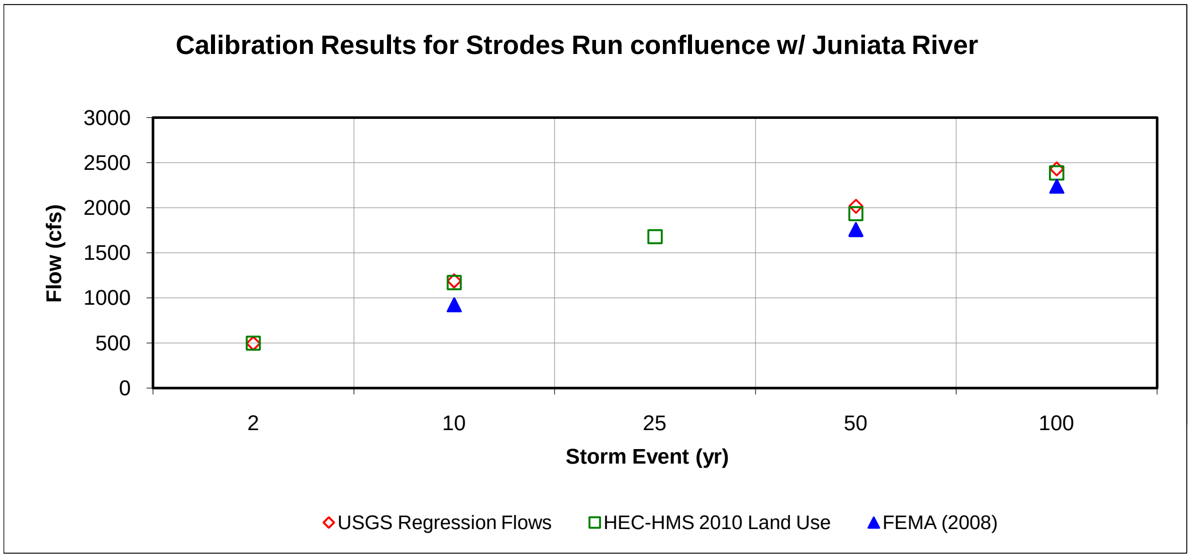
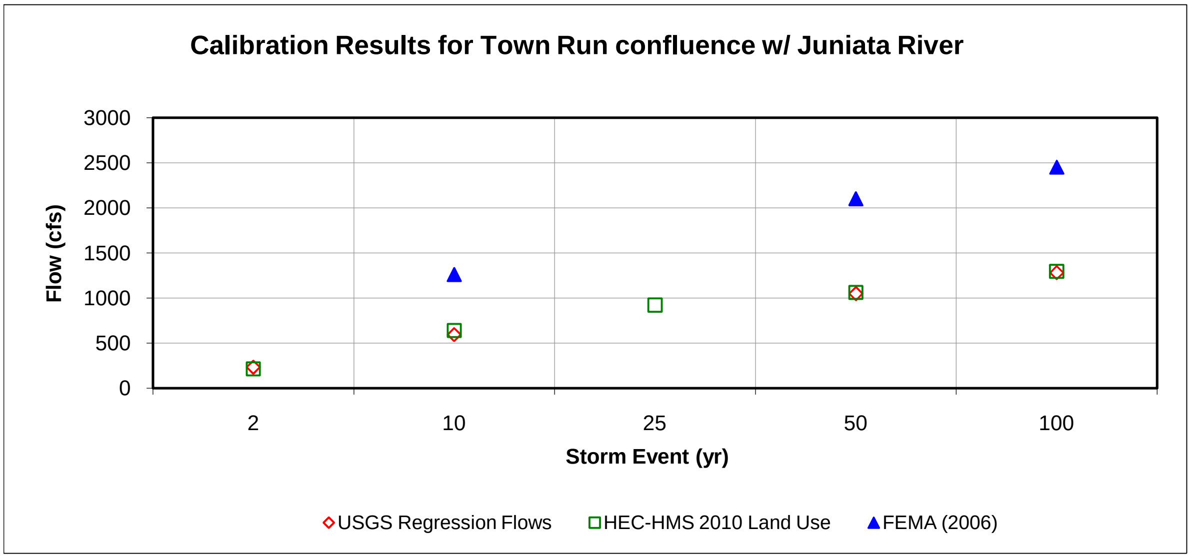
Calibration Results for HEC-HMS Models







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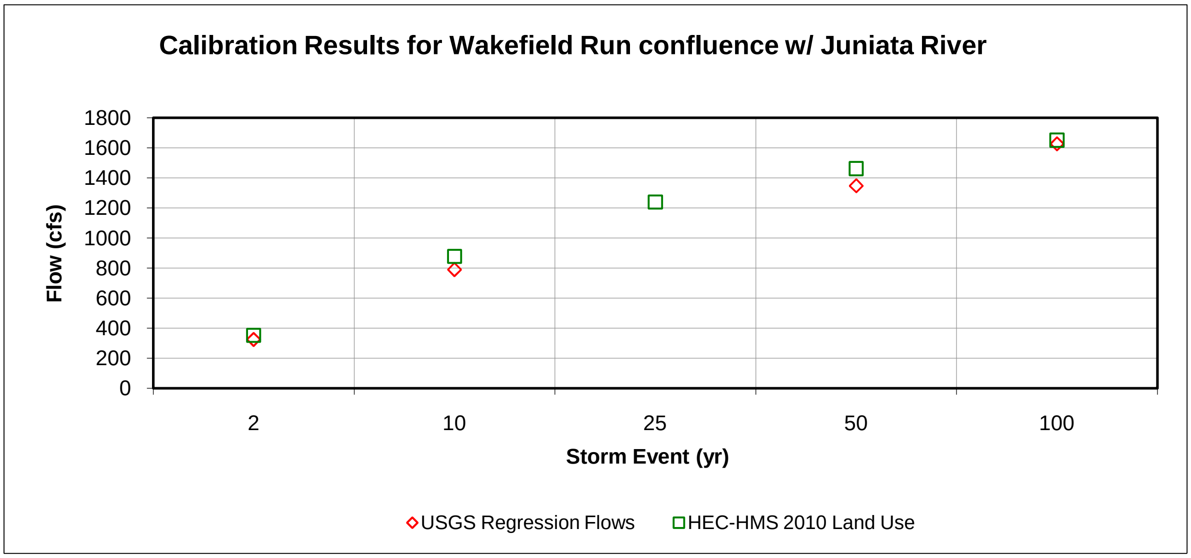
Calibration Results for Wakefield Run confluence w/ Juniata River
Flow (cfs)
1800
1600
1400
1200
1000
800
600
400
200
0
2
10
25
50
100
Storm Event (yr)
USGS Regression Flows
HEC-HMS 2010 Land Use

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Appendix B – Supporting Calculations for the Design Example

The *Model Ordinance* has been developed to implement a variety of control standards in order to achieve a holistic approach to stormwater management. The overall design process has been addressed in *Section VIII* of this Plan. The following example calculations have been provided to further clarify the design method. These calculations parallel the calculations that are made on the worksheets provided in the *Pennsylvania Stormwater Best Management Practices Manual* (PA BMP Manual) a copy of which are provided at the back of this appendix.

SUPPORTING CALCULATIONS - DESIGN EXAMPLE 1

NON-STRUCTURAL BMP CREDITS

Protect Sensitive Natural Resources
(Refer to Worksheet 2 & Worksheet 3)

Stormwater Management Area = Total Drainage Area – Protected Area

= 9.78 – 1.31(woods) – 0.37 (minimum disturbance)
= **8.1-Acres**

This is the total area used for pre-development and post-development volume calculations.

Minimum Soil Compaction
(Refer to *Worksheet 3*)

Lawn Area (post development) protected from compaction = 16,165-ft^2

16,165-ft^2 x 1/4" x 1/12 = **337-ft^3**

To be eligible for this credit, areas must not be compacted during construction and be guaranteed to remain protected from compaction. Minimum soil compaction credits for lawn area (Open Space) are applicable for this example because specific measures were utilized to protect the back yard lawn areas of Lots 9 & 10 and this area has been placed in a permanent minimum soil compaction easement. Credits for the meadow area can be applied for areas that are not disturbed during construction and will remain in pre-development vegetated cover condition.

Disconnect Non-Roof Impervious to Vegetated Areas
(Refer to *Worksheet 3*)

Lot Impervious Area = 10 (Lots) x 1,000 (ft^2/lot) = 10,000-ft^2.
10,000-ft^2 x 1/3" x 1/12 = **278-ft^3**

This credit is applied for the impervious surfaces (driveways and sidewalks) which direct runoff to vegetated surfaces and not directly into a stormwater collection system. The 1/3" credit is used because runoff discharges across the lawn area and is received by rain gardens, which are structures specifically placed to receive and infiltrate runoff. The 1/4" credit would be used for runoff not discharged to a specific infiltration structure or an area that has been protected from soil compaction.

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<u>*Summation of Non-Structural BMP Credits*</u>

= 337-ft^3 + 278-ft^3 = **615-ft^3**

CHANGE IN RUNOFF VOLUME FOR THE 2-YEAR STORM EVENT

(Refer to *Worksheet 4*)

2-year, 24-hour Rainfall Depth = 2.76”

Pre-Development 2-yr Runoff Volume = 5,682 ft^3

Post-Development 2-yr Runoff Volume = 18,281 ft^3

Change in Runoff Volume for the 2-year, 24-hour storm event:

= 18,2813-ft^3 – 5,682-ft^3 = **12,599-ft^3**

This is the volume that must be managed through a combination of non-structural BMP credits and structural BMP credits.

25% LIMIT FOR NON-STRUCTURAL BMP CREDITS

(Refer to *Worksheet 5*)

*Per Chapter 8 of the Pennsylvania Stormwater BMP Manual, Non-Structural Credits may be **no greater than 25%** of the total required control volume.*

Check 25% Non-Structural Credit Limit:

= 615-ft^3 / 12,599-ft^3 = **4.9%**

Calculated credits are under the allowable 25% limit for non-structural credits.

STRUCTURAL CONTROL VOLUME REQUIREMENT

(Refer to *Worksheet 5*)

Required Structural BMP infiltration volume:

= Change in Runoff Volume – Non-Structural BMP Credits
= 12,599-ft^3 – 615-ft^3 = **11,984-ft^3**

STRUCTURAL BMP VOLUME CREDITS

The sizing of structural infiltration BMPs is based on two primary criteria:

1. <u>Maximum loading ratios</u> – There are two different loading ratios that are important when determining the size of a structural BMP. These ratios are derived from guidelines found in the *Pennsylvania Stormwater BMP Manual*.
    a. Maximum loading ratio of Impervious Area to Infiltration Area = 5:1
    b. Maximum loading ratio of Total Drainage Area to Infiltration Area = 8:1
2. <u>Expected runoff volume loading</u> – Structural BMPs must be sized to accommodate the runoff volume they are expected to receive from the contributing drainage area. Some of this volume will be removed and the remainder must be safely conveyed through an overflow device. The removed volume, or infiltration volume, is the important

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component for sizing the infiltration BMP. A good starting point for infiltration volume is to calculate the contributing area runoff volume for the 2-year, 24-hour design storm. This volume may not be suitable for a particular site design, but starting with this volume will usually result in a design that is close to what is appropriate, and it can be adjusted as necessary. Additional design restrictions may exist for certain BMPs, so these should be considered prior to using this sizing method.

Dry Wells
(Example calculations shown for Lot #1; Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum dry well surface area for each lot based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 2,150-ft^2 (typ.)
= 2,150-ft^2 / 5 = **430-ft^2**
= minimum surface area of dry well per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 2,590-ft^2 (typ.)
= 2,590-ft^2 / 8 = **324-ft^2**
= minimum surface area of dry well per pervious loading ratio

The larger of the two calculated areas is the total minimum surface area required for each lot. An individual dry well is placed at each of the four major corners of the house to promote distribution of impervious area runoff. However, the total surface area is used throughout the remaining volume credit calculations for simplicity. The surface area of each dry well is calculated below:

Total Minimum Dry Well Surface Area ÷ Number of Dry Wells
=430 ft^2 / 4 = **107.5-ft^2**

Each dry well will be 10' x 11' to meet the minimum surface area requirements.

Volume:
Find the infiltration volume for each dry well based on the expected runoff volume.

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	I_a (0.2*S)	Runoff $Depth_{2-yr}$ (in)	Runoff $Volume_{2-yr}$ (ft^3)
Open Space (good)	B	110	0.00	61	6.393	1.279	0.28	3
Impervious	B	540	0.01	98	0.204	0.041	2.53	114
TOTAL:		**650**	**0.01**				**2.81**	**116**

Runoff volume = **116-ft^3**

Depth:
Each dry well will be filled with aggregate. The in-place aggregate will have a 40% voids ratio; therefore the volume is divided by the available void space to get a total volume.

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Depth = Total Volume / Surface Area

= (116-ft^3 / 0.40) / 110-ft^2 = **2.64-ft or approximately 2'-8"**

An overflow spillway or drain is then sized to convey any runoff that exceeds the design volume to the peak rate management facility.

Rain Gardens
(Example calculations shown for Lot #1; Refer to Worksheet 5A for additional calculations)

Surface Area:
Find the minimum surface area for each rain garden based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 1,000-ft^2
= 1,000-ft^2 / 5 = **200-ft^2**
= minimum surface area of rain garden per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 6,000-ft^2 (typ.)
= 4,775-ft^2 / 8 = **597-ft^2**
= minimum surface area of rain garden per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Rain Garden Surface Area = **597-ft^2**

Depth:
Design guidelines, from the *PA BMP Manual*, for rain gardens limit ponding depth within the facility to 12 inches or less. The rain gardens in this example have been designed with a total ponding depth of 12 inches. The overflow outlets are positioned 6 inches above the bottom elevation of the rain gardens and 6 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the rain garden is calculated by multiplying the surface area of the rain garden by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 700-ft^2 x 0.5-ft = **350-ft^3**

Bioretention
(Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum surface area for the bioretention facility based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 9,700-ft^2 (typ.)
= 9,700-ft^2 / 5 = **1,940-ft^2**

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= minimum surface area of Infiltration Trench per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 41,400-ft^2
= 41,400-ft^2 / 8 = **5,175-ft^2**
= minimum surface area of Infiltration Trench per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Infiltration Trench Surface Area = **5,175-ft^2**

Depth:
The bioretention facility in this example has been designed with a total depth of 18 inches. The overflow outlets are positioned 6 inches above the bottom elevation, and 12 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the bioretention facility is calculated by multiplying the surface area by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 5,175-ft^2 x 0.5-ft = **2,487.5-ft^3**

STRUCTURAL CONTROL VOLUME REQUIREMENT CHECK

(Refer to *Worksheet 5*)

Check the total structural volume to be certain it is adequate to meet the structural volume requirement.

= Total Structural Volume - Structural Volume Requirement
=14,613-ft^3 – 11,984-ft^3 = 2,629-ft^3

The structural volume requirement has been exceeded by 2,629-ft^3 and no further BMP calculations are necessary.

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Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 1. GENERAL SITE INFORMATION

INSTRUCTIONS: Fill out *Worksheet 1* for each watershed

Date: 2/29/2010

Project Name: DESIGN EXAMPLE 1

Municipality: VENANGO TOWNSHIP

County: ERIE

Total Area (acres): 9.78

Major River Basin: OHIO RIVER
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/default.htm#newtopics

Watershed: FRENCH CREEK

Sub-Basin: ALLEGHENY RIVER

Nearest Surface Water(s) to Receive Runoff: MILL RUN

Chapter 93 - Designated Water Use: CWF
http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

Impaired according to Chapter 303(d) List? Yes [ ] No [X]
http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/303d-Report.htm
List Causes of Impairment:

Is project subject to, or part of:

Municipal Separate Storm Sewer System (MS4) Requirements? Yes [ ] No [X]
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/GeneralPermits/default.htm

Existing or planned drinking water supply? Yes [ ] No [X]

If yes, distance from proposed discharge (miles): ____________

Approved Act 167 Plan? Yes [X] No [ ]
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/Approved_1.html

Existing River Conservation Plan? Yes [X] No [ ]
http://www.dcnr.state.pa.us/brc/rivers/riversconservation/planningprojects/

FINAL

Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 2. SENSITIVE NATURAL RESOURCES

INSTRUCTIONS:

1. Provide Sensitive Resources Map according to non-structural BMP 5.4.1 in Chapter 5 of PA Stormwater BMP Manual. This map should identify waterbodies, floodplains, riparian areas, wetlands, woodlands, natural drainage ways, steep slopes, and other sensitive natural areas.

2. Summarize the existing extent of each sensitive resource in the Existing Sensitive Resources Table (below, using Acres). If none present, insert 0.

3. Summarize Total Protected Area as defined under BMPs in Chapter 5.

4. Do not count any area twice. For example, an area that is both a floodplain and a wetland may only be considered once.

EXISTING NATURAL SENSITIVE RESOURCE	MAPPED? yes/no/n/a	TOTAL AREA (Ac.)	PROTECTED AREA (Ac.)
Waterbodies	yes	0.00	
Floodplains	no	0.00	
Riparian Areas	no	0.00	
Wetlands	no	0.00	
Woodlands	yes	2.29	1.31
Natural Drainage Ways	N/A	0.00	
Steep Slopes, 15% - 25%	N/A	0.00	
Steep Slopes, over 25%	N/A	0.00	
Other:	N/A		
Other:	N/A		
TOTAL EXISTING:		**2.29**	**1.31**

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Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 3. NON-STRUCTURAL BMP CREDITS

PROTECTED AREA

1.1 Area of Protected Sensitive/Special Value Features (see WS 2)	**1.31**	**Ac.**
1.2 Area of Riparian Forest Buffer Protection	**0.00**	**Ac.**
3.1 Area of Minimum Disturbance/Reduced Grading	**0.37**	**Ac.**
TOTAL	**1.68**	**Ac.**

Site Area	*minus*	Protected Area	=	Stormwater Management Area
9.78	-	**1.68**	=	**8.10**

VOLUME CREDITS

3.1 Minimum Soil Compaction						
Lawn	**16,165**	ft^2	x 1/4"	x 1/12	=	**337** ft^3
Meadow	**N/A**	ft^2	x 1/3"	x 1/12	=	**0** ft^3
3.3 Protect Existing Trees						
For Trees within 100 feet of impervious area:						
Tree Canopy	**N/A**	ft^2	x 1/2"	x 1/12	=	**0** ft^3
For Trees within 20 feet of impervious area:						
Tree Canopy	**N/A**	ft^2	x 1"	x 1/12	=	**0** ft^3
5.1 Disconnect Roof Leaders to Vegetated Areas						
For runoff directed to areas protected under 5.8.1 and 5.8.2						
Roof Area	**N/A**	ft^2	x 1/3"	x 1/12	=	**0** ft^3
For all other disconnected roof areas						
Roof Area	**N/A**	ft^2	x 1/4"	x 1/12	=	**0** ft^3
5.2 Disconnect Non-Roof Impervious to Vegetated Areas						
For Runoff directed to areas protected under 5.8.1 and 5.8.2						
Impervious Area	**10,000**	ft^2	x 1/3"	x 1/12	=	**278** ft^3
For all other disconnected non-roof impervious areas						
Impervious Area	**N/A**	ft^2	x 1/4"	x 1/12	=	**0** ft^3

TOTAL NON-STRUCTURAL VOLUME CREDIT* **615** ft^3

** For use on Worksheet 5*

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Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 4. CHANGE IN RUNOFF VOLUME FOR 2-YR STORM EVENT

PROJECT: DESIGN EXAMPLE 1
Drainage Area: 8.10 (acres)
2-Year Rainfall: 2.76 inches *(From NOAA Atlas 14)*

Total Site Area: 9.78 acres
Protected Site Area: 1.68 acres
Stormwater Management Area: 8.10 acres *(From Worksheet 3)*

Existing Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Woods (good)	B	42,500	0.98	55	8.1818	1.6364	0.14	481
Meadow	B	310,255	7.12	58	7.2414	1.4483	0.20	5,201
								-
								-
								-
								-
TOTAL:		352,755	8.10					5,682

Developed Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Meadow	B	54,060	1.24	58	7.2414	1.4483	0.20	906
Open Space (good)	B	243,035	5.58	61	6.3934	1.2787	0.28	5,643
Impervious	B	55,660	1.28	98	0.2041	0.0408	2.53	11,732
								-
								-
								-
TOTAL:		352,755	8.10					18,281

2-Year Volume Increase (ft^3):	12,599

2-Year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume
= 18,281 - 5,682 = 12,599 ft^3

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where
   P = 2-Year Rainfall (in)
   S = (1000/ CN)-10

2. Runoff Volume (CF) = Q x Area x 1/12
   Q = Runoff (in)
   Area = Land use area (sq. ft)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSG. The use of a weighted CN value for volume calculations is not acceptable.

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HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5. STRUCTURAL BMP VOLUME CREDITS

SUB-BASIN: N/A

Check 25% Limit for Non-Structural BMP Credits: 615
÷ 12,599
4.9%

Required Control Volume (ft^3): 12,599
Allowable Non-structural Volume Credit (ft^3): - 615

Structural Volume Reqmt (ft^3): 11,984
(Required Control Volume minus Non-structural Credit)

Proposed BMP		Area (ft^2)	Infiltration Volume (ft^3)
6.4.1	Porous Pavement		
6.4.2	Infiltration Basin		
6.4.3	Infiltration Bed		
6.4.4	Infiltration Trench		
6.4.5	Rain Garden/Bioretention	11,915	8,827
6.4.6	Dry Well / Seepage Pit	4,400	5,787
6.4.7	Constructed Filter		
6.4.8	Vegetated Swale		
6.4.9	Vegetated Filter Strip		
6.4.10	Berm		
6.5.1	Vegetated Roof		
6.5.2	Capture and Re-use		
6.6.1	Constructed Wetlands		
6.6.2	Wet Pond / Retention Basin		
6.6.3	Dry Extended Detention Basin		
6.6.4	Water Quality Filters		
6.7.1	Riparian Buffer Restoration		
6.7.2	Landscape Restoration / Reforestation		
6.7.3	Soil Amendment		
6.8.1	Level Spreader		
6.8.2	Special Storage Areas		
Other			

Total Structural Volume (ft^3): 14,613
Structural Volume Requirement (ft^3): 11,984

DIFFERENCE: 2,629 *(excess)*

* Complete BMP Design Checklist for each measure proposed
NOTE: Provide supporting Volume Calculations for each Structural BMP

FINAL

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5.A - INFILTRATION BMP SUPPORTING CALCULATIONS

Instructions: Complete this worksheet for each Point of Interest / Discharge (at a minimum)

Point of Interest / Discharge: ***Basin Outfall***
Total Drainage Area to POI: 352,755 ft²
Total Impervious Area: 55,660 ft²

Proposed Infiltration BMP(s)		Infiltration Rate				Infiltration Period			Hydraulic Loading: Imperv. Drainage Area Loading				Hydraulic Loading: Total Drainage Area Loading						
		Measured Infilt Rate[1] *in/hr*	FOS	Design Infilt Rate *in/hr*	Design Runoff Volume *cu. ft.*	Infilt. Period[2] *hrs*	Active Infilt.[3] *hrs*	Total Infilt Period *hrs*	Imperv. DA *sq. ft.*	% area draining to BMP	Imperv Area Loading Ratio	Imperv Target Area *sq. ft.*	Total Drainage Area *sq. ft.*	% area draining to BMP[4]	Total Area Loading Ratio	Total Target Area *sq. ft.*	Target BMP Area[5] *sq. ft.*	Actual BMP Area[6] *sq. ft.*	**Computed Infiltration Volume** *cu. ft.*
BMP 6.4.1	**Porous Pavement w. Infilt. Bed**							***Subtotal:***			***5***				***8***				
BMP 6.4.2	**Infiltration Basin**							***Subtotal:***			***5***				***8***				
BMP 6.4.3	**Subsurface Infiltration Bed**							***Subtotal:***			***5***				***8***				
BMP 6.4.4	**Infiltration Trench**							***Subtotal:***			***5***				***8***				
BMP 6.4.5	**Rain Garden/Bioretention**							***Subtotal:***	***19,700***		***5***		***89,685***		***8***			***11,915***	***8,827***
	Rain Garden (Lot #1)	0.93	2	0.47	350	12.9	6	18.9	1,000	100.0		200	4,775	100.0		597	597	700	513
	Rain Garden (Lot #2)	0.95	2	0.48	350	12.6	6	18.6	1,000	100.0		200	5,600	100.0		700	700	700	516
	Rain Garden (Lot #3)	0.98	2	0.49	350	12.2	6	18.2	1,000	100.0		200	5,080	100.0		635	635	700	522
	Rain Garden (Lot #4)	1.01	2	0.51	300	11.9	6	17.9	1,000	100.0		200	3,625	100.0		453	453	600	452
	Rain Garden (Lot #5)	1.02	2	0.51	458	11.8	6	17.8	1,000	100.0		200	7,005	100.0		876	876	915	691
	Rain Garden (Lot #6)	1.08	2	0.54	350	11.1	6	17.1	1,000	100.0		200	5,310	100.0		664	664	700	539
	Rain Garden (Lot #7)	0.91	2	0.46	300	13.2	6	19.2	1,000	100.0		200	4,395	100.0		549	549	600	437
	Rain Garden (Lot #8)	0.99	2	0.50	238	12.1	6	18.1	1,000	100.0		200	3,000	100.0		375	375	475	355
	Rain Garden (Lot #9)	1.05	2	0.53	300	11.4	6	17.4	1,000	100.0		200	4,520	100.0		565	565	600	458
	Rain Garden (Lot #10)	1.03	2	0.52	375	11.7	6	17.7	1,000	100.0		200	4,975	100.0		622	622	750	568
	Bioretention 1	0.92	2	0.46	2588	13.0	6	19.0	9,700	100.0		1,940	41,400	100.0		5,175	5,175	5,175	3,778
BMP 6.4.6	**Dry Well / Seepage Pit**							***Subtotal:***	***21,500***		***5***		***25,900***		***8***			***4,400***	***5,787***
	Dry Well (Lot #1)	0.98	2	0.49	468	26.0	6	32.0	2,150	100.0		430	2,590	100.0		324	430	440	576
	Dry Well (Lot #2)	0.91	2	0.46	468	28.1	6	34.1	2,150	100.0		430	2,590	100.0		324	430	440	568
	Dry Well (Lot #3)	1.06	2	0.53	468	24.1	6	30.1	2,150	100.0		430	2,590	100.0		324	430	440	585
	Dry Well (Lot #4)	1.02	2	0.51	468	25.0	6	31.0	2,150	100.0		430	2,590	100.0		324	430	440	580
	Dry Well (Lot #5)	0.93	2	0.47	468	27.4	6	33.4	2,150	100.0		430	2,590	100.0		324	430	440	570
	Dry Well (Lot #6)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
	Dry Well (Lot #7)	0.97	2	0.49	468	26.3	6	32.3	2,150	100.0		430	2,590	100.0		324	430	440	575
	Dry Well (Lot #8)	1.01	2	0.51	468	25.3	6	31.3	2,150	100.0		430	2,590	100.0		324	430	440	579
	Dry Well (Lot #9)	1.04	2	0.52	468	24.5	6	30.5	2,150	100.0		430	2,590	100.0		324	430	440	582
	Dry Well (Lot #10)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
BMP 6.4.7	**Constructed Filter[7]**										5				8				
BMP 6.4.8	**Vegetated Swale[7]**										5				8				
BMP 6.4.9	**Vegetated Filter Strip[7]**										5				8				
BMP 6.4.10	**Infilt. Berm & Ret. Grading**										5				8				
																		TOTAL:	**14,613**

[1] Assumes a soil testing procedure which finds hydraulic conductivity. (e.g. perc tests may also require a reduction factor)
[2] Time it takes for BMP to empty once it is full. (Minimum = 24 hrs, Maximum = 72 hours; Applicable to retention and detention facilities only.)
[3] Infiltration that occurs during the storm (before becoming full). Not to exceed 6 hours.
[4] A portion of the total area draining to BMP from non-pervious area may be diverted.
[5] Inherent in these calculations are the allowable loading ratios (5:1 and 8:1) from the BMP Manual. Higher loading ratios will need to be justified. In Karst Areas, the max. loading ratio should be 3:1.
[6] Actual BMP Area may be larger than (but not smaller than) the Target BMP Area.
[7] These BMPs are not well represented by this computational process. See worksheet 5.C for vegetated swales and filter strips.

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PEAK RATE CONTROL ANALYSIS

According to the National Engineering Handbook (NRCS, 2008), the direct runoff for watersheds having more than one hydrologic soil-cover complex can be estimated in either of two ways. Runoff can be estimated for each complex and then weighted to get the watershed average. Alternatively, the CN values can be weighted, based on area, to obtain a single CN value to represent the entire drainage area. Then runoff is estimated with the single CN value. If the CN for the various hydrologic soil-cover complexes are close in value, both methods of weighting give similar results for runoff. However, if there exists a large difference in curve number value, the CN weighting method can provide drastically different results.

As described in the *National Engineering Handbook*, "the method of weighted runoff always gives the correct result (in terms of the given data), but it requires more work than the weighted CN method, especially when a watershed has many complexes. The method of weighted CN is easier to use with many complexes or with a series of storms. However, where differences in CN for a watershed are large, this method either under- or over-estimates runoff, depending on the size of the storm." This often occurs when impervious area exists in a subarea. When the relatively low curve number of lawn areas is combined with the high curve number of impervious areas, the weighted CN method will minimize the impact of the impervious surface and under-estimate the amount of runoff.

The spatial distribution of the different soil-cover complexes becomes the controlling factor in selection of the appropriate method. When different land uses behave as independent watershed the areas should be analyzed as separate drainage subareas. For example, when a large parking area is surrounded by lawn area that all flows to the same collection point, runoff from the impervious surface will occur much differently than runoff from the lawn. However, when impervious area is dispersed amongst other land uses and not directly connected to a stormwater collection system, the weighted CN method may be appropriate. The decision of whether or not to use a weighted curve number is often a site specific judgment that should be discussed between the designer and the Municipal Engineer in the early planning stages of a project.

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<u>*Pre-Development Soil-Cover Complex Data*</u>

Because the wooded area along the north property line will remain unchanged, and will not be tributary to the stormwater facilities, this area has been removed from the peak rate analysis drainage areas. The weighted CN method was used for pre-development calculations in this example because Curve Numbers for the hydrologic soil-cover complexes are close in value. The drainage area and land cover information necessary to calculate the pre-development runoff is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Woods (good)	B	42,500	0.98	55
Meadow	B	310,255	7.12	58
TOTAL:		352,755	8.10	58

<u>*Pre-Development Time of Concentration*</u>

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.

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

Where:

T_{lag} = Lag time (hours)
L = Hydraulic length of the watershed (feet)
Y = Average overland slope of watershed (percent)
S = Maximum retention in the watershed, as defined by: S = [(1000/CN) – 10]
CN = NRCS Curve Number for the watershed

Lag time is related to time of concentration by the following equation:

Time of Concentration = T_c = [(T_{lag}/.6) * 60] (minutes)

One method of calculating the average overland slope of a watershed is to select locations that represent the various slopes found in the watershed and weight the slope based on the area it represents. This method is shown in the table on the following page.

Slope	End Elevation		Distance	Slope	Percent of	Product
Line	High	Low	(ft)	(%)	Total Area	(% x %)
AA	909	902	148	4.7%	5%	0.24%
BB	941	909	475	6.7%	50%	3.37%
CC	956	942	245	5.7%	15%	0.86%
DD	960	943	180	9.4%	15%	1.42%
EE	943	930	265	4.9%	15%	0.74%
					Sum of Products =	6.61%

This is an estimation of the land slope value, so the calculated number is rounded to the nearest whole number for use in the Lag Equation. The hydraulic length of the watershed was measured at 1050 ft. Therefore,

$$T_{lag} = (1050)^{0.8}\frac{((1000/CN)-10)+1)^{0.7}}{1900\sqrt{7}}$$

T_{lag} = 0.23 hours

Time of Concentration = T_C = (T_{lag} / 0.6) * 60
= (0.23 / 0.6) * 60
= 23 minutes

Pre-Development Peak Rate Flows

All of this information was used to perform a pre-development peak rate analysis using a software package based on the NRCS TR-20 procedures. The results of the analysis are as follows:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.6	4.1	7.6	11.1	15.3
Runoff Volume (ac-ft)	0.060	0.136	0.449	0.726	0.997	1.322
Runoff Depth (in)	0.09	0.20	0.66	1.08	1.48	1.96

Table B.1. Pre-Development Runoff Summary

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Post-Development Soil-Cover Complex Data

Due to the disconnection of impervious areas and overland flow paths used in this design, the area weighted CN method was deemed appropriate and used to reduce the complexity of the model. The drainage area and land cover information for the drainage sub-area directly tributary to the bioretention facility is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Lawn (good condition)	B	9,700	0.22	61
Impervious	B	31,700	0.73	98
TOTAL:		41,400	0.95	70

Post-Development Time of Concentration

The Segmental Method was used for all post-development time of concentration calculations in this example. This method is covered in more detail in various NRCS publications (NRCS, 1986; NRCS, 2008). The following segments were used to calculate a time of concentration for the drainage sub-area directly tributary to the bioretention facility:

T_t-1: Sheet flow, 100' of lawn at 5% = 10.7 min
T_t-2: Shallow concentrated flow, 110' unpaved at 5.9% = 0.5 min
T_t-3: Channel flow, 80' at 4.0% = 0.2 min
T_t-4: Channel flow, 156' at 3.85% = 0.5 min
T_t-5: Pipe flow, 38' of 15" HDPE pipe at 5.2% = 0.1 min

$T_c = T_t\text{-}1 + T_t\text{-}2 + T_t\text{-}3 + T_t\text{-}4 + T_t\text{-}5 = 12$ minutes

Post-Development Peak Rate Flows

The hydrologic model for this example contains a considerable level of detail. Each structural BMP was modeled as a pond with a unique drainage area and time of concentration. Runoff was routed through each BMP and linked to downstream BMPs for subsequent routing. A detention basin with an outlet control structure was also added to the model. A graphical representation of the model is provided in *Figure B.1*.

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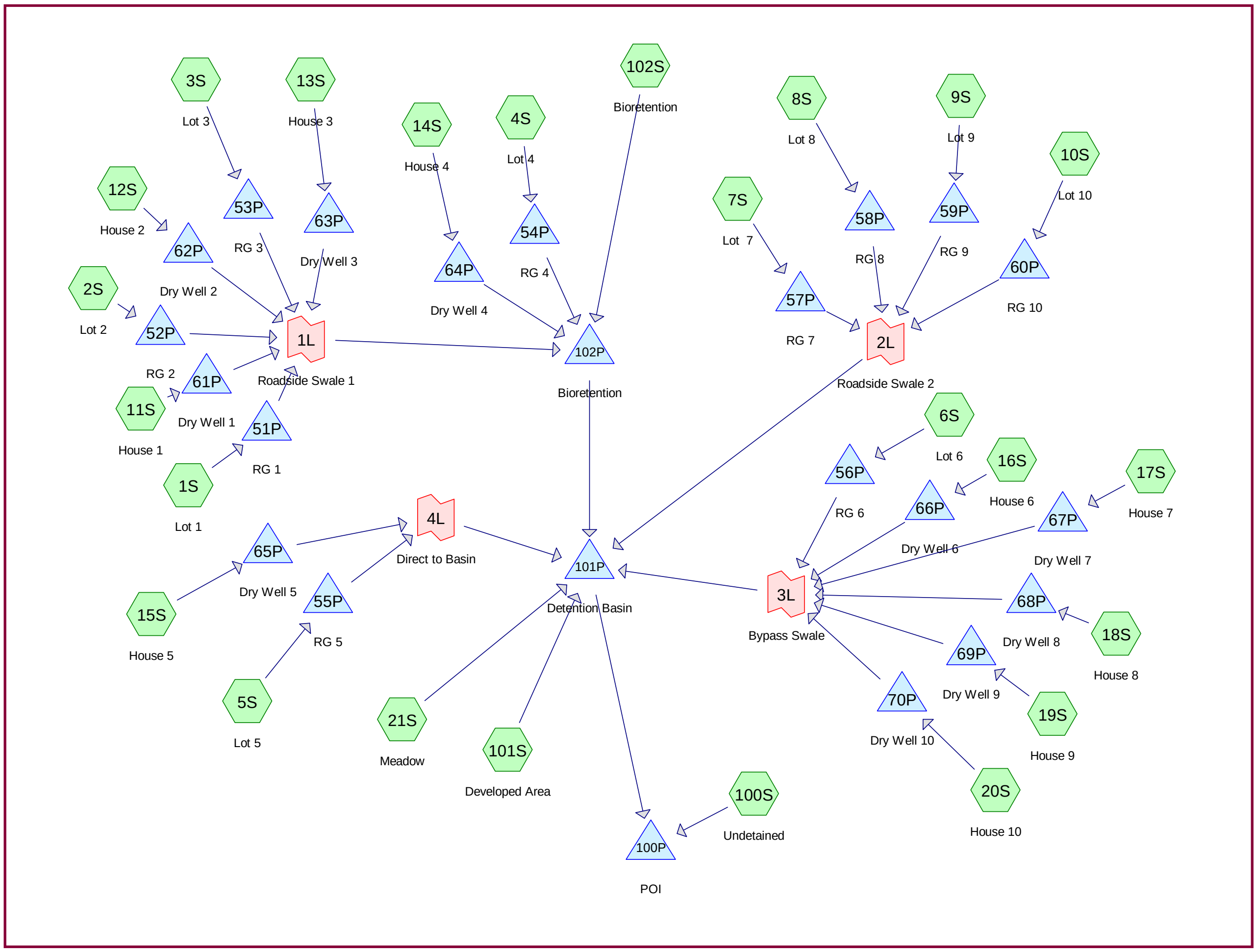

Figure B.1. Hydrologic Model of Post-Development Conditions

This model was used to estimate the post-development peak rate flows. The final configuration of the outlet structure was completed through an iterative process using the results of the model runs. This design meets the peak rate control requirements through a combination of volume removed by the structural `BMPs and the detention basin and outlet control structure. *Table B.2* shows a summary of the runoff results for the final post-development design:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.4	4.1	7.4	10.6	15.2
Runoff Volume (ac-ft)	0.079	0.147	0.445	0.717	1.011	1.367
Runoff Depth (in)	0.12	0.22	0.66	1.06	1.50	2.03

Table B.2. Summary of Post-Development Runoff with Stormwater Controls

INITIAL CONSTRUCTION COST - DESIGN EXAMPLE

Initial construction costs were estimated for each layout. The estimates include the costs incurred by the developer to complete earthwork, paving and curbing, and stormwater management facilities. All of these costs are summed to determine an initial construction cost for these facilities. This cost was then divided by the total sellable acreage of the project to determine a cost / sellable acre for each layout.

Estimate of Initial Construction Cost
Mill Run Residential – Traditional Layout

ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
EARTHWORK				**Subtotal =**	**$ 23,950**
1	Clearing & Grubbing	2.3	AC	$ 6,000.00	$ 13,800
2	Topsoil Removal/Stockpiling	5.8	AC	$ 1,750.00	$ 10,150
STORM DRAINAGE				**Subtotal =**	**$ 102,769**
3	Storm Sewer, 18" HDPE	600	LF	$ 55.00	$ 33,000
4	Storm Inlets	7	EA	$ 2,100.00	$ 14,700
5	Swales	490	LF	$ 10.00	$ 4,900
6	Install Detention Basin	1,525	CY	$ 25.00	$ 38,125
7	Anti Seep Collars	2	EA	$ 775.00	$ 1,550
8	Outlet Structure	1	EA	$ 4,000.00	$ 4,000
9	Outlet Pipe, 18" HDPE	50	LF	$ 55.00	$ 2,750
10	DW Endwall 24"	1	EA	$ 2,750.00	$ 2,750
11	Rip Rap Apron	144	SF	$ 6.90	$ 994
PAVING & CURBING				**Subtotal =**	**$ 138,657**
12	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	2,325	SY	$ 30.00	$ 69,750
13	Curbing w/Excavation & Backfill	1,465	LF	$ 27.00	$ 39,555
14	Sidewalk plain w/4" - stone	4,285	SF	$ 6.85	$ 29,352
				Initial Construction Cost =	**$ 265,376**
				Cost / Sellable Acre =	**$ 42,734**

Table B.3. Estimate of Construction Cost for Residential Design Example (Traditional Layout)

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Estimate of Initial Construction Cost ***Mill Run Residential – LID Layout***					
ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
EARTHWORK				**Subtotal =**	**$ 14,925**
1	Clearing & Grubbing	1.0	AC	$ 6,000.00	$ 6,000
2	Topsoil Removal/Stockpiling	5.1	AC	$ 1,750.00	$ 8,925
STORM DRAINAGE				**Subtotal =**	**$ 114,172**
3	Swales	1,620	LF	$ 10.00	$ 16,200
4	Storm Sewer, 18" HDPE	136	LF	$ 55.00	$ 7,480
5	DW Headwall 18"	1	EA	$ 2,750.00	$ 2,750
6	Storm Inlets	1	EA	$ 2,100.00	$ 2,100
7	Install Detention Basin	600	CY	$ 25.00	$ 15,000
8	Anti Seep Collars	2	EA	$ 775.00	$ 1,550
9	Outlet Structure	1	EA	$ 4,000.00	$ 4,000
10	Outlet Pipe, 18" HDPE	50	LF	$ 55.00	$ 2,750
11	Level Spreader	44	LF	$ 5.50	$ 242
12	Bioretention Area	5,175	SF	$ 12.00	$ 62,100
PAVING & CURBING				**Subtotal =**	**$ 53,790**
13	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	1,645	SY	$ 30.00	$ 49,350
14	Gravel Shoulder	370	SY	$ 12.00	$ 4,440
				Initial Construction Cost =	**$ 182,887**
				Cost / Sellable Acre =	**$ 28,355**

Table B.4. Estimate of Construction Cost for Residential Design Example (LID Layout)

The cost of constructing the stormwater BMPs on each individual lot was not included in the comparison of initial construction costs. This is a cost that will be borne by the owner of each individual lot. This must be included in the cost comparison analysis. *Table B.5* shows an estimate of these costs.

Estimate of Stormwater BMP Construction Cost ***Mill Run Residential – LID Layout***					
ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
STORMWATER BMPS					
1	Rain Gardens	6,740	SF	$ 10.00	$ 67,400
2	Dry Wells	450	CY	$ 32.00	$ 14,400
				Construction Cost =	**$ 81,800**
				Cost / Sellable Acre =	**$ 12,682**

Table B.5. Estimate of Stormwater BMP Construction Cost

Determining how this additional cost to homeowners will be reflected in the market value of developed land is presumptive at best. For this example, we have 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. So, the BMP construction cost per sellable acre is subtracted from the per acre market value price of the land.

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The initial construction cost is subtracted from the land sale value to determine the developers profit for each layout.

Cost = Land Sale Value - Initial Construction Cost

Traditional Layout
Cost = $310,500 - $265,376
= $45,124

LID Layout
Cost = $240,701 – $182,887
= $57,814

The final cost comparison is completed by determining the difference in profit between the two layouts. For this example, a total profit increase of $12,690 is realized by the developer using the LID layout with no additional cost to the individual homeowners.

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Appendix C – Significant Problem Area Modeling and Recommendations

The following is a more detailed overview for each problem area and obstruction. *Plate 7* illustrates the location of the reported problem areas and obstructions throughout the county.

Planning level, individualized solutions were proposed for each problem area. For any solution that involves construction or working within the bed and banks of a defined stream, a more detailed analysis should be conducted in conformance with standard engineering practice and all of laws that may govern such construction (e.g., PA Chapter 102 and 105 regulations).

PROBLEM AREA HYDROLOGY

Where appropriate, discharge estimates were developed for each problem area. Discharge estimates for the problem areas in Mifflin County are available from one of three hydrologic methods: 1) USGS Regression methodology outlined in USGS (2008); 2) the NRCS rainfall-runoff method using the Engineering Field Handbook-2; and 3) NRCS rainfall-runoff method using the HEC-HMS model discussed in Section 6 and Appendix A.

Problem Area	Cumulative Area (mi²)	Estimated Discharge (cfs)				Data Source
		2-Year	10-Year	50-Year	100-Year	
O03	5.96	307	749	1,203	1,368	USGS Regression
P03	13.33	665	1,415	2,283	2,674	USGS Regression
P04	0.33	75	215	435	561	CN(EFH-2)
P05	0.24	46	121	239	306	CN(EFH-2)
P07	11.69	499	1,170	1,934	2,386	USGS Regression
P08	10.23	410	1,131	1,921	2,167	USGS Regression
P12	165.27	3,250	6,920	11,000	12,900	USGS Regression
P17	0.27	33	72	130	162	CN(EFH-2)
P26	88.39	2,500	5,130	7,910	9,210	USGS Regression
P27	55.55	1,870	3,880	6,010	7,020	USGS Regression
P28	1.33	83	196	325	389	USGS Regression
P29	1.01	16	146	423	615	CN(EFH-2)
P30	0.45	79	229	468	606	CN(HEC-HMS)
P31	0.13	29	65	118	147	CN(EFH-2)

Table C.1. Problem Area Hydrology

PROBLEM AREA HYDRAULICS

Where a problem area involved a bridge crossing or culvert crossing, an approximate hydraulic analysis was conducted to determine the conveyance capacity of the structure. Culverts were analyzed using HY-8; Bridges were analyzed using HEC-RAS; and channel capacity was verified using Hydraflow Express. Table C.2 summarizes the results of these hydraulic analyses.

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Problem Area	Hydraulic Model	Conveyance Capacity
O03	HEC-RAS	10YR<Q<25YR
P03	HEC-RAS	2YR<Q<10YR
P04	Hydraflow Express	10YR<Q<50YR
P05	Hydraflow Express	>100YR
P07	Hydraflow Express	2YR<Q<10YR
P08	HEC-RAS	10YR<Q<50YR
P12	HEC-RAS	>100YR
P17	HY-8	<2YR
P26	HEC-RAS	10YR<Q<50YR
P27	HEC-RAS	10YR<Q<50YR
P28	HY-8	<2YR
P29	HY-8	2YR<Q<10YR
P30	HY-8	<2YR
P31	HY-8	10YR<Q<50YR

Table C.2. Problem Area Hydraulics

HIGHEST PRIORITY PROBLEM AREAS

Using the priority scheme in section 5, five of the highest priority problem areas listed in Table C.3 were included in this appendix so more detailed solution could be provided.

Problem Area	Municipality	Location
P33	Union Township	Cayuga Road
P34	Brown/Armagh Townships	Unipar Property
P2	Lewistown Borough	Fairview Avenue
P16	Burnham Borough	Kishacoquillas Creek At 2nd Street
P24	Juniata Terrace Borough	Delaware Avenue

Table C.3. Highest Priority Problem Areas

PROBLEM AREA P33- UNION TOWNSHIP- CAYUGA ROAD

DESCRIPTION

Cayuga Road floods due to the lack of a stormwater conveyance system. The existing upslope terrain directs stormwater to the area of Cayuga Road. It appears the only outlet for stormwater along the road would be through the residentail properties. The stormwater eventually discharges into Soft Run.

Figure C.1. Aerial View of Problem Area P33

Figure C.2. View of Cayuga Road

Figure C.3. View of Cayuga Road

FINAL

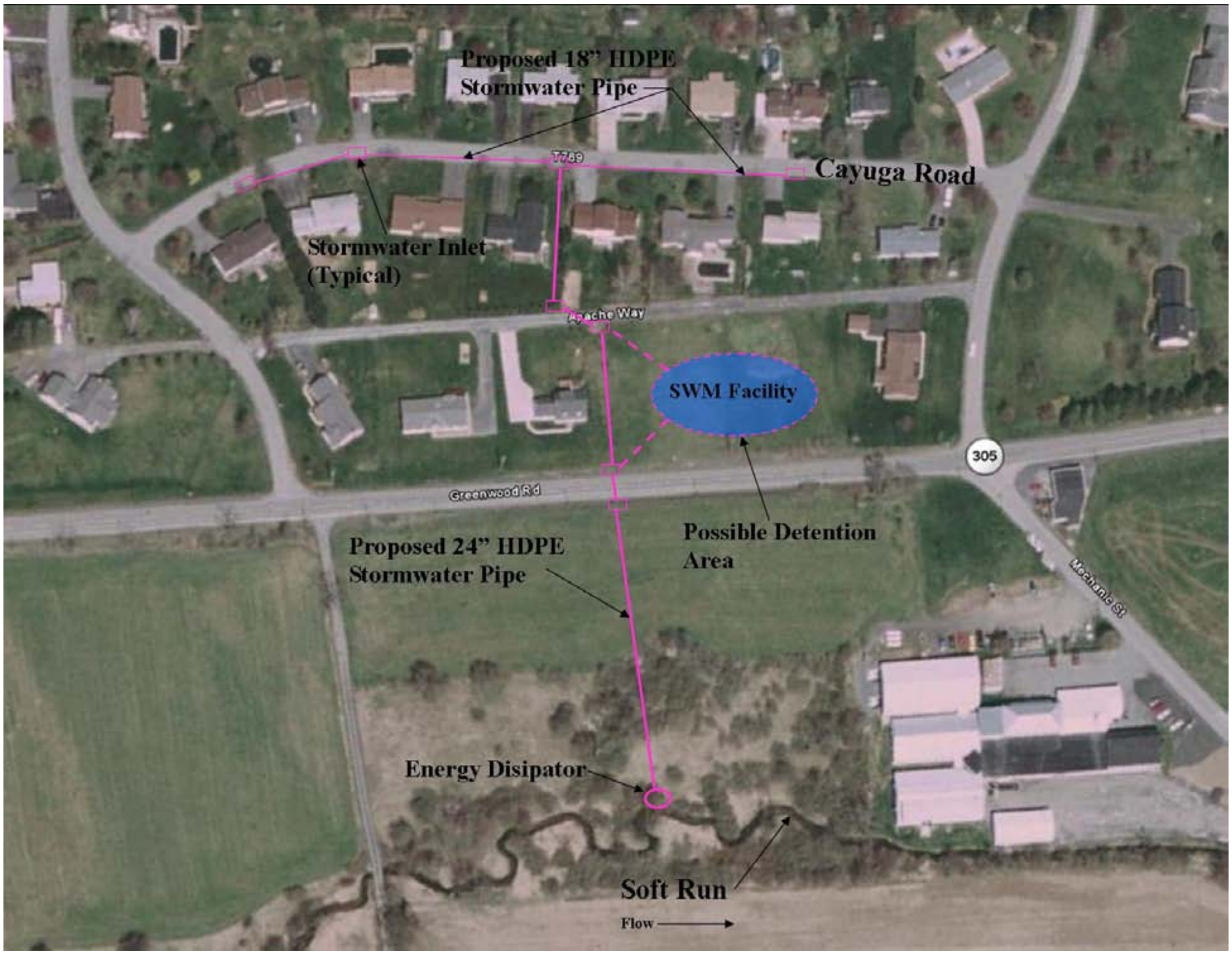


Figure C.4. Proposed Conceptual Solution

FINAL

CONCEPTUAL SOLUTION

A solution to this problem would be to install a conveyance system along Cayuga Road which would discharge into Soft Run. A stormwater detention facility may also be beneficial to the area however, this area is composed of karst topography.

The following are critical design assumptions associated with the conceptual solution:

- Acquisition of Right-of-Ways is obtainable
- Existing grades allow for the proposed improvements
- Pipe cover throughout the field along Greenwood Road is sufficient to continue farming operations.

The following are design aspects associated with the conceptual solution:

- Approximate drainage area = 5 acres (Soil Group "C" with Karst Topography)

- Land Use = 1/3 acre Residential Lots (CN=81)
- 800 linear feet of 24" diameter HDPE pipe (1% minimum slope)
- 650 linear feet of 18" diameter HDPE pipe (1% minimum slope)
- Placement of drainage inlets
- Energy Dissipator at outlet to Soft Run

PROBLEM AREA P34-BROWN/ARMAGH TOWNSHIP- UNIPAR PROPERTY

DESCRIPTION

Stormwater associated with the Unipar Property is uncontrolled and discharges onto the neighboring Hillandale Farms Property. The Hillandal Farms Property has suffered from flooding damage due to the runoff from the Unipar Property. The Unipar Property is located in Armagh Township and the Hillandal Farms Property is located in Brown Township ultimately leading to a coordination problem between the property owners and the municipalities.

Figure C.5. Aerial View of Problem Area P34

FINAL

Figure C.6. View of the Unipar Propoerty

Figure C.7. Hillandale Property looking at the Unipar Property

Figure C.8. Proposed Conceptual Solution

CONCEPTUAL SOLUTION

A solution to this problem would be to install a stormwater management facility adjacent to the Unipar property in order to control runoff from the site. The area is located in karst topography and would require a more detailed analysis to determine the impact a stormwater facility would have in this area.

- The following are critical design assumptions associated with the conceptual solution:
- The construction of a stormwater facility will not affect the karst topography in the area.
- The neighboring property could be purchased if it is not possible for Unipar to construct a stormwater facility within their property (see Stormwater Facility Alternative on Photo 4).

The following are design aspects associated with the conceptual solution:

- Approximate drainage area is less than ten (10) acres composed of Hagerstown soil with a lithic bedrock limitation between 40 - 84 inches.

- If it is n ot po ssible t o c onstruct a n a bove g round s tormwater f acility then, a n underground stormwater facility would be practical.
- Runoff from the Unipar site will be able to be collected and conveyed to the alternate stormwater facility if that option is carried out.
- The d ischarge f rom t he s tormwater f acility is po ssible w ithout n egatively im pacting downstream properties.

PROBLEM AREA P2-LEWISTOWN BOROUGH- FAIRVIEW AVENUE

DESCRIPTION

Fairview Avenue and Almost Heaven Way were graded with approximately 18% slopes, creating causing flooding and high-velocity, erosive flows at properties along Fairview Avenue.

Figure C.9. Aerial View of Fairview Avenue and Almost Heaven Way

Figure C.10. Fairview Avenue

Figure C.11. Proposed Conceptual Solution

FINAL

CONCEPTUAL SOLUTION

Since the road appears to have low volume and low maintenance the installation of open top culverts a long Almost Heaven Way and Fairview Avenue would reduce the amount of stormwater runoff flowing directing down the entire length of roadway. The open top culverts would direct water to either side of the road and discharge into a rip-rap lined stilling basin in order to prevent erosion to the vegetated/wooded area on either side of the road. The road should also be inspected and eroded areas should be reconstructed.

The following are critical design assumptions associated with the conceptual solution:

- The discharge from the open top culverts would not affect downstream properties.
- Each outlet of the open top culvert has the capability to discharge into a rip-rap lined stilling basin to allow for a more controlled release of the stormwater in order to prevent erosion.

The following are design aspects associated with the conceptual solution:

- The open top culverts should be spaced every 100 feet therefore, requiring approximately twelve (12) placement areas.
- The open top culverts should be placed in areas that will have the least impact on downstream properties.
- DEP's E&S Control BMP Manual can be used to research more details regarding open top culverts.

FINAL

PROBLEM AREA P16- BURNHAM BOROUGH- KISHACOQUILLAS CREEK AT 2ND STREET

DESCRIPTION

In comparing the USGS topograpghy from 1924 it was discovered that Kishacoquillas Creek did not make a bend at the area of the filtration plant. It appears that the centerline of the creek ran directly though the area of the filtration plant. It is assumed that the property area surrounding the filtration plant was filled in order to construct the plant therefore, redirecting Kishacoquillas Creek. As a result, Kishacoquillas Creek must make a ninety-degree bend in order to be conveyed around the filtration plant therefore causing streambank erosion.

Figure C.12. Aerial View of the Erosion Area in the Area of 2nd Street

Figure C.13. Streambank Erosion

FINAL

Figure C.14. Proposed Conceptual Solution

FINAL

CONCEPTUAL SOLUTION

Perform stream restoration/stream stabilization in the depicted area (approximately 1,500 feet) in order to restore and prevent future erosion and degradation. A more detailed site visit would be needed in order to determine the dynamics of the Kishacoquillas Creek in this area. Understanding the dynamics of a stream is vital in the development of a successful stream restoration/stabilization project. Using the U.S. Department of Transportation's Hydraulic Engineering Circular (HEC) No. 23, the following process may be used in order to provide design guidance and material selection.

- Highlight the various groups of countermeasures and identify their individual characteristics.
- For specific countermeasures, list information on their functional applicability to a particular problem, their suitability to specific river environments, the general level of maintenance resources required, and which State Highway Agencies have experience with specific countermeasures.
- Provide general criteria for selection of countermeasures for bridge scour and stream instability problems.

- Discuss countermeasure design concepts including design approach, hydraulic analysis, environmental permitting, special design considerations related to riprap, filters, and edge treatment, and biotechnical engineering approaches.

- Provide detailed design guidelines for specific countermeasures.

PROBLEM AREA P24- JUNIATA TERRACE- DELAWARE AVENUE

DESCRIPTION

The existing stormwater conveyance system in the area of Juniata Terrace appears to be insufficient. The outlet channels which conveys the stormwater associated with the conveyance system throughout Juniata Terrace receives a large drainage area from the south. The amount of runoff flowing to this area is greater than the existing system can convey.

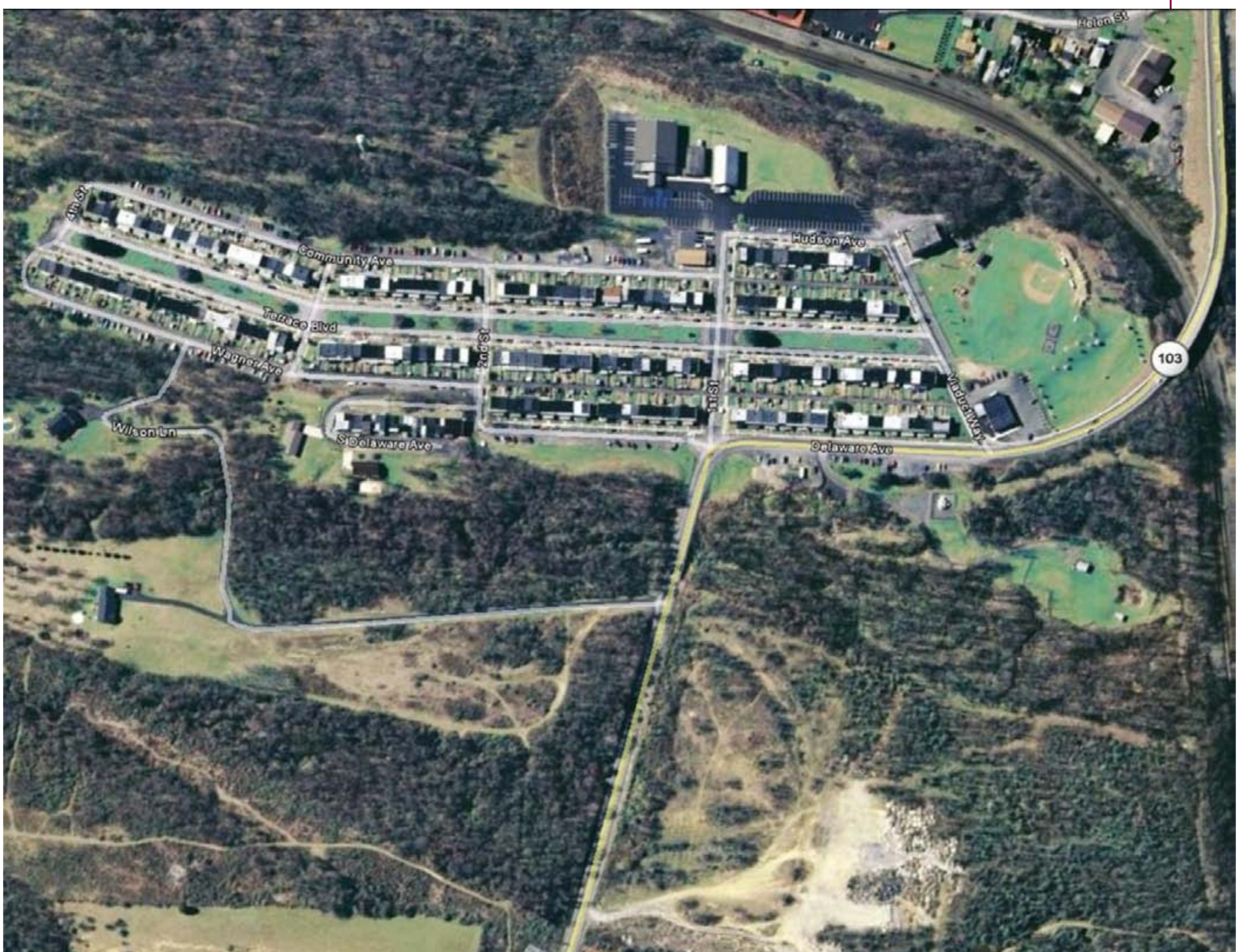


Figure C.15. Aerial View of Juniata Terrace

Figure C.16. Stormwater Inlet Located at Delaware Avenue and First Street

Figure C.17. Proposed Conceptual Solution

SOLUTION

Stormwater runoff from approximately 80 acres is ultimately entering the existing conveyance system. The outlet channels need to be modified in order to safely convey the flow from both Juniata Terrace and the area to the south. Modifications to the existing system would require the following:

- A detailed evaluation and analysis of the existing stormwater conveyance system throughout Juniata Terrace in order to determine its conveyance capacity.
- A detailed evaluation and analysis of the drainage area to the south in order to estimate the amount of runoff contributing to the outlet channels.
- Obtain design data to model the existing outlet channels in order to determine its current conveyance capacity.
- Using the analysis of the existing stormwater conveyance system and southern drainage area, a model can be created to determine the required improvements that must be made to the outlet channels in order to provide sufficient conveyance capacity.
- Using the developed model, channel lining and outlet protection can be designed in order to prevent erosion.

PROBLEM AREA SUMMARY SHEETS

Following are the problem area summary sheets with individual description, photos, and conceptual solutions.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Lewistown Borough **ID:** O01

Location: East Walnut Street **Stream:**

Problem Description:

SS Aerial collects debris.

Problem Solution:

Perform maintenance in and around the area of interest.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Menno Township **ID:** O02

Location: School House Road **Stream:**

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Granville Township **ID:** O03

Location: Granville Road **Stream:** Minehart Run

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Granville Township **ID:** O04

Location: Granville Run Road **Stream:**

Problem Description:

Problem Solution:

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Oliver Township **ID:** O05

Location: South River Road **Stream:** Musser Run

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

FINAL

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

Mifflin County Act 167 Plan

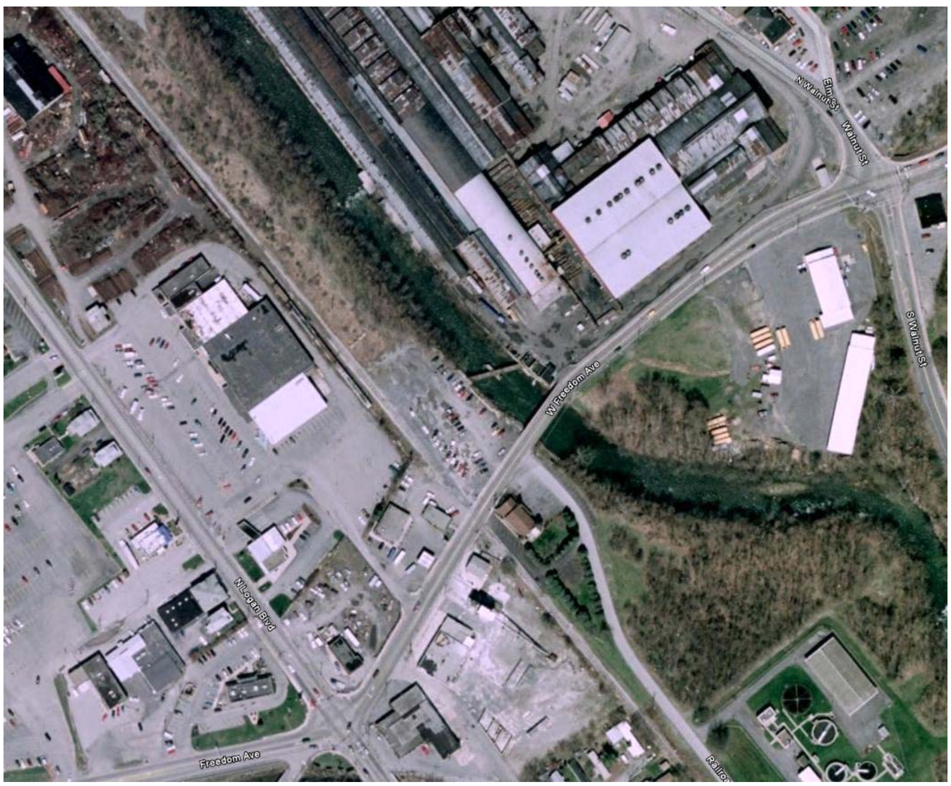
Problem Area Summary

Municipality: Burnham Borough **ID:** O06

Location: Uni-Mart on Freedom Street **Stream:**

Problem Description:

Kish. Creek flooding.



Problem Solution:

Implement prudent floodplain management measures.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** O07

Location: Naiginey **Stream:**

Problem Description:

Sinkhole development located in a farm field on private property.

FINAL

Problem Solution:

Coordinate with the landowner in order to resolve the issue.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** O08

Location: Hostetler Quarry Road **Stream:**

Problem Description:

The "Shrader Sinkhole".

Problem Solution:

Coordinate with the landowner in order to resolve the issue.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** O09

Location: **Stream:**

Problem Description:

FINAL

Problem Solution:

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** O10

Location: Honey Creek Road **Stream:** Honey Creek

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** O11

Location: Honey Creek Road **Stream:** Honey Creek

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** O13

Location: Honey Creek Road **Stream:** Honey Run

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Lewistown Borough **ID:** P01

Location: Victory Park Railroad Bridge **Stream:**

Problem Description:

Debris build up at the Victory Park Railroad Bridge during flood events.

FINAL

Problem Solution:

Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Lewistown Borough **ID:** P02

Location: Fairview Avenue **Stream:**

Problem Description:

Flooding and erosion at a private lane along Fariview Avenue.

Problem Solution:

Modify the roadside channel in order to obtain the conveyance capacity to safely convey the flow. Apply erosion protection to the channel in order to prevent erosion and stream degradation.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Decatur Township **ID:** P03

Location: Hoffman Road **Stream:** Jacks Creek

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Decatur Township **ID:** P04

Location: Back Maitland Road **Stream:**

Problem Description:

The existing channel does not appear to provide sufficient capacity and erosion protection.

Problem Solution:

Modify the roadside channel in order to obtain the conveyance capacity to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Menno Township **ID:** P05

Location: Alison Gap **Stream:**

Problem Description:

The existing channel does not appear to provide sufficient erosion protection.

Problem Solution:

Apply erosion protection to the channel in order to prevent erosion and stream degradation.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Granville Township **ID:** P06

Location: Caldwell Road **Stream:**

Problem Description:

The existing channel does not appear to provide sufficient erosion protection.

FINAL

Problem Solution:

Install stream stabilization measures to reduce erosion.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Granville Township **ID:** P07

Location: **Stream:** Strodes Run

Problem Description:

The channel banks are being to erode therefore impacting the bridge abutments and an embankment of a private pond.

FINAL

Problem Solution:

Apply erosion protection to the channel in order to prevent erosion and stream degradation.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Oliver Township **ID:** P08

Location: Old State Road **Stream:** Musser Run

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Oliver Township **ID:** P09

Location: Kansas Road **Stream:**

Problem Description:

Stormwater ponds along Kansas Road.

FINAL

Problem Solution:

Install a stormwater conveyance system in this area to safely manage the stromwater discharge.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Burnham Borough **ID:** P10

Location: Burnham Park Pool **Stream:** Hungry Run

Problem Description:

The swimming pool at Burnham Park is located in the floodway of Hungry Run

FINAL

Problem Solution:

Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Burnham Borough **ID:** P11

Location: E. Walnut St. & Freedom Ave. **Stream:** Hungry Run

Problem Description:

Flooding of Hungry Run at East Walnut Street and Freedom Avenue.

FINAL

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Burnham Borough **ID:** P12

Location: Uni-mart along Freedom Street **Stream:** Kishacoquillas Creek

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

The existing bridge appears to convey the 100-yr storm event. Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Burnham Borough **ID:** P13

Location: **Stream:** Kishacoquillas Creek

Problem Description:

Debris is deposited at the bridge pier during flooding event.

FINAL

Problem Solution:

Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Burnham Borough **ID:** P14

Location: South Logan Blvd. **Stream:** Buck Run

Problem Description:

Flooding along Buck Run.

FINAL

Problem Solution:

Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Burnham Borough **ID:** P15

Location: South Logan Blvd. **Stream:** Buck Run

Problem Description:

Flooding along Buck Run.

Problem Solution:

Implement prudent floodplain management measures.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Burnham Borough **ID:** P16

Location: 2nd Street **Stream:** Kishacoquillas Creek

Problem Description:

Streambank erosion along Kishacoquillas Creek at 2nd Street.

FINAL

Problem Solution:

Install stream stabilization measures to reduce erosion. Conduct stream assessment to best determine measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Brown Township **ID:** P17

Location: Duchess Street **Stream:**

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

FINAL

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow. Modify the channel to provide adequate erosion protection and conveyance capacity.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Brown Township **ID:** P18

Location: Reedsville Playground Baseball **Stream:**

Problem Description:

Baseball field is located in the floodway and always becomes saturated.

Problem Solution:

Implement prudent floodplain management measures.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Wayne Township **ID:** P19

Location: Wharton Road **Stream:**

Problem Description:

Wharton Road is located in the floodway.

Problem Solution:

Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Wayne Township **ID:** P20

Location: SR 0103 **Stream:**

Problem Description:

SR 0103 is located in the floodway.

FINAL

Problem Solution:

Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: McVeytown Borough **ID:** P21

Location: North Water Street **Stream:**

Problem Description:

Sewage pump station at North Water Street experiences flooding which leads to inflow and infiltration.

Problem Solution:

Modify the pump station area to prevent inflow and infiltration.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: McVeytown Borough **ID:** P22

Location: River Road Pump Station **Stream:**

Problem Description:

Sewage pump station at River Road experiences flooding which leads to inflow and infiltration.

Problem Solution:

Modify the pump station area to prevent inflow and infiltration.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Juniata Terrace **ID:** P23

Location: Delaware Avenue **Stream:**

Problem Description:

The existing conveyance system does not appear to provide sufficient conveyance capacity.

FINAL

Problem Solution:

Modify or replace the conveyance system in order to obtain sufficient capacity.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Juniata Terrace **ID:** P24

Location: Delaware Avenue **Stream:**

Problem Description:

The existing conveyance system does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the conveyance system in order to obtain sufficient capacity.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** P25

Location: Brooknar Development **Stream:**

Problem Description:

Homes and garages flood in the Brooknar Development.

Problem Solution:

Modify or replace the stormwater conveyance system in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** P26

Location: 1408 Honey Road Bridge **Stream:** Honey Run

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** P27

Location: SR 1002 **Stream:** Honey Run

Problem Description:

The existing bridge does not appear to provide sufficient conveyance capacity.

FINAL

Problem Solution:

Modify or replace the bridge in order to safely convey the flow.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** P28

Location: T-448 **Stream:**

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Armaugh Township **ID:** P29

Location: Broad Street & Anita Street **Stream:**

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Derry Township **ID:** P30

Location: Armory Building **Stream:**

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Derry Township **ID:** P31

Location: Glenwood Avenue **Stream:**

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** P32

Location: Sale Barn Lane & Kist Street **Stream:**

Problem Description:

The existing culvert does not appear to provide sufficient conveyance capacity.

Problem Solution:

Replace the existing culvert(s) with a new culvert that is sufficient to safely convey the flow.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** P33

Location: Cayuga Road **Stream:**

Problem Description:

Flooding along Cayuga Road due to the lack of a conveyance system.

Problem Solution:

Install a stormwater conveyance system in order to provide sufficient capacity.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Brown Township **ID:** P34

Location: Unipar Property **Stream:**

Problem Description:

Stormwater runoff from the Unipar Property is overtopping inadequately sized drainage channels and flooding the Hillandale Farm Property.

Problem Solution:

Modify the channel in order to obtain the conveyance capacity to safely convey the flow.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Brown Township **ID:** P35

Location: Emergency Access Road to Lu **Stream:**

Problem Description:

The driving surface on the emergency access road to Lumber City becomes unsafe during rain events.

Problem Solution:

Modify the access road in order to provide safe access to Lumber City.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Brown Township **ID:** P36

Location: Willow Lane **Stream:** Honey Run

Problem Description:

Flooding of residential houses along Honey Run.

Problem Solution:

Continue the construction of the dike that borders Willow Lane.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Granville Township **ID:** P37

Location: Middle Road **Stream:**

Problem Description:

The existing channel does not appear to provide sufficient erosion protection.

Problem Solution:

Apply erosion protection to the channel in order to prevent erosion and stream degradation.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Kistler Borough **ID:** P38

Location: Riverside Drive **Stream:**

Problem Description:

The pump station floods and causes the electrical panels to be submerged.

Problem Solution:

Install flood proofing measures at the pump station to prevent water damage to the electrical panels.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Bratton Township **ID:** P39

Location: River Road **Stream:** Juniata River

Problem Description:

River Road floods during large rainfall events.

Problem Solution:

Implement prudent floodplain management measures.

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Bratton Township **ID:** P40

Location: Carlisle Gap Road **Stream:**

Problem Description:

Flooding of Carlisle Gap Road due to stormwater overtopping the roadway channel.

Problem Solution:

Modify the roadside channel in order to obtain the conveyance capacity to safely convey the flow.

FINAL

Mifflin County Act 167 Plan

Problem Area Summary

Municipality: Menno Township **ID:** P41

Location: Water Street in Allensville **Stream:** Saddlers Run

Problem Description:

Streambank erosion and flooding along Water Street in Allensville.

FINAL

Problem Solution:

Apply erosion protection to the channel in order to prevent erosion and stream degradation.

Appendix D – Natural Resource Activities Impacting Water Quality

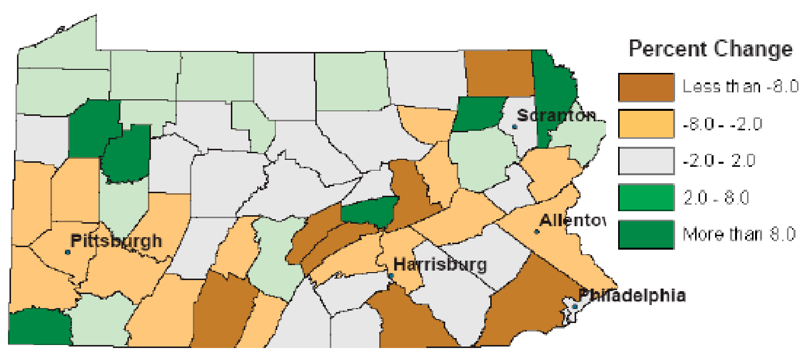
As demonstrated throughout this Plan, land use is a key factor in both the generation and control of stormwater runoff. In Pennsylvania, most types of land use can be regulated by the county or local government through land use ordinances (e.g. zoning). However, the Pennsylvania Municipalities Planning Code (MPC) limits local government control of certain land use categories. Certain types of natural resource activities such as agriculture, forestry, and mining are among the land uses protected by the MPC. Two land use categories that fall within this category were identified by the Plan Advisory Committee, and the municipalities they represent, as land uses that greatly affect the water resources of the county – timber harvesting and oil and gas wells.

Amendments made to the Pennsylvania Municipalities Planning Code by Act 67 and Act 68 of 2000, limit the regulatory control of municipalities on forestry and timber harvesting. The amendments specify Forestry activities and timber harvesting as "permitted uses by right" in all zoning districts in every municipality. The MPC amendments further clarify that zoning ordinances may not unreasonably restrict forestry activities.

Oil and gas well development in Pennsylvania is regulated by several chapters of the Pennsylvania Code and various state acts. The state's oil and gas laws (Oil and Gas Act – Act 223, Coal and Gas Resource Coordination Act – Act 214, and Oil and Gas Conservation Law – Act 359), as well as environmental protection laws that include the Clean Streams Law, the Dam Safety and Encroachments Act, the Solid Waste Management Act, and the Water Resources Planning Act delegate the authority to regulate these activities to DEP, while limiting the regulatory control of municipalities.

FINAL

FORESTRY IN PENNSYLVANIA



Change in Forest Land Area, 1989-2004 (McWilliams et al., 2007)

According to U.S. Forest Service inventories, forest once covered more than 90% (27.3 million acres) of Pennsylvania's land area in the pre-European settlement era (1630s). By the early 1900s, industrial timber harvesting and agricultural land clearing had diminished the forest land base to only 32% (9.2 millions acres). Forest land increased steadily from that point forward and has been relatively stable, at 58% of Pennsylvania's total area, for the last quarter century. Although no significant net change in total area has occurred, there have been losses of acreage to development, agriculture and mining. These losses have been offset by agricultural and other lands naturally reverting back to forests. Slightly more than 70% of the nearly 17 million acres of forests in the state are privately owned, with only a small percentage (<

5%) owned by forest product companies. The remaining 30% of the forest land in Pennsylvania is owned by state and federal government entities.

Pennsylvania is known throughout the world as a leading source of high quality hardwood products. The state leads the nation in the production of hardwood lumber (typically more than one billlion board feet), accounting for about 10% of the country's annual production (Pennsylvania Forest Products Association, 2008). Pennsylvania also ranks nationally in the production of value added wood products such as millwork and flooring; kitchen cabinets; pallets and containers.

The forest products industry is important in Pennsylvania, where it accounts for 11% of all manufacturing jobs. The forest products industry has a significant impact on the state's economy. In 2005, the state's annual forest product industry sales was $16.7 billion. The total economic impact of the forest product industry in the state was $24.7 billion. Three-quarters of this economic impact was generated by sectors depending on locally harvested hardwood timber (Pennsylvania Forest Products Association, 2008). In 2006, there were 2,420 forest prduct establishments in Pennsylvania, employing 79,910 individuals. In many rural parts of the state the forest products industry is the primary source of economic activity.

FORESTRY IN MIFFLIN COUNTY

Although it is not a dominant sector, the wood products industry provides important economic opportunities in the county. In 2007, there were 44 wood products establishments employing between five hundred and one thousand people (U.S. Census Bureau, 2008). Timber management encourages the preservation of open space. Through timber harvesting, forests are able to provide landowners with income that can be an incentive for them to maintain woodland on their property. According to a study conducted by the American Famland Trust, timberland and farmland yield an average of $3 in taxes for every $1 in required governmental services, while residential land costs $1.11 in services for every $1 collected in tax revenue (The Pennsylvania State University, 2004). Additionally, municipalities with publicly owned State Forests, State Game Lands, and State Parks within their borders receive "in lieu of tax" payments from the Commonwealth.

FORESTRY ACTIVITIES AFFECTING WATER QUALITY

As discussed in *Section IX - Water Quality Impairments and Recommendations*, forestry is one of the basic sources of nonpoint source pollution. On a national level, forestry management activities are estimated to contribute approximately 9 percent of the water quality problems in surveyed rivers and streams (EPA, 1996). Water quality concerns related to forestry were addressed in the 1972 Federal Water Pollution Control Act Amendments and later, more comprehensively, as nonpoint sources under section 208 of the 1977 Clean Water Act and section 319 of the 1987 Water Quality Act.

Forestry is listed as the primary cause for impairment in 0.02% of all non-attaining stream miles in Pennsylvania. There are no stream segments in Mifflin County listed on the *2009 Integrated List of All Waters* as non-attaining, with forestry as the primary source of impairment. However, this does not mean that the potential impacts of forestry operations on water quality can be neglected. Local impacts of timber harvesting and road construction can be severe, especially in smaller headwater streams. Many activities associated with forest management can increase the potential for erosion to occur. For this reason, sediment is the primary pollutant of concern associated with forestry activities. Other pollutants include nutrients, organic matter, chemicals and others. The fundamental forestry activities with the potential to affect water quality include

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road construction and use, timber harvesting, mechanical equipment operation, and forest management.

ROAD CONSTRUCTION AND USE

Roads are considered to be the major source of sediment from forested lands. The comparatively small area of roads contributes the vast majority of the total sediment produced from forestry operations. The greatest potential for erosion from roads occurs during road construction and during the first few years afterward. The potential for erosion on forest roads is particularly high because they are exposed to direct rainfall, they are not protected by vegetative cover, road surfaces tend to channelize runoff, and vehicle traffic continually disturb the road surface. Erosion potential is greatly increased when roads are built on cut or fill slopes, when built on steep slopes, and when they are not stabilized with stone or some other means.

Compacted road surfaces also generate increased runoff which compounds erosion problems. Other negative impacts of forest roads include concentrated overland flow on the road surface and in channels, point discharges created by culvert road crossings, and altered subsurface water flow.

TIMBER HARVESTING

Timber harvesting involves many activities that alter the forest landscape. Erosion and sedimentation resulting from these alterations is the primary concern associated with timber harvesting. Facilities used for timber harvesting such as staging (or yarding) areas, skid trails, and access roads are susceptible to increased erosion. These facilities are also at high risk for pollutants such as petroleum products, lubricants, herbicides, pesticides, and other chemicals associated with timber harvesting operations. Many detrimental effects of harvesting are related to the access and movement of vehicles and machinery. These effects include soil disturbance, soil compaction, and direct disturbance of stream channels.

Landscape changes that occur as a result of harvesting can also negatively impact water quality. Timber harvesting disturbs forest litter and changes the vegetative cover which alters the hydrologic response of a watershed. This can lead to increased runoff and erosion. Removing trees from riparian areas disturbs the sensitive ecosystem, exposes the area to pollutants associated with machinery, and reduces shade which can increase water temperatures. Utilizing appropriate timber harvesting and transport practices techniques for a given site can drastically decrease sediment production from these activities.

FOREST MANAGEMENT

Forest management activities such as site preparation for regeneration of harvested sites, prescribed burning, herbicide and pesticide application, and fertilizer application have the potential to negatively affect water quality. Sites that have been intensely harvested can be prepared for regeneration using wheeled or tracked machinery, by prescribed burning, through application of chemicals (i.e. herbicides), or a combination of these methods. These techniques can disturb the soil over large areas, remove vegetation and forest litter, and compact soil. All of these leave the area vulnerable to increased erosion and sedimentation.

FORESTRY POLLUTANTS AND IMPAIRMENTS

Nearly all forestry activities increase the potential for erosion and sediment delivery to streams. Some of these activities have long-term effects (e.g. road building and clear-cutting), while the impacts of others diminish within a few years of the occurrence. Erosion and sedimentation is the primary water quality concern related to forestry activities. Sedimentation is closely related to nutrient transport. Nutrients that are immobilized in forest soils are transported along with the

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sediment to surface waters through erosion. Other water quality pollutants resulting from forestry activities include organic debris, nutrients, chemicals, temperature, and flow variability. These pollutants, how they are generated through forestry activities, and their potential impacts on the county's waters are discussed below.

SEDIMENT

Sediment is often the primary pollutant associated with forestry activities. Accelerated overland erosion often occurs in harvested areas due to vast areas that are destabilized by removal of vegetation. Erosion of these areas discharges sediment and fine silt particles into receiving streams. Sediment transported to waterbodies by erosion can be particularly detrimental to the stream ecosystem, especially to many fish species. Suspended sediments in runoff increase water turbidity limiting the ability of sight-feeding fish to find and obtain food. In addition, the increased turbidity limits the depth to which light can penetrate and adversely affecting aquatic vegetation, increase water temperatures and lower dissolved oxygen concentrations. These effects also compromise recreational values.

When suspended sediment settles, it can fill gravel spaces in streambeds, destroying fish spawning areas and food sources. With large areas of accumulated sediment, the flow capacity of stream channels are reduced. The in stream storage capacity is also reduced, which leads to increasing flooding and decreased water supplies. In addition, nutrients and other pollutants may become adsorbed to sediment particles and be subsequently transported downstream.

ORGANIC DEBRIS

Organic material is an important part of a balanced ecosystem. Organic debris includes plant matter, residual logs, leaves, twigs and other forest litter. This material serves as a source of enefgy and provides nutrients for plants and animals. This is the primary source of nutrients for headwater streams, where upstream sources of nutrients are limited. Forestry activities can upset the balance of organic material by creating excess debris during timber havesting or by creating a debris shortage during site preparation for regeneration or by over harvesting in the riparian zone.

Excess organic debris can adversely affect water quality by causing increased biochemical oxygen demand, resulting in decreased dissolved oxygen levels (which are critical for many aquatic species) in watercourses. Logging slash and debris in or near streams can alter stream flows by forming debris dams, and can also redirect flow in the channel, increasing bank cutting and resulting in sedimentation.

NUTRIENTS

Erosion is the primary transport mechanism for nutrient pollution related to forestry activities. Forest soils act as a filter that collects and holds nutrients from decomposing organic matter such as leaves and woody debris. The soil holds many of these nutrients until they are removed by growing plants and used for plant growth. Some nutrients, like nitrogen, are easily dissolved in water and are easily moved throughout the environment. Other nutrients, such as phosphorus, bind to soil particles and are relatively immobile unless relocated by some transport mechanism (e.g. erosion). Excess nutrients in surface waters can result in eutrophication, or a proliferation of plant life, especially algae. Eutrophication causes dissolved oxygen levels to decrease, harming other aquatic organisms.

CHEMICALS

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Chemicals such as herbicides, pesticides, and fertilizers used for forestry operations can contaminate surface water through direct application, transport by surface runoff, or groundwater contamination. These chemicals can poison fish and wildlife or kill unintended plant species. Generally speaking, herbicides, pesticides, and fertilizers pose minimal threat to water quality when handled and applied properly. However, improper application and spills can have severe and long lasting effects. The petroleum products and lubricants used for machinery are of greater concern. These chemicals can be toxic to plants and animals and can contaminate drinking water supplies.

TEMPERATURE

Relatively constant water temperature is important for aquatic biota. When too much vegetation is harvested from the area surrounding stream, the loss of shade can result in increased water temperatures. Temperature increases can be dramatic in smaller (lower order) streams, adversely affecting fish and aquatic invertebrates which have adapted to cooler water temperatures. Suspended solids from sedimentation can also 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. Temperature changes can be a substantial contributor to aquatic life impairments.

STREAM FLOW

The hydrologic response of a watershed can change as a result of timber harvesting. The change resulting from large scale removal of vegetation is often increased stream flow that results from more rapid delivery of runoff to streams. When fewer trees are available to perform the function of evaporation and transpiration, more water becomes availabe as surface runoff. Increased runoff results in increased stream flow. The amount of stream flow increase is related to the total area harvested, topography, soil type, and harvesting practices (Curtis et al. 1990). Increased stream flow can lead to a variet of problems including scoured channels, erode streambanks, increase sedimentation, and increase peak flows.

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FORESTRY MANAGEMENT MEASURES FOR WATER QUALITY

Current forestry management practices and timber harvest techniques have drasticly reduced the water quality impacts that occurred from practices of the past century. The water quality impacts of forestry activities can be further minimized by implementing appropriate management measures. Management measures are steps to be taken and guidelines for operations (EPA, 2005). Best Management Practices (BMPs) are specific activities, processes, or technologies designed to serve specific functions, which are used to attain a management measure. These are simple, often low cost, practices and techniques that can be incorporated into forestry operations to diminish impacts to water quality. Additional guidance on BMPs can be found in the following resources developed specifically for Pennsylvania forests:

- Timber Harvest Operations Field Guide for Waterways, Wetlands and Erosion Control (3930-BK-DEP4016), 2009. Pennsylvania Department of Environmental Protection.
- Best Management Practices for Pennsylvania Forests, 2001. The Pennsylvania State University.

A brief overview of EPA's (2005) forestry management measures developed to protect water quality throughout the various phases of forestry activites is presented on the following pages.

Preharvest Planning

Purpose	Ensure that forestry activities are planned with water quality considerations in mind and conducted in a manner to minimize delivery of nonpoint source pollutants to surface waters.
Target Pollutant(s)	Primarily sediment. Organic matter, thermal modification, nutrients pesticides and toxics are also controlled.
Description	Preharvest planning includes consideration of all stages of a timber harvest including the road system, the harvesting system, the yarding system, and post harvest activities. Site conditions are considered and appropriate BMPs are prescribed to reduce water quality impacts. Contingency plans are developed to reduce the effects of potential problems.

Streamside Management Areas

Purpose	Protect surface waters, the ecologically sensitive areas in riparian zones and wetlands, and maintain the function of floodplains.
Target Pollutant(s)	Sediment, organic debris, and thermal modification. Nutrients, pesticides and toxics are also controlled.
Description	Establish and maintain a buffer zone along surface waters that includes a sufficient number of canopy species, and is wide enough to shade the water, provide bank stability, and filter runoff. Limit forestry activities within the buffer.

Road Construction

Purpose	Reduce erosion and sedimentation which is common during, and immediately after, construction of forestry roads.
Target Pollutant(s)	Sediment. Petroleum products and lubricants.
Description	Design and construction of roads that are planned for the topography, soils, and drainage patterns of a site. Appropriate construction methods and BMPs are used to minimize erosion from high risk areas such as the road surface, steep slopes, water crossings, and runoff conveyance structures (i.e. culverts, ditches, etc.).

Road Management

Purpose	To ensure that management of existing roads maintains their utility and minimizes polluted runoff from roads and road structures.
Target Pollutant(s)	Sediment. Petroleum products and lubricants.
Description	Minimize use during wet weather and thaw conditions. Perform routine maintenance of road surface, stream crossings, and drainage structures. Immediately repair eroding areas and implement BMPs to address problem areas. Close and decommission roads that are no longer needed.

Timber Harvesting

Purpose	Minimize the likelihood of water quality impacts resulting from timber harvesting operations.
Target Pollutant(s)	Sediment, petroleum products.
Description	Follow the plan for timber harvest operations developed during preharvest planning. Conduct operations to avoid sedimentation to the extent practicable. Use appropriate areas for high risk activities such as equipment maintenance, and petroleum and chemical storage and dispensing.

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Site Preparation for Regeneration

Purpose	Minimize erosion and runoff from areas disturbed by site preparation for forest regeneration.
Target Pollutant(s)	Sediment, organic debris, and nutrients.
Description	Select methods of site preparation for regeneration which are suitable for site conditions. Complete site preparation in sensitive areas such as steep slopes and riparian zones using low impact methods and utilizing appropriate BMPs. Leave adequate organic material but protect surface waters from debris and slash material.

Fire Management

Purpose	Minimize nonpoint source pollution and erosion resulting from prescribed burning.
Target Pollutant(s)	Sediment, organic debris, and nutrients.
Description	Use of prescribed fire should be planned and implemented in a manner to protect against excessive erosion. Area to be burned and severity of burn should be prescribed based on site conditions and erosion potential. Appropriate BMPs should be employed to reduce impacts to sensitive areas.

Revegetation of Disturbed Areas

Purpose	Reduce erosion and sedimentation of areas disturbed by forestry activities.
Target Pollutant(s)	Sediment and nutrients.
Description	Reduce erosion and sedimentation by revegetating disturbed areas with appropriate plant species immediately upon completion of earth-disturbing activities. Focus initial efforts on highly susceptible areas such as steep slopes and riparian areas.

Forest Chemical Management

Purpose	Minimize the potential of water pollution by chemicals used for forest management due to environmental transport of chemicals during and after application.
Target Pollutant(s)	Pesticides (i.e. Insecticides, herbicides, and fungicides) and fertilizers.
Description	Risks associated with the use of forest chemicals can be reduced through careful prescription of type and amount of chemicals to be used; delineation of buffer zones; and careful transport and application of chemicals. Spill prevention and contingency plans can reduce the potential impact of spills.

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OIL AND GAS DEVELOPMENT IN PENNSYLVANIA

The petroleum (oil and gas) industry has played a significant role in the history of Pennsylvania. In 1859, Edwin L. Drake drilled one of the first successful oil wells near Titusville, PA. In the years that followed, Venango and Crawford Counties became the center of an industry focused on the drilling, refining, and transporting crude oil and oil products (Harper, 1998). Although not the first natural gas well, the Drake Well (which captured natural gas and piped it to Titusville) is also attributed as the beginning of the natural gas industry in America (NaturalGas.org, 2004). Oil and gas wells are a common part of the landscape throughout much of Pennsylvania. Until recently, the petroleum industry in Pennsylvania had faded to a small fraction of what it had been during its prime.

The Marcellus Shale Formation is a Middle Devonian-age (397.5 – 385.3 million years ago), black, low density, carbonaceous shale that lies nearly a mile or more below the surface of approximately two-thirds of Pennsylvania and large portions of New York, West Virginia, and Ohio as well as small areas of Maryland, Kentucky, Tennessee, and Virginia. Organic rich shales, such as the Marcellus Formation, have been known to hold significant reservoirs of natural gas for more than 75 years (Harper, 2008). Once thought cost prohibitive to extract, recent advances in drilling technology and recent price increases for natural gas have increased interest in this extensive gas reservoir. In 2002, the United States Geological Survey's "Assessment of Undiscovered Oil and Gas Resources of the Appalachian Basin Province" calculated that the Marcellus Shale contained an estimated resource of about 1.9 trillion cubic feet of gas (USGS, 2003).

In 2003, Range Resources – Appalachia, LLC drilled a well in Washington County, Pennsylvania and found a promising flow of natural gas from the Marcellus shale. Borrowing drilling and fracturing techniques that had worked in the Barnett Shale of Texas, they began producing Marcellus gas in 2005 (Harper, 2008). In early 2008, Terry Engelder, a geoscience professor at Pennsylvania State University, and Gary Lash, a geology professor at the State University of New York at Fredonia, "said the Marcellus shale conservatively contains 168 trillion cubic feet of natural gas, but the figure might be as high as 516 trillion cubic feet" (UPI, 2008). The recoverable portion of this reserve is estimated to be around 10 percent of this total. By the end of February 2008 more than 450 suspected Marcellus wells had been permitted in Pennsylvania (Harper, 2008). The stage has been set for an extensive Marcellus Shale gas play in Pennsylvania.

OIL AND GAS ACTIVITIES AFFECTING WATER QUALITY

The potential impacts of oil and gas development on water quality are a concern across the Commonwealth. Of particular concern are: water withdrawals, storm water runoff from construction activities, pollution from drilling processes, groundwater contamination from hydraulic fracturing, and disposal of waste fluids. Water quality concerns related to oil and gas operations are addressed by a variety of federal and state regulations. The 1972 Federal Water Pollution Control Act Amendments and the 1977 Clean Water Act were the first regulations to subject the oil and gas producing industry to direct dealings with a federal agency on environmental protection issues (DOE, 2009a). Other regulations such as the Safe Drinking Water Act (1974) and the Resource Conservation and Recovery Act in (1976) authorize further federal regulation of the oil and gas industry. However, regulation of petroleum activities remains primarily a state responsibility.

In Pennsylvania, oil and gas activities are regulated by several chapters of the Pennsylvania Code and various state acts. The state's oil and gas laws (Oil and Gas Act – Act 223, Coal and Gas Resource Coordination Act – Act 214, and Oil and Gas Conservation Law – Act 359), as well

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as environmental protection laws that include the Clean Streams Law, the Dam Safety and Encroachments Act, the Solid Waste Management Act, and the Water Resources Planning Act give DEP the authority to regulate these activities while limiting the regulatory control of municipalities.

PERMIT	SOURCE/NOTES
Well Drilling Permit and Addendum	Pursuant to the Oil and Gas Act; an application addendum outlining a water management plan for that operation, pursuant to PA Code, Title 25, Chapter 78.11-33.
Earth Disturbance Permit (ESCGP-1)	Required from PA DEP regulating implementation of E&S controls, including SWM, if disturbance >5 acres. E&S plan is required if under 5 acres. PA Code, Title 25, Chapter 102.
Preparedness, Prevention and Contingency (PPC) Plan	The PPC Plan must address the types of wastes generated, disposal methods and a spill prevention plan. Construction and operation of on-site storage impoundments must also be described.
Water Withdrawal Permits	A permit is required from DEP for all withdrawals of surface or ground water. Separate withdrawal permits for projects in the Delaware or Susquehanna Basin or Susquehanna River Basin Commission.
Chapter 105 Obstruction and Encroachment Permit	Permit from DEP for work in a wetland, stream, or body of water. PA Code, Title 25, Chapter 105 (also required under the Oil and Gas Act).
Water Quality Management Permit	Permit if a centralized impoundment will hold fluids other than fresh water (such as drilling or fracing fluids). The siting, construction, use and closure of temporary pits are regulated under PA Code, Title 25, Chapter 78. Permits are only required if the pit is part of a treatment facility.

Development assciated with the Marcellus shale gas play includes construction of new roads, pipelines, compressors, water impoundments, well sites and other facilities. The development of this resource requires the use of large amounts of water and may expand to cover extensive areas. Marcellus shale gas development in Pennsylvania is a matter of local, regional, and national interest. Petroleum activities are listed as the primary cause for impairment in 0.2% of all non-attaining stream miles in Pennsylvania. Recent interest in the Marcellus shale play has the potential to greatly increase this number.

The large volumes of water required to complete a Marcellus Shale natural gas well, and the resulting large. Directional drilling and hydraulic facturing techniques used to extract gas from the Marcellus shale formation require large volumes of water to complete development of a natural gas well. These approaches require as much as 20 times the water volume as that used in conventional well completions (Harper, 2008). The hydraulic fracturing process for a typical Marcellus shale well uses approximately 3.5 million gallons of water (Harper and Kostelnik, 2010). The resulting large volume of waste water increases the environmental risk of this type of well development.

There are no stream segments in Mifflin County listed on the *2009 Integrated List of All Waters* as non-attaining, with petroleum activities as the primary source of impairment. However, this does not indicate that water quality impacts from petroleum activities are neglibible. Local impacts to surface water and groundwater resulting from petroleum activities can be severe. Oil and gas development activities with the potential to affect water quality include construction activies, well development, and gas production.

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CONSTRUCTION ACTIVITIES

Construction activities related to well development are the primary concern for impacts to surface water. Gas well construction can involve extensive earth disturbance for access roads, pad sites, and pipelines. For deeper wells the drilling pads alone can create a four to six acre disturbed area (Swistock, 2010). Earth disturbances related to well development present the potential for increased erosion and sedimentation in a manner similar to other construction activities. Well sites in remote locations can present increased risk due to the length of roads and pipelines necessary to support the facility. Other site factors such as slope, proximity to surface water, and soil type can increase the potential for impacts to surface water.

WELL DEVELOPMENT

Once the pad site and supporting facilities have been constructed well drilling begins. This is done with a drilling rig through a multi-stage process in which the wellbore is drilled, cased, and encased with concrete. A typical well can be drilled in 15-30 days if the rig is operating 24-hours a day. Well drilling requires a significant amount of water to lubricate and cool the drill bit and remove the cuttings from the borehole. Large quantities of wastewater are generated during this process. Along with the cuttings, present as suspended solids, the wastewater can contain pollutants such as sodium, chloride, iron, manganese, barium, arsenic, and organics used during the drilling process (e.g. surfactants, detergents, oil, grease, benzene, toluene) (Swistock, 2010).

Once a well has been drilled, a process called hydraulic fracturing, or fracing, is used to create additional permeability in the shale to improve the flow of gas toward the wellbore. Fracing involves pumping a fracturing fluid (typically water-based with other additives to improve performance) into a formation to generate fractures in the target formation to improve release of the natural gas trapped in the rock (DOE, 2010b). Additives used for hydraulic fracturing include sand, oils, gels, acids, alcohols, and various other chemicals. Some portion of the frac water (estimated at 10 to 70 percent) returns to the surface as “flow back” wastewater, with the rest remaining underground.

Various stages throughout well development have the potential to negatively impact water resources. Improperly sealed wells can contaminate drinking water sources; storage, transportation, and disposal of wastewater present opportunities for leaks or spills; additives injected with hydrofracing fluid may contaminate groundwater sources; or methane gas can migrate from gas wells into nearby water supply wells.

GAS PRODUCTION

The production phase of well development generally presents the lowest level of risk to water quality. Once well development is complete water continues to be pumped into the well to improve the flow of natural gas. The return fluids, called production fluids, generally contain high concentrations of salts from ancient underground saltwater deposits. Production fluids also contain some of the pollutants noted in drilling and hyrdofracturing fluids.

OIL AND GAS WATER RESOURCE CONCERNS

As previously noted, considerable quantities of water are necessary for the development of a Marcellus Shale gas well. The substantial amount of water utilized presents several challenges in protecting the Commonwealth’s water resources. In a report issued by USGS (Soeder and Kappel, 2009), three principal water-resource concerns are noted in regards to Marcellus Shale gas production:

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WATER SUPPLY MANAGEMENT

Water for drilling and hydraulic fracturing of wells typically comes from surface water bodies such as lakes. Groundwater sources, municipal water sources, and re-used process water are also sometimes used for these processes. Some concern exists about where the immense volumes of water necessary to sustain large scale well development will be obtained. Other concerns include what the potential consequences might be for local water supplies and the effects of withdrawing this amount of water when it is needed for drilling activities.

The water volumes necessary to sustain petroleum activities are large; however they generally represent a small percentage of the total water used when considered from a basin-wide surface water budget (DOE, 2010b). To put shale gas water use in perspective, the consumptive use of fresh water for electrical generation in the Susquehanna River Basin is nearly 150 million gallons per day, while the projected total demand for peak Marcellus Shale activity in the same basin is 8.4 million gallons per day (Gaudlip et al., 2008). When these withdrawals are examined at a local level, they represent a much larger percentage of the available resource. Rapid withdrawal of large quantities can have short and long-term effects on a water supply. Surface water withdrawal during dry periods could affect aquatic life, recreational activities, potable water supplies, and other industries.

WATER RESOURCE CONTAMINATION

As discussed in the previous section, petroleum activities have the potential to negatively impact water quality at several stages throughout the drilling and production process. Construction activities necessary to construct access roads, pipelines, and prepare well sites have the potential to cause increased erosion and sedimentation. Access roads and well pad sites are rarely, if ever, fully stabilized which increases the duration of potential erosion problems. Similarly, transporting large amounts of equipment, vehicles, and supplies to remote well sites can damage low capacity rural roads (often constructed of dirt and gravel) and cause accelerated erosion. These effects of these activities can be mitigated through use of common construction BMPs.

Other activities such as well drilling, hydraulic fracturing a well, and gas production all present unique challenges to protecting water quality. The various pollutants found in the process water and flowback fluids used during these activities have the potential to contaminate groundwater supplies or impair surface waters if not handled and disposed of properly. These activities require specialized practices to reduce the risk of contaminating water resources.

WASTEWATER DISPOSAL

The wastewater produced during well development and production is one of the main threats to water quality. The large volumes of liquid produced present logistical and economic challenges for recovery and disposal of the wastewater in a manner that minimizes impacts to water resources. In addition, the pollutants often present in the liquid can require wastewater treatment prior to disposal. Although the percentage of chemical additives in a typical hydrofrac fluid is typically less than 0.5 percent by volume, the quantity of fluid used is so large that the additives in an average three million gallon well development would result in about 15,000 gallons of chemicals in the wastewater (Soeder and Kappel, 2009). In addition to the chemical additives found in hydrofrac fluid, the wastewater may contain a variety of naturally occurring pollutants such as brines, organics, heavy metals, and radionuclides removed from subsurface formations. High concentrations of sodium, chloride, and bromide are often found in brine from well drilling.

Common disposal methods include processing them through wastewater treatment plants (the most common method in Pennsylvania), re-injecting the fluids into the ground, and evaporating

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the liquid and disposing the remaining solids as dry waste. The effectiveness of standard wastewater treatment for processing wastewater is not well understood. In particular, salts and other dissolved solids are not usually removed by standard treatment processes. Re-injecting the wastewater into the ground (shallow re-injection and deep re-injection) may result in groundwater contamination or other unknown problems. The evaporation method is not a very practical technique in the humid climate of Pennsylvania. Further study of these disposal methods and a better understanding of their effects are necessary to effectively protect the water resources of the Commonwealth.

OIL AND GAS MANAGEMENT PRACTICES FOR WATER QUALITY

Many standard practices in the oil and gas industry are currently being implemented in recognition of the need to protect other natural resources while extracting petroleum resources. The water quality impacts of oil and gas activities can be futher minimized by implementing appropriate management measures and by utilizing suitable Best Management Practices (BMPs). As presented here, management measures are guidance for operations and steps to be taken that will promote the sound, efficient, and environmentally appropriate development of all oil and gas activities, with a particular focus on Marcellus Shale natural gas developments. BMPs are specific activities, processes, or technologies designed to serve specific functions, which are used to attain a management measure.

Management measures and BMPs for activities associated with oil and gas development can determine what resources may be impacted, the extent of the impacts, and mitigation strategies. Use of the following management measures and BMPs does not replace the need to meet Federal and State requirements, their use (when appropriate) will aid in compliance with the applicable regulations:

- Predevelopment Planning
- Wetland and Riparian Management Areas
- Access Road Construction
- Road Management
- Pipeline Construction
- Well Site Development
- Chemical Management

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Predevelopment Planning

Purpose	Ensure that oil and gas activities are planned with water quality considerations in mind and conducted in a manner to minimize delivery of nonpoint source pollutants to surface waters and groundwater.
Description	A development plan established during the early stages of anticipated development provides the framework for avoiding or minimizing surface disturbance, protecting other resources, mitigating environmental impacts, and alleviating or addressing concerns of landowners and communities. It serves as a tool for comprehensive, coordinated planning to guide strategic development. It can also assist in meeting the requirements of the Clean Water Act, the Clean Air Act, the Endangered Species Act, and other applicable Federal, and State laws.

GUIDANCE: Develop plans to provide a comprehensive description of the characteristics of the area, along with the anticipated nature of the proposed development. Plans should address potential impacts to water quality, existing natural resources, and the potential for habitat fragmentation in sensitive areas where there are high levels of biodiversity, or sensitive and critical habitats.

Planning needs will differ by location and should be applied in different ways, depending on such things as subsurface geology, terrain, and existing and proposed land use. Plans may be simple or complex, depending upon the circumstances, and will need to be customized to fit the site specific conditions for a project. The following items should be included in the plan:

- Identification of land ownership
- Identification of existing and expected surface uses (including number and spacing of wells, roads, pipelines, water disposal and treatment facilities, compression facilities, gathering and transmission pipelines, etc.)
- Identification of existing and required infrastructure and utility corridors
- Map of the area with location of existing facilities (i.e., wells) and potential (optimal) locations for future facilities, including production facilities (well sites, processing units, etc.), roads, and utility corridors. The map should include geographic features such as streams and other water bodies, and special ecosystems, as well as topographic information.
- Identification of opportunities to avoid, reduce, and mitigate adverse impacts
- Identification of regulatory requirements
- Water management plan (strategy)
- Identification of strategies for reclamation of disturbed areas
- Consider a strategy for establishing a baseline and monitoring and steps to apply monitoring information to existing and future actions

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)
BMP 4.3.1. Background Site Factors
BMP 4.3.2. Site Factors Inventory
BMP 4.3.3. Site Factors Analysis

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Wetland and Riparian Management Areas

Purpose	Protect the ecological function and hydrologic features of riparian areas, wetlands, and floodplains.
Description	Establish and maintain a buffer zone along surface waters and wetlands that is wide enough to filter runoff, provide bank stability, and shade the water. Limit oil and gas activities within the buffer.

GUIDANCE: Establish a buffer zone around riparian areas, wetlands, and floodplains. Locate all well pads and other nonlinear facilities outside of the buffer zones.

GUIDANCE: Avoid crossings of wetland and riparian areas by pipelines and roads to the maximum extent practicable. Where crossings cannot be avoided, impacts can be minimized through use of the following measures.

- Develop site-specific avoidance and mitigation plans prior to approval process for all proposed disturbance to wetland/riparian areas, including their buffer areas
- Construct any crossings perpendicular to wetland/riparian areas
- Schedule construction adjacent to wetland areas to minimize the duration of construction activity, and to concentrate such activity during dry conditions, or when the ground is frozen during the winter
- Locate stockpiles outside the buffer areas
- Locate drilling mud pits outside of buffer areas
- Begin reclamation of disturbed wetland/riparian areas as soon as possible after project activities are complete
- Monitor any stream channel for erosion, sedimentation, degradation, and riparian health

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)
BMP 5.4.1 Protect Sensitive and Special Value Features
BMP 5.4.2 Protect/Conserve/Enhance Riparian Areas
BMP 5.4.3 Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design

Access Road Construction

Purpose	Reduce erosion and sedimentation which is common during, and immediately after, construction of oil and gas access roads.
Description	Design and construction of roads that are planned for the topography, soils, and drainage patterns of a site. Appropriate construction methods and BMPs are used to minimize erosion from high risk areas such as the road surface, steep slopes, water crossings, and runoff conveyance structures (i.e. culverts, ditches, etc.).

The location and construction of access roads require careful planning. Special attention should be given to steep slopes, surface waters, soils, and other potential hazards. Access roads should be designed with grades between 2 and 10%, located outside buffers of water features, and should have cuts and fills minimized.

GUIDANCE: Utilize existing roads to the maximum extent possible. Locate new roads in areas that will optimize year-round, all-weather access, and minimize surface disturbance and environmental impacts.

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GUIDANCE: Minimize construction of roads where it is operationally feasible and safe. Construct roads to the minimum standard necessary to achieve intended use (i.e. use two-track access roads where possible).

GUIDANCE: Road Construction and Reclamation. Plan, maintain and construct all roads in conformance with road standards. Major access roads to the general development area should be constructed to a higher road standard to avoid excess maintenance caused by poor planning and constructed. Practices that can enhance reclamation include:

- Reclaim and re-vegetate all disturbed surface that will not be used for gas operations in a manner that restores topsoil and minimizes erosion.
- Use re-forestation as a reclamation strategy where forest land was impacted during the development.
- Use only certified and inspected seed that is free of noxious weeds for reclamation/re-vegetation.

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)	
BMP 5.7.1 Reduce Street Imperviousness	
BMP 5.7.2 Reduce Parking Imperviousness	
• Structural (refer to PA Stormwater BMP Manual)	
BMP 6.4.1 Pervious Pavement with Infiltration Bed	
BMP 6.4.7 Constructed Filter	
BMP 6.4.8 Vegetated Swale	
BMP 6.4.9 Vegetated Filter Strip	
• E&S (refer to PA E&S Pollution Control Manual)	
Sediment Barriers and Filters	Compost Filter Sock, Rock Filter Outlet, Super Silt Fence, Sediment Filter Log, Straw Bale Barrier, Rock Filter, Vegetative Filter Strip
Runoff Conveyance BMPs	Broad-based Dip, Access Road Swale, Ditch Relief Culvert, Turnout
Sediment Capture & Treatment	Construction Entrances, Compost Sock Sediment Trap
Stabilization Methods and Standards	

Road Management

Purpose	To ensure that management of existing roads maintains their utility and minimizes polluted runoff from roads and road structures.
Description	Minimize use during wet weather and thaw conditions. Perform routine maintenance of road surface, stream crossings, and drainage structures. Immediately repair eroding areas and implement BMPs to address problem areas. Close and decommission roads that are no longer needed.

GUIDANCE: Plan access routes for heavy equipment and the high volume of trucks to the site with input from the local municipality and PennDOT.

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GUIDANCE: Consider operational traffic and plan for the long-term operations of the facility considering maintenance as well as potential issues with dust, compaction, and debris, as well as safety.

Water Quality BMPs:

• E&S (refer to PA E&S Pollution Control Manual)
Sediment Barriers and Filters
Runoff Conveyance BMPs
Stabilization Methods and Standards

Pipeline Construction

Purpose	Reduce erosion and sedimentation during, and immediately after, construction of oil and gas pipelines.
Description	Appropriate design and construction methods are used to minimize erosion from areas disturbed by pipeline construction. BMPs are used in high risk areas such as steep slopes and water crossings.

GUIDANCE: Use existing disturbance corridors whenever possible (ideally following access routes or existing pipeline routes).

GUIDANCE: Locate pipelines in the same trenches, or immediately parallel to, each other. Install pipelines at the same time if possible.

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)	
BMP 5.4.1 Protect Sensitive and Special Value Features	
BMP 5.4.2 Protect/Conserve/Enhance Riparian Areas	
BMP 5.4.3 Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design	
BMP 5.6.3 Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species	
• E&S (refer to PA E&S Pollution Control Manual)	
Crossings	Roadways, stream, wetlands
Outlet Protection	
Stabilization Methods and Standards	

Well Site Development

Purpose	Minimize the likelihood of water quality impacts resulting from development of oil and gas well sites.
Description	Follow the plan for oil and gas operations developed during predevelopment planning. Conduct operations to avoid sedimentation to the extent practicable. Use appropriate areas for high risk activities such as equipment maintenance, and petroleum and chemical storage and dispensing.

GUIDANCE: Minimize surface disturbance to the maximum extent practicable. Utilize techniques such as drilling multiple wells from the same pad when technically feasible.

GUIDANCE: Remove all equipment not necessary for well operations.

GUIDANCE: Locate well construction activities with the following considerations:

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- Locate well sites in stable, non-erosive soil areas, with grass or brush cover and on relatively level areas that minimize pad construction. Choose sites that avoid steep slopes, unstable soils, and close proximity to streams, floodplains, springs, and wetlands.
- Divert surface runoff from entering the constructed pad site to avoid transporting of pollutants.
- Locate facilities and roads away from occupied dwellings.
- Locate in visually acceptable areas (avoid dwelling view sheds) and paint facilities colors that blend in with the natural environment.
- Locate where safe access can be maintained year round.

Water Quality BMP's:

• Non-Structural (refer to PA Stormwater BMP Manual)	
BMP 5.5.1 Cluster Uses at Each Site; Build on the Smallest Area Possible	
BMP 5.6.1 Minimize Total Disturbed Area – Grading	
BMP 5.6.2 Minimize Soil Compaction in Disturbed Areas	
BMP 5.6.3 Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species	
BMP 5.7.2 Reduce Parking Imperviousness	
BMP 5.9 Source Control	
• E&S (*refer* to PA E&S Pollution Control Manual)	
Sediment Barriers and Filters	Compost Filter Sock, Rock Filter Outlet, Super Silt Fence, Sediment Filter Log, Straw Bale Barrier, Rock Filter, Vegetative Filter Strip
Runoff Conveyance BMPs	Channels, Top of Slope Berm, Temporary Slope Pipe
Sediment Capture & Treatment	
Outlet Protection	
Stabilization Methods and Standards	
• *Structural* (refer to PA Stormwater BMP Manual)	
BMP 6.4.1 Pervious Pavement with Infiltration Bed	
BMP 6.4.7 Constructed Filter	
BMP 6.4.8 Vegetated Swale	
BMP 6.4.9 Vegetated Filter Strip	
BMP 6.6.1 Constructed Wetland	
BMP 6.6.2 Wet Pond/Retention Basin	
BMP 6.6.3 Dry Extended Detention Basin	
BMP 6.6.4 Water Quality Filters & Hydrodynamic Devices	
BMP 6.7.1 Riparian Buffer Restoration	
BMP 6.7.2 Landscape Restoration	
BMP 6.7.3 Soil Amendment & Restoration	
BMP 6.7.4 Floodplain Restoration	
BMP 6.8.1 Level Spreader	

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Pollution Prevention

Purpose	Minimize the potential of water pollution caused by potential pollutants used for, or generated by, oil and gas operations.
Description	Risks associated with chemicals and other potential pollutants used for, and generate by, oil and gas operations can be reduced through careful transport, storage and use the substances. Spill Preparedness, Prevention, and Contingency Plans can reduce the potential impact of accidental spills.

GUIDANCE: Prepare a site specific Preparedness, Prevention, and Contingency Plan that identifies potential pollutants used or stored on site, outlines operational procedures to reduce the likelihood of accidental spills, and details a pollution incident response plan to be employed in the event of a spill.

GUIDANCE: Conduct personnel training programs to educate all employees of safe handling and disposal methods of all potential pollutants stored or generated on site. Pollution incident response should also be included in the training.

GUIDANCE: Implement pollution prevention practices when feasible. Use pollution source reduction techniques (i.e. alternative chemicals and additives), reduce or eliminate waste generated through process changes, and use new technologies to remove pollutants from wastewater to reduce the pollution potential of oil and gas activities.

Facility Reclamation and Decommissioning

Purpose	Reduce erosion and sedimentation of areas disturbed by oil and gas activities and minimize long-term impacts of oil and gas activities.
Description	Reduce erosion and sedimentation by stabilizing the work area around active facilities and establishing permanent vegetation on the surrounding area immediately upon completion of earth-disturbing activities. Remove and decommission facilities upon completion of planned use. Restore facility sites to pre-disturbance condition, or better.

GUIDANCE: Reduce facility size to the minimum area required for oil and gas production operations by restoring all areas temporarily disturbed during construction activities. Restoration should include the following:

- Re-contour disturbed areas to be compatible with existing grades.
- Replace topsoil to at least the depth and quality that existed prior to disturbance for final reclamation of the site upon abandonment of the well.
- Re-vegetate disturbed areas using native vegetation and including re-forestation.
- Remove all chemicals, equipment, materials, and waste not necessary for sustaining production from the well pad.

GUIDANCE: Stabilize facilities during operations with crushed stone or other appropriate methods.

GUIDANCE: Remove and decommission facilities as soon as reasonably possible after oil and gas production is completed. Restore the disturbed areas to their pre-disturbance condition, or better, by reshaping the site to the original contour, replacing topsoil, and re-establishing native vegetation.

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